APPENDIX N

Karst Plan

ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE

and

DOMINION TRANSMISSION, INC.
SUPPLY HEADER PROJECT

Supplemental Filing
January 27, 2017

Karst Terrain Assessment Construction, Monitoring, and Mitigation Plan

January 20, 2017

Karst Terrain Assessment Construction, Monitoring and Mitigation Plan

Atlantic Coast Pipeline Randolph and Pocahontas Counties in West Virginia and Highland, Augusta, and Nelson Counties in Virginia

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January 20, 2017

Ms. Brittany Moody
Dominion Transmission, Inc.
445 West Main Street
Clarksburg, West Virginia 26301

Subject: **Karst Terrain Assessment, Construction, Monitoring and Mitigation Plan, Atlantic Coast Pipeline, Randolph and Pocahontas Counties in West Virginia, and Highland, Augusta, and Nelson Counties in Virginia (Our 15200)**

Dear Ms. Moody:

Per your request, GeoConcepts Engineering, Inc. (GeoConcepts) has completed a Karst Terrain Assessment, Construction Monitoring, and Mitigation Plan in support of the development of the Atlantic Coast Pipeline in areas of Randolph and Pocahontas Counties, West Virginia Highland, Augusta, and Nelson Counties, Virginia, and Westmoreland County, PA.

We appreciate the opportunity to serve as your geotechnical consultant on this project. Please do not hesitate to contact me if you have any questions or want to meet to discuss the findings and recommendations contained in the report.

Sincerely,

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ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE
Docket No. PF15-6-000

and

DOMINION TRANSMISSION, INC
SUPPLY HEADER PROJECT
Docket No. PF15-5-000

Karst Terrain Assessment, Construction, Monitoring, and Mitigation Plan

Prepared by
GeoConcepts Engineering, Inc.
January 2017

GeoConcepts Engineering, Inc.

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Plan Outline

At the request of Atlantic Coast Pipeline, LLC (Atlantic), and Dominion Transmission, Inc. (DTI), GeoConcepts has developed a plan describing the assessment, monitoring, and mitigation activities for the proposed Atlantic Coast Pipeline (ACP) and the Dominion Supply Header Project (SHP) routes through areas of karst terrain. The requested plan is outlined as follows:

Definitions

This section provides a summary of karst-specific terms used in the plan.

Geological Overview

This section provides a brief discussion of karst terrain and features and the overall regional karst geology in the general area of the project. It is of note that the plan as written is a "generic" document due to possible changes that may occur in the specific project alignment. However, regardless of reroutes the alignment will need to pass across each of the provinces discussed in the geological overview section of the plan.

Pre-Construction Assessment and Field Survey

This section describes in detail the pre-construction database and remote sensing review, as well as field survey methods and procedures which are currently being completed.

Construction Monitoring Protocols

This section describes the methods and procedures to be utilized during the construction phase of the ACP/SHP. It includes:

- a description of the pre-excavation electrical resistivity investigation (ERI) methods and procedures, and the manner in which the ERI data will be analyzed, summarized, and presented; and
- a description of the activities to be conducted by the field geologist during excavation and trenching activities, including how the observations will be made and the reporting format and frequency.

Karst Mitigation and Conservation Procedures

This section discusses the best management practices (BMPs) to be utilized for mitigating, remediating, and minimizing impacts to karst features that may be encountered during construction activities. This includes features that either are within or receive drainage from the pipeline right-of-way, or features that are intercepted during the excavation and trenching process, as well as access roads, additional temporary workspace areas, or any other areas where land disturbance necessary for pipeline construction is planned. It is noted that these mitigation and conservation procedures will not apply for existing access roads that do not require land disturbance. The format and manner in which the mitigation and remedial activities will be undertaken and reported are addressed in this section of the plan. The intent is to provide agreed upon solutions to the karst features that may be encountered prior to the start of construction so that those features can be protected. However, in some cases, the actual remedial measure employed may be customized to the specific karst features identified.

Definitions

Karst Specialist – A Licensed Professional Geologist engaged in the practice of engineering geology (or) a Virginia Registered Professional Engineer engaged in the practice of Geotechnical Engineering, with a minimum of 10 years of experience in karst geology characterization and remediation. Practice experience shall be demonstrated by a statement of qualifications.[1]

[1]Adapted from the VA Cave Board Karst Assessment and Survey Guidelines (and) Denton, et al. 2016. All other definitions adapted from Field, 2002.

Cave – A natural hole in the ground, large enough for human entry. This covers the enormous variety of caves that do occur, but eliminates the many artificial tunnels and galleries incorrectly named caves. The size criterion is arbitrary and subjective, but practical, as it eliminates narrow openings irrelevant to explorers but very significant hydrologically, that may be better referred to as *proto-caves*, *sub-conduits*, or *fissures*. A cave may be a single, short length of accessible passage, or an extensive and complex network of tunnels as long as hundreds of kilometers.

Doline; Sinkhole – A basin- or funnel-shaped hollow or depression in limestone, dolostone or other soluble bedrock, ranging in diameter from a few meters up to a kilometer and in depth from a few to several hundred meters. Some dolines are gentle grassy hollows or depressions; others are rocky cliff-bounded basins. A distinction may be made by direct solution of the limestone surface zone (solution dolines), and those formed by collapse over a cave (collapse dolines), but it is generally not possible to establish the origin of individual examples. Generally referred to as a "sinkhole" in the United States, the term doline is more widely accepted by the international geology community.

Throat – An opening within a sinkhole leading into the subsurface through which material passes or has passed from the sinkhole into underlying solutional voids and conduits, which is generally too small to qualify as a cave and often called a *proto-cave*, *sub-conduit*, or *fissure*. Throats may be "open" (i.e. air-filled or water-filled), or "closed/clogged" (filled with debris including but not limited to: loose-soil; gravel; rock; dead-fall wood or brush; or trash).

Parapet – The outer edge or perimeter of a doline (sinkhole).

Ponor – a) Hole or opening in the bottom or side of a depression where a surface stream or lake flows either partially or completely underground into the karst groundwater system. b) Hole in the bottom or side of a doline through which water passes to or from an underground channel. Also known as a swallow hole or swallet.

Solution Cavity – A natural cavity or depression formed by the dissolution of soluble bedrock, typically not large enough to allow the entry of a human being and, therefore, not classified as a cave.

Breccia – Angular fragments of rock commonly, but not always, cemented by finer-grained materials including silica, iron minerals, and calcite to form a new rock. Many fault planes are marked by zones of broken rock, either loose or re-cemented, forming a fault breccia.

Non-Karst Closed Depression – A natural or non-natural topographic depression that is not formed by karst processes and is not floored by bedrock. Examples include (but are not limited to) construction-related soil subsidence, silage pits, farm ponds, scour pools, animal wallows, large animal burrows, and pits created by removal of tree stumps.

Sinking Stream/Swallet – A perennial or intermittent stream whose bed and bank disappear entirely underground, usually through an open throat sinkhole or cave entrance.

Losing Stream – A perennial or intermittent stream which loses flow volume into its bed due to the presence of sub-channel (hyporheic) solution cavities or conduits.

Geological Overview of the Karst Terrain Sections of the Proposed ACP/SHP

Overview of regional karst terrain within the project area

The term "karst" refers to a type of landform or terrain, just like "desert", "marsh", "tundra", "steppe" or "montane". It was named for a province in Slovenia where it was first described in the late 17th and early 18th century by geologists of the former Austro-Hungarian Empire. Simply stated, karst terrain is characterized or diagnosed by the presence of sinkholes, caverns, an irregular "pinnacled" bedrock surface, and many large springs; however, the development of karst terrain is a result of the presence of soluble bedrock such as limestone, dolomite, marble or gypsum. Any landscape that is underlain by soluble bedrock has the potential to develop a karst terrain landform.

As in any region where soluble bedrock is present, a karst landform regime has developed in three known regions of the proposed ACP/SHP. Folding and faulting of the local carbonate rocks has opened up numerous fractures both parallel with the axis of the geologic structures, as well as perpendicular to them. Surface fractures and joints weather differentially, producing a pinnacled or "saw-tooth" profile at the bedrock/soil interface (referred to as the "epikarst" zone). In contrast, rock-enclosed fractures can be secondarily enlarged by the action of carbon dioxide charged groundwater, in some cases forming water-filled or air-filled conduits. As the regional terrain is "mature" karst, nearly all the fractures have undergone successive cycles of sediment filling and flushing. In areas such as the ACP project area, where there is little topographic relief and a relatively minimal groundwater gradient, the great majority of solution fissures are sediment-filled.

The most prevalent type of karst features in the project area are dolines or sinkholes, and these features comprise the greatest potential geohazard risk to any type of construction in karst terrain. Sinkholes fall into two broad categories, "vault-collapse" sinkholes, and "cover-collapse" sinkholes. Vault-collapse type sinkholes (i.e., where a cavern "vault" or roof has failed catastrophically) are rare in the ACP/SHP Project area (Campbell, et al., 2006). Cover-collapse sinkholes, which are common in the ACP project area, develop by the raveling of fines from the soil overburden into solution channels within the bedrock mass, in which water is the transport medium for the movement of the soil fines. The natural raveling process is generally a very slow one, such that sinkhole development generally occurs over a very long time span. However, various changes at a site can sometimes lead to the very sudden development of sinkholes. The most common changes that will exacerbate sinkhole development are:

1. Increase or redirection of overland or subsurface water flow paths, which accelerates the raveling of soil fines;
2. Removal of vegetation cover and topsoil (i.e., stripping and grubbing), which can reduce the cohesive strength of the soils overlying a conduit; and
3. Sudden changes in the elevation of the water table (such as drought, over-pumping of wells, or quarry dewatering), which removes the neutral buoyancy of the water supporting a conduit's soil plug, and can often result in rapid and catastrophic soil collapse.

Geological Setting

The proposed ACP/SHP will cross three distinct regional provinces of karst geology, from east to west:

1. The **Great Valley subsection of the Valley and Ridge physiographic province**, encompassing the portion of Augusta County, Virginia from the Blue Ridge on the east to Little North Mountain on the west.
2. The **Folded Appalachian subsection of the Ridge and Valley province**, encompassing the westernmost section of Augusta County, and all of Bath County and Highland County, Virginia and extending from the North Mountain area on the east to the Allegheny Mountain on the west.
3. The **Allegheny Front and Appalachian Plateau** provinces of West Virginia, encompassing Pocahontas and Randolph Counties, West Virginia, and the karst section of the SHP located in Westmoreland County, Pennsylvania.

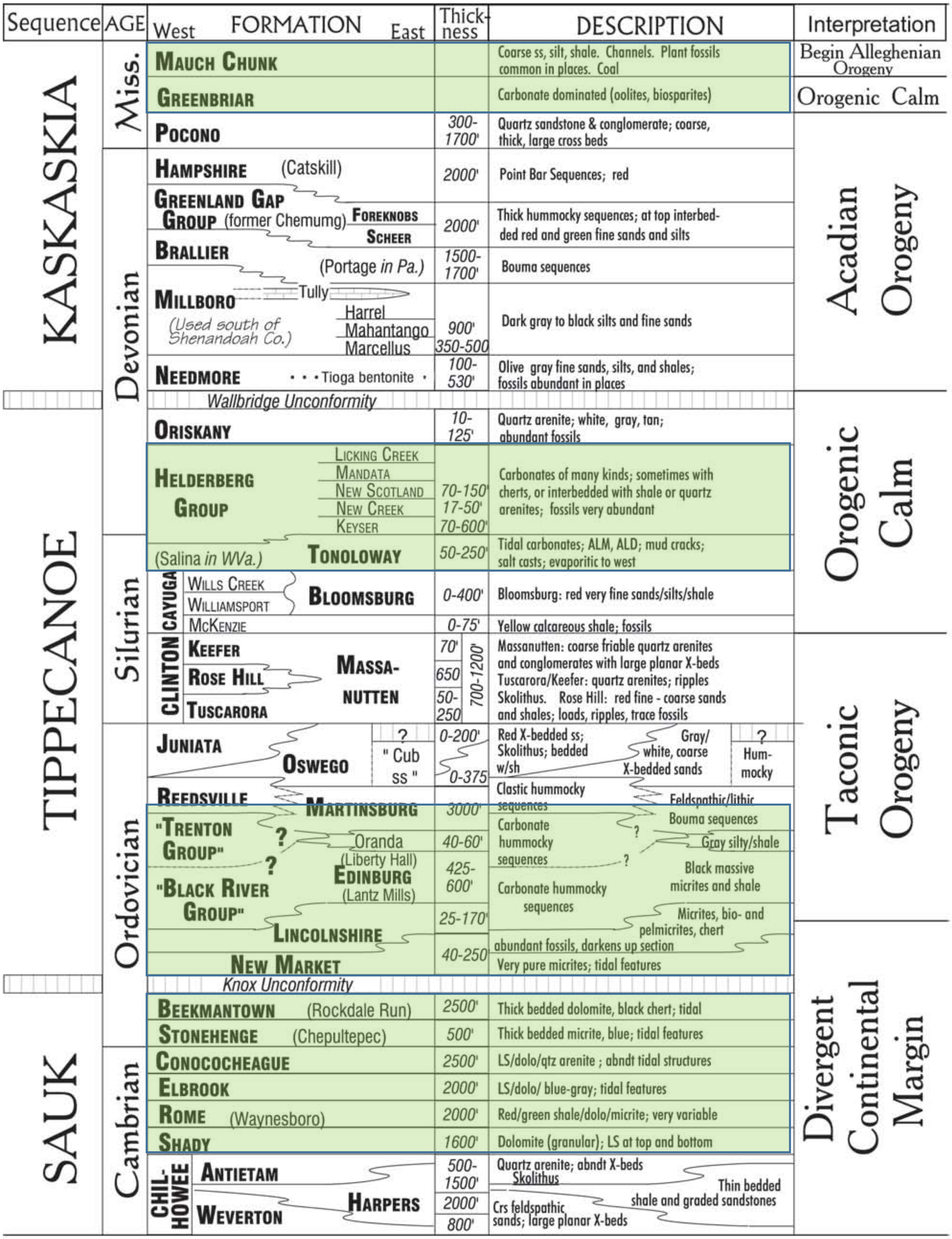

Figure 1. Stratigraphic Column of the central Virginia Great Valley, Folded Appalachians, and eastern Allegheny Front of west central Virginia and eastern West Virginia (Fichter, 2010). (The karst forming units are highlighted in green.)

The Great Valley (Augusta County, VA)

The Great Valley section is a generally downwarped trough (synclinorium) of Paleozoic limestones, shales, and sandstones that lie between the Blue Ridge Massif on the east and the Allegheny Mountains to the west. The Valley extends between the two mountain uplands from northeast to southwest, parallel with the average strike of the bedrock.

The karst terrain of the Great Valley section of the ACP project area is characterized by numerous circular to oval-shaped sinkholes, ranging in size from a few feet to several hundred feet in diameter, the majority of which are completely vegetated and lack any opening to the subsurface ("throat") at their base. Sinkhole depths can vary, but are usually controlled by the angle of repose of the sediments lining their walls. Steep, rock-walled sinkholes are rare in this section, but generally occur in the small hills and uplands that are erosional remnants of the prior valley floor.

The Great Valley section contains large karst springs in the region. It is also characterized by sinkholes called "estavelles", which are insurgences for water during dry periods, and flood or act as springs (resurgences) during wet seasons. There are also numerous caves (i.e., air-filled voids large enough to permit the entry of a human being and that have an entrance to the surface) and subsurface caverns (air-filled voids large enough for human entry with no connection to the surface) in the region. Most of the caves and caverns range in length from a few feet to several miles; however, the average length rarely exceeds 2,500 feet. This is in contrast to the Folded Appalachian and Appalachian Plateau provinces to the west, where some of the longest caves in the region have been surveyed, many of which are more than 10 miles in length. Nevertheless, though not of great length, some of the most voluminous underground chambers in the region occur in the Great Valley section.

A unique type of karst terrain has developed in the eastern portion of Augusta County along the base of the Blue Ridge Mountains. Here, the characteristic karst terrain has been buried beneath a mantle of alluvial material which was shed off the mountains to the east. This alluvium ranges in age from less than 1 million years (Quaternary Period) to over 50 million years (Paleogene Period). The alluvium thins towards the west, and disappears completely west of Waynesboro, Virginia. Although the primary karst terrain is mantled by the alluvium, numerous shallow broad sinkholes are present and indicate the presence of large karst features in the underlying bedrock.

Bedrock Geology

Specifically, the proposed ACP project area in the Great Valley section has been extensively studied and mapped as being underlain by a series of karst-forming carbonate and calcareous clastic rocks (Campbell et al., 2006; DMME, 1993; Rader & Gathright, 2001; Rader & Wilkes, 2001; Hubbard, 1988; Southworth, et al., 2013) ranging in age from the Lower Cambrian to Middle Ordovician geological periods as follows:

Ordovician Period

Martinsburg Formation (Om)

The upper 100 to 200 feet of this formation is a brown, medium-to coarse-grained, fossiliferous sandstone. An olive-green silty shale and dark-gray siltstone comprises the middle portion of this formation, along with a medium-to coarse-grained, locally pebbly sandstone. The Stickley Run Member exists as the lower 400 to 900 feet of the formation. This is a medium-gray to grayish-black, very fine-grained (aphanitic), very thin- to thin-bedded, argillaceous limestone with interbedded medium- to dark-gray, calcareous shale.

Edinburg Formation (Oeln)

A black, fine-grained to aphanitic limestone with layered black shale that commonly contains pyrite, and medium- to light-gray, fine- to coarse-grained, nodular limestone with thin partings of black shale. This formation lies in thicknesses ranging from 450 to 1,000 feet throughout the three subject areas.

Lincolnshire Limestone (Oeln)
Gradational contact with the overlying Edinburg. A light- to very dark-gray, fine- to coarse-grained, medium to very thick-bedded limestone with black chert nodules. The Murat Limestone Member, generally found at the top of the formation, is a light colored, coarse-grained limestone composed of fossil fragments. Thicknesses throughout the subject areas range from 50 to 250 feet.

New Market Limestone (Oeln)
Unconformable upper contact with the Lincolnshire. The upper unit of this formation is a medium-gray, aphanitic, thick-bedded, limestone with scattered calcite crystals. The lower unit is a medium- to dark-gray, fine-grained, thin-bedded, argillaceous, bioturbated limestone that is dolomitic in parts, with its base being a carbonate pebble conglomerate. Formation thicknesses throughout the subject areas range from 100 to 250 feet.

Pinesburg Station Dolomite* (Ob)
This formation is a medium-to light gray, fine-grained, medium- to thick-bedded dolostone, with sparse fossils. When weathered, this dolomite is very light-gray, and exhibits a "butcher-block" structure. A medium-gray, fine-grained limestone exists as the base of this unit. The formation's average thickness is 400 feet.

Rockdale Run Formation* (Ob)
The upper contact with the overlying Pinesburg Station is unconformable. This formation is comprised of a medium-gray, fine-grained, fossiliferous limestone and a light- to medium-gray, fine-grained, laminated dolomitic limestone and dolostone with mottled beds. Thin lenses of gray chert are common near the base of the formation. Formation thickness ranges from 1,500 to 2,400 feet.

Stonehenge Limestone* (Ob)
Upper contact with the Rockdale Run Formation is gradational. The upper 400 to 500 feet is comprised of a medium- to dark-gray and black, fine- to medium-grained limestone, with thin beds of macerated fossil debris. The lower 50 to 150 feet (Stoufferstown Member) is a dark-gray to black, fine-grained limestone with thin sheet-like, crinkly partings due to cleavage, and thin beds of coarse-grained, bioclastic limestone.
***Beekmantown Group (Note – This unit consists of the Pinesburg Station Dolomite, Rockdale Run Formation, and the Stonehenge Limestone)**

Cambrian Period
Conococheague Formation (OCco)
The upper contact with the Stonehenge Limestone of the Beekmantown Group is unconformable. The upper 2,000 feet of this formation is a light- to dark-gray, fine-grained, laminated limestone, dolomitic limestone, and dolostone with flat-pebble conglomerate beds. Some cross laminated sandstone beds occur in the uppermost part of this unit. The Lower 200 to 500 feet (Big Spring Station Member) consists of a light-gray, fine-grained dolostone, medium- to dark-gray, fine-grained laminated limestone and dolomitic limestone, and gray, coarse-grained sandstone and dolomitic sandstone. Beds of flat-pebble conglomerate occur in the dolomite.

Elbrook Formation (Ce)
This unit's thickness ranges from 2,000 to 2,500 feet. The formation is a dark- to medium-gray, fine- to medium-grained limestone, dolomitic limestone, dolostone, and dolomitic shale. These lithologies commonly occur as erosion-surface-bounded sequences of algal limestone overlain by laminated dolomite. Decalcified, ocherous shale-like chips on the ground surface characterize this unit. The lower 300 to 400 feet is green to greenish-gray, fine-grained dolostone, dolomitic limestone, and shale.

Waynesboro Formation (Cw)

The upper contact with the Elbrook Formation is gradational. A dusky-red to olive-gray, fine- to medium-grained sandstone and dusky-red to gray shale exists as the upper 300 feet. The middle 400 feet is a medium- to dark-gray, saccharoidal dolomite and fine-grained limestone. The lower 500 feet is dusky-red, olive-gray, and dark-gray shale and dusky-red to brownish-gray, fine- to medium-grained sandstone. Overall thickness is approximately 1,200 feet.

Tomstown Dolomite/Shady Dolomite (Ct/Cs)

The upper 600 feet is light- to dark-gray, fine- to coarse-grained, medium- to thick-bedded, locally laminated dolostone with white chert rosettes and nodules in the upper 50 feet. The middle unit (about 210 feet) is very light- to medium-gray, medium-grained, very thick-bedded dolostone and high-magnesium dolostone. The lower unit (about 325 feet) is dark-gray to black, very fine-grained, thin- to very thin-bedded limestone and dolomitic limestone with argillaceous laminations. The overall unit thickness ranges from 1,100 to 1,200 feet. The Shady Dolomite is the homologous unit in the southeastern Great Valley at the base of the western edge of the Blue Ridge Mountains.

The Folded Appalachians (Augusta County, Bath County, Highland County, VA)

The western edge of the Great Valley is demarcated by the North Mountain Fault, and the ridges of Little North and Great North Mountain. The rocks underlying this section are younger than those of the Great Valley, dating primarily from the Late Ordovician through the Devonian periods in age. In general, the mountain ridges are underlain by sandstone and siltstone, clastic rocks which are insoluble and not prone to karst terrain development. In contrast, the intervening deep valleys are often floored by carbonate rocks, and a characteristic karst landscape characterized by sinkholes, caves and springs has developed in many cases along the axis and flanks of these valleys (Hubbard, 1988; Rader & Wilkes, 2001; DMME, 1993).

Bedrock Geology

The regional geology of the Folded Appalachians in the project area has been mapped (DMME, 1993) as being underlain by a series of karst-forming carbonate rocks ranging in age from the Lower Ordovician to Lower Devonian geological periods as follows:

Devonian – Silurian Periods

Helderberg Group (Dh)

This group consists of thick- to massive-bedded, dark gray/black micritic limestone with reef structures. The limestone shows some degree of recrystallization. The uppermost Helderberg is typically silicified near its contact with the overlying Oriskany sandstone. In many areas the Helderberg gives off a distinct petroliferous odor when freshly broken. The contact with the overlying Oriskany Sandstone is poorly exposed regionally, but the contact with the underlying Tonoloway Formation is distinct and often unconformable, where the massive bedding of the Helderberg gives way to the thin-bedding of the Tonoloway Formation. The contact can be identified in places by a lag deposit consisting of flat, packstone rip-ups and pebble conglomerate.

The group is a major cave forming unit of the Folded Appalachian section, however, it is of note that the stratigraphy of this unit has been the subject of a much detailed study in recent years (Haynes, et al., 2014). The Helderberg Group consists of a series of individual formations, from oldest to youngest, respectively: the Keyser Limestone, New Creek Limestone, Corriganville Limestone, and Licking Creek Limestone formations. It should be noted that based on biostratigraphic analysis the Keyser Limestone, the basal formation of the Helderberg Group, is considered to straddle the boundary of the Silurian and Devonian periods (Denkler and Harris, 1988a).

The entire Helderberg Group varies regionally, ranging from 85 feet to over 400 feet in thickness. The Keyser is considered the thickest of the individual formations comprising the group, ranging from 50 to 230 feet in thickness.

Silurian Period

Tonoloway Limestone (Sto)

This formation consists of extremely thin-bedded (0.5 inches or less) dark gray micritic limestone interbedded with fissile, calcareous shale. The formation gives off a distinct petroliferous odor when freshly broken. The contact with the overlying Keyser Limestone is distinct; however, it grades into the underlying Wills Creek Limestone. The Tonoloway Formation varies from 150 to 600 feet in thickness.

Wills Creek Limestone (Swc)

This formation consists of thin-bedded (less than 5 inches) dark gray calcareous shale and fossiliferous micrite, which is poorly exposed in the ACP project area. The thickness is variable, ranging from 3 feet to 230 feet.

Ordovician Period

Juniata, Oswego, Reedsville, Dolly Ridge, and Eggleston Formations (Oun)

Karst forming unit present only in the westernmost Valley and Ridge section of the ACP alignment (Highland and Bath Counties). The Dolly Ridge and Eggleston Formations are the only karst-forming units and consist of a medium-gray, fine-grained, thin-bedded, argillaceous limestone with interbedded olive-gray calcareous claystone, silt argillaceous limestone, gray shale, and K-bentonite beds. Thickness is about 400 feet in Bath and Highland Counties. The unit is laterally equivalent to the Middle Ordovician ("Trenton Group") limestones and part of the lower Martinsburg Formation.

Middle Ordovician Limestones, Undivided (Olm)

These limestones consist of the Edinburg Formation, the Lincolnshire Formation, and the New Market Limestone. The Edinburg is a black, fine-grained to aphanitic limestone with layered black shale that commonly contains pyrite, and medium- to light-gray, fine- to coarse-grained, nodular limestone with thin partings of black shale. Thickness is 400 feet to 500 feet. The Edinburg grades downward into the Lincolnshire Formation, a light- to very dark-gray, fine- to coarse-grained, medium- to very thick-bedded limestone with black chert nodules. Thicknesses throughout the ACP project area range from 25 to 250 feet. This unit is underlain by the New Market Limestone. The upper contact with the Lincolnshire is generally unconformable. The upper unit of this formation is a medium-gray, aphanitic, thick-bedded, limestone with scattered calcite crystals. The lower unit is a medium- to dark-gray, fine-grained, thin-bedded, argillaceous, bioturbated limestone that is dolomitic in parts, with its base being a carbonate pebble conglomerate. Formation thicknesses throughout the ACP project area range from 0 to 150 feet.

Beekmantown Formation (Ob)

This formation is a medium- to light-gray, fine-grained, medium- to thick-bedded dolostone, with sparse fossils. When weathered, this dolomite is very light-gray, and exhibits a "butcher-block" structure. A medium-gray, fine-grained limestone exists as the base of this unit. This formation is comprised of a medium-gray, fine-grained, fossiliferous limestone and a light- to medium-gray, fine-grained, laminated dolomitic limestone and dolostone with mottled beds. Thin lenses of gray chert are common near the base of the formation. Formation thickness ranges from 1,500 to 2,400 feet. The Beekmantown Formation typically consists of three members, which although distinct in the Great Valley region are hard to distinguish in the Folded Appalachian province.

The Allegheny Front & Appalachian Plateau (Pocahontas County and Randolph County, WV)

The last section of the folded Appalachian karst is located in eastern Pocahontas County. To the west occurs the relatively flat-bedded geology of the Allegheny Front and Appalachian Plateau provinces. The karst terrain in this area is formed almost exclusively by the carbonate rocks of the Mauch Chunk and Greenbrier Groups.

In general, the Mauch Chunk and Greenbrier Group carbonates exhibit a high density of caves relative to the other two karst sections along the pipeline. There are several factors that contribute to this, the main one being that the units act as a drain system for groundwater infiltrating downward through the fractured clastic rocks above them. Where they are exposed along the mountain flanks, the steep groundwater gradients have enhanced this cavern development. In many places surface water plunges directly into the carbonates via steep-walled, open throat sinkholes (swallets). Most of the caves are linear networks, and exhibit conduit flow, capturing surface streams upgradient which then emerge as springs at the downgradient end.

Bedrock Geology

The Appalachian Plateau section has been mapped (Cardwell, et al., 1968; Davies, 1958) as being underlain by the karst-forming carbonate rocks of the Greenbrier and Mauch Chunk Groups, exclusively. The geology is described from youngest to oldest as follows:

Mississippian Period

Mauch Chunk Group – Includes the Bluestone and Princeton Formations (Mbp), Hinton Formation (Mh), and Bluefield Formation (Mbf). The group is predominantly red, green and medium-gray shale and sandstone, with a few thin limestone lenses in each formation. Although the limestone strata in the unit are considered secondary, the topographic position of the Mauch Chunk along the edges of the eroded upland of the Allegheny Plateau where there is a relatively steep downward hydraulic gradient has enhanced water flow through the carbonate lenses, forming karst conduit networks with high transmissivity (Kozar & Mathes, 2001), thus from a karst hydrology viewpoint this unit is significant.

Greenbrier Group (Mg) – In the project area the Greenbrier Group (or "Big Lime" as it is known locally) is up to 400 feet in thickness. It is primarily a gray to dark gray, massively bedded marine limestone, with interbeds of red and green marine and nonmarine shale and thin discontinuous beds of sandstone. The Group is divided into six stratigraphic units; from oldest to youngest they are: the Denmar Limestone, Taggard Shale, Pickaway Limestone, Union Limestone, Greenville Shale, and Alderson Limestone. The principle cave forming units are the Pickaway and Union limestones.

Pre-Construction Assessment and Field Survey

The proposed ACP/SHP involves the installation of a gas pipeline extending through West Virginia, Virginia, and into southern North Carolina. The currently proposed pipeline construction alignment information shows that the primary route being considered for the pipeline passes across approximately 32.5 miles of karst terrain located in Randolph and Pocahontas Counties in West Virginia, and Highland, Bath, and Augusta Counties in Virginia, based on regional geological mapping.

The "Karst Review Area" (hereinafter referred to as the "KRA") assessed by data desktop review generally extended 0.25-mile from either side of the centerline of the proposed pipeline and alternate routes, and a 300 foot "study corridor" (300FC) extending 150 feet from either side of the centerline for field review. However, if observed or mapped karst features received drainage from the proposed pipeline work area then these features were delineated to the extent possible, and included in the assessment, even if they were outside of these perimeters.

Thus, the pre-construction assessment and field survey scope can be summarized as follows:

- Located and delineated surface karst features (e.g., sinkholes and karst related subsidence, cave entrances, closed depressions, and sinking and losing streams) within the KRA, with particular emphasis on features that had a direct connection with the phreatic zone such as "open-throat" sinkholes, karst windows, cave entrances, abandoned wells, sinking streams, and areas that could affect the integrity of the pipeline, such as actively forming cover-collapse sinks, areas of soil subsidence, or caves which have passages that extend below the proposed right-of-way at elevations less than 15 feet below the surface. Direct field observations were made by conducting a site reconnaissance over the entire 300FC where access was available.
- Delineated zones of karst terrain, subsidence, and drainages based on the surface karst features assessment.
- Prepared a report summarizing the methods and findings of the assessment.

Methods and Procedures

The above scope of services was accomplished by the following means:

Existing Data Review and Analysis

Potential karst features were identified remotely and/or by database review, and then their presence was confirmed in the field. This process helped to focus the actual field location and survey tasks. The following sources were reviewed:

1. The (proprietary) Cave Databases of the Virginia Speleological Survey (VSS) and the West Virginia Speleological Survey (WVSS);
2. Caves of Virginia (Douglas, 1961);
3. Description of Virginia Caves (Holsinger, 1975);
4. Caverns of West Virginia (Davies, 1965);
5. Maps of selected karst features (sinkholes, caves, springs) available from the Virginia Division of Mines and Mineral Resources and the United State Geological Survey (USGS);
6. 2-foot and 4-foot contour interval maps for the KRA (to determine the presence of surface karst features not included in the above listed databases based on the presence of closed, descending contours or other suspect karst "fingerprint" features);
7. LIDAR data (where available);
8. Aerial photographs (both recent and historical);
9. USGS Topographic 7.5-minute topographic quadrangles;
10. Sinkhole and depression locations available from the US Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS) soil studies for the Counties through which the ACP will pass.
11. Weary, D.J. and D.H. Doctor. 2014. Karst in the United States: A digital map compilation and database, USGS open-file report 2014-1156, 23p

In addition, the survey team reviewed the readily available geological literature for bedrock and structural characteristics, relying upon the closest resolution mapping that existed for the particular KRA being examined.

Field Reconnaissance

Upon completion of the existing data review activities for a specific area, GeoConcepts undertook field reconnaissance and survey activities. Specifically, the field reconnaissance entailed:

1. Location and verification of surface karst features identified in the database review;
2. Location of uncatalogued or previously unidentified surface karst features, specifically sinkholes, cave entrances, dry runs and sinking streams.

The field reconnaissance placed particular emphasis on locations where pathways existed to phreatic groundwater such as open-throat sinkholes, cave entrances, karst "windows", and sinking streams. Potential reroutes were identified based on the field observation of sensitive karst features, such as significant caves, sinking streams, or open throat sinkholes.

The 300FC was delineated and the path of the 300FC was examined for karst features (both catalogued and previously unidentified) by field survey. This entailed conducting a site reconnaissance over the 300FC (i.e., the proposed pipeline route) in a systematic manner, to observe any existing surface karst features that fit the criteria. The locations and outlines of all relevant features were recorded using a sub-meter accurate Global Positioning System (GPS) device. For the purpose of this study, the outline (parapet) of sinkholes were defined by the last closed descending contour at mapping interval available for the area under study. Cave entrances were identified as single points, unless the entrance was located within a larger sinkhole structure, in which case the cave entrance was indicated as a point within the sinkhole's parapet. Sinking streams were located as points of entry into the subsurface; however, losing streams were identified as linear features.

All digital data was transmitted in the Universal Transverse Mercator (UTM) Coordinate system. The horizontal datum of reference is NAD83.

Summary Report

The results of the data review and field survey has been summarized in a final report. The report details the methods and findings, and contains an inventory and contained a delineation of karst features and terrain. The frequency and density of karst features was also correlated with the encompassing geological unit at the formational level (e.g., Elbrook Formation, etc.). The report is accompanied by a data set containing the attributed digital points and polygon data as shapefiles with metadata (maps and/or tables). The results of the karst survey work was used during routing and workspace design. In addition, these data will be used during the construction phase to assist in the pre-construction inspection tasks described in the following sections.

Construction Monitoring

The purpose of this section of the plan is to establish a standard set of monitoring protocols for karst features encompassed by the proposed ACP pipeline right-of-way and adjacent areas. The intent of these protocols is to minimize impact to the subterranean environment, ensure water quality, and protect the integrity of the pipeline (Burden, 2012).

I. Geophysical Survey

To obtain more information about the subsurface conditions, and possible karst development along the proposed ACP pipeline alignment, an electrical resistivity investigation (ERI) will be conducted in the areas that are mapped with limestone bedrock. The ERI will be performed along the entire length of the pipeline centerline in karst terrain prior to any earth-disturbance and/or excavation activity.

Instrumentation

The geophysical survey instrument which will be used during this survey is an electrical resistivity meter that maps the resistivity changes in the earth. Resistivity refers to the electrical resistance of a material. The ERI survey will be conducted by introducing a measured current into the earth through two electrodes and measuring the resultant voltage (i.e., potential) across two different electrodes. At the low currents used, voltage is proportional to the current. The meter measures the voltage/current ratio or resistance in Ohms.

The ERI survey will be conducted using an earth resistivity meter which measures the apparent conductivity of the subsurface employing an artificial source that is introduced through point electrodes. The automatic electrode system is designed to optimize survey efficiency by gathering maximum information with a minimum of electrodes. The instrument also uses redundancies in the data set to reduce the effects of lateral heterogeneities in the earth and to calculate uncertainties in the data. The survey will be conducted automatically using a dipole-dipole array system.

Interpretation Method

The ERI data will be converted into a resistivity depth model using a Rapid 2D resistivity inversion model and the least-squares method (RES2DINV). Soundings from each line will be modeled to produce the measured apparent resistivity pseudo-sections. The model will calculate the apparent resistivity pseudo-sections using finite-difference forward modeling. The least-squares optimization technique will be used for the inversion routine that calculates the modeled resistivity section. The generated profiles will include cross-sections that consist of the inverse model resistivity cross-section. The horizontal and vertical scales will be in meters.

The cross-section is the inverse model resistivity pseudo-section. The ER data will be converted into a resistivity depth model (RES2DINV) using a resistivity inversion model by the least-squares method, which will be topographically corrected. RES2DINV will confirm the model reliability by calculating the modeled data into empirical data or the calculated resistivity pseudo-section. The difference between the measured and calculated data is the percent error. The modeled calculated error will be calculated within the five percent range, which is considered very accurate.

Low resistive materials can be caused by certain conductive soils, such as clay, wet silts, and sands, or ionized water. High resistive materials are caused generally by porous soils (i.e., poorly consolidated gravels), laminated bedrock with interstitial clay-filled voids, wood, or large, air-filled cavities. Lower ER anomalies are generally associated with soil-filled voids, saturated sinkhole soils, and water-bearing fractures. High ER anomalies are frequently associated with caverns, buried air filled structures, or weathered, laminated bedrock with air filled cavities.

Resistivity values can vary widely as the geology, mineralogy, and stratigraphy changes from site to site. Therefore, it is important to correlate resistivity results with boring logs for equivalent sections at a specific locality. Typical values are:

Subsurface Material	**Resistivity Range (Ωm)**
Topsoil	1 – 10
Clays	10 – 100
Sands and Gravels (unconsolidated)	600 – 10,000
Fresh Water	3 – 100
Limestone	100 – 10,000
Sandstone	100 – 1,000
Igneous and Metamorphic Rocks	100 – 1,000,000
Open Voids (i.e. caverns, solution conduits)	>10,000

Although the above values are characteristic of various subsurface materials, the absolute resistivity ranges will vary considerably depending on the local geology. Therefore, it is required that the ERI survey is calibrated using soil test/air track borings. In addition, if high ER anomalies are detected, their locations will need to be documented and further investigated. The specific type of investigation will be dictated by the characteristics of each anomaly identified, but typically air track borings will be used to verify anomalies observed during an ERI survey.

II. Inspection Protocols

Inspection protocols will be provided to the contractor and will be reviewed at a pre-construction meeting led by the Karst Specialist (KS). In addition, all geologist or engineering staff utilized during construction will have received training from the KS prior to mobilization to the site regarding the identification and mitigation of karst features that have been previously identified within the project boundaries, or that may be identified during construction.

Pre-Construction Inspection

Prior to the commencement of any earth disturbance activity, the area of the pipeline that will be affected by the planned activities will be inspected by the karst specialist (KS) as follows:

a. The KS will inspect the entire section of the pipeline ROW (right-of-way) in the designated work area, and note any suspect karst features including sinkholes, caves, areas of soil subsidence, or closed depressions.

b. The KS shall conduct a final preconstruction field assessment of seeps and springs within 500 feet of construction workspaces in karst terrain. The KS shall subsequently determine if construction activities could have an impact on the seeps and/or springs, and provide construction alternatives to avoid or mitigate impacts where practical.

c. The locations of observed features will be noted on site drawings and flagged for surveying and/or recorded using sub-meter accuracy GPS instrumentation.

d. The KS will issue a report summarizing the findings of the inspection. Findings will supplement the summary report and shall include an inventory of feature type(s), drainages, and potential impact to the feature by the planned activities, and recommendations to limit impacts if they are expected. This inspection is intended to supplement the aforementioned pre-construction karst assessment and field survey report, as new features may have developed, or existing features described in identified in the original assessment may have changed.

e. Features that are considered to have potential impacts are: caves, sinkholes with open throats, ponors, open solution cavities, abandoned wells, and sinking streams. (Note – If a sinkhole throat is filled, the type of fill, i.e. rock, soil, flood debris, etc., will be described in detail).

f. Features that are not considered to have a potential impact are: soil-bottomed (stable) sinkholes (i.e., no evidence of recent soil raveling or tension cracks along the parapet), karst springs, or non-karst closed depressions. However, it is of note that land disturbance to stable sinkholes can render them unstable. Not structurally unstable in general, but strictly in terms of raveling of surface materials (sediment) and associated contaminants into the subsurface.

g. The pre-construction inspection will have a "shelf-life" of 1 year from the day of the inspection. If work does not commence within 1 year, a new inspection will need to be completed prior to any earth disturbing activities.

h. The pre-construction inspection report shall be delivered to Atlantic/DTI no later than 1-month after the completion of the field survey.

Monitoring of Pre-Identified Features During Construction

Features identified during the pre-construction inspection will be monitored as follows:

a. If an identified feature with potential impact to the subterranean environment falls within the area designated for earth disturbing activities and cannot be avoided, the feature will be documented by field location and photographs, and then assessed for pre-construction remediation by Atlantic/DTI staff with input and guidance to be provided by the KS. Remediation will be in compliance with the USDA-NRCS's Conservation Practice Standard Code 527 "Karst Sinkhole Treatment" (2010) and the West Virginia Department of Environmental Protection Division of Water and Waste Management Ground Water Protection Program Sinkhole Mitigation Guidance, August 8, 2005. (see Appendix A)

b. If a feature that has potential impact falls within the right-of-way but is not intercepted by the excavation, that feature will be monitored during the work by Atlantic/DTI staff for changes such as:

   1. soil subsidence;
   2. rock collapse;
   3. sedimentation;
   4. increased surface water infiltration;
   5. flooding;
   6. clogging; and/or other changes in morphology or function that might indicate potential impact to the epikarst stratum caused by the work.

c. All features, whether remediated or left in an undisturbed natural state, will be monitored by Atlantic/DTI staff, or their designee, for any changes in appearance, drainage, siltation, etc., at 1 year, 2 year, and 5 year intervals after the completion of the earth disturbing activities. If changes in the features are observed, Atlantic/DTI staff will report the condition to the KS who will provide consultation on potential impacts to the karst environment and possible remedial actions.

Monitoring of Features That are Intercepted During Construction

Features that are intercepted during construction shall be monitored as follows:

Level 1 Inspection of Features Intercepted During Construction

If any feature is intercepted during work activities including borings, blasting, and excavation or trenching, the onsite geologist will conduct an initial assessment of the feature to determine if further inspection (Level 2) by the KS will be required. Suspect features shall include:

1. Bedrock enclosed conduits, cave entrances[2] and voids;
2. Solution pockets that extend beyond visual examination range (and therefore may be open);
3. Areas of soft soils;
4. Soil voids;
5. Highly fractured bedrock;
6. Areas of breccia enclosed within the surrounding bedrock.

Level 2 Inspection of Features Intercepted During Construction

If any of the aforementioned features are observed during the Level 1 inspection, work will stop within a 100-foot radius of the feature, and then the KS will conduct a Level 2 inspection as follows:

a. The KS will examine the feature and determine if it has potential impact to the subterranean environment based on potential connectivity with the phreatic aquifer via the epikarst stratum (Moore, et al, 2013). The choice of characterization methods will be determined by the KS, and will include any combination of (but not be limited to):

   1. visual assessment;
   2 geophysical survey;
   3 track drill probes;
   4. infiltration or dye trace testing; or
   5. other techniques utilized to facilitate subsurface characterization of karst features.

b. If the feature is determined to have potential impact to the subterranean environment, the KS will advise Atlantic/DTI staff regarding appropriate remedial actions.

[2] If an opening to a cave is intercepted during construction activities, there should be immediate coordination with the US Fish and Wildlife Service, US Forest Service (if within Forest Service ownership land) Virginia DCR-NHP Karst Program (or) West Virginia Department of Conservation, for investigation.

c. If the feature is determined to not have potential impact to the subterranean environment, work will resume as planned.

d. All features that are intercepted during construction and subsequently remediated will be located by project surveyors exclusively, and monitored by Atlantic/DTI staff, or their designee, for any changes in appearance, drainage, siltation, etc., at 1 year, 2 year, and 5 year intervals after the completion of the earth disturbing activities. If any changes are observed, the KS will provide consultation on potential impact and recommend remedial actions, if necessary.

e. All Level 2 inspections, findings, and remedial activity will be summarized in a report by the KS, to be delivered to Atlantic/DTI after the completion of the field work.

Monitoring of Features That Form During Construction

Features that form during construction will be monitored as follows:

Level 1 Inspection of Features That Form During Construction

If any feature forms during work activities including hydrostatic testing, drilling, blasting, and excavation or trenching, Atlantic/DTI staff will conduct an initial assessment of the feature to determine if further inspection (Level 2) by the KS will be required. Suspect features will include:

a. Cave entrances[3]
b. Sinkholes;
c. Soil subsidence areas; and/or
d. Rock collapses.

This will apply to any of the above features that may form either within the work area, whether located along the proposed disturbance section or anywhere within a 300-foot radius of the work area.

Level 2 Inspection of Features That Form During Construction

If any of the aforementioned features are observed during the Level 1 inspection, work will stop in the area of the feature based on the observed site conditions, and then the KS will conduct a Level 2 Inspection as follows:

a. The KS will examine the feature and determine if it has potential impact to the subterranean environment based on potential hydraulic connectivity with the karst aquifer via the epikarst stratum.

b. The choice of characterization methods will be determined by the KS, and will include any combination of (but not be limited to) the following:

    a. visual assessment;
    b. electrical resistivity survey;
    c. track drill probes;
    d. infiltration testing; and/or
    e. other techniques utilized to perform subsurface characterization of karst features.

c. If the feature is determined to have potential impact to the subterranean environment, the KS will consult with Atlantic/DTI staff regarding appropriate remedial actions.

d. If the feature is determined to not have potential impact to the subterranean environment, work will commence as planned.

e. All features that form during construction, whether remediated or left in an undisturbed natural state, will be located on the site plans by the project surveyors, and will be monitored for any changes in appearance, drainage, siltation, etc. at 1 year, 2 year, and 5 year intervals after the completion of the earth disturbing activities. If any changes are observed, the KS will provide consultation on potential impact to the karst environment and remedial actions, if necessary. This

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[3] If an opening to a cave forms during construction activities, should be immediate coordination with the Virginia DCR-NHP Karst Program (or) West Virginia Department of Conservation for investigation.

monitoring will be carried out on all features that form during work activities, regardless of whether they have a potential impact to the karst environment or not.

III. Notification and Consultation

Notification of, and consultation with State and Federal regulatory and administrative agencies will be completed for the following:

1. Any planned invasive subsurface exploration, including: geotechnical soil borings; rock coring; air track borings; test pits; or other invasive investigative measures that have the potential for intercepting subsurface voids, conduits, or caverns.
2. Any karst features that were identified and located prior to construction that will require remediation or mitigation.
3. Any karst features that were identified and located prior to construction that will require periodic monitoring, whether remediated or left in an undisturbed natural state. The results of the monitoring shall be documented and reported to the appropriate agencies.
4. Any karst features that are intercepted during construction. Notification and consultation will take place after the performance of the Level I inspection.
5. Any karst features that form during construction. Notification and consultation will take place after the performance of the Level I inspection.
6. Any karst features that form following construction which are observed during the post-construction karst feature monitoring (*see* Level 2 Inspection of Features that form during construction, part e).

Federal Agencies to be Notified

United States Fish and Wildlife Service (USFWS)
Federal Energy Regulatory Agency (FERC)
United States Forest Service (USFS)[4]

State Agencies to be Notified (Virginia)

Virginia Department of Conservation and Recreation – Natural Heritage Program (DCR-NHP)
Virginia Department of Environmental Quality (VDEQ)

State Agencies to be Notified (West Virginia)

West Virginia Division of Natural Resources (WVDNR)
West Virginia Department of Environmental Protection (WVDEP)

Karst Mitigation and Conservation Procedures

The following procedures will be used to avoid and minimize any impact of pipeline construction and/or O&M activity which might present a risk to environmental receptors, in particular obligate subterranean taxa. Please note that other resource protection measures that may be implemented for the ACP may provide redundancy with regard to the karst mitigation and conservation procedures detailed herein.

Measures to Avoid Impact to the Karst Aquifer and Environment

These measures shall apply to any karst feature which allows the unfiltered and unimpeded flow of surface drainage into the subsurface environment, including (but not limited to): open throat sinkholes, caves which receive surface drainage, sinking streams, and losing stream segments. These avoidance measures were derived from the NiSource Habitat Conservation Plan, Madison Cave Isopod Avoidance and Minimization Measures, and the Columbia Pipeline Group HCP and non-HCP species Best Management Practices

[4] Only if within USFS lands.

Guidance Document. They are intended to prevent impact to the karst aquifer and the subsurface habitat of obligate stygobiont species through protection of groundwater quantity and quality (Burden, 2012).

1. Protect known and/or future mapped recharge areas of cave streams and other karst features by following relevant conservation standards, specifically the FERC 2013 Upland Erosion Control, Revegetation and Maintenance Plan, the FERC 2013 Wetland and Waterbody Construction and Mitigation Procedures, and the ACP Spill Prevention, Containment, and Control (SPCC) plan.
2. Buffers of 300 feet around karst features in all work areas (within and off-ROW including discharge areas) must be clearly marked in the field with signs and/or highly visible flagging until construction related ground disturbing activities are completed. If a karst feature or its 300-ft buffer falls within the 125-ft wide workspace the following steps should be taken:
   a. The workspace should be narrowed (if practicable) to impact as little of the buffer as possible.
   b. No spraying of insecticides or herbicides shall be allowed within the 300-ft buffer.
   c. No refueling, repair or maintenance of vehicle or equipment shall be allowed within the 300-ft buffer.
   d. Soil disturbance within the buffer (i.e. trenching) shall be performed in a manner which prevents sediment from entering the subsurface through the use of carefully designed and continuously maintained sediment and erosion control measures, and shall follow the procedures and BMPs specified in the FERC plans and procedures mentioned in section 1, above.
   e. If the karst feature is located downgradient from the area of soil disturbance, drainage shall be directed away from the karst feature and its 300-ft buffer through the use of diversion trenches, water breaks, or other engineered methods. This shall apply even if the feature itself is located outside of the 125-ft workspace, but the workspace intercepts the 300-ft buffer.
   f. No activity of any kind shall be allowed within the parapet of a sinkhole or within a 25-ft buffer around the parapet, which should remain in an undisturbed, natural state. The sinkhole and the 25-ft parapet buffer should be delineated using temporary fencing.
3. Earth disturbing activities will be conducted in a manner that minimizes alteration of existing grade and hydrology of existing surficial karst features. Pre-existing flow channels will be stabilized but will not otherwise be altered. Concentrated flow caused by construction activities will be dispersed with a suitable spreading or diversion technique. Surface water flow volume will be maintained at historic (or predevelopment) levels as changes to the volume of surface water flow can disturb the subsurface hydrology.
4. Any open-throat sinkholes and cave entrances within 300 feet of the workspace, located downgradient from the centerline which receives drainage from the workspace will be carefully protected using silt fences, diversion trenches, constructed temporary berms around the parapet, or water breaks. If the feature receives flow via a discreet drainage channel, the channel will be equipped with absorptive boom and a double row of silt fences.
5. In addition to the aforementioned requirements, the following will be implemented in construction workspace areas:
   a. If a new open throat, cover-collapse sinkhole forms within the ROW or construction work space, work in that area will stop and the sinkhole will be isolated from the rest of the work area with sandbags or other suitable materials. The sinkhole will be inspected by the KS and appropriate action taken (e.g., pipeline relocated, sinkhole remediated, etc.) to ensure pipeline integrity and protection of the aquatic resource and subterranean habitat. The preferred method for remediation will be the graded/inverted filter method (Ralstein and Oweis, 1999). This technique involves excavation and cleaning out collapsed, soft soils in the weakened zone to limit further soil raveling, and placing rocks or boulders large enough to bridge the bedrock conduit or "throat" at the bottom of the excavation. Progressively finer rock and gravel are then placed and compacted above the base course, above which is placed a layer of permeable

geotextile fabric and soil to the final grade which is then seeded. The advantage of this method is that it allows surface water to continue to infiltrate into the subsurface, but prevents further soil raveling (which is the root cause of cover-collapse sinkholes). The vegetated soil stratum and underlying gravel acts as a natural filter for the water infiltrating to the underlying solution enlarged conduits and fracture system. (see Appendix A).

b. If a subsurface void or conduit should open or be intersected in the process of excavation and/or trenching, work in that area will stop and the void will be isolated from the rest of the work area with sandbags or other suitable materials. The void will be inspected by the KS and the most appropriate remedial method will be determined on a case-by-case basis. Soil voids will be backfilled using the graded filter method as described above. Small conduits (< 1 foot in diameter) may be closed with low mobility grout and/or flowable fill. Large conduits (>1 foot in diameter) will require specific remedial actions (capping, void bridging, or plugging) based on the location and geometry of the conduit (i.e. whether the conduit is located at the bottom, one side, or both sides of the trench).

c. If a subsurface void or conduit should open or be intersected in the process of excavation and/or trenching through which water is flowing (i.e. an underground stream) work in that area will stop, and the void will be isolated from the rest of the work area with sandbags or other suitable materials. The void will be inspected by the KS, and the most appropriate remedial method will be determined on a case-by-case basis. All efforts will be made to ensure that the existing flow path is not interrupted by isolating the stream using trench breakers, and backfilling the location of the saturated karst feature or stream with permeable material such as well-graded stone or other material which will not interfere with the continued flow of water from one side of the trench to the other.

d. In linear excavations adjacent to karst features, spoils will be placed on the upgradient side of the excavation so that if any erosion takes place the stockpiled soil will flow back into the excavation and not downgradient towards the karst feature.

e. Surface water control measures, including, but not limited to: diversion (direct water flow into trench or off right-of-way areas past the area of concern), detention or collection and transportation, will be utilized to prevent construction-influenced surface water from free flowing into open throated surface karst features, and eventually into the subsurface.

f. Open throat surface karst features will not be utilized for the disposal of water. This shall include, but not be limited to: hydrostatic test water, water from trench dewatering, or any other water generated by, or utilized in, construction activities.

6. Blasting will be conducted in a manner that will not compromise the structural integrity or alter the karst hydrology of known or inferred subsurface karst structures. If blasting or hammering is deemed necessary then the following parameters will be adhered to:

   a. The excavation will be carefully inspected for any voids, openings or other tell-tale signs of solution activity.

   b. If the rock removal intercepts an open void, channel, or cave, the work in that area will be stopped until a remedial assessment can be carried out by a qualified geologist or engineer with experience in karst terrain.

   c. All use of explosives will be limited to low-force charges that are designed to transfer the explosive force only to the rock which is designated for removal (e.g., maximum charge of 2 inches per second ground acceleration).

   d. If the track drill used to prepare the hole(s) for the explosive charge(s) encounters a subsurface void larger than 6 inches within the first 10 feet of bedrock, or a group of voids totaling more than 6 inches within the first 10 feet of bedrock, then explosives should not be used (or) a subsurface exploration should be conducted to determine if the voids have connectivity with a deeper structure. The subsurface exploration can be carried out with track drill probes, coring drill, electrical resistivity, or other techniques capable of resolving open voids in the underlying bedrock. If a track drill or coring rig is used, then all open holes will be grouted shut after the completion of the investigation.

7. Horizontal Directional Drilling (HDD) will not be used in karst terrain.
8. If authorized by the landowner, block (e.g. gate) all access roads and ROWs leading to cave entrances or open throat sinkhole structures to prevent unauthorized access.
9. Comply with requirements of project SPCC plan.
10. A Spill Prevention, Control, and Countermeasures Plan (SPCC) has been developed for the proposed ACP/SHP which will further avoid and minimize potential impact of spills by implementing the following measures:
    g. equipment refueling will not be performed within flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features, except by hand-carried cans (5 gallon maximum capacity) when necessary;
    h. equipment servicing and maintenance areas will be sited outside of flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features;
    i. prevent runoff resulting from construction equipment washing operations to directly enter any karst feature by locating these operations outside of the buffer area;
    j. construction equipment vehicles, materials, hazardous materials, chemicals, fuels, lubricating oils, and petroleum products will not be parked, stored, or serviced within 300 feet of any karst feature;
    k. all equipment will be checked by a construction inspector daily for leaks prior to beginning work in karst areas; damaged or defective equipment will be removed or repaired; and
    l. if a reportable spill has impacted a karst feature:
        i. follow the SPCC Plan and
        ii. call the National Response Center (800-424-8802) and the Virginia Department of Environmental Quality (800-469-8892) or the West Virginia Department of Environmental Protection (304-558-5938), as appropriate.
11. Hydrostatic test water will not be obtained from karst features (only free-flowing streams).
12. Hydrostatic testing water from new pipe installations shall not be discharged into flagged or marked buffer areas of sinkholes, fissures, or other karst features or channels or surface features that flow towards those features. Discharging of hydrostatic testing water shall be performed in the following manner (in order of priority and preference):
    a. Discharge hydrostatic test water downgradient of flagged or marked buffer areas of sinkholes, fissures, or other karst features unless on-the-ground circumstances (e.g., man-made structures, terrain, or other sensitive resources) prevent such discharge.
    b. If water cannot be discharged downgradient as described in 12a, discharge water into uplands greater than 300 feet from flagged or marked buffer areas of sinkholes, fissures, or other karst features unless on-the-ground circumstances (e.g. man-made structures, terrain, other sensitive resources) prevent such discharge.
    c. If the conditions listed in either 12a or 12b are not practicable, discharge water as far from flagged or marked sinkholes, fissures, or other karst features as is practical and utilize additional sediment and water flow control devices to minimize effects.

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West Virginia DEP, 2005, Sinkhole Mitigation Guidance Document, August 8, 2005, WVDEP Division of Water and Waste Management, Groundwater Protection Program.

Appendix A – Sinkhole Mitigation Guidance Documents

West Virginia Department of Environmental Protection
Division of Water and Waste Management
Groundwater Protection Program

Sinkhole Mitigation Guidance

August 8, 2005

Purpose:

These sinkhole mitigation designs serve to allow the filling of sinkholes while maintaining recharge to the aquifer, reducing potential contamination threats to groundwater, and eliminating safety hazards at sinkhole entries.

General:

Consideration should be given to the method used for removing contaminated materials from sinkholes and reducing or eliminating direct inflow of surface water into sinkholes. Land treatment methods that improve the filtration and infiltration of surface water before it enters the sinkhole should be used along with the mitigation of the sinkhole.

Before selecting a treatment option the following should be considered:

- Land use
- Existing and planned land treatment
- Sinkhole drainage area
- Dimensions of the sinkhole opening
- Safe outlet for diverted surface water
- Environmentally safe disposal of sinkhole “clean out” material
- Availability and quality of filter material
- Safety of equipment and operators and laborers during installation

Treatment selection should be based on the dimensions of the sinkhole drainage area and include direct sinkhole treatment with surface water control measures and filter strips. Whichever treatment option is chosen, it should avoid surface water ponding or the creation of high soil moisture conditions in excess of 72 hours.

Treatment designs apply to sinkholes with excavated depths of 5 to 25 feet and with drainage areas up to 15 acres. Excavations up to 5 feet are sufficient for most sinkholes. Sinkholes with excavation depths of greater than 25 feet or with uncontrolled drainage areas greater than 15 acres may require adjustments to the treatment measure(s) and/or surface water control measure(s). In these cases, geologic and engineering assistance must be obtained and a site-specific treatment design prepared.

Treatment for Sinkholes with Drainage Areas Less than 5 Acres

Treat the sinkhole using the mitigation design in Figure 1 of this guidance document. The treatment site should be inspected after periods of heavy precipitation because some material may run into adjacent sinkhole voids causing a surface depression. In this case, maintenance will include adding soil material at the surface. The existing land use or practice may continue over the treated sinkhole as long as the treatment is maintained.

Treatment for Sinkholes with Drainage Areas of 5 Acres or More and Having a Safe Outlet

The following additional treatment criteria are applicable to sinkholes with drainage areas of 5 acres or more where a safe outlet can be provided to divert surface water away from the sinkhole. A safe outlet is one that does not erode, divert surface water to another sinkhole or injection well, or cause flood damage to crops, property, buildings, or highways/roads.

Surface water control measures should be situated to reduce the internal drainage area around the sinkhole to less than 5 acres. The choice of surface water control measures is generally based on site-specific conditions.

Treatment for Sinkholes with Drainage Areas of 5 to 15 acres and Having No Safe Outlet

Treat the sinkhole using the mitigation design in Figure 2 of this guidance document. The site should be inspected after periods of heavy precipitation because some material may run into adjacent sinkhole voids causing a surface depression. In this case, maintenance will include adding soil material at the surface. The sinkhole should remain as unused land.

Vegetated Buffer Area

A vegetated buffer area should be installed around the sinkhole to improve runoff water quality by filtration and adsorption of contaminants. The vegetated buffer area should be installed within the sinkhole drainage area and should begin at the treated sinkhole.

The minimum width (in feet) of the vegetated buffer area is determined by multiplying the sinkhole drainage area (in acres) by seven. This width should provide beneficial filtering for some distance outside the sinkhole because surface water runoff may be temporarily held before reaching the treated sinkhole.

Appropriate vegetation should be used for the buffer area. Use native vegetation as much as possible. **DO NOT** use noxious plants or weeds. It is recommended that a plant nursery be consulted for the appropriate vegetation.

Acceptable Materials

Engineering fabric - must meet the applicable requirements of AASHTO M-288.

Aggregates – fine aggregates, gravel, or rock rip rap that conforms to the West Virginia Department of Highways, Standard Specifications for Roads and Bridges, Sections 702, 703, and 704.

Specifications

Use the following guidance for installing a mitigation design for sinkholes and sinkhole areas with drainage areas of less than 5 acres:

1. Remove and properly dispose of materials dumped in and around the sinkhole in accordance with applicable federal, state, and local laws.

2. Excavate loose material from the sinkhole and try to expose the solution void(s) in the bottom. Enlarge the sinkhole, as necessary, to allow for installation of the filter material.

3. Select stone that is approximately 1.5 times larger than the solution void(s). Place the stone into the void(s) forming a competent bridge. Stone used for the bridge should have rock strength equal to, at least, moderately hard (*e.g.*, resistant to abrasion or cutting by a knife blade but can be easily dented or broken by light blows with a hammer). Shale or similar soft and non-durable rock is not acceptable.

4. Place a layer of filter material over the bridge to a minimum thickness of 24 inches. Approximately 35 percent of the material should be larger than the opening between the bridge and the void(s). There should be no discernable large openings around the bridge. The material should be either gabion stone, stone for rip rap, or stone for special rock fill that conforms to West Virginia Department of Highways, *Standard Specification Roads and Bridges*, Section 704.

5. Place a layer of smaller size filter material over the previous layer to a minimum thickness of 10 inches. The size of the material should be ¼ to ½ the size of that used in the previous layer. The material should be No. 57 aggregate, which conforms to West Virginia Department of Highways, *Standard Specifications Roads and Bridges*, Sections 703.1.1, 703.1.2, 703.1.3, 704.1.4, and 703.2.1. Unacceptable filter material consists of pea gravel or slags (steel, electromagnetic, or power plant).

6. Place a layer of sand-sized filter material over the previous layer ~~at~~ to a minimum thickness of 10 inches. The sand must be compatible in size with the previous layer to prevent piping. The material should be fine aggregate that conforms to West Virginia Department of Highways, *Standard Specification Roads and Bridges*, Sections 702.1.1, 702.1.2, and 702.1.3.

7. Engineering fabric conforming to AASHTO M 288 may be substituted for the stone and sand filter materials discussed in 5 and 6.

8. Backfill over the top filter layer or engineering fabric with soil material to the surface. This should be mineral soil with at least 12 percent fines. Reuse soil material excavated from the sinkhole as much as possible and place any available topsoil over the backfill. Overfill by about 5 percent to allow for settling.

9. Establish vegetation on the mitigated sinkhole and other disturbed areas of the site.

Use the following guidance for installing a mitigation design for sinkholes and sinkhole areas with drainage areas of 5 to 15 acres:

1. Remove and properly dispose of materials dumped in and around the sinkhole.

2. Excavate loose material from the sinkhole.

3. Place a layer of filter material into the sinkhole, allowing the stone to fill the void(s) below the bottom of excavated sinkhole. The size should be ¼ to ½ the size of the void(s). This material can be WVDOH gabion stone, rip rap stone, or special rock fill stone.

4. Place a layer of the same size filter material to a thickness of about ¾ TD (TD = total depth) above the sinkhole bottom.

5. Place a layer of smaller size filter material over the previous layer to a thickness of about ¼ D. Bring this layer to surface level. The size should be ¼ to ½ the size of the previous layer. The material should be No. 57 aggregate, which conforms to West Virginia Department of Highways, *Standard Specification Roads and Bridges*, Sections 703.1.1, 703.1.2, 703.1.3, 703.2.1, and 704.1.4. Unacceptable stone consists of pea gravel or slags (steel, electrometallurgical, or power plant).

6. Shale or similar soft and non-durable rock is not acceptable.

7. Establish vegetation on the mitigated sinkhole and disturbed areas of the site.

Engineering Fabric Requirements for Subsurface Drainage

Engineering fabric used in the mitigation of sinkholes should meet the applicable requirements of AASTHO M 288, Section 7.2

Engineering Fabric Installation

Proper construction and installation techniques are essential to ensure that the intended function of the engineering fabric is fulfilled.

When sewn seams are necessary, the seam strength must be equal to or greater than 90 percent of the specified grab strength, as measured in accordance with ASTM D 4632.

When sewn seams are used for the seaming of the engineering fabric, the thread must be high strength polypropylene, or polyester. Nylon thread is unacceptable.

For Sinkhole Mitigation Design A, place the engineering fabric loosely, with no wrinkles or folds, and with no void spaces between the fabric and the bridge. Overlap successive sheets of engineering fabric a minimum of 12 inches, with the upstream sheet overlapping the downstream sheet.

Prior to covering, the engineering fabric should be inspected to ensure that it has not been damaged (*e.g.* holes, tears, rips) during installation. An engineer or the engineer's designated representative should conduct the inspection. The designated representative should be a certified field inspector.

Damaged fabric must be repaired immediately. Cover the damaged area with an engineered fabric patch that overlaps to 12 inches beyond the damaged area.

Any damaged engineering fabric that cannot be repaired shall be replaced as directed by the engineer.

Place material over the engineering fabric in such a manner as to avoid stretching and subsequently tearing the fabric. Do not drop stone and soil placement from a height greater then one meter. Do not allow stone with a mass of more than 100 kg to roll down the slope of the sinkhole.

Grading the sinkhole slope is not permitted if the grading will result in the movement of the stone directly above the engineering fabric.

Operation and Maintenance

The owner/operator is responsible for maintaining the mitigated sinkhole and sinkhole area. At a minimum, the following maintenance practices should be performed:

1. Mow grass and plantings as necessary to promote vigorous growth.

2. Inspect mitigation measures at least twice a year and after all major rain events. Repairs to the sinkhole mitigation measures should be made promptly were warranted.

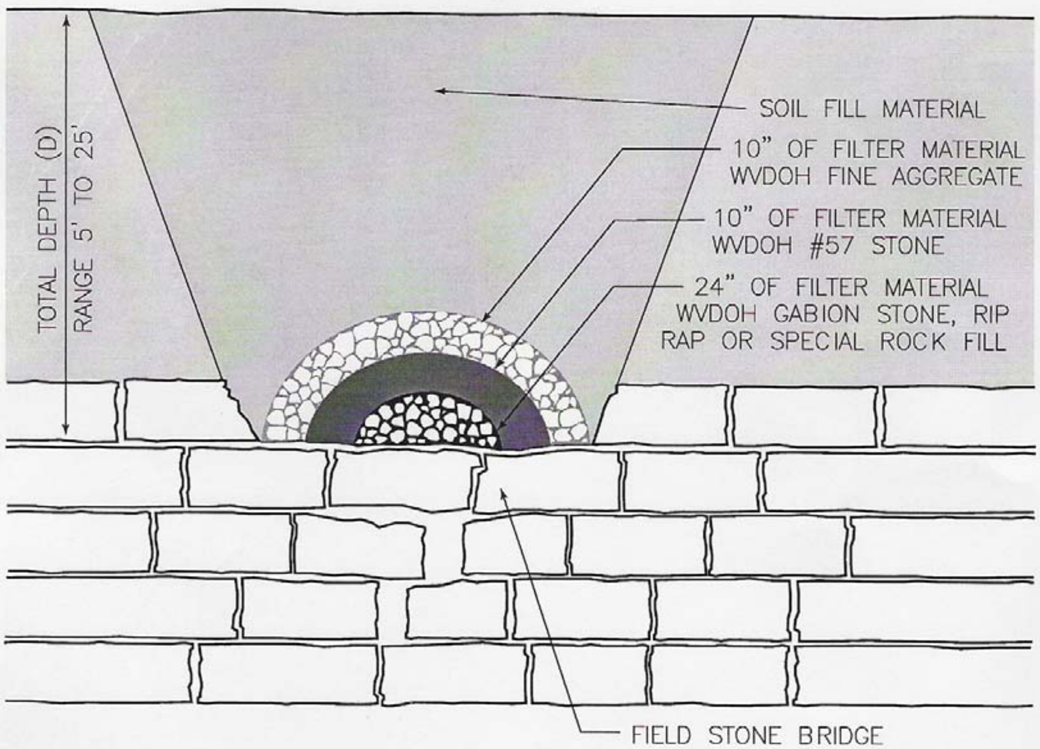
References:

USDA Natural Resources Conservation Center, January 2004. *Maryland Conservation Practice Standard, Sinkhole and Sinkhole Area Treatment, Code 725.*

West Virginia Department of *Highways, Standard Specifications Roads and Bridges*, 2000, Section 702, "Fine Aggregates", Section 703, "Coarse Aggregates", Section 704, "Stone and Crushed Aggregate", Section 715, "Miscellaneous Materials".

WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
SINKHOLE MITIGATION GUIDANCE

FIGURE 1



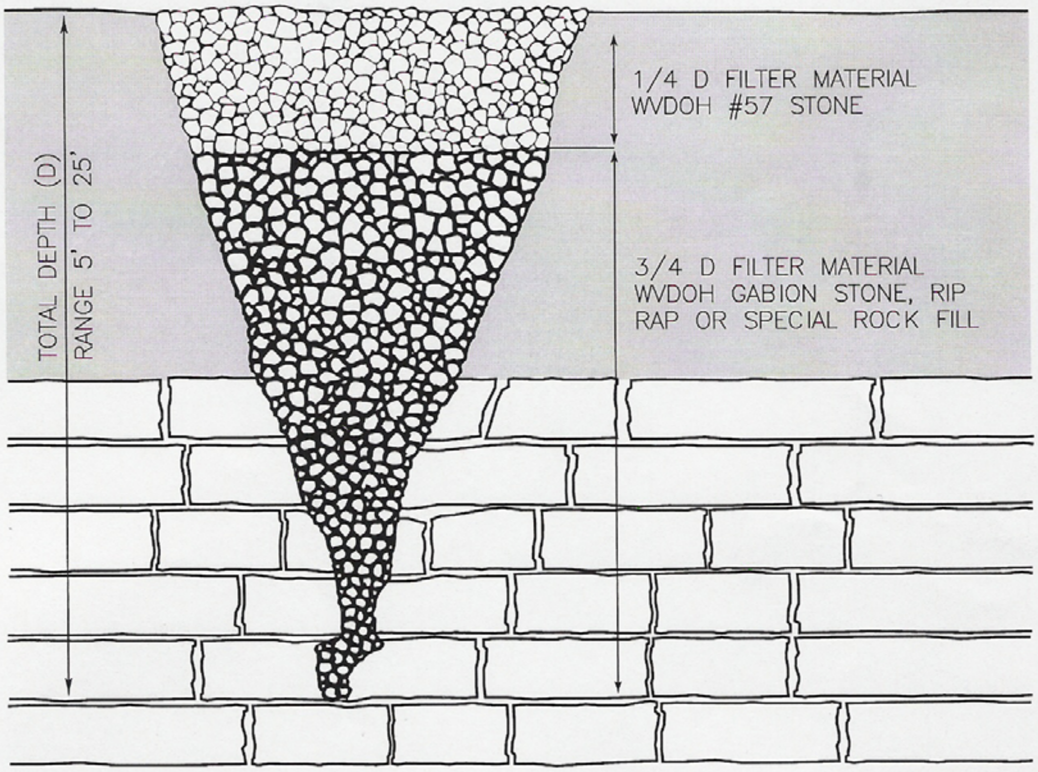
NOTE:
A NONWOVEN GEOTEXTILE MEETING AASHTO M288, SECTIONS 7.1+7.2 MAY BE SUBSTITUTED FOR THE WVDOH #57 STONE AND WVDOH FINE AGGREGATE

SINKHOLE MITIGATION

(DRAINAGE AREA LESS THAN 5 ACRES)

WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION
SINKHOLE MITIGATION GUIDANCE

FIGURE 2



SINKHOLE MITIGATION

(DRAINAGE AREA 5 TO 15 ACRES)

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

KARST SINKHOLE TREATMENT

(No.)

CODE 527

DEFINITION

The treatment of sinkholes in karst areas to reduce contamination of groundwater resources, and/or to improve farm safety.

PURPOSE

This practice may be applied as part of a conservation management system in karst topography, which is an area underlain by solutioned carbonate bedrock with sinkholes and caverns. The practice supports one or more of the following purposes:

- Improve water quality
- Improve farm safety

CONDITIONS WHERE PRACTICE APPLIES

On any land surface or in conjunction with any existing practice where the soils and geologic conditions are characterized by sinkholes or karst topography.

This practice does not apply to erosional or collapse features caused by failure or leakage of underground pipes or constructed surface drainage features (e.g., canals), or due to piping of unstable soil materials, or due to poorly compacted or poorly constructed features.

This practice does not apply to sinkholes that may appear in or beneath structures or in flowing streams. Treatment of sinkholes in these areas will be determined through engineering investigations and structural design solutions.

CRITERIA

General Criteria Applicable to all Purposes

The installation and operation of karst sinkhole treatment(s) will comply with all Federal, State, and local laws, rules, and regulations.

A geologic investigation of the potential impact of the treatment on groundwater, surface water run-in, and the karst features will be conducted by a qualified geologist.

Trash and other material will be removed from the sinkhole and disposed of in an environmentally sound manner.

Excess surface water caused by construction activities will be diverted from the sinkhole area.

Nutrient and pest management plans will be developed for the drainage area of the sinkhole controlled by the landowner.

Vegetative Treatment. All sinkholes treated will have a vegetated buffer established and/or maintained. The buffer will be a minimum of 25-feet wide measured from the rim of the sinkhole. The buffer area may be extended to prevent concentrated flow channels from occurring and entering the sinkhole. The width of the vegetated buffer will be established and maintained in accordance with the type of buffer chosen. The sinkhole and surrounding buffer area will be fenced.

Livestock will be excluded from the vegetative buffer except when grazing would be beneficial to maintenance of the buffer.

Nutrients, herbicides, pesticides, and animal waste will not be applied within an established buffer area. Only mechanical treatments shall be used for weed control.

Appropriate erosion and sediment control measures will be used to reduce the amount of sediment entering sinkhole openings during the establishment of the vegetative buffer.

Surface Water Control. Changes to the volume of surface water that enters a sinkhole may disturb the underground hydrology. To the extent possible, the surface water flow should be maintained at historic (or predevelopment) volumes.

Pre-existing concentrated flow channels will be stabilized but should not otherwise be altered. If a plug or inverted filter is used, the area to be protected will be characterized by a qualified Geologist to enable a suitable design. Concentrated flow caused by construction activities will be dispersed with a suitable spreading or diversion technique.

Sinkhole Treatment/Closing. Adequate protection of most sinkhole and sinkhole areas can be achieved by the use of vegetative buffers and livestock exclusion. However, if an open sinkhole is a safety hazard, it may be treated with a rock filter, gabions, or other methods approved by the State Conservation Engineer or delegated authority.

Sinkholes to be treated or closed via a reverse filter or plug shall be excavated to stable, unweathered bedrock, if possible, prior to construction.

Sinkholes that open into caves shall not be filled under any circumstances. Gated openings may be used for safety reasons.

CONSIDERATIONS

Current and planned land use should be considered. In particular, structures, septic drain fields, wells, feedlots, ponds, and animal waste storage systems should not be located over a sinkhole site or within the impact area.

Sinkholes may be natural conveyances of organic material and nutrients important to cave fauna.

For a sinkhole receiving contaminated overland flow, every effort should be made to first treat the source of the contamination. Although it is important to maintain the hydrology of the karst system, it may be more beneficial to the groundwater quality to divert the contaminated water away from the sinkhole. In some cases, it may be necessary to completely plug a sinkhole with sealing materials rather than treat it with an inverted filter. Acceptable sealing materials are provided in ASTM D 5299, part 6.4. An example of this would be a sinkhole in a feedlot or a site that is difficult to protect by any other method.

The sinkhole treatment should not result in excessive surface water ponding or high soil moisture conditions over an extended period of time.

When filling a sinkhole, mounding of the fill material may be needed to offset future settlement due to consolidation and migration of the fill material into subsurface voids. Additional fill may be required as treatment ages.

Treatment of one sinkhole may have an effect on other sinkholes or solution features in the vicinity.

The use of a conservation easement for the buffer and sinkhole should be considered.

PLANS AND SPECIFICATIONS

Plans and specifications for Sinkhole and Sinkhole Area Treatment will be in keeping with this standard and will describe the requirements for applying the practice to achieve its intended purpose.

Plans and specifications shall include the following:

- Plan view showing sinkhole and sinkhole area Include topographic information and photographs
- The geologic investigation will include a study of potential impacts on the karst resource
- Depth to stable, unweathered bedrock
- Description of planned treatment measures
- The drainage area of sinkhole delineated on a topographic map
- Availability of safe outlet for surface water, if applicable
- Operation and Maintenance requirements
- Special safety requirements

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan will provide specific instructions for maintaining the sinkhole and sinkhole area treatment, including reference to periodic inspections and the prompt repair and/or replacement of damaged components.

APPENDIX O

Wetlands Crossed Table

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
AP-1								
Virginia								
Highland County								
	85.4	02080201	whia407f	PFO	0	<0.1	0.0	NA
	85.4	02080201	whia406f	PFO	49	0.1	<0.1	Open Cut
	88.3	02080201	whia403e	PEM	29	<0.1	0.0	Open Cut
	90.6	02080201	whia400e	PEM	2	<0.1	0.0	Open Cut
	91.3	02080201	whic121e	PEM	0	<0.1	0.0	NA
Bath County								
	94.8	02080201	nwi_va_e_002	PEM	0	<0.1	0.0	Open Cut
	95.5	02080201	nwi_va_e_003	PEM	0	<0.1	0.0	NA
	97.6	02080201	wbaa003f	PFO	1,233	2.1	0.8	Open Cut
	97.7	02080201	wbaa004e	PEM	155	0.3	0.0	Open Cut
	99.3	02080201	wbaa005f	PFO	16	<0.1	<0.1	Open Cut
	99.3	02080201	wbaa005f	PFO	52	0.1	<0.1	Open Cut
	99.3	02080201	wbaa005f	PFO	6	<0.1	<0.1	Open Cut
	100.6	02080201	wbaa002e	PEM	7	<0.1	0.0	Open Cut
	101.0	02080201	wbar009f	PFO	0	<0.1	<0.1	Open Cut
	101.2	02080201	wbaf001f	PFO	0	<0.1	<0.1	Open Cut
	101.2	02080201	wbaf001e	PEM	0	<0.1	0.0	Open Cut
	103.1	02080202	wbar004e	PEM	89	<0.1	0.0	Open Cut
	103.1	02080202	wbar003e	PEM	64	0.1	0.0	Open Cut
	103.2	02080202	wbar003e	PEM	0	<0.1	0.0	NA
	104.2	02080202	wbar001f	PFO	0	<0.1	<0.1	Open Cut
	104.8	02080202	nwi_va_k_006	PFO	126	0.2	0.1	Open Cut
	104.8	02080202	nwi_va_k_006	PFO	49	0.2	<0.1	Open Cut
	105.0	02080202	nwi_va_e_014	PFO	0	0.1	0.0	NA
	105.7	02080202	wbar007f	PFO	15	<0.1	<0.1	Open Cut
Augusta County								
	108.3	02080202	waur001f	PFO	14	<0.1	<0.1	Open Cut
	108.3	02080202	waur001e	PEM	78	0.1	0.0	Open Cut

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	108.3	02080202	waur001e	PEM	17	<0.1	0.0	Open Cut
	109.0	02080202	waua408e	PEM	0	<0.1	0.0	NA
	109.6	02080202	wauz007e	PEM	0	0.1	0.0	NA
	109.6	02080202	wauz006e	PEM	0	0.1	0.0	Open Cut
	109.7	02080202	wauz005e	PEM	9	<0.1	0.0	Open Cut
	109.8	02080202	wauz004e	PEM	10	<0.1	0.0	Open Cut
	110.2	02080202	wauc112e	PEM	35	0.1	0.0	Open Cut
	110.3	02080202	wauc113e	PEM	216	0.4	0.0	Open Cut
	111.1	02080202	wauy005e	PEM	174	0.2	0.0	Open Cut
	111.3	02080202	wauy004e	PEM	70	0.2	0.0	Open Cut
	112.0	02080202	wauc110e	PEM	19	<0.1	0.0	Open Cut
	113.1	02080202	waua402s	PSS	0	<0.1	0.0	NA
	113.1	02080202	waua402s	PSS	0	<0.1	0.0	NA
	113.1	02080202	wauz003e	PEM	0	<0.1	0.0	NA
	113.5	02080202	waua403e	PEM	6	<0.1	0.0	Open Cut
	115.4	02080202	waub100e	PEM	9	<0.1	0.0	Open Cut
	115.8	02080202	waub101e	PEM	15	<0.1	0.0	Open Cut
	115.8	02080202	waua411e	PEM	21	<0.1	0.0	Open Cut
	116.5	02080202	wauz001e	PEM	0	<0.1	0.0	NA
	116.5	02080202	wauz002e	PEM	0	<0.1	0.0	NA
	117.1	02080202	waua408f	PFO	12	<0.1	<0.1	Open Cut
	120.4	02070005	waua009s	PSS	0	<0.1	<0.1	Open Cut
	143.2	02070005	wauc101e	PEM	0	<0.1	0.0	NA
	143.2	02070005	waub001e	PEM	10	<0.1	0.0	Open Cut
	148.5	02070005	wauc102f	PFO	204	0.4	0.1	Open Cut
	148.6	02070005	wauc102f	PFO	385	0.7	0.3	Open Cut
	148.7	02070005	wauc102e	PEM	0	<0.1	0.0	NA
	150.8	02070005	wauc103f	PFO	0	<0.1	0.0	NA
	152.4	02070005	waub103f	PFO	282	0.5	0.2	Open Cut
	153.4	02070005	waua059f	PFO	3	<0.1	<0.1	Open Cut
	153.4	02070005	waua060f	PFO	0	<0.1	0.0	NA

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	153.6	02070005	waua061f	PFO	43	0.1	<0.1	Open Cut
	153.6	02070005	waua061f	PFO	25	0.1	<0.1	Open Cut
	153.6	02070005	waua061f	PFO	45	0.1	<0.1	Open Cut
	154.6	02070005	waua410e	PEM	0	<0.1	0.0	NA
	156.0	02070005	waua053s	PSS	13	<0.1	<0.1	Open Cut
	156.0	02070005	waua053s	PSS	27	<0.1	<0.1	Open Cut
	156.2	02070005	waua052e	PEM	0	0.0	0.0	NA
	156.2	02070005	waua052e	PEM	0	<0.1	0.0	NA
	156.2	02070005	waua052e	PEM	20	0.1	0.0	Open Cut
	156.4	02070005	waua051e	PEM	20	<0.1	0.0	Open Cut
	156.4	02070005	waua051e	PEM	21	0.1	0.0	Open Cut
	156.9	02070005	waue001s	PSS	103	0.1	<0.1	Open Cut
	157.5	02070005	waua400f	PFO	128	0.3	0.1	Open Cut
Nelson County								
	158.9	02080203	wnea020f	PFO	0	<0.1	0.0	NA
	165.5	02080203	wnec050e	PEM	29	<0.1	0.0	Open Cut
	165.5	02080203	wnec050e	PEM	0	<0.1	0.0	Open Cut
	166.2	02080203	wnea051f	PFO	24	<0.1	<0.1	Open Cut
	166.2	02080203	wnea051f	PFO	33	<0.1	<0.1	Open Cut
	166.3	02080203	wnea051f	PFO	0	<0.1	0.0	NA
	171.0	02080203	wnez004s	PSS	0	<0.1	0.0	NA
	171.8	02080203	wnea402e	PEM	0	<0.1	0.0	Open Cut
	182.9	02080203	wnep001f	PFO	0	<0.1	0.0	NA
	184.5	02080203	wnea023f	PFO	10	<0.1	<0.1	HDD
	184.6	02080203	wnea022f	PFO	110	0.2	0.1	HDD
Buckingham County								
	184.8	02080203	wbuc109f	PFO	281	0.9	0.2	Open Cut
	185.4	02080203	wbup007e	PEM	0	<0.1	0.0	NA
	186.8	02080203	wbuz002e	PEM	0	<0.1	0.0	Open Cut
	187.6	02080203	wbup005f	PFO	104	0.2	0.1	Open Cut
	188.2	02080203	wbup004f	PFO	26	<0.1	<0.1	Open Cut

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	188.2	02080203	wbup003f	PFO	0	<0.1	0.0	NA
	190.1	02080203	wbuc108f	PFO	25	0.1	<0.1	Open Cut
	190.6	02080203	wbua001f	PFO	56	0.1	<0.1	Open Cut
	190.7	02080203	wbua010f	PFO	0	<0.1	0.0	NA
	191.0	02080203	wbua002f	PFO	0	<0.1	0.0	NA
	191.0	02080203	wbua002f	PFO	15	<0.1	<0.1	Open Cut
	191.0	02080203	wbua002f	PFO	36	0.1	<0.1	Open Cut
	191.5	02080203	wbub050f	PFO	94	0.1	0.1	Open Cut
	191.9	02080203	wbub051s	PSS	34	0.1	<0.1	Open Cut
	193.5	02080203	wbuc003f	PFO	115	0.2	0.1	Open Cut
	194.1	02080203	wbuc004e	PEM	11	<0.1	0.0	Open Cut
	194.1	02080203	wbuc005f	PFO	0	<0.1	<0.1	Open Cut
	195.0	02080203	wbuk001e	PEM	24	<0.1	0.0	Open Cut
	196.1	02080203	wbuk005e	PEM	124	0.2	0.0	Open Cut
	196.1	02080203	wbuk005e	PEM	53	0.1	0.0	Open Cut
	197.5	02080203	wbuk007e	PEM	0	<0.1	0.0	Open Cut
	198.5	02080203	wbua200e	PEM	28	<0.1	0.0	Open Cut
	198.5	02080203	wbua201e	PEM	47	0.1	0.0	Open Cut
	198.5	02080203	wbua201f	PFO	68	0.1	<0.1	Open Cut
	200.1	02080203	wbul004s	PSS	29	0.1	<0.1	Open Cut
	200.5	02080203	wbup002e	PEM	132	0.2	0.0	Open Cut
	201.2	02080203	wbup001s	PSS	0	<0.1	<0.1	Open Cut
	201.2	02080203	wbup001f	PFO	30	<0.1	<0.1	Open Cut
	201.2	02080203	wbup001f	PFO	121	0.2	0.1	Open Cut
	201.2	02080203	wbup001s	PSS	0	<0.1	0.0	NA
	201.8	02080203	wbul005f	PFO	51	0.1	<0.1	Open Cut
	201.8	02080203	wbul005f	PFO	78	0.1	0.1	Open Cut
	203.6	02080205	wbul002f	PFO	171	0.3	0.1	Open Cut
	203.6	02080205	wbul002f	PFO	53	0.1	<0.1	Open Cut
	205.2	02080205	wbul003f	PFO	0	<0.1	0.0	NA
	206.6	02080205	wbul007f	PFO	0	<0.1	0.0	NA

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	206.9	02080205	wbul006f	PFO	35	0.1	<0.1	Open Cut
	206.9	02080205	wbul006f	PFO	46	0.1	<0.1	Open Cut
	207.8	02080205	wbua004f	PFO	14	<0.1	<0.1	Open Cut
	207.8	02080205	wbua004f	PFO	22	<0.1	<0.1	Open Cut
	208.8	02080205	wbua400f	PFO	0	<0.1	0.0	NA
	209.1	02080205	wbuk013f	PFO	0	<0.1	0.0	NA
	209.2	02080205	wbuk013f	PFO	0	<0.1	<0.1	Open Cut
	209.2	02080205	wbuk013f	PFO	28	0.1	<0.1	Open Cut
	209.4	02080205	wbuk016f	PFO	0	<0.1	0.0	NA
	209.5	02080205	wbuk017e	PEM	31	0.1	0.0	Open Cut
	209.5	02080205	wbuk018e	PEM	157	0.2	0.0	Open Cut
	210.1	02080205	wbuc104f2	PFO	210	0.4	0.1	Open Cut
	210.2	02080205	wbuc104f2	PFO	62	0.1	<0.1	Open Cut
	210.9	02080205	wbuk010f	PFO	68	0.1	<0.1	Open Cut
	211.7	02080205	wbua203e	PEM	0	<0.1	0.0	NA
	211.7	02080205	wbua401f	PFO	0	<0.1	0.0	NA
	211.7	02080205	wbua401f	PFO	0	<0.1	0.0	NA
	211.8	02080205	wbua402e	PEM	17	<0.1	0.0	Open Cut
Cumberland County								
	213.8	02080207	wcuk001f	PFO	19	<0.1	<0.1	Open Cut
	213.9	02080207	wcuk002f	PFO	0	0.1	0.0	NA
	214.5	02080207	wcuc001f	PFO	32	0.1	<0.1	Open Cut
	214.8	02080207	wcua400f	PFO	53	0.1	<0.1	Open Cut
	214.8	02080207	wcua400f	PFO	0	<0.1	0.0	NA
	215.0	02080207	wcuk014f	PFO	0	<0.1	0.0	NA
	215.4	02080207	wcuk016f	PFO	0	<0.1	0.0	NA
	216.0	02080207	wcuk017e	PEM	0	<0.1	0.0	NA
	218.2	02080207	wcuk012s	PSS	41	<0.1	<0.1	Open Cut
	218.7	02080207	wcuk011f	PFO	12	<0.1	<0.1	Open Cut
	218.7	02080207	wcuk011f	PFO	0	<0.1	<0.1	Open Cut
	218.7	02080207	wcuk011f	PFO	0	<0.1	0.0	NA

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	218.7	02080207	wcuk011f	PFO	0	<0.1	0.0	NA
	219.5	02080207	wcuk008f	PFO	45	0.1	<0.1	Open Cut
	219.5	02080207	wcuk008f	PFO	10	<0.1	<0.1	Open Cut
	220.0	02080207	wcuc100e	PEM	0	<0.1	0.0	NA
	220.4	02080207	wcuk006e	PEM	18	<0.1	0.0	Open Cut
	220.5	02080207	wcuk006e	PEM	199	0.4	0.0	Open Cut
	220.7	02080207	wcuk005e	PEM	70	0.1	0.0	Open Cut
Prince Edward County								
	221.7	02080207	wpek001e	PEM	90	0.1	0.0	Open Cut
	222.6	02080207	wpek002e	PEM	72	0.1	0.0	Open Cut
	223.1	02080207	wpea005f	PFO	309	0.5	0.2	Open Cut
	223.2	02080207	wpea005f	PFO	294	0.4	0.2	Open Cut
	223.9	02080207	wpea002f	PFO	0	<0.1	0.0	NA
	224.1	02080207	wpea003f	PFO	59	0.1	<0.1	Open Cut
	224.3	02080207	wpea004f	PFO	42	0.1	<0.1	Open Cut
	225.2	02080207	wpec001f	PFO	53	0.1	<0.1	Open Cut
	225.5	02080207	wpea006f	PFO	41	0.1	<0.1	Open Cut
	225.5	02080207	wpea006f	PFO	17	<0.1	<0.1	Open Cut
Nottoway County								
	226.0	02080207	wnok021s	PSS	25	<0.1	<0.1	Open Cut
	226.1	02080207	wnok022f	PFO	61	0.1	<0.1	Open Cut
	226.8	02080207	wnok001f	PFO	0	<0.1	0.0	NA
	227.2	02080207	wnok002f	PFO	30	<0.1	<0.1	Open Cut
	227.2	02080207	wnok002f	PFO	0	<0.1	0.0	NA
	228.3	02080207	wnok003f	PFO	0	<0.1	<0.1	Open Cut
	228.3	02080207	wnok003e	PEM	155	0.2	0.0	Open Cut
	228.8	02080207	wnok005f	PFO	44	0.1	<0.1	Open Cut
	229.2	02080207	wnok006e	PEM	153	0.3	0.0	Open Cut
	229.3	02080207	wnok007f	PFO	3	<0.1	<0.1	Open Cut
	229.9	02080207	wnok008f	PFO	7	<0.1	<0.1	Open Cut
	229.9	02080207	wnok008f	PFO	0	<0.1	<0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	230.0	02080207	wnok009f	PFO	47	0.1	<0.1	Open Cut
	231.8	02080207	wnol001f	PFO	61	0.1	<0.1	Open Cut
	232.4	02080207	wnol003f	PFO	0	<0.1	0.0	NA
	232.7	02080207	wnok017f	PFO	30	0.1	<0.1	Open Cut
	232.7	02080207	wnok017e	PEM	56	0.1	0.0	Open Cut
	232.7	02080207	wnok017f	PFO	82	0.1	0.1	Open Cut
	232.8	02080207	wnok018s	PSS	0	<0.1	0.0	NA
	232.8	02080207	wnok018s	PSS	0	<0.1	0.0	NA
	233.4	02080207	wnok019f	PFO	24	<0.1	<0.1	Open Cut
	233.4	02080207	wnok019f	PFO	62	0.1	<0.1	Open Cut
	233.5	02080207	wnok020s	PSS	0	<0.1	<0.1	Open Cut
	233.5	02080207	wnok020f	PFO	33	0.1	<0.1	Open Cut
	235.2	02080207	wnom005e	PEM	0	<0.1	0.0	Open Cut
	235.5	02080207	wnom006f	PFO	190	0.2	0.1	Open Cut
	235.5	02080207	wnom006f	PFO	84	0.2	0.1	Open Cut
	236.0	02080207	wnok101f	PFO	274	0.4	0.2	Open Cut
	236.1	02080207	wnok100f	PFO	34	0.1	<0.1	Open Cut
	236.1	02080207	wnok100f	PFO	53	0.1	<0.1	Open Cut
	237.4	02080207	wnop001f	PFO	32	0.1	<0.1	Open Cut
	238.6	02080207	wnok010f	PFO	277	0.4	0.2	Open Cut
	238.6	02080207	wnok010e	PEM	0	<0.1	0.0	NA
	238.6	02080207	wnok010e	PEM	0	<0.1	0.0	NA
	238.8	02080207	wnok011e	PEM	21	<0.1	0.0	Open Cut
	238.8	02080207	wnok011e	PEM	29	<0.1	0.0	Open Cut
	238.8	02080207	wnok011e	PEM	0	<0.1	0.0	NA
	239.1	02080207	wnok012f	PFO	0	<0.1	<0.1	Open Cut
	240.0	02080207	wnok013e	PEM	11	<0.1	0.0	Open Cut
	240.5	02080207	wnok014s	PSS	242	0.3	0.1	Open Cut
	240.6	02080207	wnok016f	PFO	225	0.4	0.2	Open Cut
	241.4	02080207	wnoc100f	PFO	57	0.1	<0.1	Open Cut
	241.5	02080207	wnoc100f	PFO	356	0.6	0.2	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	241.6	02080207	wnoc100f	PFO	53	0.1	<0.1	Open Cut
	242.8	02080207	wnoc001f	PFO	360	0.6	0.2	Open Cut
	242.8	02080207	wnoc001e	PEM	0	<0.1	0.0	Open Cut
	242.9	02080207	wnoc001e	PEM	158	0.2	0.0	Open Cut
	242.9	02080207	wnoc001e	PEM	333	0.6	0.0	Open Cut
	243.0	02080207	wnoc001f	PFO	105	0.2	0.1	Open Cut
	244.1	02080207	wnos002f	PFO	396	0.7	0.3	Open Cut
	244.1	02080207	wnos002f	PFO	46	0.1	<0.1	Open Cut
	244.1	02080207	wnos002f	PFO	151	0.3	0.1	Open Cut
	244.9	02080207	wnos001f	PFO	19	<0.1	<0.1	Open Cut
	245.1	02080207	wnol006f	PFO	51	0.1	<0.1	Open Cut
	245.1	02080207	wnol006f	PFO	117	0.2	0.1	Open Cut
	245.4	02080207	wnoa010f	PFO	17	<0.1	<0.1	Open Cut
	245.6	02080207	wnol007f	PFO	111	0.2	0.1	Open Cut
	246.0	02080207	wnol008f	PFO	64	0.1	<0.1	Open Cut
	246.0	02080207	wnol008f	PFO	49	0.1	<0.1	Open Cut
	247.2	02080207	wnok024f	PFO	0	0.1	<0.1	Open Cut
	247.2	02080207	wnok025f	PFO	0	<0.1	<0.1	Open Cut
	247.7	03010201	wnom001e	PEM	0	<0.1	0.0	Open Cut
	247.7	03010201	wnom001e	PEM	0	<0.1	0.0	Open Cut
	247.8	03010201	wnom001e	PEM	0	0.0	0.0	NA
	247.8	03010201	wnom001e	PEM	10	<0.1	0.0	Open Cut
	247.8	03010201	wnom001e	PEM	42	<0.1	0.0	Open Cut
	247.8	03010201	wnom001e	PEM	0	<0.1	0.0	NA
	248.1	03010201	wnom002e	PEM	52	0.1	0.0	Open Cut
	248.1	03010201	wnom003f	PFO	30	0.1	<0.1	Open Cut
	248.2	03010201	wnom003f	PFO	10	<0.1	<0.1	Open Cut
	248.4	03010201	wnom003f	PFO	0	<0.1	0.0	NA
	248.4	03010201	wnom003f	PFO	0	0.1	0.0	NA
	248.6	03010201	wnom004f	PFO	7	<0.1	<0.1	Open Cut
	248.6	03010201	wnom004f	PFO	111	0.2	0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
Dinwiddie County								
	249.1	03010201	wdim001f	PFO	53	0.1	<0.1	Open Cut
	249.1	03010201	wdim001e	PEM	59	0.1	0.0	Open Cut
	249.1	03010201	wdim001f	PFO	0	<0.1	0.0	NA
	249.2	03010201	wdim002s	PSS	60	0.1	<0.1	Open Cut
	249.5	03010201	wdim003e	PEM	9	<0.1	0.0	Open Cut
	249.6	03010201	wdim003e	PEM	135	0.2	0.0	Open Cut
	249.8	03010201	wdim004e	PEM	37	0.1	0.0	Open Cut
	249.9	03010201	wdim005s	PSS	0	<0.1	0.0	NA
	250.2	03010201	wdim006f	PFO	0	<0.1	<0.1	Open Cut
	250.2	03010201	wdim006f	PFO	51	0.1	<0.1	Open Cut
	250.2	03010201	wdim006f	PFO	0	<0.1	0.0	NA
	250.5	03010201	wdim007f	PFO	5	<0.1	<0.1	Open Cut
	250.5	03010201	wdim007f	PFO	12	<0.1	<0.1	Open Cut
	250.6	03010201	wdim011f	PFO	166	0.3	0.1	Open Cut
	251.2	03010201	wdim010f	PFO	11	<0.1	<0.1	Open Cut
	251.2	03010201	wdim010f	PFO	29	<0.1	<0.1	Open Cut
	251.4	03010201	wdim008e	PEM	7	<0.1	0.0	Open Cut
	251.5	03010201	wdim009e	PEM	58	0.1	0.0	Open Cut
	251.5	03010201	wdim009f	PFO	7	<0.1	<0.1	Open Cut
	251.5	03010201	wdim012f	PFO	82	0.1	<0.1	Open Cut
	252.0	03010201	wdim015f	PFO	54	0.1	0.1	Open Cut
	252.0	03010201	wdim015f	PFO	20	<0.1	<0.1	Open Cut
	252.1	03010201	wdim016f	PFO	7	<0.1	<0.1	Open Cut
	252.1	03010201	wdim016f	PFO	4	<0.1	<0.1	Open Cut
	252.6	03010201	wdim018f	PFO	61	0.1	<0.1	Open Cut
	252.7	03010201	wdim019f	PFO	14	<0.1	<0.1	Open Cut
	252.7	03010201	wdim019f	PFO	0	<0.1	0.0	NA
	252.7	03010201	wdim019f	PFO	18	0.1	<0.1	Open Cut
	252.9	03010201	wdim020f	PFO	30	0.1	<0.1	Open Cut
	253.1	03010201	wdim021f	PFO	24	<0.1	<0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	253.6	03010201	wdic013f	PFO	908	1.6	0.6	Open Cut
	253.8	03010201	wdic013f	PFO	515	0.8	0.4	Open Cut
	254.0	03010201	wdic011f	PFO	494	0.7	0.3	Open Cut
	254.3	03010201	wdic010f	PFO	29	0.1	<0.1	Open Cut
	254.5	03010201	wdic008e	PEM	0	<0.1	0.0	NA
	254.6	03010201	wdic007e	PEM	0	<0.1	0.0	NA
	254.6	03010201	wdib006f	PFO	75	0.1	0.1	Open Cut
	254.8	03010201	wdia006f	PFO	159	0.4	0.1	Open Cut
	255.4	03010201	wdib004f	PFO	30	<0.1	<0.1	Open Cut
	255.4	03010201	wdib005e	PEM	54	0.1	0.0	Open Cut
	255.5	03010201	wdib003s	PSS	48	0.1	<0.1	Open Cut
	255.7	03010201	wdib002s	PSS	156	0.3	<0.1	Open Cut
	255.9	03010201	wdib001f	PFO	105	0.1	0.1	Open Cut
	256.2	03010201	wdic006f	PFO	29	0.1	<0.1	Open Cut
	256.5	03010201	wdic004f	PFO	100	0.2	0.1	Open Cut
	256.7	03010201	wdio030f	PFO	0	<0.1	<0.1	Open Cut
	257.3	03010201	wdio028f	PFO	94	0.2	0.1	Open Cut
	257.8	03010201	wdia401f	PFO	16	0.1	<0.1	Open Cut
	259.3	03010201	wdic001f	PFO	77	0.1	<0.1	Open Cut
	259.3	03010201	wdic001f	PFO	158	0.3	0.1	Open Cut
	259.4	03010201	wdia400f	PFO	230	0.3	0.2	Open Cut
	259.7	03010201	wdio026f	PFO	0	<0.1	<0.1	Open Cut
	260.6	03010201	wdic003f	PFO	410	0.7	0.3	Open Cut
Brunswick County								
	260.7	03010201	wbrc003f	PFO	33	0.1	<0.1	Open Cut
	260.8	03010201	wbrc003f	PFO	80	0.1	0.1	Open Cut
	260.8	03010201	wbra201f	PFO	100	0.2	0.1	Open Cut
	261.3	03010201	wbrc001f	PFO	46	0.1	<0.1	Open Cut
	261.5	03010201	wbra202f	PFO	14	<0.1	<0.1	Open Cut
	261.5	03010201	wbra202f	PFO	17	<0.1	<0.1	Open Cut
	261.6	03010201	wbra400f	PFO	34	0.1	<0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	262.5	03010201	wbra203f	PFO	26	<0.1	<0.1	Open Cut
	262.5	03010201	wbra203f	PFO	125	0.2	0.1	Open Cut
	262.6	03010201	wbra203f	PFO	26	<0.1	<0.1	Open Cut
	262.8	03010201	wbra204f	PFO	242	0.3	0.2	Open Cut
	262.9	03010201	wbra204f	PFO	202	0.4	0.1	Open Cut
	262.9	03010201	wbra204f	PFO	0	0.0	0.0	NA
	264.2	03010201	wbrc050e	PEM	0	<0.1	0.0	Open Cut
	265.1	03010201	wbro003f	PFO	0	<0.1	0.0	NA
	265.4	03010201	wbro005f	PFO	0	<0.1	<0.1	Open Cut
	265.4	03010201	wbro005f	PFO	64	0.1	<0.1	Open Cut
	266.1	03010201	wbrr013f	PFO	0	<0.1	0.0	NA
	266.1	03010201	wbrr013f	PFO	0	<0.1	0.0	NA
	266.3	03010201	wbrr012f	PFO	36	<0.1	<0.1	Open Cut
	266.6	03010201	wbrr011s	PSS	160	0.3	<0.1	Open Cut
	266.7	03010201	wbrr010f	PFO	142	0.2	0.1	Open Cut
	266.8	03010201	wbrr010f	PFO	39	0.1	<0.1	Open Cut
	266.9	03010201	wbrr009e	PEM	4	<0.1	0.0	Open Cut
	266.9	03010201	wbrr014f	PFO	63	0.1	<0.1	Open Cut
	267.4	03010201	wbrr015s	PSS	56	0.1	<0.1	Open Cut
	267.4	03010201	wbrr015f	PFO	0	0.1	<0.1	Open Cut
	267.5	03010201	wbro010f	PFO	0	<0.1	0.0	NA
	267.8	03010201	wbro008f	PFO	0	<0.1	0.0	NA
	267.9	03010201	wbro009f	PFO	77	0.1	<0.1	Open Cut
	267.9	03010201	wbro009e	PEM	0	<0.1	0.0	Open Cut
	267.9	03010201	wbro009f	PFO	37	<0.1	<0.1	Open Cut
	267.9	03010201	wbro009e	PEM	0	<0.1	0.0	Open Cut
	269.4	03010201	nwi_va_b_061	PFO	113	0.2	0.1	Open Cut
	269.7	03010201	wbrr006f	PFO	0	<0.1	0.0	NA
	270.0	03010201	wbrr001f	PFO	12	<0.1	<0.1	Open Cut
	270.0	03010201	wbrr001f	PFO	10	<0.1	<0.1	Open Cut
	270.0	03010201	wbrr001e	PEM	0	<0.1	0.0	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	270.2	03010201	wbrr002e	PEM	17	<0.1	0.0	Open Cut
	270.2	03010201	wbrr002f	PFO	97	0.1	<0.1	Open Cut
	270.5	03010201	wbrr003e	PEM	108	0.1	0.0	Open Cut
	270.5	03010201	wbrr003f	PFO	0	0.1	0.0	NA
	270.5	03010201	wbrr003e	PEM	15	<0.1	0.0	Open Cut
	270.6	03010201	wbrr003f	PFO	0	<0.1	0.0	NA
	271.8	03010201	wbrr005f	PFO	0	<0.1	<0.1	Open Cut
	271.8	03010201	wbrr005e	PEM	18	<0.1	0.0	Open Cut
	271.9	03010201	wbrr005e	PEM	23	0.1	0.0	Open Cut
	271.9	03010201	wbrr005f	PFO	351	0.5	0.2	Open Cut
	272.0	03010201	wbrr007f	PFO	19	<0.1	<0.1	Open Cut
	272.6	03010201	wbrr008e	PEM	35	<0.1	0.0	Open Cut
	272.9	03010201	wbro001e	PEM	0	<0.1	0.0	Open Cut
	273.0	03010201	wbro011f	PFO	0	<0.1	0.0	NA
	273.0	03010201	nwi_va_b_054	PFO	48	0.1	<0.1	Open Cut
	273.0	03010201	nwi_va_b_054	PFO	90	0.3	0.1	Open Cut
	274.3	03010201	wbrc101e	PEM	55	0.1	0.0	Open Cut
	274.3	03010201	wbrc101e	PEM	23	<0.1	0.0	Open Cut
	274.4	03010201	wbrc100e	PEM	94	0.1	0.0	Open Cut
	274.4	03010201	wbrc102e	PEM	21	<0.1	0.0	Open Cut
	274.6	03010204	wbrr016e	PEM	1,002	1.9	0.0	Open Cut
	274.9	03010204	nwi_va_b_045	PFO	385	0.7	0.3	Open Cut
	275.0	03010204	nwi_va_b_045	PFO	14	<0.1	<0.1	Open Cut
	275.5	03010204	wbro015e	PEM	71	0.1	0.0	Open Cut
	275.5	03010204	wbro015f	PFO	0	<0.1	0.0	NA
	275.5	03010204	wbro016e	PEM	122	0.2	0.0	Open Cut
	275.6	03010204	wbro017e	PEM	51	0.1	0.0	Open Cut
	275.9	03010204	wbrp002f	PFO	0	0.2	<0.1	Open Cut
	276.1	03010204	wbrp003f	PFO	27	0.2	<0.1	Open Cut
	276.1	03010204	wbrp003e	PEM	85	0.1	0.0	Open Cut
	276.1	03010204	wbrp003e	PEM	45	0.1	0.0	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	276.1	03010204	wbrp003f	PFO	0	0.1	<0.1	Open Cut
	276.8	03010204	wbro018f	PFO	0	<0.1	0.0	NA
	277.0	03010204	wbro019e	PEM	10	<0.1	0.0	Open Cut
	277.0	03010204	wbro020f	PFO	0	<0.1	<0.1	Open Cut
	277.0	03010204	wbro020e	PEM	13	<0.1	0.0	Open Cut
	277.0	03010204	wbro020f	PFO	0	<0.1	<0.1	Open Cut
	277.0	03010204	wbro020e	PEM	32	<0.1	0.0	Open Cut
	277.6	03010204	wbrc103e	PEM	0	<0.1	0.0	NA
	277.6	03010204	wbrc103e	PEM	104	0.1	0.0	Open Cut
	277.7	03010204	wbrc104e	PEM	60	0.1	0.0	Open Cut
	278.9	03010204	wbro014e	PEM	28	<0.1	0.0	Open Cut
	279.2	03010204	wbrp001e	PEM	26	<0.1	0.0	Open Cut
	279.2	03010204	wbrp001f	PFO	0	<0.1	0.0	NA
	280.0	03010204	wbra217s	PSS	0	<0.1	0.0	NA
	280.1	03010204	wbra217s	PSS	0	<0.1	<0.1	Open Cut
	280.4	03010204	wbra216f	PFO	603	0.9	0.4	Open Cut
	280.5	03010204	wbra216f	PFO	0	<0.1	<0.1	Open Cut
	280.6	03010204	wbra215f	PFO	131	0.3	0.1	Open Cut
	281.0	03010201	wbra214f	PFO	0	<0.1	0.0	NA
	281.3	03010201	wbra213s	PSS	42	0.1	<0.1	Open Cut
	281.9	03010204	wbrb003f	PFO	10	<0.1	<0.1	Open Cut
	282.0	03010204	wbrb002f	PFO	73	0.1	<0.1	Open Cut
	282.1	03010204	wbrb001f	PFO	44	0.1	<0.1	Open Cut
	282.2	03010204	wbrb001f	PFO	202	0.3	0.1	Open Cut
	282.3	03010204	wbrb004f	PFO	93	0.1	0.1	Open Cut
	282.8	03010204	wbra002f	PFO	0	0.2	<0.1	Open Cut
	282.9	03010204	wbra001f	PFO	34	0.1	<0.1	Open Cut
	282.9	03010204	wbra001f	PFO	10	<0.1	<0.1	Open Cut
Greensville County								
	283.0	03010204	WVA-DDF-002	PFO	24	0.1	<0.1	Open Cut
	283.0	03010204	WVA-DDF-	PFO	386	0.7	0.3	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
			002					
	283.3	03010204	WVA-DDF-010	PFO	61	0.1	<0.1	Open Cut
	283.5	03010204	WVA-DDF-011	PEM	104	0.2	0.0	Open Cut
	283.9	03010204	wgra016f	PFO	72	0.1	<0.1	Open Cut
	284.1	03010204	wgra016f	PFO	81	0.2	0.1	Open Cut
	284.1	03010204	wgra016e	PEM	0	<0.1	0.0	NA
	284.2	03010204	wgra016f	PFO	16	<0.1	<0.1	Open Cut
	284.2	03010204	wgra016f	PFO	34	0.1	<0.1	Open Cut
	284.4	03010204	WVA-RDK-002	PSS	0	<0.1	0.0	NA
	284.5	03010204	WVA-RDK-001	PSS	1,109	1.9	0.3	Open Cut
	285.0	03010204	wgrc108f	PFO	0	<0.1	0.0	NA
	285.0	03010204	wgrc108f	PFO	0	<0.1	0.0	NA
	285.4	03010204	wgra040f	PFO	0	0.1	0.0	NA
	285.9	03010204	wgra013f	PFO	27	<0.1	<0.1	Open Cut
	285.9	03010204	wgra013f	PFO	35	0.1	<0.1	Open Cut
	286.2	03010204	wgra014f	PFO	0	<0.1	0.0	NA
	286.2	03010204	wgra014f	PFO	0	<0.1	0.0	NA
	286.3	03010204	wgra015f	PFO	46	0.1	<0.1	Open Cut
	286.4	03010204	wgra008f	PFO	334	0.6	0.2	Open Cut
	286.5	03010204	wgra008e	PEM	104	0.2	0.0	Open Cut
	286.8	03010204	wgra009f	PFO	294	0.5	0.2	Open Cut
	287.6	03010204	wgra039f	PFO	216	0.6	0.2	Open Cut
	287.8	03010204	wgra011f1	PFO	261	0.4	0.2	Open Cut
	287.8	03010204	wgra011f2	PFO	376	0.7	0.3	Open Cut
	288.2	03010204	wgra001f	PFO	118	0.2	0.1	Open Cut
	288.5	03010204	wgra002f	PFO	59	0.1	<0.1	Open Cut
	288.5	03010204	wgra002f	PFO	285	0.4	0.2	Open Cut
	288.8	03010204	wgra002f	PFO	206	0.3	0.1	Open Cut
	289.1	03010204	wgrc109s	PSS	19	<0.1	<0.1	Open Cut
	290.1	03010204	wgrc010e	PEM	471	0.8	0.0	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	290.2	03010204	wgrc011f	PFO	40	0.1	<0.1	Open Cut
	290.2	03010204	wgrc011f	PFO	10	<0.1	<0.1	Open Cut
	290.4	03010204	wgrc009f	PFO	511	0.8	0.3	Open Cut
	291.4	03010204	wgra003f	PFO	28	0.1	<0.1	Open Cut
	292.4	03010204	wgra012s	PSS	2,443	0.6	0.1	Open Cut
	293.8	03010204	wgro002f	PFO	32	<0.1	<0.1	Open Cut
	294.0	03010204	wgro003f	PFO	91	0.1	0.1	Open Cut
	294.0	03010204	wgro003f	PFO	918	1.5	0.6	Open Cut
	294.2	03010204	wgro003f	PFO	110	0.2	0.1	Open Cut
	295.6	03010204	wgrb003f	PFO	368	0.6	0.3	Open Cut
	295.7	03010204	wgrb003f	PFO	239	0.4	0.2	Open Cut
	295.9	03010204	wgrp004f	PFO	138	0.3	0.1	Open Cut
	296.1	03010204	wgrp003f	PFO	78	0.1	0.1	Open Cut
	296.8	03010204	wgrb001f	PFO	242	0.4	0.2	Open Cut
	296.9	03010204	wgrb002f	PFO	772	1.3	0.5	Open Cut
	297.4	03010204	wgrb002f	PFO	159	0.2	0.1	Open Cut
	297.5	03010204	wgrc012f	PEM	148	0.3	0.0	Open Cut
	297.7	03010204	wgra034s	PSS	580	0.8	0.1	Open Cut
	297.8	03010204	wgra034e	PEM	373	0.9	0.0	Open Cut
	297.9	03010204	wgra033f	PFO	1,919	3.3	1.3	Open Cut
	298.3	03010204	nwi_va_a_011	PFO	105	0.2	0.1	Open Cut
	298.4	03010204	nwi_va_a_010	PFO	0	<0.1	<0.1	Open Cut
	298.4	03010204	nwi_va_a_009	PFO	24	0.1	<0.1	Open Cut
	298.4	03010204	wgra031f	PFO	172	0.2	0.1	Open Cut
	298.4	03010204	nwi_va_a_008	PFO	0	<0.1	0.0	NA
	298.4	03010204	wgra030f	PFO	153	0.3	0.1	Open Cut
	298.5	03010204	nwi_va_a_006	PFO	0	0.1	0.0	NA
	298.6	03010204	wgra029f	PFO	101	0.2	0.1	Open Cut
	298.7	03010204	wgrp005s	PSS	803	1.4	0.2	Open Cut
	299.3	03010204	wgrp006s	PSS	561	1.0	0.1	Open Cut
	299.4	03010204	wgrp006s	PSS	657	1.1	0.1	Open Cut

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Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	299.6	03010204	wgrp006f	PFO	217	0.4	0.1	Open Cut
	299.6	03010204	wgrp006f	PFO	1,094	1.9	0.7	Open Cut
	292.9	03010204	nwi_va_o_001	PEM	0	<0.1	0.0	NA
AP-3								
Virginia								
Greensville County								
	12.3	03010204	wgrp001f	PFO	497	0.9	0.3	Open Cut
Southampton County								
	12.4	03010204	wsop004f	PFO	1,359	2.3	0.9	Open Cut
	12.9	03010204	wsop004f	PFO	658	1.2	0.5	Open Cut
	13.4	03010204	wsop001f	PFO	111	0.2	0.1	Open Cut
	13.5	03010204	wsop001f	PFO	3,446	6.1	2.4	Open Cut
	14.3	03010204	wsop006s	PSS	263	0.7	0.1	Open Cut
	14.3	03010204	wsop006e	PEM	437	0.5	0.0	Open Cut
	14.4	03010204	wsop006f	PFO	0	<0.1	0.0	NA
	14.4	03010204	wsop006e	PEM	73	1.7	0.0	Open Cut
	14.4	03010204	wsop006f	PFO	3,635	4.6	1.7	Open Cut
	14.5	03010204	wsop006f	PFO	0	<0.1	0.0	NA
	15.2	03010204	wsop022e	PEM	120	0.1	0.0	Open Cut
	15.2	03010204	wsop022f	PFO	0	0.1	<0.1	Open Cut
	15.3	03010204	wsop023f	PFO	1,024	1.4	0.5	Open Cut
	15.4	03010204	wsop023e	PEM	0	0.4	0.0	Open Cut
	15.6	03010204	wsor001e	PEM	765	1.1	0.0	Open Cut
	16.3	03010204	wsoo007f	PFO	0	0.1	<0.1	Open Cut
	16.5	03010204	wsoo001f	PFO	83	0.2	0.1	Open Cut
	16.5	03010204	wsoo001f	PFO	86	0.1	0.1	Open Cut
	16.8	03010204	wsop015e	PEM	262	0.3	0.0	Open Cut
	16.8	03010204	wsop015f	PFO	0	0.1	0.0	NA
	17.0	03010204	wsop016e	PEM	187	0.2	0.0	Open Cut
	17.0	03010204	wsop016f	PFO	0	0.2	<0.1	Open Cut
	17.1	03010204	wsop017e	PEM	1,184	1.6	0.0	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	17.2	03010204	wsop017f	PFO	0	0.4	0.0	NA
	17.3	03010204	wsop017f	PFO	0	<0.1	0.0	NA
	17.7	03010204	wsop018f	PFO	1,061	1.8	0.7	Open Cut
	17.7	03010204	nwi_va_n_003	PFO	0	<0.1	0.0	NA
	17.8	03010204	wsop018e	PEM	0	0.1	0.0	Open Cut
	18.0	03010204	wsop018f	PFO	489	0.8	0.3	Open Cut
	18.0	03010204	wsop018e	PEM	0	<0.1	0.0	NA
	18.1	03010204	wsoa073e	PEM	157	0.2	0.0	Open Cut
	18.2	03010204	wsoa073f	PFO	0	0.1	<0.1	Open Cut
	18.3	03010204	wsoa072e	PEM	152	0.2	0.0	Open Cut
	18.3	03010204	wsoa072f	PFO	0	0.1	<0.1	Open Cut
	18.4	03010204	wsoa071e	PEM	760	0.6	0.0	Open Cut
	18.4	03010204	wsoa071f	PFO	61	0.2	0.1	Open Cut
	18.5	03010204	wsoa071f	PFO	75	0.5	0.1	Open Cut
	19.0	03010204	wsoa070f	PFO	46	0.1	<0.1	Open Cut
	19.0	03010204	wsoa070f	PFO	37	0.1	<0.1	Open Cut
	19.2	03010204	wsoo002e	PFO	96	0.2	0.1	Open Cut
	19.2	03010204	wsoo002e	PFO	100	0.2	0.1	Open Cut
	20.0	03010204	wsop014e	PEM	39	<0.1	0.0	Open Cut
	20.0	03010204	wsop014e	PEM	10	<0.1	0.0	Open Cut
	20.4	03010204	wsop013e	PEM	0	<0.1	0.0	Open Cut
	20.4	03010204	wsop013f	PFO	52	0.1	<0.1	Open Cut
	20.7	03010204	wsop012f	PFO	110	0.1	0.1	Open Cut
	20.7	03010204	wsop012e	PEM	0	<0.1	0.0	Open Cut
	20.7	03010204	wsop012f	PFO	12	0.1	<0.1	Open Cut
	20.7	03010204	wsop012e	PEM	0	<0.1	0.0	Open Cut
	20.8	03010204	wsop011e	PEM	67	0.1	0.0	Open Cut
	20.8	03010204	wsop011f	PFO	205	0.4	0.1	Open Cut
	21.0	03010204	wsop011e	PEM	0	<0.1	0.0	Open Cut
	21.0	03010204	wsop011e	PEM	0	<0.1	0.0	Open Cut
	21.1	03010204	wsop011e	PEM	0	0.1	0.0	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	21.1	03010204	wsop011e	PEM	0	<0.1	0.0	NA
	21.3	03010204	wsoa076e	PEM	107	0.1	0.0	Open Cut
	21.3	03010204	wsoa076e	PEM	37	<0.1	0.0	Open Cut
	21.3	03010204	wsoa076f	PFO	0	<0.1	<0.1	Open Cut
	21.3	03010204	wsoa076e	PEM	152	0.1	0.0	Open Cut
	21.3	03010204	wsoa076f	PFO	0	0.2	<0.1	Open Cut
	21.5	03010204	wsoa075e	PEM	1,063	0.7	0.0	Open Cut
	21.6	03010204	wsoa075f	PFO	0	0.9	0.3	Open Cut
	21.7	03010204	wsoa075e	PEM	224	0.2	0.0	Open Cut
	21.8	03010204	wsoa075f	PFO	0	<0.1	<0.1	Open Cut
	21.8	03010204	wsoa075f	PFO	135	0.4	0.1	Open Cut
	22.3	03010204	wsoa074e	PEM	20	<0.1	0.0	Open Cut
	22.8	03010201	wsoa032f	PFO	300	0.3	0.2	Open Cut
	23.0	03010201	wsoa031f	PFO	74	0.1	0.1	Open Cut
	23.5	03010201	wsoa005f	PFO	31	0.1	<0.1	Open Cut
	23.7	03010201	wsoo003f	PFO	332	0.5	0.2	Open Cut
	24.5	03010201	wsoo008f	PFO	0	<0.1	0.0	NA
	24.9	03010201	wsoo009f	PFO	0	<0.1	<0.1	Open Cut
	25.1	03010201	wsop021f	PFO	77	0.1	0.1	Open Cut
	25.3	03010201	wsop020f	PFO	275	0.5	0.2	Open Cut
	25.4	03010201	wsop019f	PFO	68	0.2	<0.1	Open Cut
	26.6	03010201	wsoo006e	PEM	0	<0.1	0.0	Open Cut
	26.6	03010201	wsoo006f	PFO	45	<0.1	<0.1	Open Cut
	27.3	03010201	wsol009f	PFO	232	0.4	0.2	Open Cut
	27.4	03010201	wsol009f	PFO	236	0.4	0.2	Open Cut
	27.7	03010201	wsol010f	PFO	301	0.6	0.2	Open Cut
	27.7	03010201	wsol010e	PEM	206	0.3	0.0	Open Cut
	27.9	03010201	wsol011e	PEM	35	0.1	0.0	Open Cut
	28.1	03010201	wsol012f	PFO	521	0.9	0.4	Open Cut
	28.3	03010201	wsol014f	PFO	131	0.2	0.1	Open Cut
	28.6	03010201	wsop100f	PFO	140	0.2	0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	28.7	03010201	wsol015f	PFO	66	0.1	<0.1	Open Cut
	29.2	03010201	wsol016f	PFO	76	0.1	0.1	Open Cut
	29.4	03010201	wsol017s	PSS	207	0.5	<0.1	Open Cut
	29.5	03010201	wsol018f	PFO	208	0.3	0.1	Open Cut
	29.7	03010201	wsoc009f	PFO	48	0.1	<0.1	Open Cut
	30.0	03010201	wsol019e	PEM	209	0.3	0.0	Open Cut
	30.0	03010201	wsol019f	PFO	254	0.5	0.2	Open Cut
	30.1	03010201	wsol020f	PFO	453	0.7	0.3	Open Cut
	30.7	03010201	wsoa017f	PFO	227	0.4	0.2	Open Cut
	31.8	03010201	wsoa020f	PFO	503	0.8	0.3	Open Cut
	32.1	03010201	wsol031f	PFO	121	0.2	0.1	Open Cut
	32.1	03010201	wsol031f	PFO	327	0.6	0.2	Open Cut
	32.3	03010201	wsol030f	PFO	301	0.5	0.2	Open Cut
	32.3	03010201	wsol029f	PFO	153	0.3	0.1	Open Cut
	32.4	03010201	wsol029s	PSS	196	0.3	<0.1	Open Cut
	32.5	03010201	wsol028s	PSS	47	0.1	<0.1	Open Cut
	32.5	03010201	wsol027f	PFO	149	0.5	0.1	Open Cut
	32.5	03010201	wsol027f	PFO	0	<0.1	0.0	NA
	32.6	03010201	wsol026f	PFO	113	0.1	0.1	HDD
	32.6	03010201	wsol021f	PFO	728	0.8	0.5	HDD
	33.0	03010201	wsol022f	PFO	52	0.1	<0.1	Open Cut
	33.5	03010201	wsoa026e	PEM	32	0.1	0.0	Open Cut
	33.6	03010201	wsoa027s	PSS	141	0.2	<0.1	Open Cut
	33.7	03010201	wsoa028f	PFO	254	0.4	0.2	Open Cut
	34.6	03010201	wsoo010f	PFO	6	<0.1	<0.1	Open Cut
	34.9	03010201	wsol025f2	PFO	1,081	1.8	0.7	Open Cut
	35.1	03010201	wsol025f1	PFO	54	0.1	<0.1	Open Cut
	35.1	03010201	wsol025s	PSS	469	0.8	0.1	Open Cut
	35.2	03010201	wsol024s	PSS	507	0.9	0.1	Open Cut
	35.4	03010201	wsol023s	PSS	1,232	2.1	0.3	Open Cut
	35.6	03010201	wsol023f	PFO	292	0.5	0.2	Open Cut

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	35.7	03010201	wsol023f	PFO	754	1.3	0.5	Open Cut
	35.8	03010202	wsoa025e	PEM	27	0.1	0.0	Open Cut
	37.0	03010202	wsol033e	PEM	433	0.7	0.0	Open Cut
	37.3	03010202	wsol034f	PFO	172	0.3	0.1	Open Cut
	37.4	03010202	wsoa023f	PFO	804	1.4	0.6	Open Cut
	37.6	03010202	wsoc008f	PFO	105	0.1	0.1	Open Cut
	37.7	03010202	wsoc017f	PFO	111	0.2	0.1	Open Cut
	37.8	03010202	wsoa022f	PFO	95	0.2	0.1	Open Cut
	38.1	03010202	wsoa021f	PFO	74	0.1	0.1	Open Cut
	38.1	03010202	wsoa021f	PFO	563	1.0	0.4	Open Cut
	38.4	03010202	wsoa024f	PFO	1,093	1.2	0.8	HDD
City of Suffolk								
	38.6	03010202	wsoa024f	PFO	15	<0.1	<0.1	HDD
	38.6	03010202	wsua006f	PFO	209	0.2	0.1	HDD
	39.1	03010202	wsua007s	PSS	50	0.1	<0.1	Open Cut
	39.4	03010202	wsua008f	PFO	44	0.2	<0.1	Open Cut
	39.4	03010202	wsua008f	PFO	96	0.2	0.1	Open Cut
	39.5	03010202	wsua021f	PFO	39	0.1	<0.1	Open Cut
	39.5	03010202	wsua021f	PFO	234	0.4	0.2	Open Cut
	39.6	03010202	wsua021f	PFO	213	0.3	0.1	Open Cut
	39.7	03010202	wsua020f	PFO	25	<0.1	<0.1	Open Cut
	39.7	03010202	wsua020f	PFO	12	<0.1	<0.1	Open Cut
	39.7	03010202	wsua019s	PSS	111	0.2	<0.1	Open Cut
	39.9	03010202	wsua018s	PSS	33	<0.1	<0.1	Open Cut
	40.0	03010202	wsua009f	PFO	32	0.1	<0.1	Open Cut
	40.1	03010202	wsua010f	PFO	62	0.1	<0.1	Open Cut
	40.1	03010202	wsua010f	PFO	31	<0.1	<0.1	Open Cut
	40.2	03010202	wsua010f	PFO	62	0.1	<0.1	Open Cut
	40.2	03010202	wsua010f	PFO	38	0.1	<0.1	Open Cut
	41.0	03010202	wsua072f	PFO	68	0.1	<0.1	Open Cut
	41.1	03010202	wsua070f	PFO	83	0.2	0.1	Open Cut

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	41.2	03010202	wsua071f	PFO	490	0.8	0.3	Open Cut
	41.4	03010202	wsuo037f	PFO	32	0.1	<0.1	Open Cut
	41.4	03010202	wsuo037f	PFO	72	0.1	0.1	Open Cut
	42.2	03010202	wsuo013f	PFO	89	0.1	0.1	Open Cut
	42.3	03010202	wsuo013f	PFO	172	0.3	0.1	Open Cut
	42.3	03010202	wsuo013f	PFO	156	0.3	0.1	Open Cut
	42.7	03010202	wsuo012f	PFO	107	0.2	0.1	Open Cut
	43.1	03010202	wsup030e	PEM	11	<0.1	0.0	Open Cut
	43.7	03010202	wsup014e	PEM	26	<0.1	0.0	Open Cut
	43.7	03010202	wsup014f	PFO	0	<0.1	<0.1	Open Cut
	43.8	03010202	wsup013e	PEM	490	0.8	0.0	Open Cut
	43.9	03010202	wsup013f	PFO	0	0.3	0.1	Open Cut
	43.9	03010202	wsup013f	PFO	94	0.2	0.1	Open Cut
	44.0	03010202	wsup013f	PFO	200	0.2	0.1	Open Cut
	44.0	03010202	wsup013f	PFO	184	0.1	0.1	Open Cut
	44.2	03010202	wsup026e	PEM	483	0.8	0.0	Open Cut
	44.2	03010202	wsup026f	PFO	0	0.1	<0.1	Open Cut
	44.3	03010202	wsup026f	PFO	0	<0.1	<0.1	Open Cut
	44.5	03010202	wsup025f	PFO	336	0.6	0.3	Open Cut
	44.6	03010202	wsup025f	PFO	0	0.1	0.0	NA
	44.6	03010202	wsup025e	PEM	31	<0.1	0.0	Open Cut
	44.6	03010202	wsup025e	PEM	0	<0.1	0.0	NA
	44.6	03010202	wsuo017f	PFO	287	0.5	0.2	Open Cut
	45.1	03010202	wsuo020f	PFO	62	0.1	<0.1	Open Cut
	45.1	03010202	wsuo020f	PFO	28	0.1	<0.1	Open Cut
	45.5	03010202	wsua076f	PFO	562	1.0	0.4	Open Cut
	45.6	03010202	wsua076e	PEM	82	0.1	0.0	Open Cut
	46.1	03010202	wsua074e	PEM	2	<0.1	0.0	Open Cut
	46.1	03010202	wsua074e	PEM	11	<0.1	0.0	Open Cut
	46.2	03010202	wsua073f	PFO	1,525	2.7	1.0	Open Cut
	46.5	03010203	wsuc101f	PFO	2,347	4.0	1.6	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	47.0	03010203	wsuc101e	PEM	72	0.1	0.0	Open Cut
	47.0	03010203	wsuc101f	PFO	118	0.2	0.1	Open Cut
	47.0	03010203	wsuc101f	PFO	783	1.4	0.5	Open Cut
	47.2	03010203	wsuc101s	PSS	332	0.6	0.1	Open Cut
	47.3	03010203	wsuc100f	PFO	235	0.4	0.2	Open Cut
	47.3	03010203	wsuc100s	PSS	281	0.5	0.1	Open Cut
	47.4	03010203	wsuc100f	PFO	604	1.0	0.4	Open Cut
	47.5	03010203	wsuc005f	PFO	801	2.2	0.6	Open Cut
	47.6	03010203	wsuc005s	PSS	1,556	1.8	0.4	Open Cut
	48.1	03010203	wsuc006e	PEM	293	0.2	0.0	Open Cut
	48.1	03010203	wsuc006f	PFO	0	0.3	0.1	Open Cut
	48.6	03010203	wsuc007e	PEM	470	0.8	0.0	Open Cut
	49.3	03010203	nwi_va_b_047	PFO	241	0.4	0.2	Open Cut
	49.4	03010203	nwi_va_b_048	PFO	800	1.5	0.6	Open Cut
	49.6	03010203	wsuo027f	PFO	218	0.3	0.2	Open Cut
	49.7	03010203	wsuo027e	PEM	141	0.2	0.0	Open Cut
	49.7	03010203	wsuo027f	PFO	0	<0.1	0.0	NA
	49.7	03010203	wsuo027f	PFO	28	<0.1	<0.1	Open Cut
	49.8	03010203	wsuo026f	PFO	113	0.2	0.1	Open Cut
	49.9	03010203	wsuo026f	PFO	76	0.2	0.1	Open Cut
	50.0	03010203	wsuo025f	PFO	1,167	2.0	0.8	Open Cut
	50.4	03010203	wsuo024f	PFO	0	<0.1	0.0	NA
	50.5	03010203	wsuo024f	PFO	56	0.1	<0.1	Open Cut
	50.5	03010203	wsuo024f	PFO	25	0.1	<0.1	Open Cut
	50.8	03010203	wsuo022f	PFO	2,402	4.1	1.7	Open Cut
	51.4	03010203	wsuo023f	PFO	866	1.6	0.6	Open Cut
	52.1	03010203	wsup037f	PFO	142	0.2	0.1	Open Cut
	52.3	03010203	wsup021f	PFO	420	0.8	0.3	Open Cut
	52.6	03010203	wsup024s	PSS	59	0.1	<0.1	Open Cut
	52.6	03010203	wsup024s	PSS	112	0.2	<0.1	Open Cut
	52.6	03010203	wsup024s	PSS	0	<0.1	<0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	52.6	03010203	wsup024f	PFO	90	0.1	0.1	Open Cut
	52.7	03010203	wsup023f	PFO	259	0.4	0.2	Open Cut
	52.8	03010203	wsup022f	PFO	1,350	2.3	0.9	Open Cut
	53.0	02080208	wsup022s	PSS	2,744	4.7	0.6	Open Cut
	53.6	02080208	wsuo039f	PFO	21	<0.1	<0.1	Open Cut
	53.9	02080208	wsup027s	PSS	2,052	3.5	0.5	Open Cut
	54.4	02080208	wsup028s	PSS	359	0.6	0.1	Open Cut
	54.5	02080208	wsup028f	PFO	85	0.1	0.1	Open Cut
	54.6	02080208	wsup029f	PFO	203	0.3	0.1	Open Cut
	54.6	02080208	nwi_va_n_006	PFO	32	0.1	<0.1	Open Cut
	54.6	02080208	wsur007f	PFO	49	0.1	<0.1	Open Cut
	54.7	02080208	wsur008f	PFO	0	0.1	<0.1	Open Cut
	54.9	02080208	wsuo047f	PFO	795	1.4	0.5	Open Cut
	55.1	02080208	wsuo046f	PFO	145	0.3	0.1	Open Cut
	55.2	02080208	wsuo046e	PEM	21	<0.1	0.0	Open Cut
	55.2	02080208	wsuo045f	PFO	319	0.6	0.2	Open Cut
	55.4	02080208	wsuo044f	PFO	13	<0.1	<0.1	Open Cut
	55.4	02080208	wsuo044f	PFO	34	0.1	<0.1	Open Cut
	56.1	02080208	wsup032f	PFO	856	1.4	0.6	Open Cut
	56.3	02080208	wsup032f	PFO	143	0.2	0.1	Open Cut
	56.3	02080208	wsup033f	PFO	76	0.1	<0.1	Open Cut
	56.4	02080208	wsup034e	PEM	21	0.1	0.0	Open Cut
	56.4	02080208	wsup034e	PEM	131	0.2	0.0	Open Cut
	56.6	02080208	wsup035f	PFO	0	<0.1	<0.1	Open Cut
	56.7	02080208	wsup035f	PFO	80	0.1	0.1	Open Cut
	57.4	02080208	wsup038f	PFO	135	0.2	0.1	Open Cut
	57.5	02080208	wsuo032f	PFO	441	0.8	0.3	Open Cut
	57.9	02080208	wsuo033f	PFO	465	0.8	0.3	Open Cut
	59.3	02080208	wsuo034f	PFO	37	0.1	<0.1	Open Cut
	59.3	02080208	wsuo034f	PFO	0	<0.1	0.0	NA
	59.4	02080208	wsuo035f	PFO	63	0.1	<0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	59.4	02080208	wsuo035f	PFO	44	0.1	<0.1	Open Cut
	59.4	02080208	wsuo035f	PFO	37	<0.1	<0.1	Open Cut
	62.7	02080208	wsuo041f	PFO	0	<0.1	0.0	NA
	62.7	02080208	wsuo041f	PFO	3	<0.1	<0.1	Open Cut
	62.7	02080208	wsuo041f	PFO	21	<0.1	<0.1	Open Cut
	63.0	02080208	wsuo042f	PFO	52	0.1	<0.1	Open Cut
	63.0	02080208	wsuo042f	PFO	32	<0.1	<0.1	Open Cut
	63.6	02080208	wsup015f	PFO	50	0.1	0.1	HDD
	63.6	02080208	wsup015e	PEM	20	<0.1	0.0	HDD
	63.6	02080208	nwi_va_c_001	E2E	1,938	2.2	0.0	HDD
	64.0	02080208	wsup018e	PEM	50	0.1	0.0	HDD
	64.3	02080208	wsup016e	PEM	37	<0.1	0.0	HDD
	64.3	02080208	nwi_va_c_002	E2E	297	0.3	0.0	HDD
	64.4	02080208	nwi_va_c_005	E2U	1,864	2.1	0.0	HDD
	64.8	02080208	wsuc112e	PEM	349	0.4	0.0	HDD
	66.1	02080208	wsuo043e	PEM	711	0.6	0.0	Open Cut
	66.2	02080208	wsuo043f	PFO	0	0.7	0.1	Open Cut
	66.3	02080208	wsuo018e	PEM	3,487	2.5	0.0	Open Cut
	66.4	02080208	wsuo018f	PFO	0	0.3	<0.1	Open Cut
	66.7	02080208	wsuo018s	PSS	0	3.0	0.0	Open Cut
	67.0	02080208	wsuo019e	PEM	2,181	1.8	0.0	Open Cut
	67.2	02080208	wsuo019s	PSS	1,066	3.8	0.3	Open Cut
	68.1	02080208	wsup020e	PEM	2,259	0.3	0.0	Open Cut
	71.1	02080208	wsuo011f	PFO	419	0.7	0.3	HDD
	71.2	02080208	wsuo011e	PEM	22	<0.1	0.0	HDD
	70.5	02080208	nwi_va_o_012	PEM	0	<0.1	0.0	NA
	70.3	02080208	nwi_va_o_012	PEM	0	<0.1	0.0	NA
	68.8	02080208	nwi_va_o_004	PFO	0	0.3	0.0	NA
	69.0	02080208	nwi_va_o_005	PFO	0	0.1	<0.1	Open Cut
	69.2	02080208	nwi_va_o_007	PFO	0	0.5	0.2	Open Cut
	70.6	02080208	nwi_va_o_010	PFO	0	0.1	<0.1	Open Cut

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	69.8	02080208	nwi_va_o_010	PFO	0	6.9	1.1	Open Cut
	70.6	02080208	nwi_va_o_013	PFO	2,194	3.7	1.5	Open Cut
	69.0	02080208	nwi_va_o_006	PSS	0	0.1	0.0	NA
City of Chesapeake								
	71.8	02080208	wchr002f	PFO	7,177	10.6	4.9	Open Cut
	71.8	02080208	wchr002e	PEM	0	<0.1	0.0	NA
	71.8	02080208	wchr002f	PFO	0	<0.1	0.0	NA
	73.1	02080208	wchr002e	PEM	99	1.9	0.0	Open Cut
	73.1	02080208	wchr002f	PFO	1,681	2.9	1.2	Open Cut
	73.5	02080208	wchr002e	PEM	240	0.4	0.0	Open Cut
	73.5	02080208	wchr002f	PFO	586	1.0	0.4	Open Cut
	73.6	02080208	wchr002f	PFO	245	0.4	0.2	Open Cut
	73.7	02080208	wchr002f	PFO	1,431	2.5	1.0	Open Cut
	74.0	02080208	wchr002f	PFO	1,885	3.3	1.3	Open Cut
	74.3	02080208	wchr002f	PFO	3,853	6.6	2.6	Open Cut
	75.1	02080208	wchr001f	PFO	4,845	7.9	3.3	Open Cut
	76.0	02080208	nwi_va_i_008	PFO	233	0.4	0.2	Open Cut
	76.4	02080208	wcho001f	PFO	2,023	2.3	1.4	Open Cut
	76.9	02080208	wchc002f	PFO	179	0.2	0.1	Open Cut
	77.1	02080208	wchc001f	PFO	54	0.1	<0.1	Open Cut
	77.3	02080208	wcho002f	PFO	8	0.1	<0.1	Open Cut
	77.4	02080208	wcho004f	PFO	84	0.2	0.1	Open Cut
	77.4	02080208	wcho004f	PFO	49	0.1	<0.1	Open Cut
	77.9	02080208	wcho011e3	PEM	21	<0.1	0.0	HDD
	78.0	02080208	wcho011e3	PEM	34	0.1	0.0	Open Cut
	78.0	02080208	wcho011f3	PFO	602	1.1	0.4	Open Cut
	78.0	02080208	wcho011f3	PFO	0	<0.1	0.0	NA
	78.2	02080208	wcho011f	PFO	837	1.2	0.6	Open Cut
	78.5	02080208	wcho011e	PEM	394	1.3	0.0	Open Cut
	79.1	02080208	wcho008e	PEM	5	<0.1	0.0	HDD
	79.5	02080208	wcho005e	PEM	0	0.1	0.0	NA

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	79.9	02080208	wcho009e	PEM	72	0.1	0.0	Open Cut
	79.9	02080208	wcho009f	PFO	0	0.1	0.0	NA
	80.4	02080208	wcho010e	PEM	1,594	1.7	0.0	Open Cut
	80.4	02080208	wcho010f	PFO	0	0.1	<0.1	Open Cut
	80.4	02080208	wchro001e	PEM	0	<0.1	0.0	Open Cut
	80.7	02080208	wcho010f	PFO	443	1.9	0.4	Open Cut
	80.8	02080208	wchro002e	PEM	487	1.0	0.0	Open Cut
	80.8	02080208	wchro002e	PEM	0	<0.1	0.0	NA
	80.8	02080208	wchro002e	PEM	0	<0.1	0.0	NA
	80.8	02080208	wchro002e	PEM	0	0.1	0.0	Open Cut
	80.9	02080208	wchro002f	PFO	305	0.4	0.1	Open Cut
	80.9	02080208	wchro002f	PFO	351	0.5	0.2	Open Cut
	80.9	02080208	wchro002f	PFO	0	<0.1	<0.1	Open Cut
	81.0	02080208	wchro002f	PFO	8	<0.1	<0.1	Open Cut
	81.0	02080208	wchro002e	PEM	0	0.1	0.0	Open Cut
	81.0	02080208	wcho012e	PEM	6	<0.1	0.0	Open Cut
	81.4	02080208	wcho014f	PFO	0	1.4	<0.1	Open Cut
	81.7	02080208	wcho016f	PFO	0	0.2	<0.1	Open Cut
	81.7	02080208	wcho017e	PEM	0	<0.1	0.0	NA
	81.8	02080208	wcho016e	PEM	319	0.4	0.0	HDD
	82.4	02080208	nwi_va_i_009	PFO	452	0.4	0.2	Open Cut
	82.5	02080208	nwi_va_n_007	PFO	63	0.1	<0.1	Open Cut
AP-4								
Virginia								
Brunswick County			None		0	0	0	NA
AP-5								
Virginia								
Greensville County			None		0	0	0	NA
ABOVEGROUND FACILITIES								
Compressor Station 2								

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Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
Virginia								
Buckingham County	191.5	02080203	wbub050f	PFO	94	0.5	0.0	NA
	191.5	02080203	wbub050f	PFO	0	<0.1	0.0	NA
	191.5	02080203	wbub050e	PEM	0	0.8	0.0	NA
	191.8	02080203	wbub051s	PSS	0	1.3	0.0	NA
Elizabeth River M&R								
Virginia								
City of Chesapeake	82.7	02080208	wcha001f	PFO	0	0.1	0.1	NA
CONTRACTOR YARDS/PIPE YARDS								
AP-1								
CY Spr 03-A								
Virginia								
Highland County	87.6	02080201	whic100e	PEM	0	0.2	0.0	NA
	87.6	02080201	whic101e1	PEM	0	<0.1	0.0	NA
	87.6	02080201	whic101e2	PEM	0	0.1	0.0	NA
	87.6	02080201	whic101s	PSS	0	<0.1	0.0	NA
CY Spr 04-A								
Virginia								
Highland County	109.0	02080201	whie003e	PEM	0	0.4	0.0	NA
	109.0	02080201	whie005e	PEM	0	<0.1	0.0	NA
	109.0	02080201	whie006e	PEM	0	<0.1	0.0	NA
CY GWNF-6 Spr 04-A								
Virginia								
Augusta County	109.1	02080202	wauf002e	PEM	0	<0.1	0.0	NA
	109.1	02080202	wauf002e	PEM	0	<0.1	0.0	NA
	109.2	02080202	wauf002e	PEM	0	0.1	0.0	NA
	109.2	02080202	wauf001e	PEM	0	0.6	0.0	NA
CY Spr 07-B								
Virginia								
Brunswick County	274.8	03010204	wgrc106e	PEM	0	<0.1	0.0	NA

Appendix O

Wetlands Crossed and Crossing Methods for the Atlantic Coast Pipeline within Virginia

Facility/State or Commonwealth/ County or City	Approximate Milepost	Hydrologic Unit Code (HUC8)	Unique ID	Cowardin Classification [a]	Crossing Length (feet) [b]	Temporary Construction Impacts (acres) [c]	Operation Impacts (acres) [d]	Construction Method [e, f]
	274.9	03010204	wgrc107e	PEM	0	0.1	0.0	NA

____

[a] Wetland types according to Cowardin et al. (1979):

PFO = palustrine forested
PSS = palustrine scrub-shrub
PEM = palustrine emergent
PUB = palustrine unconsolidated bottom
E = estuarine
R = riverine

[b] The crossing length is the measure of the distance of the centerline through the wetland. It does not include feet crossed outside the centerline. A value of 0 indicates that the centerline does not cross the wetland.

[c] Temporary wetland impacts associated with the construction right-of-way (includes permanent impacts, temporary impacts, ATWS impacts, ground bed impacts and water impoundment impacts).

[d] Operational impacts are associated with scrub-shrub and forested wetlands. Operational requirements allow a 10-foot-wide corridor centered over the pipeline to be maintained in an herbaceous state, and for the removal of trees within 15 feet on either side of the pipeline. To determine conversion impacts on scrub-shrub wetlands, a 10-foot-wide corridor centered over the pipeline was assessed. A 30-foot-wide corridor centered over the pipeline was assessed for forested wetlands. Because the easement will be maintained in an herbaceous state, there will be no operational impacts on emergent wetlands.

[e] Pending the results of geotechnical investigations and final engineering, Atlantic is evaluating use of the HDD method to cross six waterbodies, a water impoundment area, two highways, and the Appalachian Trail/Blue Ridge Parkway. Use of the HDD method would avoid these features as well as adjacent wetlands and riparian areas. If successfully implemented, the HDD method would avoid impacts on the adjacent wetlands, including wetlands identified in this table.

[f] NA = wetland occurs within workspace but is not crossed by the centerline, trenching thru the wetland is not expected.

Note: The totals shown in this table may not equal the sum of addends due to rounding.

APPENDIX P

Waterbodies Crossed Table

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	3A	AP-1	85.0	shia407	UNT to Warwick Run	Perennial		45	Dam and Pump or Flume	WQS not assessed; Class I-IV	Potential for USFS-listed species	March 15 to June 30 / October 1 to March 31
Virginia	3A	AP-1	85.1	shia410	UNT to Warwick Run	Perennial		10	Dam and Pump or Flume	WQS not assessed; Class I-IV	Potential for USFS-listed species	March 15 to June 30 / October 1 to March 31
Virginia	3A	AP-1	85.1	shia411	UNT to Warwick Run	Perennial	24		Perm AR	WQS not assessed; Class I-IV		March 15 to June 30 / October 1 to March 31
Virginia	3A	AP-1	85.4	shia409	UNT to Lick Draft	Perennial		10	Dam and Pump or Flume	WQS not assessed; Class I-IV		October 1 to March 31
Virginia	3A	AP-1	85.4	shia412	Warwick Run	Perennial	80		Perm AR	Class I-IV	Potential for USFS-listed species	March 15 to June 30 / October 1 to March 31
Virginia	3A	AP-1	85.4	shia414	Lick Draft	Perennial	12		Perm AR	Aquatic Life		October 1 to March 31
Virginia	3A	AP-1	85.4	shia415	UNT to Lick Draft	Intermittent	24		Perm AR	Aquatic Life		October 1 to March 31
Virginia	3A	AP-1	85.4	shia413	Lick Draft	Perennial			Perm AR	Aquatic Life		October 1 to March 31
Virginia	3A	AP-1	85.4	shia413	Lick Draft	Perennial			Perm AR	Aquatic Life		October 1 to March 31
Virginia	3A	AP-1	85.4	shia408	Lick Draft	Perennial			Perm AR	WQS not assessed; Class I-IV	Potential for USFS-listed species	October 1 to March 31
Virginia	3A	AP-1	85.5	shia408	Lick Draft	Perennial		8	Dam and Pump or Flume	WQS not assessed; Class I-IV	Potential for USFS-listed species	October 1 to March 31
Virginia	3A	AP-1	87.2	shie061	Back Creek	Perennial		73	Cofferdam or Dam and Pump	Aquatic Life	Potential for ESA-listed species	March 15 to June 30
Virginia	3A	AP-1	87.3	ohie020	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	3A	AP-1	88.5	shia405	UNT to Back Creek	Ephemeral		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	3A	AP-1	88.8	shia421	UNT to Back Creek	Intermittent	5		Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	88.8	shia406	UNT to Back Creek	Intermittent		9	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	3A	AP-1	89.2	shia422	UNT to Back Creek	Intermittent	3		Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	89.2	shif001	UNT to Back Creek	Intermittent	2		Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	89.4	nhd_va_l_009	UNT to Jackson River	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	3A	AP-1	89.4	nhd_va_l_010	UNT to Jackson River	Intermittent	6		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	3A	AP-1	89.4	nhd_va_l_014	UNT to Jackson River	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	3A	AP-1	89.4	nhd_va_l_016	UNT to Jackson River	Intermittent	6		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	3A	AP-1	89.4	nhd_va_l_018	UNT to Jackson River	Intermittent	13		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	3A	AP-1	89.4	nhd_va_l_022	UNT to Jackson River	Perennial	14		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15/March 15 to June 30
Virginia	3A	AP-1	89.4	nhd_va_l_030	UNT to Jackson River	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	3A	AP-1	90.0	shif002	Peak Run	Ephemeral	3	2	Dam and Pump or Flume	Aquatic Life		NA
Virginia	3A	AP-1	90.1	shia423	UNT to Peak Run	Intermittent			Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	90.3	shia416	UNT to Peak Run	Ephemeral	3		Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	90.4	shia417	UNT to Peak Run	Ephemeral	2		Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	90.4	shia419	UNT to Peak Run	Intermittent	32		Perm AR	UNT to Aquatic Life		NA
Virginia	3A	AP-1	90.4	shia420	UNT to Jackson River	Ephemeral	3		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	3A	AP-1	90.4	shia400	Peak Run	Perennial			Perm AR	Aquatic Life		March 15 to June 30
Virginia	3A	AP-1	90.4	shia400	Peak Run	Perennial			Perm AR	Aquatic Life		March 15 to June 30
Virginia	3A	AP-1	90.4	shia400	Peak Run	Perennial		9	Dam and Pump or Flume	Aquatic Life		March 15 to June 30
Virginia	3A	AP-1	90.8	shia401	UNT to Stony Run	Ephemeral		5	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	3A	AP-1	90.8	shia402	Stony Run	Perennial		31	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31/ March 15 to June 30
Virginia	3A	AP-1	91.1	shic117	Morris Run	Perennial		11	Dam and Pump or Flume	Aquatic Life		March 15 to June 30
Virginia	3A	AP-1	91.1	shic116	UNT to Morris Run	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	91.4	nhd_va_j_002	Morris Run	Perennial		11	Dam and Pump or Flume	Aquatic Life		March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4	AP-1	91.5	nhd_va_j_003	Jackson River	Perennial		63	Cofferdam or Dam and Pump	Aquatic Life, I-IV	Potential for ESA-listed species	October 1 to March 31/March 15 to May 15/March 15 to June 30
Virginia	4	AP-1	91.7	nhd_va_l_034	UNT to Jackson River	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	4	AP-1	91.7	nhd_va_l_036	UNT to Jackson River	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	4	AP-1	91.8	nhd_va_j_004	UNT to Givens Run	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	91.9	nhd_va_l_035	UNT to Jackson River	Intermittent	13		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31/March 15 to May 15
Virginia	4	AP-1	93.0	nhd_va_e_023	Little Valley Run	Intermittent		6	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	93.0	nhd_va_l_025	UNT to Little Valley Run	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	93.7	sbaa008	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa008	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa008	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa009	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa009	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa010	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa010	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa010	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	93.7	sbaa011	UNT to Muddy Run	Intermittent			Perm AR	WQS not assessed		NA
Virginia	4	AP-1	94.1	sbaa004	Laurel Run	Perennial	6	7	Flume or Dam and Pump	Impaired; Class I-IV		October 1 to March 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4	AP-1	94.1	sbaa004	Laurel Run	Perennial			Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	94.1	nhd_va_l_040	Laurel Run	Intermittent			Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	94.2	nhd_va_l_041	Laurel Run	Perennial	38		Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	94.2	nhd_va_l_027	UNT to Laurel Run	Intermittent	7		Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	94.4	nhd_va_l_033	Laurel Run	Perennial	10		Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	94.5	nhd_va_l_045	Laurel Run	Perennial	32		Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	94.7	sbaa012	UNT to Laurel Run	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	94.7	nhd_va_e_025	UNT to Dry Run	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	94.7	nhd_va_e_025	UNT to Dry Run	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	94.7	sbaa012	UNT to Laurel Run	Intermittent		62	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	94.7	nhd_va_e_025	UNT to Dry Run	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	94.8	nhd_va_e_025	UNT to Dry Run	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	94.8	nhd_va_l_046	Laurel Run	Perennial	12		Perm AR	Impaired; Class I-IV		October 1 to March 31
Virginia	4	AP-1	95.2	sbay008	UNT to Dry Run	Ephemeral		9	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	95.5	nhd_va_e_027	UNT to Dry Run	Intermittent	6	5	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	95.6	nhd_va_l_021	UNT to Dry Run	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4	AP-1	96.5	obaa001	Unnamed Pond	Pond	Pond	Pond	Pond	NA		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4	AP-1	97.8	sbaa015	Cowpasture River	Perennial		106	Cofferdam or Dam and Pump	Aquatic Life	Potential for ESA-listed species	March 15 to June 30/May 15 to July 31
Virginia	4	AP-1	97.8	sbaa016	UNT to Cowpasture River	Perennial		54	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	4	AP-1	97.9	nhd_va_n_002	UNT to Cowpasture River	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	4	AP-1	98.0	nhd_va_n_006	UNT to Cowpasture River	Perennial		11	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	4	AP-1	98.3	sbaa005	UNT to Cowpasture River	Perennial		20	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	4	AP-1	98.9	sbaa006	UNT to Cowpasture River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	4	AP-1	99.0	sbaa022	UNT to Gibson Hollow	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	4	AP-1	99.0	sbaa007	UNT to Cowpasture River	Intermittent		11	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	4	AP-1	99.0	sbaa021	UNT to Gibson Hollow	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	99.2	sbaa020	UNT to Gibson Hollow	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	99.3	nhd_va_l_037	UNT to Stuart Run	Intermittent	6		Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	99.3	sbaa019	Gibson Hollow	Perennial	10	10	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	99.3	nhd_va_l_038	UNT to Stuart Run	Intermittent	7		Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	99.3	sbaa003	UNT to Gibson Hollow	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	99.3	sbaa019	Gibson Hollow	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	4	AP-1	99.4	nhd_va_l_001	UNT to Stuart Run	Intermittent	29		Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	99.4	nhd_va_l_042	UNT to Stuart Run	Perennial	27		Perm AR	UNT to Aquatic Life		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4	AP-1	99.4	nhd_va_l_043	UNT to Stuart Run	Perennial	48		Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	100.4	sbaz003	UNT to White Sulphur Spring	Ephemeral			Perm AR	Unclassified		NA
Virginia	4	AP-1	100.6	sbaa002	White Sulphur Spring Branch	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4	AP-1	100.7	sbaa001	Stuart Run	Perennial		65	Dam and Pump or Flume	Aquatic Life		March 15 to June 30
Virginia	4	AP-1	100.8	sbar010e	UNT to Stuart Run	Ephemeral		8	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.0	sbar013	UNT to Stuart Run	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.0	sbar018	UNT to Stuart Run	Ephemeral			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.0	sbar014	UNT to Stuart Run	Perennial		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.1	sbar019e	UNT to Stuart Run	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.1	sbar019p	UNT to Stuart Run	Perennial			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.2	sbar020	UNT to Stuart Run	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.3	sbaf001	UNT to Stuart Run	Ephemeral		4	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.3	sbaa013	UNT to Stuart Run	Ephemeral			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.3	sbaa013	UNT to Stuart Run	Ephemeral		3	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.5	sbar021	UNT to Stuart Run	Perennial		6	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.5	sbar022	UNT to Stuart Run	Perennial		6	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.6	sbar011	UNT to Stuart Run	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.6	sbaz002	UNT to Stuart Run	Intermittent			Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.8	sbar017	UNT to Stuart Run	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	101.9	sbay005	UNT to Stuart Run	Perennial		4	Flume or Dam and Pump	UNT to Aquatic Life		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4	AP-1	102.0	sbay007	UNT to Stuart Run	Ephemeral			Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	102.0	sbay007	UNT to Stuart Run	Ephemeral			Perm AR	UNT to Aquatic Life		NA
Virginia	4	AP-1	102.1	sbay006	UNT to Stuart Run	Ephemeral		4	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	4	AP-1	102.1	nhd_va_e_042	UNT to Stuart Run	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	102.5	nhd_va_j_011	UNT to Stuart Run	Intermittent		6	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4	AP-1	103.1	sbar008	Mill Creek	Perennial		29	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA
Virginia	4A	AP-1	103.1	sbar009	UNT to Mill Creek	Perennial		5	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA
Virginia	4A	AP-1	103.6	sbar006	UNT to Mill Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	103.8	sbar005	UNT to Mill Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	103.9	sbar004	UNT to Mill Creek	Perennial		7	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	103.9	sbaz001	Mill Creek	Perennial	24		Perm AR	Aquatic Life	Potential for ESA-listed species	NA
Virginia	4A	AP-1	104.0	sbar003	UNT to Mill Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	104.1	sbar002	UNT to Mill Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	104.2	nhd_va_j_017	UNT to Mill Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	104.4	nhd_va_j_018	UNT to Mill Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	104.6	nhd_va_j_019	UNT to Mill Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	104.7	nhd_va_l_007	Back Draft	Perennial	10		Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	104.8	nhd_va_j_020	UNT to Mill Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	104.8	nhd_va_j_021	UNT to Mill Creek	Perennial		11	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	105.0	nhd_va_h_025	Mill Creek	Perennial	11		Perm AR	Aquatic Life	Potential for ESA-listed species	NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4A	AP-1	105.7	sbar015	UNT to Mill Creek	Perennial		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	105.7	sbar016	UNT to Mill Creek	Perennial		3	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	4A	AP-1	107.1	saua408	UNT to Hamilton Branch	Intermittent		8	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	107.1	sauz016	UNT to Hamilton Branch	Ephemeral	3		Perm AR	Unclassified		NA
Virginia	4A	AP-1	107.3	dauz001	UNT to Hamilton Branch	Canal/Ditch			Perm AR	Unclassified		NA
Virginia	4A	AP-1	107.3	sauz015	UNT to Hamilton Branch	Ephemeral		1	Flume or Dam and Pump	Unclassified		NA
Virginia	4A	AP-1	107.5	saur020	UNT to Hamilton Branch	Perennial		7	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	107.5	saur011	UNT to Hamilton Branch	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	107.5	saur013	UNT to Hamilton Branch	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	107.5	saur012	UNT to Hamilton Branch	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	107.5	saur015i	UNT to Hamilton Branch	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	107.7	saur016	UNT to Hamilton Branch	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	107.7	saur016	UNT to Hamilton Branch	Perennial			Perm AR	Unclassified		NA
Virginia	4A	AP-1	107.9	saur017	UNT to Hamilton Branch	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	108.0	saua412	UNT to Hamilton Branch	Intermittent	5		Perm AR	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4A	AP-1	108.1	saua411	UNT to Hamilton Branch	Intermittent		8	Flume or Dam and Pump	Unclassified		NA
Virginia	4A	AP-1	108.3	saur019	UNT to Hamilton Branch	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	108.3	saur018	UNT to Hamilton Branch	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	108.4	sauf003	Hamilton Branch	Perennial		45	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	108.5	sauf002	UNT to Hamilton Branch	Ephemeral		10	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	108.6	sauf001	UNT to Hamilton Branch	Intermittent		6	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	108.6	sauz004	Hamilton Branch	Perennial			Perm AR	Unclassified		NA
Virginia	4A	AP-1	108.8	saua414	Hughart Run	Perennial		19	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.0	saua415	UNT to Hamilton Branch	Intermittent		7	Flume or Dam and Pump	Unclassified		NA
Virginia	4A	AP-1	109.2	sauf004	UNT to Hamilton Branch	Intermittent			Contractor Yard - Temporary Impact	Unclassified		NA
Virginia	4A	AP-1	109.2	sauf004	UNT to Hamilton Branch	Intermittent			Contractor Yard - Temporary Impact	Unclassified		NA
Virginia	4A	AP-1	109.2	saur002	UNT to Guy Hollow	Intermittent		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.2	saur006	Guy Hollow	Perennial		11	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.3	saur003	UNT to Hamilton Branch	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.3	saur004	UNT to Hamilton Branch	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.3	sauy002	UNT to Hamilton Branch	Intermittent	6		Perm AR	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4A	AP-1	109.5	saur005	UNT to Hamilton Branch	Intermittent		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.6	sauz002	UNT to Hamilton Branch	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.7	sauz001	UNT to Hamilton Branch	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	109.8	sauz005	UNT to Hamilton Branch	Perennial			Perm AR	Unclassified		NA
Virginia	4A	AP-1	110.1	sauc127	UNT to Calfpasture River	Perennial		21	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	110.5	sauc129	UNT to Calfpasture River	Intermittent		9	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	110.7	sauc130	Tizzle Branch	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	110.8	sauc131	Benson Run	Perennial		20	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	110.8	sauc132	UNT to Benson Run	Perennial		19	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	110.9	sauc133	Tim's Draft	Perennial		23	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	111.1	saue305	UNT to Tizzle Branch	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	111.4	sauy004	Calfpasture River	Perennial		52	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	111.4	sauy003	White Rock Branch	Intermittent		14	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	111.5	saue301	UNT to White Rock Branch	Ephemeral		69	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	111.5	saue302	White Rock Branch	Ephemeral		23	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	112.1	sauc123	UNT to Calfpasture River	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	112.2	sauc124	Calfpasture River	Perennial		65	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	112.6	sauc125	UNT to Calfpasture	Perennial		24	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
					River							
Virginia	4A	AP-1	113.0	sauc126	UNT to Calfpasture River	Intermittent			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	113.1	saua437	Baker Draft	Perennial		14	Dam and Pump or Flume	Aquatic Life		NA
Virginia	4A	AP-1	113.1	sauc126	UNT to Calfpasture River	Intermittent	35		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	113.1	saua437	Baker Draft	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	113.1	saur008	UNT to Baker Draft	Perennial			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	4A	AP-1	113.3	saua410	UNT to Calfpasture River	Perennial		14	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	113.4	saua406	UNT to the Calfpasture River	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	113.5	sauz012	UNT to Body Lick Branch	Perennial	4		Perm AR	UNT to Aquatic Life		NA
Virginia	4A	AP-1	113.5	saua405	Calfpasture River	Perennial		31	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	113.9	saue304	UNT to Calfpasture River	Ephemeral			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	113.9	saue303	UNT to Calfpasture River	Perennial		7	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	114.0	sauz010	UNT to Calfpasture River	Perennial			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	114.0	sauz010	UNT to Calfpasture River	Perennial			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	114.0	sauz009	UNT to Calfpasture River	Perennial			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	114.0	sauz009	UNT to Calfpasture River	Perennial	17		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	114.1	sauz008	UNT to Calfpasture River	Ephemeral	1		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4A	AP-1	114.2	sauz007	UNT to Calfpasture River	Ephemeral			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	115.2	nhd_va_o_001	Broad Draft	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	115.4	saub105	UNT to Calfpasture River	Intermittent	31		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	115.4	saub105	UNT to Calfpasture River	Intermittent	15		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	115.4	saub105	UNT to Calfpasture River	Intermittent		3	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	115.7	saub106	UNT to Barn Lick Branch	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	115.8	saua436	Barn Lick Branch	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	115.8	saua436	Barn Lick Branch	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	116.3	saub109	UNT to Calfpasture River	Perennial		12	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	116.5	saua435	Braley Branch	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	116.5	saua435	Braley Branch	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	116.5	saua435	Braley Branch	Perennial		12	Flume or Dam and Pump	Aquatic Life		NA
Virginia	4A	AP-1	116.5	saua435	Braley Branch	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	116.5	saua435	Braley Branch	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	116.5	saua435	Braley Branch	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	116.7	saup004	Calfpasture River	Perennial		30	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	117.1	saua416	Dowell's Draft	Perennial	8	10	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	117.2	saua418	UNT to Dowell's Draft	Intermittent		9	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		NA
Virginia	4A	AP-1	117.2	saua418	UNT to Dowell's Draft	Intermittent			Perm AR	UNT to Aquatic Life, I-IV		NA
Virginia	4A	AP-1	117.2	saua418	UNT to Dowell's Draft	Intermittent			Perm AR	UNT to Aquatic Life, I-IV		NA
Virginia	4A	AP-1	117.3	saua420	East Branch Dowells Draft	Perennial	10		Perm AR	Aquatic Life		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4A	AP-1	117.7	saua419	UNT to East Branch Dowell's Draft	Intermittent		7	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	120.2	saua427e	Buckhorn Creek	Ephemeral		2	Flume or Dam and Pump	Aquatic Life		NA
Virginia	4A	AP-1	120.2	saua427p	Buckhorn Creek	Perennial		25	Dam and Pump or Flume	Aquatic Life		NA
Virginia	4A	AP-1	120.2	saua426	UNT to Buckhorn Creek	Perennial	21		Temp AR	UNT to Aquatic Life		NA
Virginia	4A	AP-1	120.2	saua424	Buckhorn Creek	Perennial			Perm AR	Aquatic Life		NA
Virginia	4A	AP-1	120.3	saua425	UNT to Buckhorn Creek	Ephemeral	1		Temp AR	UNT to Aquatic Life		NA
Virginia	4A	AP-1	120.4	saua428	UNT to Buckhorn Creek	Perennial		29	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	4A	AP-1	120.6	saua429	UNT to Stoutameyer Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	120.7	saub013	UNT to Stoutameyer Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	120.7	saub013	UNT to Stoutameyer Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	4A	AP-1	120.9	saub012	UNT to Stoutameyer Branch	Intermittent	4	5	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	121.1	nhd_va_030	Stoutameyer Branch	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	121.1	nhd_va_030	Stoutameyer Branch	Perennial		1	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	122.5	saua421	UNT to Jennings Branch	Intermittent		3	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	122.8	saua422	UNT to Jennings Branch	Intermittent		6	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	4A	AP-1	123.0	saua423	UNT to Jennings Branch	Ephemeral		3	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	4A	AP-1	123.9	saub119	UNT to Elk Run	Intermittent	8	6	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	124.0	saub118	UNT to Elk Run	Intermittent			Perm AR	Unclassified		NA
Virginia	4A	AP-1	124.1	saub004	UNT to Elk Run	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	124.2	saub117	UNT to Elk Run	Intermittent			Perm AR	Unclassified		NA
Virginia	4A	AP-1	124.2	saub117	UNT to Elk Run	Intermittent			Perm AR	Unclassified		NA
Virginia	4A	AP-1	124.4	saub003	UNT to Elk Run	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	125.1	saub002	UNT to Elk Run	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	4A	AP-1	125.8	saub001	UNT to Elk Run	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	129.2	saua413	Jennings Branch	Perennial		92	Cofferdam or Dam and Pump	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	130.4	saua070	Middle River	Perennial		68	Cofferdam or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	138.6	nhd_va_043	UNT to Folly Mills Creek	Intermittent		9	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	139.1	nhd_va_k_011	Folly Mills Creek	Perennial		10	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	139.1	nhd_va_k_012	UNT to Folly Mills Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	139.6	saup002	UNT to Folly Mills Creek	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	140.0	saup001	UNT to Folly Mills Creek	Perennial		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	142.3	saup007	UNT to Christians Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	142.5	saub007	Christian`s Creek	Perennial		28	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA
Virginia	5	AP-1	142.5	saub008	UNT to Christian`s Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	143.9	saub011	UNT to Barterbrook Branch	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	5	AP-1	144.0	saub010	Barterbrook Branch	Intermittent		2	Dam and Pump or Flume	Aquatic Life		NA
Virginia	5	AP-1	145.6	sauc117	UNT to South River	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	146.2	saua073	UNT to South River	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	146.2	saua073	UNT to South River	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	147.5	dauc100	UNT to South River	Canal/Ditch		21	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	148.6	sauc113	South River	Perennial		46	Flume or Dam and Pump	Aquatic Life	Potential for ESA-listed species	NA
Virginia	5	AP-1	150.8	sauc115	UNT to South River	Ephemeral		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	151.5	saua407	UNT to the South River	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	152.3	oaub100	UNP to Back Creek	Pond	Pond	Pond	Pond	NA		NA
Virginia	5	AP-1	152.4	saub115	UNT to Back Creek	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	152.9	saua052	Mills Creek	Perennial		33	Flume or Dam and Pump	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	152.9	saua051	UNT to Mills Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	153.1	saua050	UNT to Mills Creek	Perennial		7	Dam and Pump or Flume	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	153.4	saua067	Orebank Creek	Perennial		24	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	153.6	saua069	UNT to Back Creek	Intermittent		3	Dam and Pump or Flume	Aquatic Life		NA
Virginia	5	AP-1	153.6	saua068	UNT to Back Creek	Perennial		7	Flume or Dam and Pump	Aquatic Life		NA
Virginia	5	AP-1	153.7	nhd_va_a_014	UNT to Back Creek	Perennial		13	Flume or Dam and Pump	Aquatic Life		NA
Virginia	5	AP-1	153.7	nhd_va_l_005	Laurel Springs Branch	Perennial			Perm AR	Unclassified		NA
Virginia	5	AP-1	153.7	nhd_va_l_015	UNT to Laurel Springs Branch	Intermittent	5		Perm AR	Unclassified		NA
Virginia	5	AP-1	153.8	nhd_va_a_001	Back Creek	Perennial		32	Flume or Dam and Pump	Aquatic Life	Potential for ESA-listed species	NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	5	AP-1	154.2	saua072	UNT to Back Creek	Intermittent		5	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	154.4	saua434	UNT to Back Creek	Intermittent		8	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	154.5	saua071	UNT to Back Creek	Intermittent		4	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	154.8	saua433	UNT to Back Creek	Intermittent		10	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	154.9	saua432	UNT to Back Creek	Ephemeral		6	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.0	saua431	UNT to Back Creek	Intermittent		2	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.1	saua430	UNT to Back Creek	Ephemeral		11	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.2	saua064	UNT to Back Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.3	saua065	UNT to Back Creek	Intermittent		5	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.3	saua066	UNT to Back Creek	Intermittent		6	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.5	sauc105	UNT to Back Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.6	sauc106	UNT to Back Creek	Ephemeral		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.8	saua062	UNT to Back Creek	Perennial		10	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.9	sauc107	UNT to Back Creek	Perennial			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.9	saua060	UNT to Back Creek	Intermittent		7	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.9	saua061	UNT to Back Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	155.9	saua059	UNT to Back Creek	Intermittent		8	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	156.0	saua057	UNT to Back Creek	Intermittent		4	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	156.2	saua056	UNT to Back Creek	Perennial		5	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	5	AP-1	156.4	saua054	UNT to Back Creek	Intermittent		3	Flume or Dam and Pump	UNT to Aquatic Life		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	5	AP-1	156.6	saue004	UNT to South Fork Back Creek	Intermittent		8	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	156.6	saue003	UNT to South Fork Back Creek	Perennial		18	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	156.7	saue006	UNT to South Fork Back Creek	Intermittent		28	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	156.7	saue005	UNT to South Fork Back Creek	Ephemeral		10	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	156.9	saue002e	UNT to South Fork Back Creek	Ephemeral			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	156.9	saue002i	UNT to South Fork Back Creek	Intermittent		7	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.0	saue001	UNT to South Fork Back Creek	Perennial		6	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.0	saue001	UNT to South Fork Back Creek	Perennial			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.0	saue007	UNT to South Fork Back Creek	Intermittent			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.0	saue007	UNT to South Fork Back Creek	Intermittent			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.0	saue001	UNT to South Fork Back Creek	Perennial			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.3	nhd_va_a_056	UNT to South Fork Back Creek	Intermittent			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.3	nhd_va_353	UNT to Back Creek	Intermittent	38		Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	157.3	nhd_va_375	UNT to Back Creek	Intermittent			Perm AR	UNT to Aquatic Life		NA
Virginia	5	AP-1	157.4	nhd_va_353	UNT to Back Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	157.4	saua404	UNT to South Fork Back	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
					Creek							
Virginia	5	AP-1	157.6	saua401	UNT to South Fork Back Creek	Perennial		17	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.6	saua402i	UNT to South Fork Back Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.6	saua402e	UNT to South Fork Back Creek	Ephemeral		11	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.6	nhd_va_m_002	UNT to South Fork Back Creek	Intermittent	6		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.7	saua403	UNT to South Fork Back Creek	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	157.8	saua403	UNT to South Fork Back Creek	Intermittent		7	Flume or Dam and Pump	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.6	snea022	UNT to South Fork Rockfish River	Perennial			Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.6	snea022	UNT to South Fork Rockfish River	Perennial			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.7	snea022	UNT to South Fork Rockfish River	Perennial			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.7	nhd_va_c_040	South Fork Rockfish River	Intermittent	7		Perm AR	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.7	nhd_va_c_041	South Fork Rockfish River	Intermittent	84		Perm AR	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.8	snea020	UNT to South Fork Rockfish River	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.9	snea020	UNT to South Fork Rockfish River	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	158.9	snea021	South Fork Rockfish River	Perennial		20	Flume or Dam and Pump	Aquatic Life, I-IV		October 1 to March 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	5	AP-1	160.4	nhd_va_c_033	Spruce Creek	Perennial	16		Perm AR	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	161.1	nhd_va_c_028	Spruce Creek	Perennial	10		Perm AR	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	161.4	nhd_va_c_032	UNT to South Fork Rockfish River	Intermittent	6		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	161.8	nhd_va_c_029	UNT to South Fork Rockfish River	Intermittent	5		Perm AR	UNT to Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	161.8	nhd_va_c_037	South Fork Rockfish River	Perennial	10		Perm AR	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	162.4	nhd_va_387	Spruce Creek	Perennial		13	Flume or Dam and Pump	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	163.1	nhd_va_a_004	Spruce Creek	Perennial		11	Dam and Pump or Flume	Aquatic Life, I-IV		October 1 to March 31
Virginia	5	AP-1	163.9	nhd_va_362	UNT to Rockfish River	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	164.4	nhd_va_348	UNT to Rockfish River	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	165.4	snec052	UNT to Rockfish River	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	165.5	snec051	UNT to Rockfish River	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	165.5	snec050	UNT to Rockfish River	Perennial		7	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	165.9	nhd_va_336	UNT to Rockfish River	Perennial		16	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	166.2	snea051	UNT to Rockfish river	Perennial		5	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	166.3	snea050	UNT to Rockfish river	Perennial		9	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	166.7	nhd_va_a_038	UNT to Rockfish River	Perennial	75		Perm AR	Unclassified		NA
Virginia	5	AP-1	166.7	snea052	UNT to Rockfish river	Perennial		9	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	166.7	snea052	UNT to Rockfish river	Perennial			Perm AR	Unclassified		NA
Virginia	5	AP-1	166.9	nhd_va_c_031	UNT to Rockfish River	Perennial	11		Perm AR	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	5	AP-1	167.8	nhd_va_c_030	UNT to Rockfish River	Intermittent	11		Perm AR	Unclassified		NA
Virginia	5	AP-1	168.8	nhd_va_f_001	Davis Creek	Perennial		10	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	168.9	nhd_va_f_002	UNT to Davis Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	169.3	nhd_va_f_003	Muddy Creek	Perennial		10	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	169.7	nhd_va_f_004	UNT to Rockfish River	Intermittent		7	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	170.0	nhd_va_f_005	UNT to Rockfish River	Perennial		16	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	170.3	nhd_va_n_003	UNT to Rockfish River	Perennial		16	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	171.0	snez003	UNT to Rockfish River	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	5	AP-1	171.0	snez002	UNT to Rockfish River	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	171.3	snez001	UNT to Rockfish River	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	171.3	snez001	UNT to Rockfish River	Perennial			Perm AR	Unclassified		NA
Virginia	5	AP-1	171.3	snec054	UNT to Rockfish River	Perennial	10		Perm AR	Unclassified		NA
Virginia	5	AP-1	171.3	snec054	UNT to Rockfish River	Perennial			Perm AR	Unclassified		NA
Virginia	5	AP-1	171.6	snea400	UNT to Rockfish River	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	171.7	snea402	UNT to Rockfish River	Intermittent			Perm AR	Unclassified		NA
Virginia	5	AP-1	172.8	sney001	UNT to Dutch Creek	Perennial		4	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	172.9	sney002	UNT to Dutch Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	5	AP-1	173.2	nhd_va_a_002	UNT to Dutch Creek	Intermittent		11	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	175.1	snec057	UNT to Dutch Creek	Perennial		21	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	175.6	snec056	Dutch Creek	Perennial	17	18	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	5	AP-1	175.9	snee201	UNT to Dutch Creek	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	176.2	snee200	Dutch Creek	Perennial		21	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	177.4	nhd_va_c_036	UNT to Beaver Creek	Intermittent	5		Perm AR	Unclassified		NA
Virginia	5	AP-1	179.0	nhd_va_335	UNT to Buffal	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	180.2	snea001	UNT to Buffalo Creek	Perennial		22	Flume or Dam and Pump	Unclassified		NA
Virginia	5	AP-1	180.5	snec002	UNT to Buffalo Creek	Intermittent		8	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	180.6	snec002	UNT to Buffalo Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	5	AP-1	180.9	snec003	UNT to Buffalo Creek	Intermittent		1	Dam and Pump or Flume	Unclassified		NA
Virginia	5	AP-1	181.5	snec004	UNT to Mayo Creek	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	181.9	snec005	Mayo Creek	Perennial		10	Dam and Pump or Flume	Aquatic Life		NA
Virginia	5	AP-1	182.6	snec006	UNT to Mayo Creek	Intermittent		10	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	182.9	snep002	UNT to Mayo Creek	Perennial			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	5	AP-1	182.9	snep001	UNT to Mayo Creek	Perennial		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	5	AP-1	182.9	snep003	UNT to Mayo Creek	Perennial			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	6	AP-1	183.3	snep005	UNT to Mayo Creek	Perennial		6	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	183.4	snep006	UNT to Mayo Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	183.7	snec058	UNT to Mayo Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	184.5	snep008	Mayo Creek	Perennial		35	HDD	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30/April 15 to June 15 and August 15 to September 30/May 15 to July 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	6	AP-1	184.7	sbup015	James River	Perennial		396	HDD	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30/April 15 to June 15 and August 15 to September 30/May 15 to July 31
Virginia	6	AP-1	184.9	sbua008	UNT to James River	Perennial	21		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30/April 15 to June 15 and August 15 to September 30/May 15 to July 31
Virginia	6	AP-1	184.9	sbuc111	UNT to James River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30/ May 15 to July 31
Virginia	6	AP-1	185.0	sbuc110	UNT to James River	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30
Virginia	6	AP-1	185.4	sbua007	UNT to James River	Intermittent			Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		March 15 to June 30
Virginia	6	AP-1	185.4	sbua006	UNT to James River	Perennial	14		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30/April 15 to June 15 and August 15 to September 30/May 15 to July 31
Virginia	6	AP-1	185.4	sbup017	UNT to James River	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	March 15 to June 30
Virginia	6	AP-1	186.6	sbuz005	UNT to Sycamore Creek	Ephemeral		1	Flume or Dam and Pump	Unclassified		NA
Virginia	6	AP-1	186.8	sbuz006	UNT to Sycamore Creek	Perennial		1	Flume or Dam and Pump	Unclassified		NA
Virginia	6	AP-1	186.8	sbuz006	UNT to Sycamore Creek	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	186.8	sbuz004	UNT to Sycamore Creek	Perennial		7	Flume or Dam and Pump	Unclassified		NA
Virginia	6	AP-1	187.3	sbuz003	UNT to Sycamore	Perennial			Perm AR	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
					Creek							
Virginia	6	AP-1	187.3	sbuz003	UNT to Sycamore Creek	Perennial			Perm AR	Unclassified		NA
Virginia	6	AP-1	187.6	sbup005	Sycamore Creek	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	187.9	sbup004	UNT to Sycamore Creek	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	189.1	sbuc008	Walton Fork	Intermittent			Perm AR	Unclassified		NA
Virginia	6	AP-1	189.1	sbuc008	Walton Fork	Intermittent			Perm AR	Unclassified		NA
Virginia	6	AP-1	190.0	sbuc108	UNT to Walton Fork	Intermittent			Perm AR	Unclassified		NA
Virginia	6	AP-1	190.0	sbuc108	UNT to Walton Fork	Intermittent			Perm AR	Unclassified		NA
Virginia	6	AP-1	190.0	sbuc107	UNT to Walton Fork	Intermittent			Perm AR	Unclassified		NA
Virginia	6	AP-1	190.1	sbuc109	Walton Fork	Perennial		11	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	191.0	sbua002	UNT to Ripley Creek	Perennial		17	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	191.5	sbuc050	UNT to Ripley Creek	Intermittent			Compressor Station - Temporary Impact	Unclassified		NA
Virginia	6	AP-1	191.5	sbuc050	UNT to Ripley Creek	Intermittent		4	Compressor Station - Temporary Impact	Unclassified		NA
Virginia	6	AP-1	191.9	sbuz002	UNT to Ripley Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	193.1	sbuc004	UNT to Matthews Creek	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	194.1	sbuc005	North River	Perennial		34	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	194.9	sbuc007	UNT to North River	Intermittent		18	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	195.1	sbuk005	UNT to North River	Perennial		7	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	195.2	sbuc105	North River	Perennial			Perm AR	Unclassified		NA
Virginia	6	AP-1	195.3	sbuc105	North River	Perennial			Perm AR	Unclassified		NA
Virginia	6	AP-1	195.5	sbue002	UNT to North River	Ephemeral			Contractor Yard - Temporary Impact	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	6	AP-1	195.5	sbuk004	UNT to North River	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	195.6	sbue003	UNT to North River	Intermittent	6		Perm AR	C		NA
Virginia	6	AP-1	196.1	sbuk003	UNT to North River	Intermittent		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	196.3	sbuk001	UNT to North River	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	196.9	sbuk006	UNT to Slate River	Ephemeral		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	197.1	sbua004	UNT to Slate River	Perennial	4		Perm AR	Unclassified		NA
Virginia	6	AP-1	197.4	sbuk009	UNT to Slate River	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	197.4	sbuk010	UNT to Slate River	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	197.9	sbuk012	Slate River	Perennial		36	Dam and Pump or Flume	Unclassified	Potential for ESA-listed species	NA
Virginia	6	AP-1	198.1	sbuk013	UNT to Slate River	Ephemeral		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	198.1	sbuk014	UNT to Slate River	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	198.1	sbuk015	UNT to Slate River	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	198.3	sbua200	UNT to Licky Branch	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	198.5	sbua202	UNT to Licky Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	198.5	sbua201	Licky Branch	Perennial		19	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	199.4	sbul012	UNT to Licky Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	200.3	sbul013	UNT to Pitman Creek	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	201.2	sbup002	Horsepen Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	201.3	sbup001i	UNT to Horsepen Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	201.8	sbul014	UNT to Horsepen	Intermittent		4	Dam and Pump or Flume	Unclassified		NA

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					Creek							
Virginia	6	AP-1	201.8	sbul015	UNT to Horsepen Creek	Perennial		8	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	202.7	sbul004	UNT to Willis River	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	203.6	sbul003	UNT to Willis River	Perennial		12	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	204.2	sbue001	UNT to Willis River	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	204.5	sbul005	UNT to Willis River	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	204.5	sbul006	UNT to Willis River	Ephemeral		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	204.7	sbul007	UNT to Willis River	Perennial		13	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	204.8	sbul008	UNT to Willis River	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	205.1	sbul009	Willis River	Perennial		24	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	205.1	sbuc009	Willis River	Perennial	28		Temp AR	Unclassified		NA
Virginia	6	AP-1	205.2	sbul010	UNT to Willis River	Intermittent	3	7	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	205.6	sbuk041	UNT to Little Willis River	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	205.7	sbuk042	UNT to Little Willis River	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	205.7	sbuk043	UNT to Little Willis River	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	205.7	sbuk044	UNT to Little Willis River	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	205.9	sbuk045	UNT to Little Willis River	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	205.9	sbuk046	UNT to Little Willis River	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	206.1	sbup016	UNT to Willis River	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	206.5	sbul022	UNT to Willis River	Intermittent			Not Crossed by Centerline	Unclassified		NA

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Virginia	6	AP-1	206.9	sbul021	UNT to Willis River	Perennial		8	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	207.1	sbuk024	UNT to Bishop Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	207.2	sbuk026	UNT to Bishop Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	207.3	sbuk027	UNT to Bishop Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	207.3	sbuk028	UNT to Bishop Creek	Intermittent		10	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	207.4	sbuk029	UNT to Bishop Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	207.8	sbuk030	Bishop Creek	Perennial		8	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	208.2	sbuk031	UNT to Little Willis River	Perennial		34	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	208.6	sbuk035	UNT to Little Willis River	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	208.9	sbuk020	UNT to Little Willis River	Ephemeral		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	209.1	sbuk022a	UNT to Little Willis River	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	209.1	sbuc101	UNT to Little Willis River	Ephemeral		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	209.1	sbuc101	UNT to Little Willis River	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	209.2	sbua005	UNT to Little Willis River	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	209.5	sbuk037	Little Willis River	Perennial		15	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	210.0	dbuc100	UNT to Gills Creek	Canal/Ditch		16	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	210.0	dbuc101	UNT to Gills Creek	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	210.2	sbuc106	Gills Creek	Perennial		11	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	211.0	sbuk018	UNT to Little Willis River	Ephemeral		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	211.0	sbua003	UNT to Perkins Creek	Ephemeral			Perm AR	Unclassified		NA

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Virginia	6	AP-1	211.0	sbua003	UNT to Perkins Creek	Ephemeral			Perm AR	Unclassified		NA
Virginia	6	AP-1	211.4	sbuk017	Perkins Creek	Perennial		25	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	211.7	sbuk016	UNT to Perkins Creek	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	212.0	scuk029	UNT to Perkins Creek	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	212.2	scuk027	UNT to Perkins Creek	Intermittent		9	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	212.4	scuk026	UNT to Perkins Creek	Intermittent		14	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	212.9	scuk001	UNT to Little Willis River	Ephemeral		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	213.0	scuk002	UNT to Little Willis River	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	213.7	scuk004	UNT to Dry Creek	Ephemeral		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	213.9	scuk005	UNT to Dry Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	214.0	scuk007	UNT to Dry Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	214.0	scuk008	UNT to Dry Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	214.0	scuk009	UNT to Dry Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	214.0	scuk006	UNT to Dry Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	214.2	scuk010	UNT to Dry Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	214.3	scuc001	UNT to Dry Creek	Intermittent		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	214.5	scuc002	UNT to Dry Creek	Ephemeral		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	214.6	scuc003	UNT to Dry Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	214.8	scua400	Dry Creek	Perennial		15	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	215.0	scuk030	UNT to Dry Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA

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Virginia	6	AP-1	215.1	scuk032b	UNT to Dry Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	215.1	scuk032a	UNT to Dry Creek	Ephemeral		4	Flume or Dam and Pump	Unclassified		NA
Virginia	6	AP-1	215.2	scuk033	Dry Creek	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	215.2	scuk035	UNT to Dry Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	215.4	scuk037	UNT to Dry Creek	Ephemeral		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	215.9	scuk039b	UNT to Green Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	215.9	scuk039a	UNT to Green Creek	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	215.9	scuk041	UNT to Green Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	216.2	scuk042	UNT to Green Creek	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	216.8	scua006	UNT to Green Creek	Perennial		7	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	217.0	scuc004	UNT to Green Creek	Intermittent		7	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	217.4	scua001	UNT to Green Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	217.5	ocuc001	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	6	AP-1	217.6	scua003	UNT to Green Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	217.6	scua004	UNT to Green Creek	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	217.6	scua005	UNT to Green Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	218.1	scuk025	UNT to Green Creek	Ephemeral		1	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	218.1	scuk024	UNT to Green Creek	Perennial		18	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	218.2	scuk023	UNT to Green Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	218.4	scuk022	UNT to Green Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	218.6	scuk021	UNT to Green Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA

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Virginia	6	AP-1	218.7	scuk020	UNT to Green Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	218.8	scua011	Green Creek	Perennial	14		Temp AR	Unclassified		NA
Virginia	6	AP-1	219.2	scuk015	UNT to Green Creek	Perennial		39	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	219.4	scuk016	UNT to Green Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	219.4	scuk017	Green Creek	Perennial		43	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	219.5	scuk018	UNT to Green Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	219.6	scuk019	UNT to Green Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	219.8	scuk014	UNT to Green Creek	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	219.8	scuk013	UNT to Green Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	220.8	scuk011	Appomattox River	Perennial		106	Cofferdam	Aquatic Life	Potential for ESA-listed species	May 15 to July 31
Virginia	6	AP-1	221.6	spek004	UNT to Appomattox River	Perennial		9	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	6	AP-1	221.7	spek005	UNT to Appomattox River	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	221.8	spek006	UNT to Appomattox River	Perennial		14	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	6	AP-1	222.0	spek007	UNT to Appomattox River	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	222.1	spek008	UNT to Appomattox River	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	222.2	spek009	UNT to Appomattox River	Perennial		4	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31
Virginia	6	AP-1	222.4	spek010	UNT to Appomattox River	Perennial		14	Dam and Pump or Flume	UNT to Aquatic Life		May 15 to July 31

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	6	AP-1	222.5	spek011	UNT to Appomattox River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	222.6	spek012	UNT to Appomattox River	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	223.2	spea401	Little Saylers Creek	Perennial		29	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	223.4	spea006	UNT to Little Saylers Creek	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	223.8	spea002	UNT to Little Saylers Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	223.9	spea003	UNT to Little Saylers Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	223.9	spea004	UNT to Little Saylers Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	224.1	spea005	UNT to Little Saylers Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	225.2	spec001	UNT to Little Saylers Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	225.5	spea007	UNT to Little Saylers Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	226.6	snok001	Saylers Creek	Perennial		12	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	227.2	snok002	UNT to Ellis Creek	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	227.6	snok003	UNT to Ellis Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	227.8	snom011	UNT to Ellis Creek	Ephemeral		4	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	228.2	snok005	Ellis Creek	Perennial		5	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA
Virginia	6	AP-1	228.6	snok004	UNT to Ellis Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	6	AP-1	228.8	snok006	UNT to Flat Creek	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	229.0	snok007	UNT to Flat Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	229.2	snok008	Flat Creek	Perennial		38	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA

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Virginia	6	AP-1	229.9	snok009	UNT to Flat Creek	Ephemeral			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	6	AP-1	230.7	snom007	UNT to Little Creek	Perennial			Not Crossed by Centerline	UNT to Aquatic Life		NA
Virginia	6	AP-1	230.7	snom006	Little Creek	Perennial		10	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA
Virginia	6	AP-1	230.9	snom005	UNT to Little Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	231.0	snoc100	UNT to Little Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	6	AP-1	231.8	snol002	UNT to West Creek	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	231.8	snol001	UNT to West Creek	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	231.9	snol003	UNT to West Creek	Intermittent		7	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	232.0	snol005	UNT to West Creek	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	232.0	snol004	West Creek	Perennial		7	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	232.2	snol006	UNT to West Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	232.4	snol007	UNT to West Creek	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	232.4	snol008	UNT to West Creek	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	232.7	snok020	West Creek	Perennial		11	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	232.8	snok022	UNT to West Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	233.0	snok024	UNT to West Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	233.0	snok023	UNT to West Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	233.1	snok025	UNT to West Creek	Ephemeral		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	233.1	snok026a	UNT to West Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	6	AP-1	233.4	snok027	UNT to Little West Creek	Perennial		8	Dam and Pump or Flume	Unclassified		NA

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Virginia	6	AP-1	234.2	snok028	Little West Creek	Perennial		21	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	234.3	snok029b	UNT to Little West Creek	Intermittent		14	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	235.1	snom008	UNT to Deep Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	235.2	snom009	UNT to Deep Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	235.5	snom010	UNT to Deep Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	235.7	snok103	UNT to Deep Creek	Ephemeral		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	235.7	snok102	UNT to Deep Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	236.0	snok100	Deep Creek	Perennial		26	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	236.1	snok101	UNT to Deep Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	236.2	snoc001	UNT to Deep Creek	Perennial		12	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	236.5	snol021	UNT to Deep Creek	Intermittent		21	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	236.9	snol020	UNT to Deep Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	236.9	snoc050	UNT to Deep Creek	Intermittent			Perm AR	Unclassified		NA
Virginia	6	AP-1	237.0	snol019	UNT to Deep Creek	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	237.4	snop001	UNT to Deep Creek	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	238.2	snok010	UNT to Winningham Creek	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	238.6	snok011	Winningham Creek	Perennial		35	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	238.8	snok012	UNT to Winningham Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	6	AP-1	239.1	snok014	UNT to Winningham Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	239.9	snok016	UNT to Woody Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	239.9	snok018	UNT to Woody Creek	Ephemeral		2	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	240.0	onok001	UNP to Woody Creek	Pond		Pond	Pond	Unclassified		NA
Virginia	7	AP-1	240.6	snok019	Woody Creek	Perennial		11	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	241.5	snoc103	UNT to Watson Creek	Ephemeral		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	241.6	snoc101	Watson Creek	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	242.6	snoc004	UNT to Cellar Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	242.9	snoc003	Cellar Creek	Perennial		14	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	242.9	snoc002	UNT to Cellar Creek	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	244.1	snos005	Lees Creek	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	244.1	snos006	UNT to Lees Creek	Perennial		2	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	244.4	snoo005	UNT to Lees Creek	Perennial		4	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	244.5	snoo004	UNT to Lees Creek	Perennial		3	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	244.7	snoo003	UNT to Lees Creek	Perennial		3	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	244.9	snol011	UNT to Less Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	245.1	snol012	UNT to Less Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	245.4	snol013	UNT to Bland Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	245.4	snol014	UNT to Bland Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	245.5	snol015	UNT to Bland Creek	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	245.6	snol016	UNT to Bland Creek	Perennial		16	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	245.6	snol017	UNT to Bland Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	246.0	snol018	UNT to Bland Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	247.0	snoc102	UNT to Lake Lee	Intermittent		5	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	7	AP-1	247.2	snok031	UNT to Bland Creek	Ephemeral		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	247.8	snom001	UNT to Butterwood Creek	Ephemeral		3	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	248.2	snom002	UNT to Twin Lakes	Intermittent		8	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	248.4	snom003	UNT to Twin Lakes	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	248.6	snom004	UNT to Twin Lakes	Ephemeral		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	249.1	sdim002	UNT to Butterwood Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	249.1	sdim001	Butterwood Creek	Perennial		4	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	March 15 to June 30
Virginia	7	AP-1	249.6	sdim003	UNT to Butterwood Creek	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	249.7	sdim004	UNT to Butterwood Creek	Intermittent		1	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	249.9	sdim005	UNT to Butterwood Creek	Intermittent		8	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	250.2	sdim008	UNT to Butterwood Creek	Ephemeral		5	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	250.5	sdim011	UNT to Butterwood Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	250.7	sdim014	UNT to Butterwood Creek	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	251.2	sdim013	UNT to Butterwood Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	251.5	sdim012	UNT to Butterwood Creek	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	251.7	sdim016	UNT to Butterwood Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	251.8	sdim017	UNT to Butterwood Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	252.0	sdim018	UNT to Butterwood Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	252.1	sdim019	UNT to Butterwood Creek	Ephemeral		4	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	252.6	sdim020	UNT to Butterwood Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	252.7	sdim021	UNT to Butterwood Creek	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	253.7	wdic013f	Butterwood Creek	Wetland-Waterbody Complex			Open Cut	Aquatic Life		March 15 to June 30
Virginia	7	AP-1	253.9	ddic001	UNT to Butterwood Creek	Canal/Ditch		10	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	254.0	sdic015	UNT to Butterwood Creek	Intermittent		24	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	254.3	sdic013	UNT to Butterwood Creek	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	254.4	odic001	Unnamed Pond	Pond		Pond	Pond	UNT to Aquatic Life		NA
Virginia	7	AP-1	254.5	sdic012	UNT to Butterwood Creek	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life		March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	254.9	sdib003	UNT to Butterwood Creek	Intermittent		3	Flume or Dam and Pump	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	255.0	sdib002	UNT to Butterwood Creek	Intermittent		2	Flume or Dam and Pump	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	255.9	sdib001	UNT to Beaver Pond Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	7	AP-1	256.2	sdil001	Beaver Pond Creek	Perennial		8	Dam and Pump or Flume	Aquatic Life		March 15 to June 30
Virginia	7	AP-1	256.5	sdil001	Beaver Pond Creek	Perennial		10	Dam and Pump or Flume	Aquatic Life		March 15 to June 30
Virginia	7	AP-1	256.6	sdil001	Beaver Pond Creek	Perennial			Perm AR	Aquatic Life		March 15 to June 30
Virginia	7	AP-1	256.6	sdil001	Beaver Pond Creek	Perennial	7		Perm AR	Aquatic Life		March 15 to June 30
Virginia	7	AP-1	256.7	sdio017	UNT to Beaver Pond Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	256.8	sdio019	UNT to Beaver Pond Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	7	AP-1	259.3	sdic001	Beaver Pond Creek	Perennial		7	Open Cut	Aquatic Life	Potential for ESA-listed species	March 15 to June 30
Virginia	7	AP-1	259.9	sdio013	Ditch	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	260.3	sdic008	UNT to Tommeheton Creek	Intermittent		18	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	260.7	sdic007	Nottoway River	Perennial		96	Cofferdam	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	7	AP-1	260.8	sbra201	UNT to Nottoway River	Ephemeral		7	Flume or Dam and Pump	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	261.3	sbrc001	UNT to Nottoway River	Ephemeral		1	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	7	AP-1	261.5	sbra202	UNT to Nottoway River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	7	AP-1	261.8	sbra212	Miry Run	Perennial		7	Dam and Pump or Flume	Aquatic Life	Potential for ESA-listed species	NA
Virginia	7	AP-1	262.5	sbra203	Hickory Run	Perennial		8	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	262.6	sbra204	UNT to Hickory Run	Intermittent		4	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	262.9	sbra205	UNT to Hickory Run	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	263.8	sbra206	UNT to Hickory Run	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	264.6	sbra207	UNT to Great Branch	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	264.7	sbra208	UNT to Great Branch	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	264.7	nhd_va_c_035	UNT to Great Branch	Perennial	13		Perm AR	Unclassified		NA
Virginia	7	AP-1	264.7	sbra208	UNT to Great Branch	Perennial			Perm AR	Unclassified		NA
Virginia	7	AP-1	265.1	sbro004	UNT to Great Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	265.1	sbro003	UNT to Great Branch	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	265.1	sbro005	UNT to Great Branch	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	265.4	sbro006	UNT to Great Branch	Intermittent		1	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	265.6	sbro007	UNT to Great Branch	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	265.6	sbro008	UNT to Great Branch	Perennial		1	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	265.8	sbro009	UNT to Great Branch	Perennial		4	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	266.1	sbrr012	UNT to Waqua Creek	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	266.3	sbrr011	UNT to Waqua Creek	Perennial		4	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	266.8	sbrr010	UNT to Waqua Creek	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	266.9	sbrr013	UNT to Waqua Creek	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	267.4	sbrr014	Waqua Creek	Perennial		38	Flume or Cofferdam	Aquatic Life	Potential for ESA-listed species	March 15 to June 30
Virginia	7	AP-1	267.5	sbro010	UNT to Waqua Creek	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life		March 15 to June 30
Virginia	7	AP-1	267.9	sbro011	Big Branch	Perennial		16	Flume or Dam and Pump	Aquatic Life	Potential for ESA-listed species	NA
Virginia	7	AP-1	268.9	nhd_va_437	UNT to Waqua Creek	Perennial		11	Dam and Pump or Flume	UNT to Aquatic Life		NA
Virginia	7	AP-1	270.0	sbrr001	UNT to Beaver Branch	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	270.5	sbrr003	Beaver Branch	Perennial		7	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	270.8	sbrr004	UNT to Beaver Branch	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	271.6	sbrr005i	UNT to Sturgeon Creek	Intermittent		3	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	7	AP-1	271.9	sbrr006i	UNT to Sturgeon Creek	Intermittent		2	Flume or Dam and Pump	UNT to Aquatic Life		NA
Virginia	7	AP-1	271.9	sbrr008	UNT to Sturgeon Creek	Perennial		2	Flume or Dam and Pump	UNT to Aquatic Life		May 15 to July 31/ April 15 to June 15 and August 15 to September 30/ March 15 to June 30
Virginia	7	AP-1	272.0	sbrr007	Sturgeon Creek	Perennial		42	Flume or Dam and Pump	Aquatic Life	Potential for ESA-listed species	May 15 to July 31/ April 15 to June 15 and August 15 to September 30/ March 15 to June 30
Virginia	7	AP-1	272.6	sbrr009	UNT to Spring Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	272.9	sbro001	UNT to Spring Branch	Intermittent		5	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	272.9	sbro002	UNT to Spring Branch	Intermittent			Not Crossed by Centerline	Unclassified		NA

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Virginia	7	AP-1	273.0	nhd_va_456	Spring Branch	Perennial		10	Dam and Pump or Flume	Unclassified	Potential for ESA-listed species	NA
Virginia	7	AP-1	274.3	sbrc100	Spring Branch	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	274.8	sbrs002	UNT to Flatrock Branch	Ephemeral			Contractor Yard - Temporary Impact	Unclassified		NA
Virginia	7	AP-1	274.9	nhd_va_509	Reedy Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	275.0	nhd_va_439	UNT to Reedy Creek	Intermittent		6	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	275.0	nhd_va_d_009	UNT to Reedy Creek	Pond		Pond	Pond	Unclassified		NA
Virginia	7	AP-1	276.1	sbrp001	UNT t o Brunswick County Pond	Perennial		4	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	276.2	sbrp002	UNT t o Brunswick County Pond	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	276.3	sbro019	UNT to Reedy Creek	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	276.7	sbro020	UNT to Reedy Creek	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	276.7	sbro021	UNT to Reedy Creek	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	276.8	sbro022	UNT t o Brunswick County Pond	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	277.0	sbro023	UNT t o Brunswick County Pond	Perennial		2	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	277.4	sbro024	UNT to Reedy Creek	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	277.6	sbrc102	UNT to Brunswick County Pond	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	277.6	sbrc101	UNT to Brunswick County Pond	Perennial		11	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	277.9	nhd_va_500	UNT to Reedy Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	278.3	nhd_va_441	UNT to Reedy Creek	Intermittent		7	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	278.6	sbro017	UNT to Reedy Creek	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	278.9	sbro016	UNT to Reedy Creek	Perennial		5	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	278.9	sbro015	UNT to Reedy Creek	Perennial		10	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	279.3	sbro014	UNT to Reedy Creek	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	279.3	sbro013	UNT to Reedy Creek	Perennial		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	279.7	sbro018	UNT to Reedy Creek	Perennial		8	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	280.1	sbra221	UNT to Reedy Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	280.2	sbra220	UNT to Reedy Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	280.4	sbra219	UNT to Reedy Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	280.5	sbra218	UNT to Reedy Creek	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	281.5	nhd_va_178	UNT to Reedy Creek	Intermittent	5		Perm AR	Unclassified		NA
Virginia	7	AP-1	282.5	nhd_va_179	Greensville Creek	Intermittent	5		Perm AR	Unclassified		NA
Virginia	7	AP-1	282.7	nhd_va_180	UNT to Greensville Creek	Intermittent	5		Perm AR	Unclassified		NA
Virginia	7	AP-1	282.9	sbra001	UNT to Greensville Creek	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	283.0	SVA-AWN-001	Greensville Creek	Perennial		13	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	283.2	SVA-DDF-012	UNT to Greensville Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	283.3	SVA-DDF-013	UNT to Greensville Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	283.4	dgra002	UNT to Greensville Creek	Canal/Ditch		11	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	284.2	sgra015	UNT to Greensville Creek	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	285.0	sgrc103	UNT to Greensville Creek	Intermittent		19	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	285.7	sgra011	UNT to Meadows Branch	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	285.9	sgra012	UNT to Meherrin River	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	286.2	sgra013	UNT to Meherrin River	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	286.2	sgra014	UNT to Meherrin River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	286.3	sgra007	Meherrin River	Perennial		183	Cofferdam	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30
Virginia	7	AP-1	286.6	sgrc001	UNT to Meherrin River	Intermittent			Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	286.8	sgra008	UNT to Meherrin River	Intermittent		11	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	287.0	sgro003	UNT to Meherrin River	Perennial		4	Flume or Dam and Pump	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30
Virginia	7	AP-1	288.5	sgra001	UNT to Falling Run	Ephemeral		12	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	288.5	sgra002	Falling Run	Intermittent		8	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	288.8	sgra003	UNT to Falling Run	Intermittent		5	Dam and Pump or Flume	Unclassified		NA
Virginia	7	AP-1	290.0	sgra004	UNT to Fountains Creek	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	290.4	sgra005	UNT to Fountains Creek	Ephemeral		2	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	290.4	dgrc001	UNT to Fountains Creek	Canal/Ditch		1	Flume or Dam and Pump	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	293.4	dgrc100	UNT to Mill Swamp	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	7	AP-1	293.5	dgrc100	UNT to Mill Swamp	Canal/Ditch		6	Flume or Dam and Pump	Unclassified		NA
Virginia	7	AP-1	295.7	sgrp002	UNT to Camey Swamp	Intermittent		6	Open Cut	Unclassified		NA
Virginia	7	AP-1	296.9	sgrb001	UNT to Fountains Creek	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	297.4	sgrb001	UNT to Fountains Creek	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	297.6	nhd_va_390	UNT to Fontaine Creek	Intermittent	5		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	298.6	nhd_va_a_064	Unnamed Pond	Pond	Pond	Pond	Pond	NA		NA
Virginia	7	AP-1	299.4	sgrp004	Fontaine Creek	Perennial		19	Open Cut	Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	7	AP-1	299.4	sgrp005	Fontaine Creek	Perennial		12	Open Cut	Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	7	AP-1	299.6	sgro001	Fontaine Creek	Intermittent		30	Dam and Pump or Flume	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30
Virginia	7	AP-1	299.6	sgro002	Fontaine Creek	Perennial		29	Open Cut	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30
Virginia	11	AP-3	12.4	sgrp001	Meherrin River	Perennial		147	Cofferdam	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30
Virginia	11	AP-3	13.3	dsoc053	UNT to Meherrin River	Canal/Ditch		15	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	13.5	ssop002	UNT to Meherrin River	Perennial		6	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30
Virginia	11	AP-3	13.6	ssop001	UNT to Meherrin River	Perennial			Not Crossed by Centerline	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30
Virginia	11	AP-3	14.4	ssop003	UNT to Meherrin River	Perennial		10	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30
Virginia	11	AP-3	15.9	nhd_va_479	UNT to Buckhorn Swamp	Perennial		12	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	16.5	ssoo017	Buckhorn Swamp	Perennial		7	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	17.8	wsop018e/wsop 018f	Tarrara Creek	Wetland-Waterbody Complex			Open Cut	Unclassified		NA
Virginia	11	AP-3	18.6	ssoa072	UNT to Tarrara Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	18.9	ssoa071	UNT to Tarrara Creek	Ephemeral			Not Crossed by Centerline	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	19.0	ssoa070	UNT to Tarrara Creek	Perennial		5	Open Cut	Unclassified		NA
Virginia	11	AP-3	19.2	ssoo005	UNT to Tarrara Creek	Perennial		3	Open Cut	Unclassified		NA
Virginia	11	AP-3	20.0	ssop008	UNT to Tarrara Creek	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	20.1	ssop009	UNT to Tarrara Creek	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	20.7	ssop007	UNT to Tarrara Creek	Intermittent		2	Open Cut	Unclassified		NA
Virginia	11	AP-3	21.0	ssop006	UNT to Tarrara Creek	Perennial		6	Open Cut	Unclassified		NA
Virginia	11	AP-3	21.3	ssoa074	UNT to Meherrin River	Intermittent		9	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	21.7	ssoa073	UNT to Meherrin River	Intermittent		6	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	22.1	dsoa070	UNT to Tarrara Creek	Canal/Ditch		2	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	22.6	dsoo001	UNT to Tarrara Creek	Canal/Ditch		7	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	22.6	dsoo001	UNT to Tarrara Creek	Canal/Ditch			Perm AR	Unclassified		NA
Virginia	11	AP-3	22.8	dsoa006	UNT to Darden Run	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	23.7	ssoa001	UNT to Darden Pond	Perennial		6	Open Cut	Unclassified		NA
Virginia	11	AP-3	23.9	dsoo006	Ditch	Canal/Ditch		5	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	24.2	nhd_va_d_005	UNT to Darden Pond	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	24.3	ssoo008	UNT to Darden Pond	Perennial		3	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	24.5	ssoo011	UNT to Darden Pond	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	24.8	dsoo008	Ditch	Canal/Ditch		4	Dam and Pump or Flume	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	26.0	ssoo010	UNT to Mill Swamp	Intermittent		1	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	26.1	ssoo009	UNT to Mill Swamp	Intermittent		6	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	27.0	dsoo005	Ditch	Canal/Ditch		2	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	27.4	ssol006	UNT to Nottoway River	Ephemeral		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	28.8	ssol008	UNT to Nottoway River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	28.8	ssoo001	UNT to Nottoway River	Intermittent	4		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	30.7	wsoa017f	UNT to Nottoway River	Wetland-Waterbody Complex			Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	11	AP-3	31.3	ssoa006	UNT to Nottoway River	Intermittent		2	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	31.6	nhd_va_201	UNT to Nottoway River	Perennial	10		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	31.8	wsoa020f	UNT to Nottoway River	Wetland-Waterbody Complex			Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	11	AP-3	31.8	wsoa020f	UNT to Nottoway River	Wetland-Waterbody Complex			Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	11	AP-3	32.6	ssol015	Nottoway River	Perennial		240	HDD	Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	11	AP-3	33.0	ssol009	UNT to Nottoway River	Intermittent	5		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	33.1	ssol009	UNT to Nottoway River	Intermittent		5	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	33.1	dsoc051	UNT to Nottoway River	Canal/Ditch			Not Crossed by Centerline	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	33.1	ssol010	UNT to Nottoway River	Intermittent	5		Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	33.1	ssol010	UNT to Nottoway River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	33.3	ssol011	UNT to Nottoway River	Intermittent		10	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	33.9	ssoc006	UNT to Nottoway River	Perennial		27	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	11	AP-3	33.9	dsoc001	UNT to Nottoway River	Canal/Ditch		6	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	33.9	ssoc008	UNT to Nottoway River	Intermittent		12	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	34.3	dsoc002	UNT to Nottoway River	Canal/Ditch		10	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	34.4	ssoc009	UNT to Nottoway River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	34.5	dfrp001	Ditch	Canal/Ditch			Contractor Yard - Temporary Impact	Unclassified		NA
Virginia	11	AP-3	34.6	ssoo012	UNT to Nottoway River	Perennial		22	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	34.6	ssoo013	UNT to Nottoway River	Perennial		14	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery	Potential for ESA-listed species	February 15 to June 30/May 15 to July 31/April 15 to June 15 and August 15 to September 30/March 15 to May 31 and August 15 to October 15/March 15 to June 30
Virginia	11	AP-3	34.8	dsoo010	Ditch	Canal/Ditch		2	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	34.9	dsoo009	Ditch	Canal/Ditch		3	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	35.7	ssol012	UNT to Nottoway River	Intermittent		5	Open Cut	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30/March 15 to June 30
Virginia	11	AP-3	35.9	dsoa001	UNT to Blackwater River	Canal/Ditch		2	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	35.9	dsoa002	UNT to Blackwater River	Canal/Ditch		2	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	36.3	ssol013	UNT to Blackwater River	Perennial		18	Flume or Dam and Pump	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	36.6	dsoc050	UNT to Blackwater River	Canal/Ditch		14	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	36.6	ssol014	UNT to Blackwater River	Intermittent		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	38.6	ssoa010	Blackwater River	Perennial		208	HDD	Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	39.4	ssua004	UNT to Blackwater River	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	39.5	dsua001	UNT to Blackwater River	Canal/Ditch		4	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	39.7	ssua005	UNT to Blackwater River	Intermittent		3	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	40.1	ssua007	UNT to Blackwater River	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	40.2	ssua008	UNT to Blackwater River	Perennial		7	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	40.5	dsuc053	UNT to Blackwater River	Canal/Ditch		5	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	41.4	ssuo111	UNT to Blackwater River	Perennial		5	Flume or Dam and Pump	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	41.6	ssua071	UNT to Blackwater River	Ephemeral		3	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	42.3	ssuo007	UNT to Blackwater River	Perennial		8	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	42.3	ssuo006	UNT to Blackwater River	Perennial		5	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	42.7	ssuo016	UNT to Blackwater River	Intermittent		7	Dam and Pump or Flume	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	42.7	ssuo017	UNT to Blackwater River	Intermittent			Not Crossed by Centerline	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	44.5	ssup015	UNT to Kingsale Swamp	Perennial		5	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	44.6	ssuo010	UNT to Kindpole Swamp	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	44.6	ssuo010	UNT to Kindpole Swamp	Perennial		7	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	44.6	dsup008	Unnamed Ditch	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	44.6	dsup007	Unnamed Ditch	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	45.1	ssuo099	UNT to Kingsale Swamp	Perennial		11	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	45.4	dsuo004	Ditch	Canal/Ditch		11	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	45.5	dsuo003	Ditch	Canal/Ditch		10	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	45.7	dsua071	UNT to Kingsale Swamp	Canal/Ditch		8	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	45.8	dsua072	UNT to Kingsale Swamp	Canal/Ditch		6	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	46.1	ssur007	UNT to Kingsale Swamp	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	46.2	dsua070	UNT to Kingsale Swamp	Canal/Ditch		5	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	48.0	dsuc050	UNT to Jones Swamp	Canal/Ditch		8	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	48.5	dsuc051	UNT to Jones Swamp	Canal/Ditch		5	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	48.7	dsuc052	UNT to Jones Swamp	Canal/Ditch		26	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	49.2	dsur007	Ditch	Canal/Ditch		4	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	49.5	wsuo048f/wsuo 048e	Quaker Swamp	Wetland-Waterbody Complex			Open Cut	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	49.9	ssuo015	UNT to Quaker Swamp	Perennial		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	50.2	wsuo025f	Quaker Swamp	Wetland-Waterbody Complex			Open Cut	Unclassified		NA
Virginia	11	AP-3	50.5	ssuo014	UNT to Quaker Swamp	Perennial		2	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	51.7	dsuo010	Ditch	Canal/Ditch		8	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	52.1	ssup036	UNT to Quaker Swamp	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	52.1	ssup027	UNT to Quaker Swamp	Perennial		6	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	52.2	ssup035	UNT to Quaker Swamp	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	52.6	ssup032	UNT to Quaker Swamp	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	52.6	ssup031	UNT to Quaker Swamp	Intermittent		2	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	53.9	ssuo024	UNT to Speights Run	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	53.9	ssuo025	UNT to Speights Run	Intermittent		4	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	53.9	ssuo026	UNT to Speights Run	Intermittent		3	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	54.6	ssur008	UNT to Cohoon Creek	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	55.3	ssuo118	UNT to Lake Cohoon	Perennial		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	55.4	ssuo117	UNT to Lake Cohoon	Perennial		9	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	55.5	dsup010	Ditch	Canal/Ditch		2	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	56.1	wsup032f	Cohoon Creek	Wetland-Waterbody Complex			Open Cut	Unclassified		NA
Virginia	11	AP-3	56.2	ssup019	UNT to Cohoon Creek	Perennial		15	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	56.3	ssup023	UNT to Cohoon Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	56.3	ssup023	UNT to Cohoon Creek	Intermittent		1	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	56.3	ssup022	UNT to Cohoon Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	56.4	ssup024	UNT to Cohoon Creek	Perennial		10	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	56.7	ssup026	UNT to Cohoon Creek	Intermittent		2	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	56.7	nhd_va_c_042	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	57.0	ssup033	UNT to Eley Swamp	Intermittent		2	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	58.0	ssuo105	UNT to Eley Swamp	Perennial		9	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	58.1	ssuo106	UNT to Eley Swamp	Perennial		4	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	58.8	dsup009	Ditch	Canal/Ditch			Perm AR	Unclassified		NA
Virginia	11	AP-3	59.3	ssuo107	UNT to Lake Prince	Perennial		3	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	59.4	ssuo109	UNT to Lake Prince	Perennial		5	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	59.4	ssuo110	UNT to Lake Prince	Intermittent		13	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	60.5	ssuo011	UNT to Prince Lake	Perennial		2	Flume or Dam and Pump	UNT to Public fishing Lake		NA
Virginia	11	AP-3	60.9	ssuo013	UNT to Prince Lake	Intermittent			Not Crossed by Centerline	UNT to Public fishing Lake		NA
Virginia	11	AP-3	61.0	osur001	Prince Lake	Reservoir		388	HDD	Public fishing Lake		NA
Virginia	11	AP-3	61.1	ssur002	UNT to Prince Lake	Ephemeral		3	HDD	UNT to Public fishing Lake		NA
Virginia	11	AP-3	61.6	ssuo103	UNT to Western Branch Reserv	Intermittent			Not Crossed by Centerline	UNT to Public fishing Lake		NA
Virginia	11	AP-3	61.7	ssuo102	UNT to Western Branch Reserv	Perennial		9	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	61.8	ssuo101	UNT to Western Branch Reserv	Perennial		3	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	61.8	ssuo100	UNT to Western Branch Reserv	Perennial			Not Crossed by Centerline	UNT to Public fishing Lake		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	62.4	osua400	Western Branch Reservoir	Reservoir		302	HDD	Public fishing Lake		NA
Virginia	11	AP-3	62.7	ssuo114	UNT Western Branch Reserv	Perennial		3	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	63.0	ssuo116	UNT Western Branch Reserv	Perennial		2	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	63.0	ssuo115	UNT Western Branch Reserv	Perennial		5	Dam and Pump or Flume	UNT to Public fishing Lake		NA
Virginia	11	AP-3	63.6	ssup013	Western Branch Nansemond River	Perennial		60	HDD	Aquatic Life, Migratory fish Spawning and Nursery	Essential Fish Habitat	February 15 to June 30
Virginia	11	AP-3	63.6	nhd_va_c_047	Western Branch Nansemond River	Perennial		143	HDD	Aquatic Life, Migratory fish Spawning and Nursery	Essential Fish Habitat	February 15 to June 30
Virginia	11	AP-3	64.4	nhd_va_c_048	Nansemond River	Perennial		460	HDD	Aquatic Life, Migratory fish Spawning and Nursery	Essential Fish Habitat; Potential for ESA-listed species; potential for MMPA-species	February 15 to June 30
Virginia	11	AP-3	65.5	dsuc100	UNT to Nansemond River	Canal/Ditch			Not Crossed by Centerline	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	65.9	nhd_va_c_007	UNT to Unnamed Reservoir	Intermittent		7	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	66.0	nhd_va_m_001	UNT to Nansemond River	Canal/Ditch			Perm AR	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 15 to June 30
Virginia	11	AP-3	66.3	ssus004	UNT to Great Dismal Swamp	Intermittent	5		Temp AR	Unclassified		NA
Virginia	11	AP-3	66.3	ssus003	UNT to Great Dismal Swamp	Intermittent			Temp AR	Unclassified		NA
Virginia	11	AP-3	66.3	ssus002	UNT to Great Dismal Swamp	Intermittent	9		Temp AR	Unclassified		NA
Virginia	11	AP-3	66.3	ssus003	UNT to Great Dismal Swamp	Intermittent			Temp AR	Unclassified		NA
Virginia	11	AP-3	66.9	ssuo019	UNT to Dismal Swamp	Perennial		9	Flume or Dam and Pump	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	67.0	ssuo020	UNT to Dismal Swamp	Perennial		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	67.6	ssup028	UNT to Dismal Swamp	Perennial		24	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	68.0	ssup029	UNT to Dismal Swamp	Perennial		25	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	68.5	ssuo021	UNT to Dismal Swamp	Intermittent		6	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	68.5	osup002	UNT to Dismal Swamp	Pond			Pond	Unclassified		NA
Virginia	11	AP-3	69.6	ssup038	UNT to Dismal Swamp	Perennial		24	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	70.2	ssup037	UNT to Dismal Swamp	Intermittent		18	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	70.5	nhd_va_o_002	UNT to East Ditch	Canal/Ditch		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	71.2	nhd_va_o_003	UNT to Dismal Swamp	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	71.2	ssur006	UNT to Dismal Swamp	Perennial		15	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	71.2	nhd_va_418	Unnamed Ditch	Canal/Ditch		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	71.3	nhd_va_416	Unnamed Ditch	Canal/Ditch		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	71.4	nhd_va_409	East Ditch	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	71.4	nhd_va_409	East Ditch	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	71.4	schr009	East Ditch	Perennial			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	71.6	schr010	UNT to East Ditch	Perennial		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	71.6	schr009	East Ditch	Perennial		31	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	71.7	schr011	UNT to East Ditch	Perennial		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	71.8	schr013	UNT to East Ditch	Perennial		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	73.6	schr006	UNT to Dismal Swamp	Perennial		13	Flume or Dam and Pump	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	73.7	schr005	UNT to Dismal Swamp	Intermittent		9	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	73.9	schr004	UNT to Dismal Swamp	Perennial		17	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	74.1	dchc001	UNT to Dismal Swamp	Canal/Ditch	15		Temp AR	Unclassified		NA
Virginia	11	AP-3	74.1	dchc002	UNT to Dismal Swamp	Canal/Ditch			Temp AR	Unclassified		NA
Virginia	11	AP-3	74.2	dchc002	UNT to Dismal Swamp	Canal/Ditch			Temp AR	Unclassified		NA
Virginia	11	AP-3	74.3	dchc002	UNT to Dismal Swamp	Canal/Ditch			Temp AR	Unclassified		NA
Virginia	11	AP-3	74.3	schr003	UNT to Dismal Swamp	Perennial		15	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	74.8	dchc002	UNT to Dismal Swamp	Canal/Ditch			Temp AR	Unclassified		NA
Virginia	11	AP-3	74.9	dchc002	UNT to Dismal Swamp	Canal/Ditch			Temp AR	Unclassified		NA
Virginia	11	AP-3	75.0	dchc002	UNT to Dismal Swamp	Canal/Ditch			Perm AR	Unclassified		NA
Virginia	11	AP-3	75.0	schr001	UNT to Dismal Swamp	Perennial		44	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	75.1	dchr001	UNT to Dismal Swamp	Canal/Ditch			Perm AR	Unclassified		NA
Virginia	11	AP-3	75.1	dchc003	UNT to Dismal Swamp	Canal/Ditch			Perm AR	Unclassified		NA
Virginia	11	AP-3	76.0	schp002	UNT to Dismal Swamp	Intermittent		34	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	76.9	scho003	UNT to Deep Creek	Intermittent			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	77.4	scho001	Deep Creek	Perennial		32	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	77.4	scho002	UNT to Deep Creek	Perennial		6	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	77.4	scho013	UNT to Deep Creek	Intermittent		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	77.5	dcho013	UNT to Deep Creek	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	77.8	nhd_va_419	Unnamed Ditch	Canal/Ditch		5	HDD	Unclassified		NA
Virginia	11	AP-3	78.3	nhd_va_286	UNT to Deep Creek	Canal/Ditch			Perm AR	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	11	AP-3	78.3	scho014	UNT to Deep Creek	Intermittent		42	Dam and Pump or Flume	Unclassified		NA
Virginia	11	AP-3	78.8	scho005	UNT to Deep Creek	Perennial		20	HDD	Unclassified		NA
Virginia	11	AP-3	78.8	ocho001	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	78.9	ocho001	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	79.0	dcho006	Ditch	Canal/Ditch		7	HDD	Unclassified		NA
Virginia	11	AP-3	79.0	ocho002	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	79.7	ocho003	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	81.0	scho012	UNT to Deep Creek	Ephemeral		3	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	81.2	ocho005	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	81.6	ocho004	Unnamed Pond	Pond		Pond	Pond	NA		NA
Virginia	11	AP-3	81.8	schp001	South Branch Elizabeth River	Perennial		835	HDD	Aquatic Life, Migratory fish Spawning and Nursery	Essential Fish Habitat; Potential for ESA-listed species; potential for MMPA-species	February 1 to June 30
Virginia	11	AP-3	82.1	schp004	UNT to S B of Elizabeth River	Intermittent		17	Part of Elizabeth River HDD	UNT to Aquatic Life, Migratory fish Spawning and Nursery		February 1 to June 30
Virginia	11	AP-3	82.1	dchp004	Ditch	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	82.3	dchr008	Ditch	Canal/Ditch		6	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	82.4	schr007e	UNT to Dismal Swamp	Ephemeral			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	82.4	schr007p	UNT to Dismal Swamp	Perennial		5	Flume or Dam and Pump	Unclassified		NA
Virginia	11	AP-3	82.5	dchb001	UNT to Newton Creek	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	82.5	dchb001	UNT to Newton Creek	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	11	AP-3	82.5	dchb001	UNT to Newton Creek	Canal/Ditch			Not Crossed by Centerline	Unclassified		NA
Virginia	12	AP-5	0.2	SVA-RDK-002	UNT to Greensville Creek	Intermittent		2	Flume or Dam and Pump	Unclassified		NA
Virginia	12	AP-5	0.4	SVA-RDK-001	UNT to Greensville Creek	Intermittent	4	4	Flume or Dam and Pump	Unclassified		NA

State	Spread	Project Segment	Milepost	Unique ID	Feature_Name	Waterbody Regime	Access Road Crossing (feet)	Centerline Crossing (feet)	Construction Method	State Reg Class	Federal Classifications	State/Commonwealth or Federal Time of Year Restrictions (work limited between dates listed)
Virginia	12	AP-5	0.8	SVA-AWN-001	Greensville Creek	Perennial		21	Dam and Pump or Flume	Unclassified		NA

APPENDIX Q

Site Specific Construction Plans for Major Waterbody Crossed

LEGEND

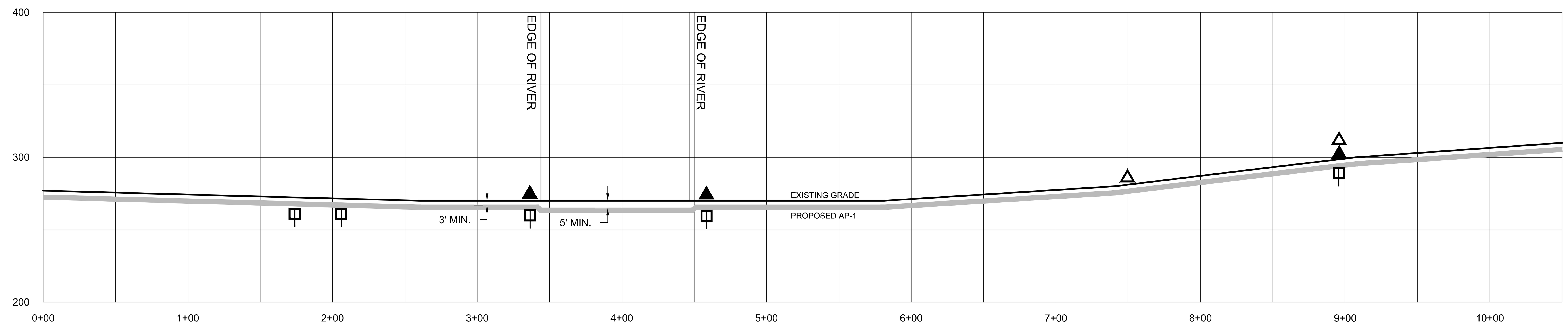
- PERMANENT RIGHT-OF-WAY
- TEMPORARY RIGHT-OF-WAY
- TOPSOIL SEGRAGATION AREA
- EXTRA WORK SPACE
- WETLAND
- STREAM
- LIMITS OF DISTURBANCE
- 100 CONTOUR
- SILT FENCE
- SILT SOCK
- ROCK CONSTRUCTION ENTRANCE
- TRENCH PLUG
- WATER BAR
- TEMPORARY SLOPE BREAKER

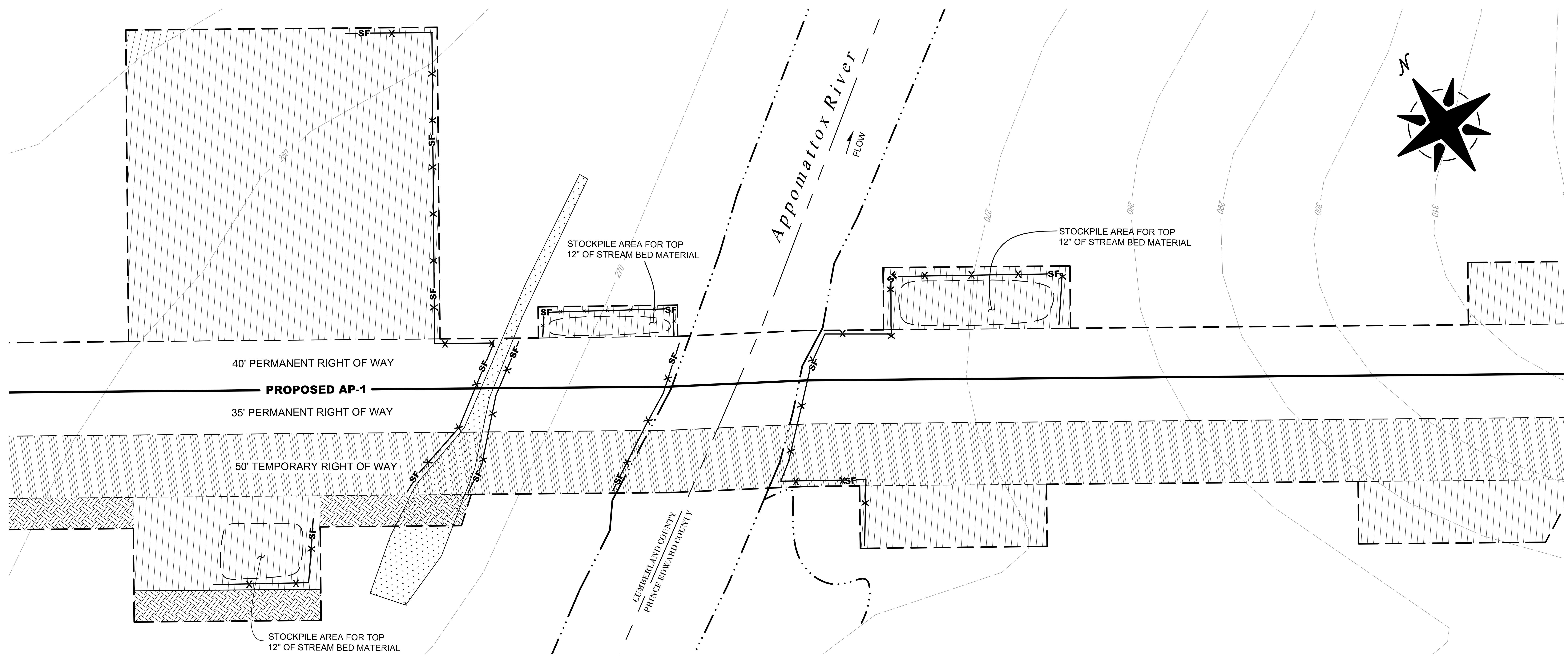
WATERBODY IMPACT		
WATERBODY #	TEMP. IMPACT	PERMANENT IMPACT
SCUK011	0.22 ACRES	0.0 ACRES

WATERBODY IMPACT

WATERBODY CONSTRUCTION NOTES:

1. CROSSING TO BE COMPLETED VIA THE USE OF A COFFERDAM.
2. CONSTRUCTION TO BE PREFORMED IN LOW FLOW PERIODS. FLOW SHALL BE MAINTAINED AT ALL TIMES.
3. RIP RAP (OR OTHER NON-ERODIBLE MATERIALS) TO BE PLACED IN SEMICIRCLE ALONG SIDE OF STREAM.
4. DISCHARGE ALL WATER THROUGH AN APPROVED SEDIMENT TRAPPING DEVICE.
5. STABILIZE WATER WATERBODY BANKS AND INSTALL TEMPORARY SEDIMENT BARRIERS WITHIN 24-HOURS OF COMPLETING IN-STREAM CONSTRUCTION ACTIVITIES.
6. RETURN ALL WATERBODY BANKS TO PRE-CONSTRUCTION CONTOURS OR TO A STABLE ANGLE OF REPOSE AS APPROVED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALL TRENCH PLUGS AND WATERBARS AS DIRECTED BY THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN ON BOTH SIDES OF THE WATERWAY, AND AS DEPICTED. ON THIS PLAN.
8. PIPELINE SHALL BE WEIGHTED WITH PIPESAK OR APPROVED E□UAL IN RIVER CROSSING TO ACHIEVE NEGATIVE BUOYANCY.





PLAN VIEW

50' 0 50' 100'

SCALE:1"=50'

GENERAL NOTES AND COMMENTS:

REFERENCE

ELEVATION DATA FROM THE USGS GIS DATA CLEARING HOUSE.

PIPELINE SURVEY INFORMATION PROVIDED BY GAI CONSULTANTS.

STREAM AND WETLAND DATA COLLECTED BY NATIONAL RESOURCE GROUP, LLC.

MAPPING DATUM-VA STATE PLANE SOUTH-NAD 83
CONTOUR INTERVAL - 10 FEET

SYM.	DATE	BY	REVISION INFORMATION		
A	7/13/15	RRC	ISSUED FOR REVIEW		

PROJECT/TASK APP.

SEAL

DRAWN:	RRC/RLR	7/13/15
CHECKED:	RVS / DLM	7/13/15
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	AS SHOWN	

Atlantic Coast Pipeline, LLC

445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: **AP-1 SITE SPECIFIC PLAN FOR APPOMATTOX RIVER**

DISTRICT: | COUNTY: CUMBERLAND | STATE: VA | GROUP | DWG. NO. 1 | REV. A

DIR/FILE: DOM/ACP/Site Specific/Appo□attox River

LEGEND

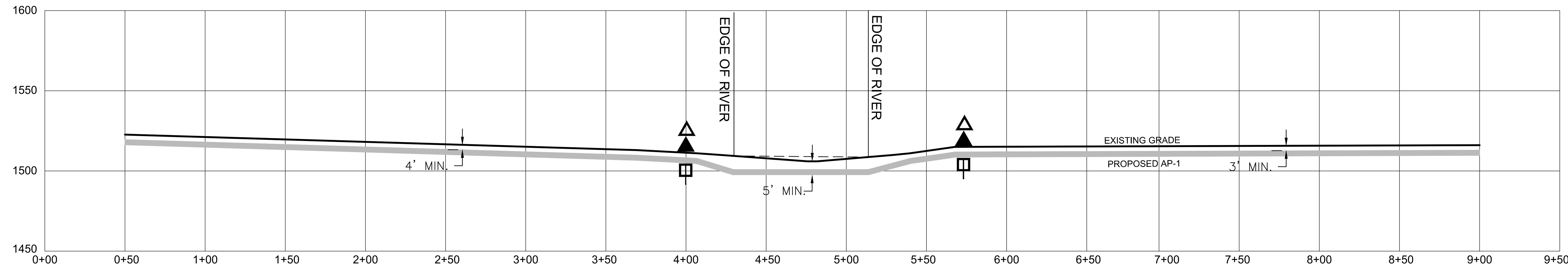
- PERMANENT RIGHT-OF-WAY
- TEMPORARY RIGHT-OF-WAY
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- WETLAND
- STREAM
- LIMITS OF DISTURBANCE
- CONTOUR
- SILT FENCE
- SILT SOCK
- ROCK CONSTRUCTION ENTRANCE
- TRENCH PLUG
- WATER BAR
- TEMPORARY SLOPE BREAKER

WATERBODY IMPACT		
WATERBODY #	TEMP. IMPACT	PERMANENT IMPACT
	0.25 ACRES	0.00 ACRES

WATERBODY IMPACT

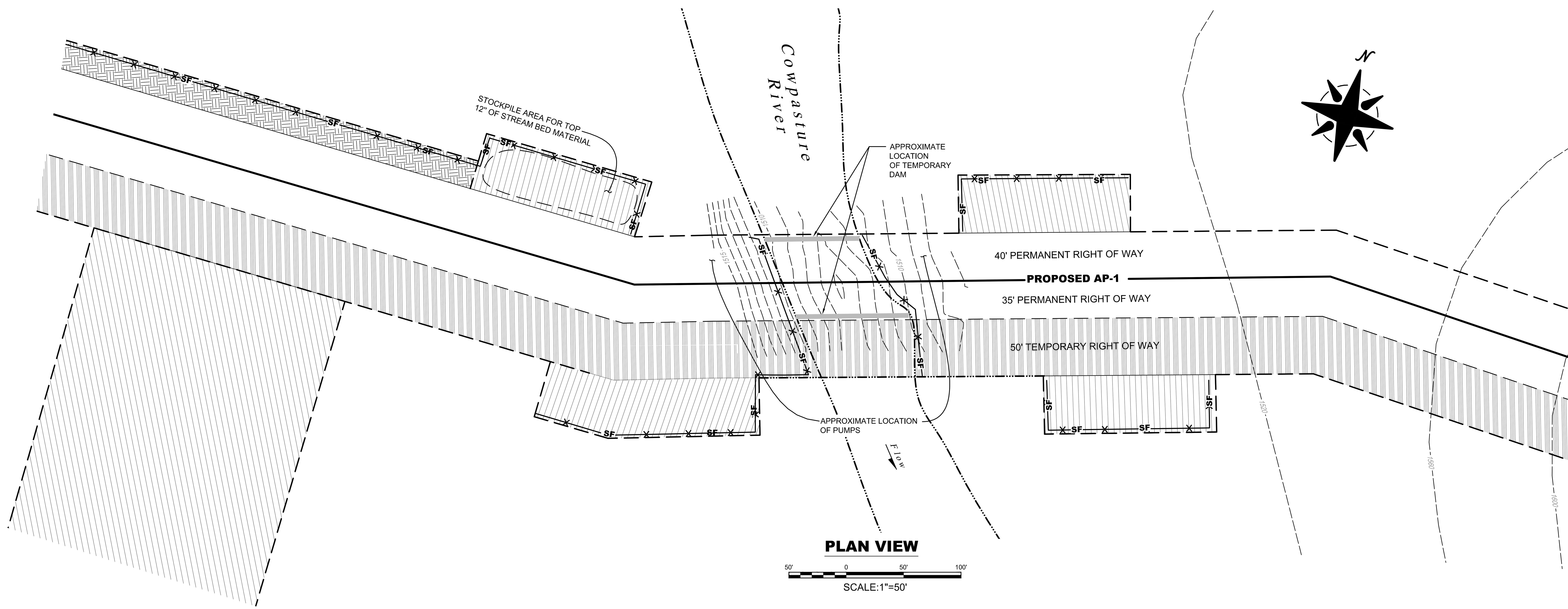
WATERBODY CONSTRUCTION NOTES:

1. CROSSING TO BE COMPLETED VIA THE DAM AND PUMP METHOD.
2. SUFFICIENT PUMPS TO MAINTAIN 1.5 TIMES THE FLOW PRESENT IN THE STREAM DURING CONSTRUCTION.
3. MAINTAIN EQUAL NUMBER OF BACKUP PUMPS ON SITE AS BEING USED FOR REQUIRED CAPACITY.
4. DAMS CONSTRUCTED WITH MATERIALS THAT PREVENT SEDIMENT AND OTHER POLLUTANTS FROM ENTERING THE WATERBODY (E.G. SANDBAGS OR CLEAN GRAVEL WITH PLASTIC LINER.
5. SCREENS SHALL BE INSTALLED ON PUMP INTAKES.
6. STREAMBED SCOUR PREVENTED AT PUMP DISCHARGE.
7. STABILIZE WATER WATERBODY BANKS AND INSTALL TEMPORARY SEDIMENT BARRIERS WITHIN 24-HOURS OF COMPLETING IN-STREAM CONSTRUCTION ACTIVITIES.
8. RETURN ALL WATERBODY BANKS TO PRE-CONSTRUCTION CONTOURS OR TO A STABLE ANGLE OF REPOSE AS APPROVED BY THE ENVIRONMENTAL INSPECTOR. FILL BELOW THE ORDINARY HIGH WATER MARK SHOULD BE AVOIDED.
9. INSTALL TRENCH PLUGS AND WATERBARS AS DIRECTED BY THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN ON BOTH SIDES OF THE WATERWAY, AND AS DEPICTED. ON THIS PLAN.
10. PUMPS SHALL BE INSTALLED IN SECONDARY CONTAINMENT.
11. FUEL SHALL BE STORED IN SECONDARY CONTAINMENT AND AT LEAST 100 FEET FROM WATERBODY.
12. SEGREGATE TOP 12" OF STREAM BED MATERIAL AND STORE WITHIN APPROVED CONSTRUCTION WORKSPACE.
13. EQUIPMENT BRIDGE WILL BE CONSTRUCTED ACROSS STREAM CHANNEL IN A MANNER THAT WILL MAINTAIN UNRESTRICTED FLOW, PREVENT SOIL FROM ENTERING WATERBODY, AND WITH STAND THE HIGHEST FLOW EXPECTED TO OCCUR WHILE BRIDGE IS IN PLACE.
14. OPTION A (COFFERDAM) OR OPTION B (DAM & PUMP) WILL BE DETERMINED AT TIME OF CONSTRUCTION AND BASED ON SITE CONDITIONS.



STREAM CROSSING PROFILE

SCALE:1"=50'



PLAN VIEW

SCALE:1"=50'

GENERAL NOTES AND COMMENTS:

REFERENCE

ELEVATION DATA PROVIDED BY GAI CONSULTANTS.

PIPELINE SURVEY INFORMATION PROVIDED BY GAI CONSULTANTS.

STREAM AND WETLAND DATA COLLECTED BY NATIONAL RESOURCE GROUP, LLC.

MAPPING DATUM-UTM 17-NAD 83
CONTOUR INTERVAL - 1 FOOT □ 40 FOOT

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK	APP.
A	11/16/15	RLR	ISSUED FOR REVIEW		

SEAL

DRAWN:	RLR	11/16/16
CHECKED:	RVS / DLM	11/16/16
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	AS SHOWN	

Atlantic Coast Pipeline, LLC

445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: **AP-1 SITE SPECIFIC PLAN FOR COWPASTURE RIVER - OPTION B DAM & PUMP**

DISTRICT: | COUNTY: BATH | STATE: VA | GROUP | DWG. NO. | REV. A

DIR/FILE: DOM/ACP/Site Specific/Co□pasture

LEGEND

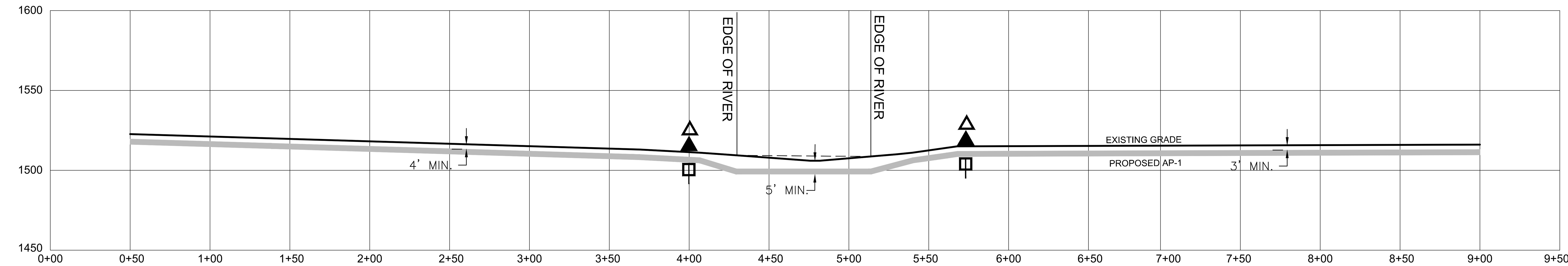
- PERMANENT RIGHT-OF-WAY
- TEMPORARY RIGHT-OF-WAY
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- WETLAND
- STREAM
- LIMITS OF DISTURBANCE
- CONTOUR
- SILT FENCE
- SILT SOCK
- ROCK CONSTRUCTION ENTRANCE
- TRENCH PLUG
- WATER BAR
- TEMPORARY SLOPE BREAKER

WATERBODY IMPACT		
WATERBODY #	TEMP. IMPACT	PERMANENT IMPACT
	0.25 ACRES	0.00 ACRES

WATERBODY IMPACT

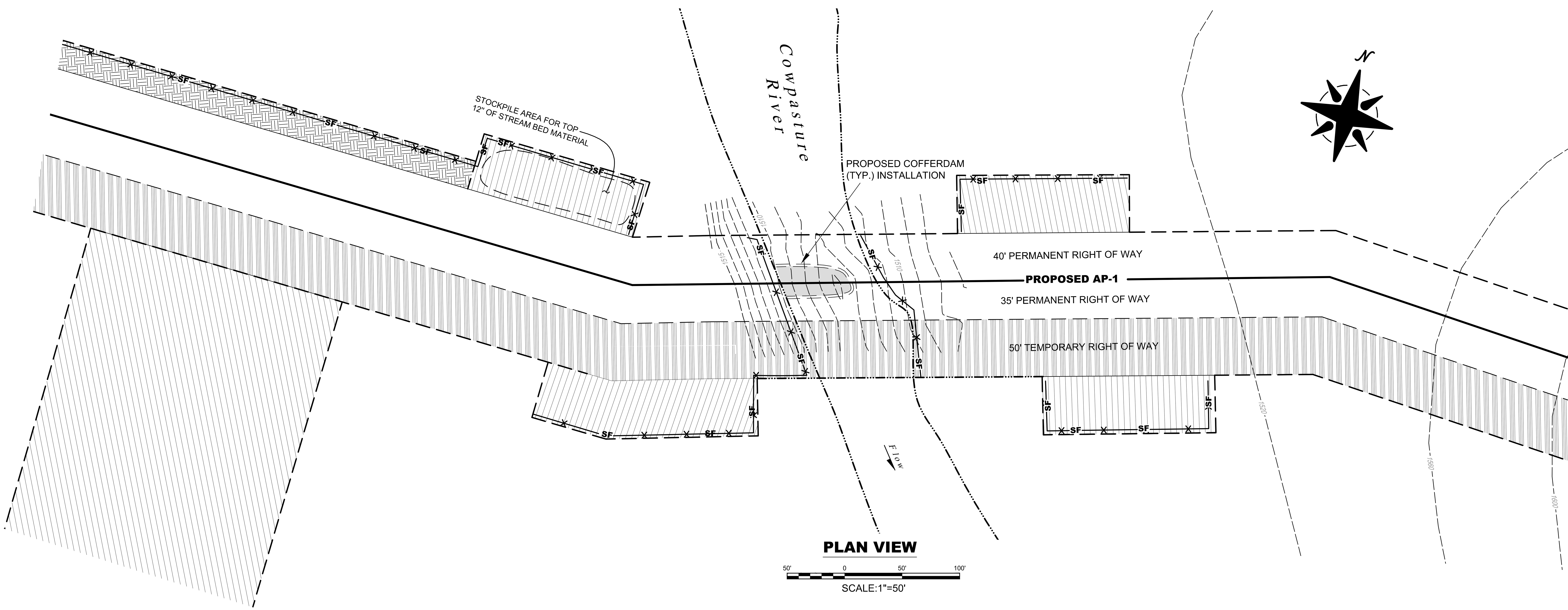
WATERBODY CONSTRUCTION NOTES:

1. CROSSING TO BE A COFFERDAM.
2. CONSTRUCTION TO BE PERFORMED IN LOW FLOW PERIODS.
3. RIP RAP (OR OTHER NON-ERODIBLE MATERIALS) TO BE PLACED IN SEMICIRCLE ALONG SIDE OF STREAM.
4. DISCHARGED WATER INTO A SEDIMENT TRAPPING DEVICE.
5. STABILIZE WATERBODY BANKS AND INSTALL TEMPORARY SEDIMENT BARRIERS WITHIN 24-HOURS OF COMPLETING IN-STREAM CONSTRUCTION ACTIVITIES.
6. RETURN ALL WATERBODY BANKS TO PRE-CONSTRUCTION CONTOURS OR TO A STABLE ANGLE OF REPOSE AS APPROVED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALL TRENCH PLUGS AND WATERBARS AS DIRECTED BY THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN ON BOTH SIDES OF THE WATERWAY, AND AS DEPICTED. ON THIS PLAN.
8. DO NOT USE HERBICIDES OR PESTICIDES WITHIN 100 FEET OF THE WATERBODY.



STREAM CROSSING PROFILE

SCALE:1"=50'



PLAN VIEW

SCALE:1"=50'

GENERAL NOTES AND COMMENTS:

REFERENCE

ELEVATION DATA PROVIDED BY GAI CONSULTANTS.

PIPELINE SURVEY INFORMATION PROVIDED BY GAI CONSULTANTS.

STREAM AND WETLAND DATA COLLECTED BY NATIONAL RESOURCE GROUP, LLC.

MAPPING DATUM-UTM 17-NAD 83

CONTOUR INTERVAL - 1 FOOT □ 40 FOOT

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK	APP.
A	11/16/15	RLR	ISSUED FOR REVIEW		

SEAL

DRAWN:	RLR	11/16/16
CHECKED:	RVS / DLM	11/16/16
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	AS SHOWN	

Atlantic Coast Pipeline, LLC

445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: **AP-1 SITE SPECIFIC PLAN FOR COWPASTURE RIVER - OPTION A COFFERDAM**

DISTRICT: | COUNTY: BATH | STATE: VA | GROUP | DWG. NO. | REV. A

DIR/FILE: DOM/ACP/Site Specific/Co□pasture

LEGEND

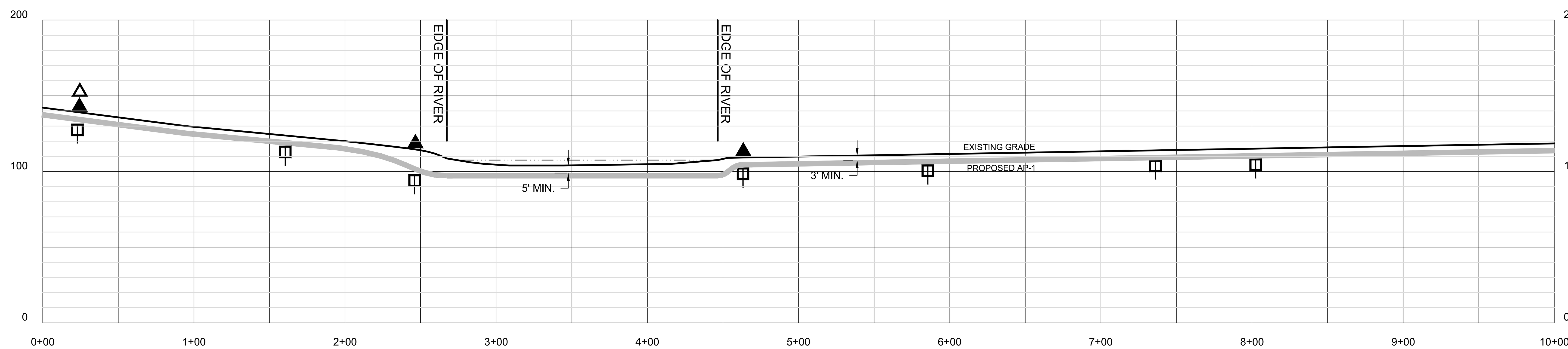
- PERMANENT RIGHT-OF-WAY
- TEMPORARY RIGHT-OF-WAY
- TOPSOIL SEGRAGATION AREA
- EXTRA WORK SPACE
- WETLAND
- STREAM
- LIMITS OF DISTURBANCE
- CONTOUR
- SILT FENCE
- SILT SOCK
- ROCK CONSTRUCTION ENTRANCE
- TRENCH PLUG
- WATER BAR
- TEMPORARY SLOPE BREAKER

WATERBODY IMPACT		
WATERBODY #	TEMP. IMPACT	PERMANENT IMPACT
SGRA007	0.48 ACRES	0.0 ACRES

WATERBODY IMPACT

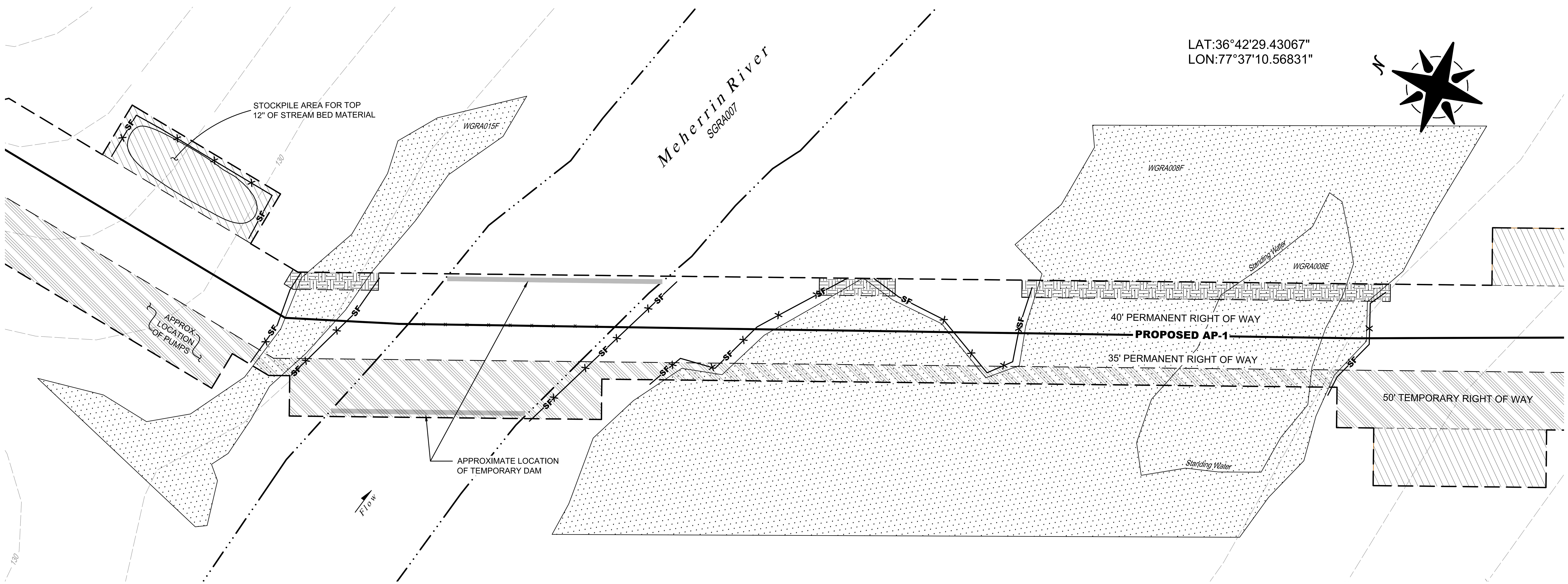
WATERBODY CONSTRUCTION NOTES:

1. CROSSING TO BE COMPLETED VIA THE DAM AND PUMP METHOD.
2. SUFFICIENT PUMPS TO MAINTAIN 1.5 TIMES THE FLOW PRESENT IN THE STREAM DURING CONSTRUCTION.
3. MAINTAIN ONE BACKUP PUMP ON SITE.
4. DAMS CONSTRUCTED WITH MATERIALS THAT PREVENT SEDIMENT AND OTHER POLLUTANTS FROM ENTERING THE WATERBODY (E.G. SANDBAGS OR CLEAN GRAVEL WITH PLASTIC LINER.
5. SCREENS SHALL BE INSTALLED ON PUMP INTAKES.
6. STREAMBED SCOUR PREVENTED AT PUMP DISCHARGE.
7. STABILIZE WATER WATERBODY BANKS AND INSTALL TEMPORARY SEDIMENT BARRIERS WITHIN 24-HOURS OF COMPLETING IN-STREAM CONSTRUCTION ACTIVITIES.
8. RETURN ALL WATERBODY BANKS TO PRE-CONSTRUCTION CONTOURS OR TO A STABLE ANGLE OF REPOSE AS APPROVED BY THE ENVIRONMENTAL INSPECTOR. FILL BELOW THE ORDINARY HIGH WATER MARK SHOULD BE AVOIDED.
9. INSTALL TRENCH PLUGS AND WATERBARS AS DIRECTED BY THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN ON BOTH SIDES OF THE WATERWAY, AND AS DEPICTED. ON THIS PLAN.
10. PUMPS SHALL BE INSTALLED IN SECONDARY CONTAINMENT.
11. FUEL SHALL BE STORED IN SECONDARY CONTAINMENT AND AT LEAST 100 FEET FROM WATERBODY.



STREAM CROSSING PROFILE

SCALE:1"=50'



PLAN VIEW

SCALE:1"=50'

GENERAL NOTES AND COMMENTS:

REFERENCE

ELEVATION DATA FROM THE USGS GIS DATA CLEARING HOUSE.

PIPELINE SURVEY INFORMATION PROVIDED BY GAI CONSULTANTS.

STREAM AND WETLAND DATA COLLECTED BY NATIONAL RESOURCE GROUP, LLC.

MAPPING DATUM-VA STATE PLANE SOUTH-NAD 83
CONTOUR INTERVAL - 10 FEET

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK	APP.
E	3/22/17	KLA	REVISED PER CLIENT COMMENTS		
D	11/20/15	RRC	REVISED PER CLIENT COMMENTS		
C	8/18/15	RRC	REVISED PER CLIENT COMMENTS		
B	8/4/15	RRC	ISSUED FOR REVIEW - BATHOMETRIC DATA ADDED		
A	7/13/15	RRC	ISSUED FOR REVIEW		

SEAL

DRAWN:	RRC/RLR	7/13/15
CHECKED:	RVS / DLM	7/13/15
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	AS SHOWN	

Atlantic Coast Pipeline, LLC

445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: **AP-1 SITE SPECIFIC PLAN FOR MEHERRIN RIVER**

DISTRICT: | COUNTY: GREENSVILLE | STATE: VA | GROUP | DWG. NO. | REV. E

DIR/FILE: DOM/ACP/Site Specific/Meherrin River Rev E

LEGEND

- PERMANENT RIGHT-OF-WAY
- TEMPORARY RIGHT-OF-WAY
- TOPSOIL SEGRAGATION AREA
- EXTRA WORK SPACE
- WETLAND
- STREAM
- LIMITS OF DISTURBANCE
- CONTOUR
- SILT FENCE
- SILT SOCK
- ROCK CONSTRUCTION ENTRANCE
- TRENCH PLUG
- WATER BAR
- TEMPORARY SLOPE BREAKER

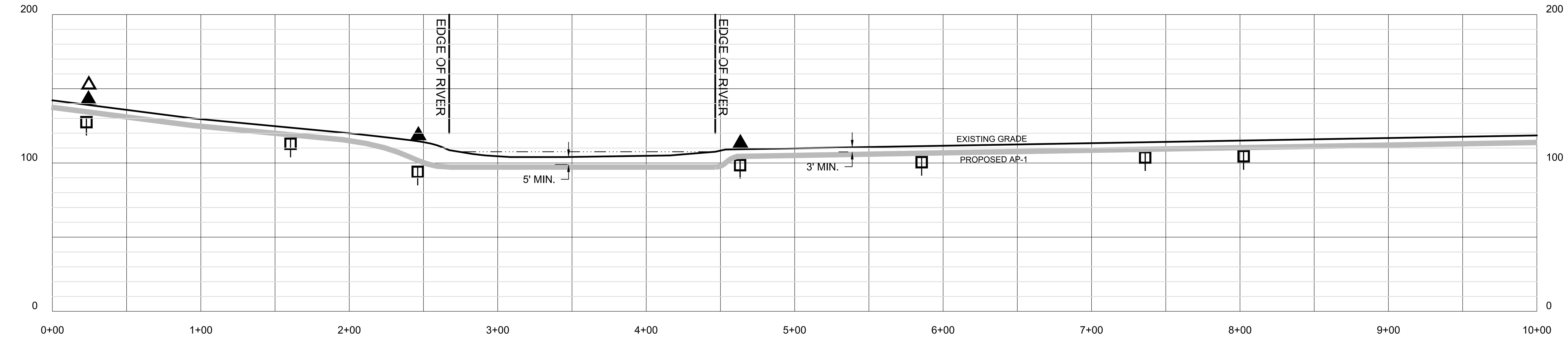
WATERBODY IMPACT

WATERBODY #	TEMP. IMPACT	PERMANENT IMPACT
SGRA007	0.48 ACRES	0.0 ACRES

WATERBODY IMPACT

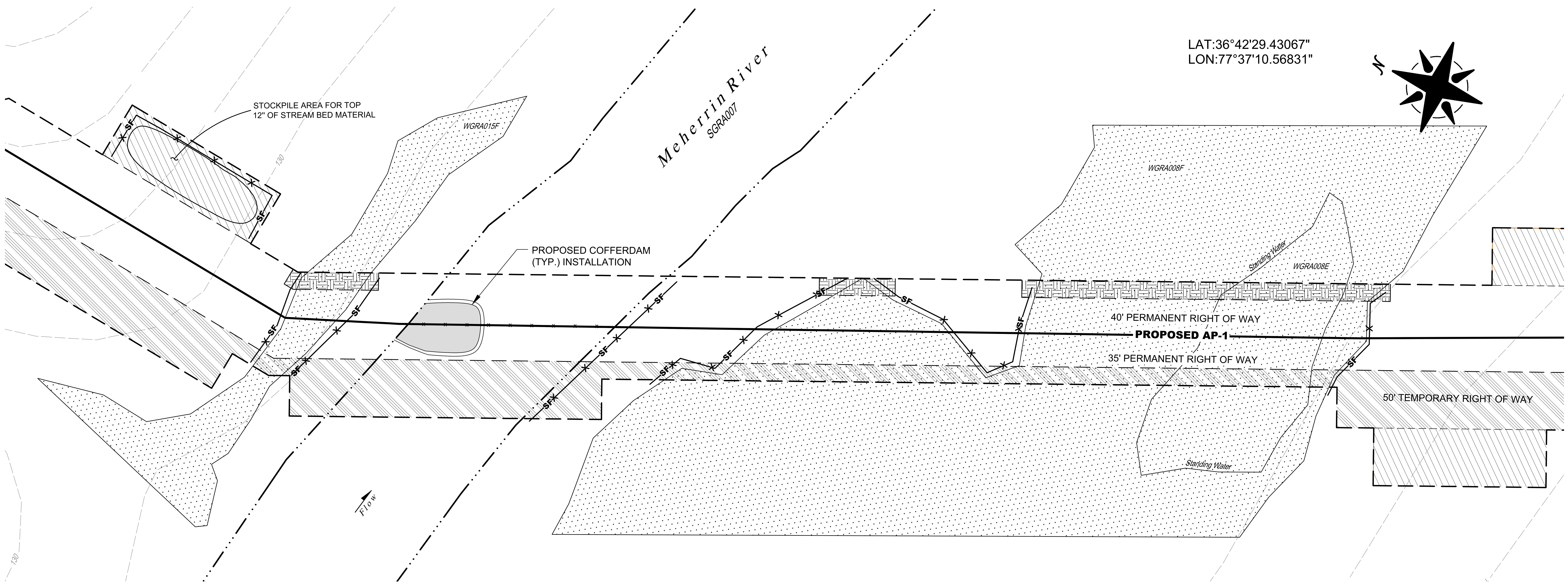
WATERBODY CONSTRUCTION NOTES:

1. CROSSING TO BE A COFFERDAM.
2. CONSTRUCTION TO BE PERFORMED IN LOW FLOW PERIODS.
3. RIP RAP (OR OTHER NON-ERODIBLE MATERIALS) TO BE PLACED IN SEMICIRCLE ALONG SIDE OF STREAM.
4. DISCHARGED WATER INTO A SEDIMENT TRAPPING DEVICE.
5. STABILIZE WATERBODY BANKS AND INSTALL TEMPORARY SEDIMENT BARRIERS WITHIN 24-HOURS OF COMPLETING IN-STREAM CONSTRUCTION ACTIVITIES.
6. RETURN ALL WATERBODY BANKS TO PRE-CONSTRUCTION CONTOURS OR TO A STABLE ANGLE OF REPOSE AS APPROVED BY THE ENVIRONMENTAL INSPECTOR.
7. INSTALL TRENCH PLUGS AND WATERBARS AS DIRECTED BY THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN ON BOTH SIDES OF THE WATERWAY, AND AS DEPICTED. ON THIS PLAN.
8. DO NOT USE HERBICIDES OR PESTICIDES WITHIN 100 FEET OF THE WATERBODY.



STREAM CROSSING PROFILE

SCALE:1"=50'



PLAN VIEW

SCALE:1"=50'

GENERAL NOTES AND COMMENTS:

REFERENCE

ELEVATION DATA FROM THE USGS GIS DATA CLEARING HOUSE.

PIPELINE SURVEY INFORMATION PROVIDED BY GAI CONSULTANTS.

STREAM AND WETLAND DATA COLLECTED BY NATIONAL RESOURCE GROUP, LLC.

MAPPING DATUM-VA STATE PLANE SOUTH-NAD 83
CONTOUR INTERVAL - 10 FEET

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK	APP.
A	3/21/17	KLA	ISSUED FOR REVIEW		

SEAL

DRAWN:	RRC/RLR/KLA	3/22/17
CHECKED:	RVS / DLM	3/22/17
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	AS SHOWN	

Atlantic Coast Pipeline, LLC
445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: **AP-1 SITE SPECIFIC PLAN FOR MERHERRIN RIVER**

DISTRICT: | COUNTY: GREENSVILLE | STATE: VA | GROUP | DWG. NO. | REV. A

DIR/FILE: DOM/ACP/Site Specific/Meherrin River CofferdamRev A

LEGEND

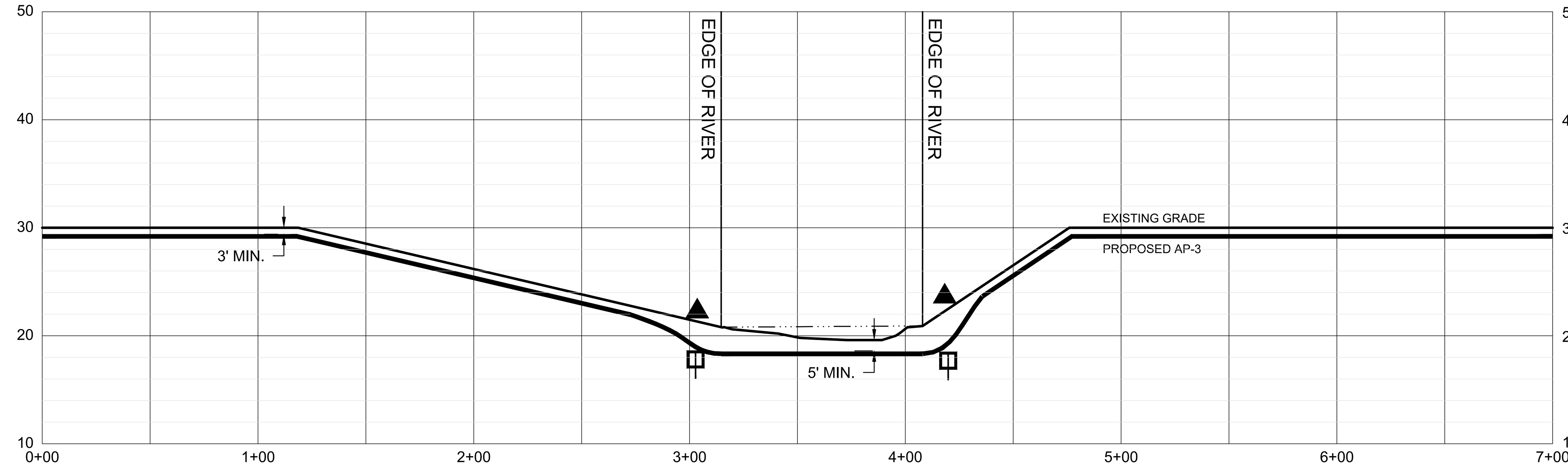
- PERMANENT RIGHT-OF-WAY
- TEMPORARY RIGHT-OF-WAY
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- WETLAND
- STREAM
- LIMITS OF DISTURBANCE
- 100 CONTOUR
- SILT FENCE
- SILT SOCK
- ROCK CONSTRUCTION ENTRANCE
- TRENCH PLUG
- WATER BAR
- TEMPORARY SLOPE BREAKER
- SEDIMENT CURTAIN

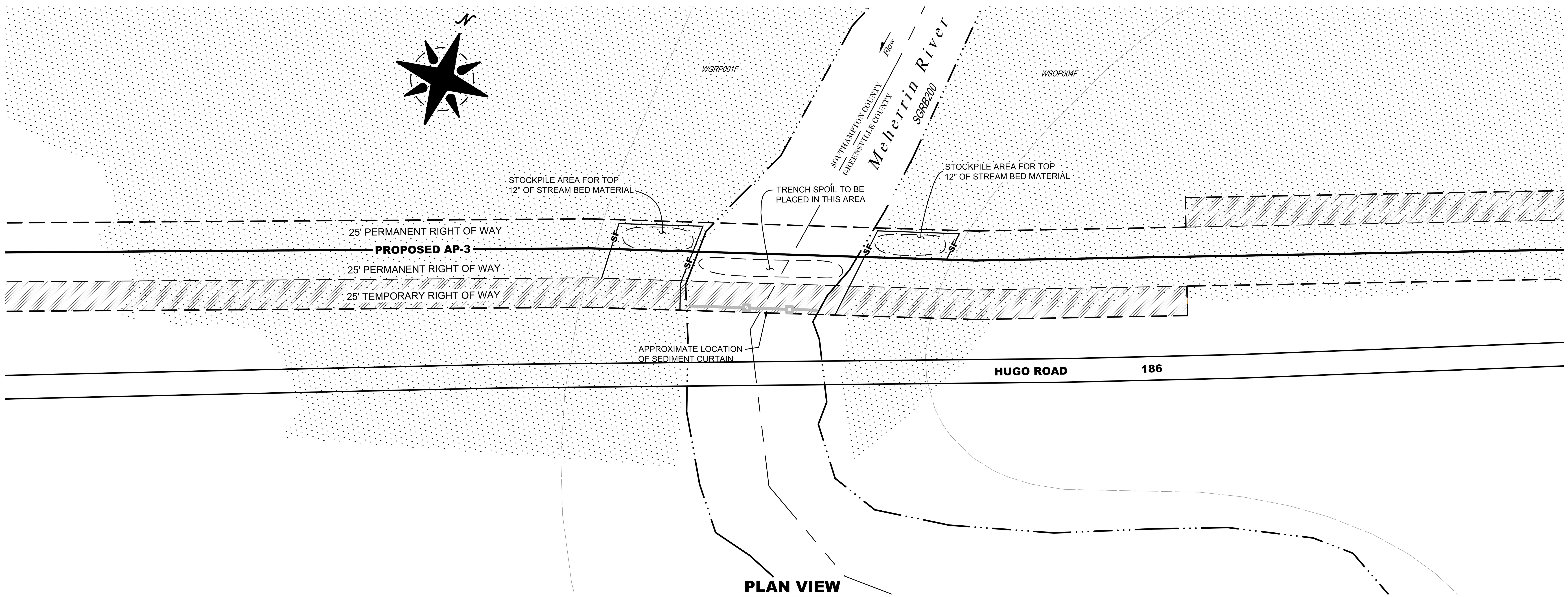
WATERBODY IMPACT		
WATERBODY #	TEMP. IMPACT	PERMANENT IMPACT
SGRB200	0.19 ACRES	0.0 ACRES

WATERBODY IMPACT

WATERBODY CONSTRUCTION NOTES:

1. CONSTRUCTION TO BE AN OPEN CUT WET CROSSING.
2. LIMIT USE EQUIPMENT OPERATING IN THE WATERBODY TO THAT NEEDED TO CONSTRUCT THE CROSSING.
3. WHILE OPEN CUTTING IN THE WATERWAY, KEEP EXCAVATION AS CLOSE TO THE BOTTOM OF THE WATERBODY AS POSSIBLE. USE A SMOOTH MOTION AND PLACE THE SEDIMENT ON THE BOTTOM OF THE STREAM. AVOID DROPPING THE MATERIAL AS MUCH AS POSSIBLE.
4. A SEDIMENT CURTAIN SHALL BE USED IN STREAM ON THE DOWNSTREAM SIDE OF THE WORK AREA.
5. STABILIZE WATER WATERBODY BANKS AND INSTALL TEMPORARY SEDIMENT BARRIERS WITHIN 24-HOURS OF COMPLETING IN-STREAM CONSTRUCTION ACTIVITIES.
6. RETURN ALL WATERBODY BANKS TO PRE-CONSTRUCTION CONTOURS OR TO A STABLE ANGLE OF REPOSE AS APPROVED BY THE ENVIRONMENTAL INSPECTOR. FILL BELOW THE ORDINARY HIGH WATER MARK SHOULD BE AVOIDED.
7. INSTALL TRENCH PLUGS AND WATERBARS AS DIRECTED BY THE APPROVED EROSION AND SEDIMENTATION CONTROL PLAN ON BOTH SIDES OF THE WATERWAY, AND AS DEPICTED. ON THIS PLAN.
8. THE TRAVEL LANE SHALL BE CLEARED WITH SUBSOIL EXCAVATED FROM PIPELINE TRENCH ONLY.
9. PIPELINE SHALL BE WEIGHTED WITH PIPESAK OR APPROVED EQUAL IN RIVER CROSSING TO ACHIEVE NEGATIVE BUOYANCY.





PLAN VIEW

50' 0 50' 100'

SCALE:1"=50'

GENERAL NOTES AND COMMENTS:

REFERENCE

ELEVATION DATA FROM THE USGS GIS DATA CLEARING HOUSE.

PIPELINE SURVEY INFORMATION PROVIDED BY GAI CONSULTANTS.

STREAM AND WETLAND DATA COLLECTED BY NATIONAL RESOURCE GROUP, LLC.

MAPPING DATUM-VA STATE PLANE SOUTH-NAD 83
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E	3/22/17	KLA	REVISED PER CLIENT COMMENTS		
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SEAL

DRAWN:	RRC/RLR	7/13/15
CHECKED:	RVS / DLM	7/13/15
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	AS SHOWN	

Atlantic Coast Pipeline, LLC

445 West Main St. Clarksburg, West Virginia 26301 / Phone: (304) 623-8000

TITLE: **AP-3 SITE SPECIFIC PLAN FOR MEHERRIN RIVER**

DISTRICT: | COUNTY: GREENSVILLE | STATE: VA | GROUP | DWG. NO. | REV. E

DIR/FILE: DOM/ACP/Site Specific/Meherrin River Rev E

APPENDIX R

Restoration and Rehabilitation Plan

ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE
Docket Nos. CP15-554-000 &
CP15-554-001

and

DOMINION TRANSMISSION, INC.
SUPPLY HEADER PROJECT
Docket No. CP15-555-000

Restoration and Rehabilitation Plan

Updated, Rev 6

Prepared by

ERM

May 1, 2017

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LIST OF ACRONYMS AND ABBREVIATIONS

ACP	Atlantic Coast Pipeline
Atlantic	Atlantic Coast Pipeline, LLC
BFM	bonded fiber matrix
BMP	best management practice
DTI	Dominion Transmission, Inc.
EI	Environmental Inspector
FERC	Federal Energy Regulatory Commission
NRCS	Natural Resources Conservation Service
Plan	Upland Erosion Control, Revegetation, and Maintenance Plan
Procedures	Wetland and Waterbody Construction and Mitigation Procedures
Projects	Atlantic Coast Pipeline and Supply Header Projects
RU	revegetation unit
SHP	Supply Header Project
USFS	U.S. Forest Service
WMA	Wildlife Management Area

1.0 INTRODUCTION

Atlantic Coast Pipeline, LLC (Atlantic) – a company formed by four major energy companies – Dominion Resources, Inc.; Duke Energy Corporation; Piedmont Natural Gas Co., Inc.; and AGL Resources, Inc. – proposes to construct and operate approximately 600 miles of natural gas transmission pipelines and associated aboveground facilities in West Virginia, Virginia, and North Carolina. This Project, referred to as the Atlantic Coast Pipeline (ACP), will deliver up to 1.5 million dekatherms per day of natural gas from supply areas in the Appalachian region to demand areas in Virginia and North Carolina. Atlantic has contracted with Dominion Transmission, Inc. (DTI), a subsidiary of Dominion Resources, Inc., to construct and operate the ACP on behalf of Atlantic.

In conjunction with the ACP, DTI proposes to construct and operate approximately 37.5 miles of pipeline loop and modify existing compression facilities in Pennsylvania and West Virginia. This Project, referred to as the Supply Header Project (SHP), will enable DTI to provide firm transportation service to various customers, including Atlantic.

2.0 PURPOSE

This *Restoration and Rehabilitation Plan* was prepared for the ACP and SHP (collectively, the Projects) to address post-construction restoration and rehabilitation activities. The plan will be implemented in conjunction with the 2013 versions of the Federal Energy Regulatory Commission's (FERC) *Upland Erosion Control, Revegetation, and Maintenance Plan* (Plan) (FERC, 2013a) and *Wetland and Waterbody Construction and Mitigation Procedures* (Procedures) (FERC, 2013b) as well as Atlantic's and DTI's other construction, restoration, and mitigation plans (e.g., *Spill Prevention, Control, and Countermeasures Plan, Invasive Species Management Plan*, and *Winter Construction Plan*). In addition, where state-specific erosion and sediment control requirements are more stringent than the FERC Plan and Procedures, the more stringent requirements will be implemented. The measures described in this plan reflect generally accepted best management practices (BMP) for restoration and rehabilitation of pipeline projects.

Atlantic and DTI have consulted with the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and are still in the process of consulting with other Federal, State/Commonwealth, and local agencies, including Federal and State/Commonwealth land managing agencies, to identify appropriate seed mixes for use during restoration. Based on discussions to date with the local NRCS offices, seed mixes have been developed and added to this plan. Seed mixes and how they were developed are described below. A more detailed description of seed mixes by region is presented in Appendix B.

On most pipeline projects, the seed mixes used for rights-of-way restoration generally consist of cool season grass species that grow well in the local area. Cool season grasses typically become established quickly and form a dense mat of grass and roots that is effective in controlling soil erosion in areas that have been disturbed by pipeline construction. These grasses may also provide food and habitat for some wildlife.

Atlantic is planning to incorporate regionally-specific and endemic forb (flowering plant) seeds in its traditionally all-grass seed mix. The incorporation and development of native flowering plants on the pipeline rights-of-way will create, where conditions and land management practices are suitable (i.e., areas with slope less than or equal to about 15 percent), substantial acreages of pollination habitat where this type of habitat is currently non-existent, primarily previously forested areas.

Atlantic has consulted and continues to consult with various county offices of the NRCS, Federal land management resource specialists at the U.S. Forest Service (USFS) and U.S. Fish and Wildlife Service, soil and water conservation districts, the Xerces Society, private groups, and organizations that have specific knowledge of both perennial cover grasses as well as native pollinator forb species seed mixes. Atlantic has obtained recommendations regarding species, seeding rates, mulching during planting, and maintenance mowing. Atlantic has also met and consulted with various national, State/Commonwealth, and local groups and experts on pollinators and pollination species endemic to the region that the pipeline crosses to learn which native forb seed mixes will be complimentary to the various grass seed mixes. These meetings and consultations provided information about the appropriate seeding rates and percentages of each type of seed within a specific seed mix, as well as the location each seed mix is to be used considering the various soil types, elevations, temperatures, and other growing conditions along the rights-of-way.

Through consultations with regional native seed experts, particularly those working with the NRCS and the Xerces Society, Atlantic has determined that native flowering forbs grow best and reproduce most successfully when planted with native warm season grasses. Warm season grasses are slower to establish than cool season grasses, and are bunch grasses instead of mat forming. Warm season grasses and forbs do not provide soil coverage that is as dense or as effective at controlling erosion as cool season grasses. Therefore, Atlantic was advised and has elected to use native warm season grass and forb mixtures only in areas with gradual or low percent slopes. In general, in areas of the rights-of-way with slopes greater than 15 percent Atlantic will use cool season grass mixes without flowering forbs to most effectively control the potential for erosion. These areas are specified in Section 5.7.5 and in Appendix B.

Atlantic is committed to use only forb species that are native to the area or region where they will be planted, to try to source seed from local growers, as available, and to avoid the introduction of non-native and potentially invasive species to the extent practicable.

3.0 TRAINING

Prior to the start of construction, Atlantic and DTI will conduct environmental and safety training for Company and Contractor personnel. The training program will focus on the FERC's Plan and Procedures; other construction, restoration, and mitigation plans, including this *Restoration and Rehabilitation Plan*; and applicable permit conditions. In addition, Atlantic and DTI will provide large-group training sessions before each work crew commences construction with periodic follow-up training for groups of newly assigned personnel.

4.0 VEGETATION TYPES IN PROJECT AREA

Atlantic and DTI characterized vegetation types in the ACP Project area and SHP Project area based on review of the U.S. Geological Survey's National Gap Analysis Program Land Cover Data and recent digital aerial photography augmented by field reconnaissance (2014 and 2015). Based on these data, the proposed ACP pipeline facilities cross upland forest/woodland (241.8 miles), cultivated cropland (86.8 miles), wetlands (69.9 miles), pasture land (64.2 miles), tree plantation/harvested forest (59.4 miles), developed land (21.7 miles), open land (17.0 miles), and open water (3.3 miles). The proposed SHP pipeline facilities cross upland forest/woodland (33.0 miles), pasture land (2.2 miles), developed land (1.3 miles), cultivated cropland (0.5 mile), wetlands (0.3 mile), open water (0.2 mile), tree plantation/harvested forest (less than 0.1 mile), and open land (less than 0.1 mile). The types of upland woodland/forest crossed by the Projects include coniferous forests, deciduous forests, mixed forests, deciduous savanna and glades, and floodplain and riparian forests.

5.0 BEST MANAGEMENT PRACTICES

Based on FERC requirements identified in the Plan and Procedures and industry-accepted practices, Atlantic and DTI have identified and developed BMPs for restoration and rehabilitation of areas disturbed by construction. These BMPs have been used to establish Atlantic's and DTI's standards for restoration and revegetation as described below. It is noted that states in which the Projects are located may in some cases have erosion and sediment control requirements that are more stringent than requirements in the FERC Plan and Procedures. Where this occurs, the more stringent requirements will be implemented as depicted on the state-specific erosion and sediment control plans.

5.1 EROSION CONTROL

Atlantic and DTI anticipate that construction activities requiring the installation of temporary erosion control devices will begin with access road preparation and timber clearing in 2017, and continue through the completion of construction in late 2019. Construction of the pipelines will be followed by restoration of the rights-of-way, stabilization of the soil, and seeding (where needed). Atlantic and DTI will complete final grading and installation of permanent erosion control structures (e.g., trench breakers or permanent slope breakers) generally within 20 days after backfilling the trench (10 days in residential areas), seasonal or other weather conditions permitting. For construction activities occurring in Winter, conditions such as frozen soils or snow cover could delay successful soil compaction mitigation or seeding activities. In these conditions, Atlantic and DTI will resume clean-up and restoration efforts the following Spring. Atlantic and DTI will monitor and maintain temporary erosion controls (e.g., temporary slope breakers, sediment barriers, or mulch) until conditions allow for completion of cleanup and installation of permanent erosion control structures.

Temporary erosion control measures and permanent erosion control devices to be employed during and after construction are described below. Atlantic and DTI will continue to consult with the applicable land managing agencies to identify other site-specific measures which may be required on Federal or State/Commonwealth lands.

- Slope Breakers – Temporary and permanent slope breakers will be installed, where required, to slow runoff velocity and direct water off the rights-of-way. Temporary slope breakers, such as earthen berms, will be installed prior to the start of construction activities. Permanent slope breakers will be installed during final grading.

- Temporary Sediment Barriers – Temporary sediment barriers, such as belted silt retention fence, compost filter sock or a combination of barriers, will be installed at the base of slopes adjacent to road, wetland, and waterbody crossings, and in other areas where required to prevent the transport of sediment off the construction rights-of-way.

- Permanent Trench Breakers – Sacks of subsoil or sand, polyurethane foam, or bentonite clay bags installed around the pipe will remain in the trench to prevent subsurface channeling of water along the trench.

- Mulch – Straw (weed free), hay (weed free), erosion-control fabric, or other equivalent material will be placed on the rights-of-way, where required, to protect the soil surface from water and wind erosion and to optimize the soil moisture regime necessary for successful revegetation, especially on dry, sandy sites.

During construction, the effectiveness of temporary erosion control devices will be monitored by Atlantic's and DTI's Environmental Inspectors (EI). Where appropriate for local resource needs, the role of the EI may be filled by agricultural or horticultural monitors. The effectiveness of revegetation and permanent erosion control devices will be monitored for the life of the project by Atlantic and DTI operating personnel during the long-term operation and maintenance of the pipeline systems.

5.2 SOIL RESTORATION

Successful revegetation is dependent on appropriate soil conditions and can be influenced by several factors, including soil texture, drainage class, salinity, and acidity. Soil characteristics along the pipeline routes and access roads and at contractor yards and aboveground facility sites are identified in Resource Report 7. Unless otherwise approved by a land managing agency or landowner, soil restoration will include:

- removal of excavated rock that is not returned to the trench and is considered construction debris;

- distribution of rock on the work area that is of similar size and density to adjacent areas not disturbed by construction;

- grading of the rights-of-way to restore preconstruction contours to the extent practicable; and

- preparation of the soil for revegetation.

5.3 SOIL COMPACTION

Soil compaction resulting from construction activities may reduce the potential for successful revegetation. Fine-textured soils with poor internal drainage that are moist or saturated during construction are the most susceptible to compaction and rutting. Atlantic and DTI will minimize impacts by implementing the mitigation measures for compaction and rutting as described in the Plan and Procedures. Atlantic and DTI will test for soil compaction:

- in residential and agricultural areas (e.g., active croplands, pastures, nurseries, and orchards);

- in other areas requested by the land managing agency or landowner;

- in undisturbed areas adjacent to the construction workspace with the same soil type under similar moisture conditions to approximate preconstruction conditions; and

- in areas identified by the EIs, who will be responsible for conducting subsoil and topsoil compaction testing and determining the need for corrective measures.

Compaction impacts will be mitigated through the use of tillage equipment during restoration activities such as a paraplow or similar implement. In areas where topsoil segregation occurs, plowing with a paraplow or other deep tillage implement to alleviate subsoil compaction will be conducted before replacement of the topsoil. In rocky or heavily rooted soils, compaction may be impossible to measure and rectify without additional damage. If compaction testing is impeded by rock or roots, Atlantic and DTI may conclude that there is a suitable amount of large material in the soil to rectify potential compaction. Soil compaction will be remediated prior to re-spreading of salvaged topsoil.

5.4 TOPSOIL SEGREGATION, REPLACEMENT, AND SOIL CONDITIONING

The potential mixing of topsoil or surface soil with the subsoil from construction activities could result in a loss of soil fertility. To prevent mixing of the soil horizons or incorporation of additional rock into the topsoil, topsoil segregation will be:

- performed in the trenchline within non-saturated wetlands, croplands, pastures, hayfields, residential areas, and in other areas requested by the land managing agency or landowner;

- conducted as described in the Plan and Procedures;

- stockpiled on the rights-of-way; and

- excluded from materials used for padding the pipe.

Topsoil will be layered above subsoil where seeds stored in the soil will be encouraged to grow. Topsoil segregation will generally not occur in forested areas. Most forested areas are not conducive to topsoil segregation due to the amount of root materials present and the wider construction rights-of-way that would be required to store segregated topsoil. Topsoil segregation may be required on certain public lands as identified by land managing agencies; these will be identified and addressed through ongoing consultations with the land managing agencies (see Sections 5.0 and 6.0).

5.5 RE-CONTOURING

Grading will be conducted prior to construction where necessary to provide a reasonably level work surface. Upon completion of construction, Atlantic and DTI will:

- restore the ground surface as closely as practicable to original contours to restore natural overland water flow patterns, aquifer recharge, and drainage patterns;

- re-contour disturbed areas in a fashion designed to stabilize slopes, remove ruts and scars, and support successful revegetation; and

- restore, to original or better condition, drainage ditches, and culverts that are diverted or damaged during construction.

5.6 STEEP SLOPE AREAS

Areas with steep slopes along the pipeline routes may make the establishment of vegetation more difficult due to the increased potential for stormwater runoff and erosion by water. In areas with slopes greater than 15 percent, Atlantic and DTI are planning to use seed mix prescriptions that utilize appropriate cool season grass species to quickly stabilize the disturbed areas and minimize erosion and sedimentation. Table 5.6-1 in Appendix A quantifies by county the major soil drainage and slope classes crossed by the Projects. Soil drainage classes were used to determine some of the grass seed types utilized in specific mixes (see Section 5.7.5).

The use of fast-growing cool season grasses will help to ensure faster soil stabilization in steeper terrain because of the faster development of stable root systems, which hold the soil in place. Additionally, in areas with slopes greater than 35 percent, the rights-of-way will be restored to natural contours to the extent practicable or in accordance with requests from land managing agencies or landowners. These steep slope areas are mostly located along the route in the Appalachian region of West Virginia and western Virginia but occasionally in other areas along the entire rights-of-way. Restoration of steep terrain may include:

- grading to the natural conditions;
- installation of permanent erosion control devices (i.e., slope breakers) designed to reduce runoff velocity, divert water from the surface of the rights-of-way, and encourage retention of soils; and

- the use of additional structural materials (e.g., rock or woody debris) to provide an anchor for revegetation and deposition of soil.

In addition to these general measures, Atlantic and DTI will develop and implement other additional site-specific measures, where warranted, to address land movement, surface erosion, backfill erosion, general soil stability when backfilling the trench, and restoring of the rights-of-way in steep slope areas. Specifically, as discussed in Resource Report 6, Atlantic and DTI are committed to employing best in class measures to protect the environment in steep slope areas. Best in class is defined as the most efficient and/or protective design or configuration with the least environmental impact providing reliable construction and operations.

Also as discussed in Resource Report 6, Atlantic and DTI will implement the Slip Avoidance, Identification, Prevention, and Remediation – Policy and Procedure, and are conducting geotechnical studies along the proposed pipeline routes in Pennsylvania, West Virginia, and western Virginia in steep terrain areas to assess the potential for landslides and landslips to occur during construction and operation of the Projects.

The following lists some of the design and construction mitigation measures that will be implemented during construction in steep slope areas:

- targeted management and diversion of surface water around landslide sites, including the use of ditches, berms, slope breakers, and/or grading;

- mitigation of surface erosion by armoring or otherwise stabilizing surface soils using riprap, coir cloth, hydroseeding, mulching, and/or tracking;

- targeted management of water sources along the trench, including the use of trench breakers and/or added drainage piping in the trench;

- targeted mitigation of seeps, springs, or other subsurface water encountered along the rights-of-way using subsurface drains or other special drainage measures;

- engineering of the backfill around or within steep slope areas to dry the backfill, add compaction, improve backfill soil strength, and reduce saturation;

- installation of targeted structures to stabilize backfill using engineered fill, retaining walls, sack-crete placements, key trenches, and/or shear trenches; and

- reduction in surcharge on steep slope areas by reducing excess or saturated backfill.

5.7 SITE PREPARATION AND SEEDING

Atlantic and DTI will complete final grading and permanent erosion control measures within 20 days after backfilling of the trench (10 days in residential areas), seasonal or other weather conditions permitting. In the event that these timeframes cannot be met or construction or restoration activities are interrupted for an extended period, mulch will be spread prior to seeding. In these cases, all slopes within 100 feet of wetlands or waterbodies will be mulched at a rate of 3 tons per acre.

5.7.1 Seedbed Preparation

Proper preparation of the soil surface and seedbed is essential for rapid and healthy revegetation (Virginia Department of Environmental Quality, 1992). Successful germination of seed is enhanced by a well-prepared seedbed, the suitability of which decreases rapidly after rainfall.

Seedbed preparation starts immediately after soil has been replaced on the rights-of-way and final grading, contouring, and de-compaction activities are complete. Seedbed preparation will be conducted immediately prior to seeding to prepare a firm seedbed conducive to proper seed placement. Seedbed preparation will also be performed to break up surface crusts and to reduce weeds that develop between the initial ground clearing and final seeding.

Unless otherwise specified by land managing agencies or landowners or as needed to support the establishment of pollinator habitat, the seedbed will be prepared in disturbed areas to a depth of 3 to 4 inches using appropriate equipment (e.g., cultipacker roller) to provide a seedbed that is firm, yet rough. Atlantic and DTI will imprint exposed soils with a sheepsfoot, landfill compactor, tractor with studded tires, or land imprinter equipment. Soil imprinting, or tracking, leaves divots on the ground surface that trap moisture and seeds, creating catchments for native plant material to be spread across the seeded area (West Virginia Department of Environmental Protection, 2012). In addition, a seedbed with a rough surface is conducive to the capturing or lodging of seed when broadcasted or hydroseeded, and can reduce runoff and erosion potential. The rough seedbed surface will also retain soil moisture for seedling germination and promote faster establishment of vegetation.

In compacted areas, additional measures such as chisel plowing or disking may be necessary to improve water infiltration and soil aeration, which are needed to prepare an adequate seedbed. When hydroseeding, Atlantic and DTI will scarify the soil surface prior to seeding to anchor the seed to the soil surface and encourage germination. Where residential lawns or landscaped areas are disturbed or as needed to support the establishment of pollinator habitat, more intensive ground and seedbed preparations may be required, including rock collection, grading, and soil preparation/amending.

5.7.2 Seeding

Seeding will not be conducted in actively cultivated croplands unless requested by the landowner. In residential areas, lawns will be restored on a schedule established during easement negotiations with the landowner. On all other lands, Atlantic and DTI will perform seeding of permanent vegetation during the Fall of the year construction is completed, within the recommended seeding dates, and within six working days of final grading, weather and soil conditions permitting. Atlantic and DTI will prioritize seeding and other restoration work in high-elevation areas, in an attempt to avoid restoration delays due to Winter-related weather and field conditions. If seeding cannot be done within recommended Fall timeframes, appropriate temporary erosion control measures will be installed and temporary grass cover will be seeded.

If temporary grass cover is used, seeding of permanent vegetation will occur at the beginning of the next recommended seeding season.

In addition, as part of the restoration and rehabilitation plan to revegetate disturbed areas along the pipeline routes, Atlantic and DTI will use cool season grasses to revegetate areas with slopes greater than 15 percent.

All seed will be certified weed free. The EIs will review all seed tags prior to use to ensure that the seed is properly certified.

5.7.2.1 Pollinator Habitat Planting

Atlantic, in support of a 2014 Presidential Memorandum that directs federal agencies to cooperate on the development of a national pollinator strategy, has committed to a pollinator habitat initiative where suitable along the rights-of-way. The successful establishment of pollinator habitat will require specialized: soil preparation, seeding techniques, and maintenance practices.

The most common causes for failed establishment when planting pollinator species are: (1) poor soil/seed contact and planting the seed more than one-quarter inch deep in the soil, and (2) competition from annual weeds, non-natives, or invasive vegetation. To prevent competition from other vegetation, Atlantic will reduce the existing seed bank in the rights-of-way. The seed bank will be reduced by clearing the existing vegetation (done during construction) and by using herbicides.

Additional soil preparation is also needed to ensure seed germination. The soil surface must be relatively smooth and compact to allow shallow seeding, no more than one-quarter inch deep. Typically, planting will include the use of a nurse crop or cover crop to ensure proper soil erosion control and the survival of the pollinator plant species. Cover crops (e.g., annual oats) are also generally used in traditional rights-of-way seeding.

The warm season grasses and endemic forbs used to establish pollinator habitat need to be planted in the Spring. Therefore,

- For Fall, Rights-of-way Restoration: Plant a cover crop and then plant the pollinator seed mix with a nurse crop in the Spring after a herbicide application.
- For Spring, Rights-of-way Restoration: Apply an herbicide prior to planting but after the weed seeds germinate and then plant the pollinator seed mix and a nurse crop together.
- For Summer, Rights-of-way Restoration: Plant a cover crop and then plant the pollinator seed mix with a nurse crop in the Spring after a herbicide application.

Atlantic plans to plant the pollinator species in both the permanent and construction rights-of-way. Atlantic has proposed seed mixes based on the recommendations from consultations with state and federal agencies. These seed mixes are described in more detail below and in Appendix B. Pollinator species seed mixes will be finalized in consultation with these agencies.

5.7.2.2 Pollinator Habitat Maintenance

Additional mowing is required in the first two years to reduce the height of the weeds and to prevent them from going to seed which will greatly reduce weed competition. Spot use of herbicides should be an option to control woody and invasive plants. Pollinator habitat experts recommend periodic prescription burning of the rights-of-way to reduce accumulated duff (i.e., dead vegetation on top of the ground) so that the pollinator species (flowers) can continue to reseed and maintain a viable population. Mowing close, 4 inches, and or thatching/raking may be viable alternatives to prescribed burning. Maintenance practices should be adapted to what is proven to be the best practices to ensure quality pollinator habitat.

5.7.3 Seeding Revegetation Units along the Pipeline Route

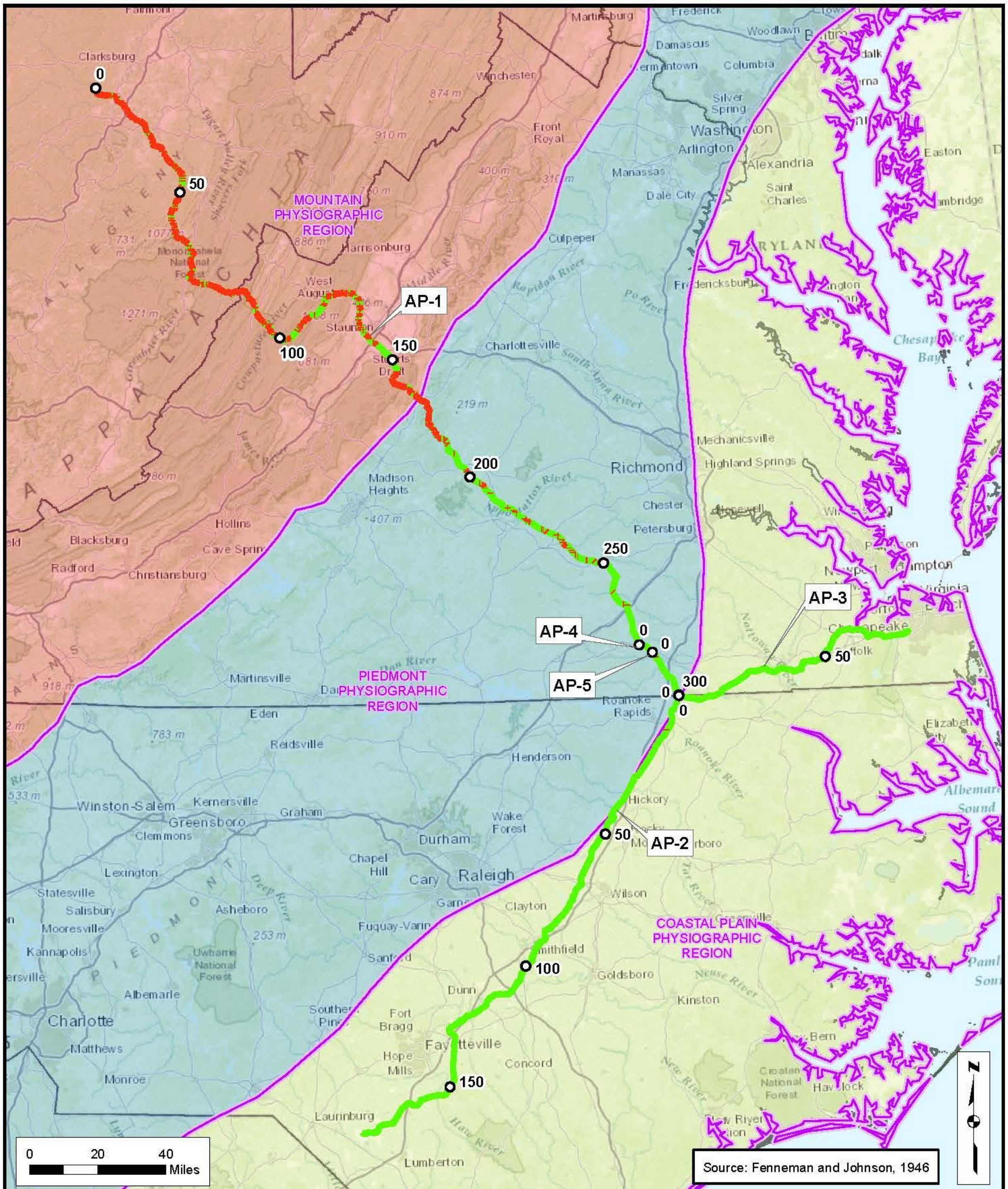
After consultations with Federal, State/Commonwealth, local resource and land managing agencies, and subject matter experts and in order to ensure optimum seed germination and growth, the areas crossed by the Projects were divided into four Revegetation Units (RU). One of the RUs is dependent on and defined by the steepness of the slopes crossed by the proposed pipelines. This RU can occur in site-specific locations anywhere along the pipeline corridors. The three other RUs are based on physiographic regions, and cover areas that are relatively homogenous with regards to factors such as soil type, vegetation, and climate that will affect the revegetation potential of the area. Each RU has distinct seed mix prescriptions. The four RUs include the following:

- Steep to Very Steep Slope RU;
- Mountain Physiographic Region RU;
- Piedmont Physiographic Region RU; and
- Coastal Plain Physiographic Region RU.

Figure 5.7.3-1 shows the distribution of the RUs, including the areas with slopes greater than 15 percent, along the pipeline route. Seed mix descriptions specific for each RU are provided in Appendix B.

5.7.3.1 Steep to Very Steep Slope

Although the Steep to Very Steep Slope RU includes areas with greater than 15 percent slope located anywhere along the Projects, most of these areas are located within the mountainous areas of the western Piedmont Physiographic RU and the Mountain Physiographic RU (see Figure 5.7.3-1). To a much lesser extent, the Steep to Very Steep Slope RU may also be found in smaller, site-specific areas along the pipeline rights-of-way where the steepness of the local terrain increases the erosion potential. The areas in this RU require appropriate seed mix prescriptions, erosion control measures, and BMPs that are able to quickly stabilize the disturbed areas to minimize erosion and sedimentation.



Atlantic Coast Pipeline
Dominion

Route Slope = 0-15%
Route Slope = 16% or Greater
Revegetation Unit Areas

Figure 5.7.3-1
Revegetation Unit Areas Along the Pipeline Corridor
Atlantic Coast Pipeline

FILE: M:\Clients\D-F\DOM\SRPP_ArcGIS\2015\12\09_Slope_for_Seeding_for_Doug_DRS_ACP_Seed_Phys_Prov.mxd, REVISED: 03/14/2016, SCALE: 1:2,500,000 DRAWN BY: 0239

5.7.3.2 Mountain Physiographic Region

The ACP Project area extends across the Mountain Physiographic Region RU in West Virginia and western Virginia (see Figure 5.7.3-1). In West Virginia, the RU encompasses the Western Allegheny Plateau, Central Appalachians, and Ridge and Valley ecoregions. The SHP Project area also extends across the Western Allegheny Plateau in northeastern West Virginia and southwestern Pennsylvania. In Virginia, this RU encompasses the Ridge and Valley, Blue Ridge (mountains), and the Southeastern Plains ecoregions. The soils in the Mountain Region RU generally consist of shallow soils with a loamy surface and subsoil texture. Steep slopes with shallow, stony, droughty soils are common throughout the area, and many mountainous soils have been severely eroded due to steepness. In less steep areas, the soils are deep and stable (less erodible).

5.7.3.3 Piedmont Physiographic Region

The proposed ACP Project area extends across the Piedmont Physiographic Region RU in Virginia and encompasses the Piedmont, Northern Piedmont, and Southeastern Plains ecoregions. The Piedmont ecoregion is an area of rolling landscape, gentle hills and valleys with a few isolated mountains (see Figure 5.7.3-1). The Piedmont is characterized by deep, weathered, very old eroded rock surfaces. The ecoregion primarily consists of agricultural land and managed woodlands. The temperate climate supports forests dominated by hardwood species. In general, the Piedmont and Northern Piedmont ecoregions are similar, as they are characterized by irregular plains, open valleys, and hills with stony soils that support both forested and agricultural lands. The Southeastern Plains ecoregion consists of flat plains interspersed with croplands, pastures, forests, and wetlands with primarily sandy soils. The overall climate is warm with a much longer rainy season, which contributes to a longer growing season compared to the Piedmont and Northern Piedmont ecoregions.

5.7.3.4 Coastal Plain Region

The proposed ACP Project area extends across the Coastal Plain Region RU in Virginia and North Carolina (see Figure 5.7.3-1). This RU encompasses two ecoregions: the Southeastern Plains and Mid-Atlantic Coastal Plain. As described above, the Southeastern Plains region consists of flat plains interspersed with croplands, pastures, forests, and wetlands with primarily sandy soils. The Mid-Atlantic Coastal Plain ecoregion borders the Piedmont ecoregion and the Atlantic Ocean, and contains a mix of forests, agricultural lands, and wetlands. The soils crossed by the Projects in these ecoregions are generally well drained soils with a loamy surface and subsoil texture.

5.7.4 Summary of State and Federal Agencies and Subject Matter Experts Consulted

Table 5.7.4-1 provides a list of the Federal and State/Commonwealth agencies, and subject matter experts consulted to determine the appropriate seed mix prescriptions and BMPs to revegetate areas disturbed by the construction of the ACP and SHP facilities.

5.7.5 Seed Mix Recommendations

Appendix B compiles the recommended seeding mixes and amendments provided by Federal, State/Commonwealth, local resource, and land managing agencies and subject matter experts into seed mix prescriptions by County/City and by spread for the Projects. Atlantic and DTI will work with the Federal and State/Commonwealth land managing agencies to determine appropriate seed mixes and methods for revegetation and restoration of Federal and State/Commonwealth lands crossed by the pipelines (see Sections 6 and 7). The Virginia Department of Game and Inland Fisheries has requested that it be responsible for the reseeding of Wildlife Management Area (WMA) lands crossed in Virginia and under the jurisdiction of that agency.

The recommended seed mix prescriptions identified for each of the RUs will be identified by milepost in Appendix C, which will be filed with the FERC prior to construction. The site-specific seed mixes will also be included on the construction alignments sheets to identify the seed mixes to be used by the construction contractors during restoration.

TABLE 5.7.4-1

Summary of Federal and State/Commonwealth Agencies and Subject Matter Expert Consultations

Contact Name	Agency/ Organization	County	Title/Role	Phone	Email
West Virginia					
Greg Stone	NRCS - State Office	All Counties	Acting State Resource Conservationist	304-284-7579	greg.stone@wv.usda.gov
Jeff Griffith	USDA NRCS	Harrison; Lewis; Doddridge	District Conservationist	304-624-9232 x 110	jeff.griffith@wv.usda.gov
Jack O'Connell	USDA NRCS	Pocahontas	District Conservationist	304-799-4317	jack.oconnell@wv.usda.gov
Barbara Sargent	West Virginia Department of Natural Resources	Wetzel	Wildlife Biologist	304-637-0245	barbara.d.sargent@wv.gov
Cliff Brown	West Virginia Department of Natural Resources	Wetzel	Wildlife Biologist	304-637-0245	clifford.l.brown@wv.gov
Idun Guenther	NRCS	Pocahontas	District Conservationist	304-255-9225	idun.guenther@wv.usda.gov
Susan Davis	NRCS	Pocahontas	Soil Conservationist	304-799-4317	susan.davis@wv.usda.gov
Rob Silvester	West Virginia Department of Natural Resources	Randolph	District Wildlife Biologist	304-924-6211	rob.a.silvester@wv.gov
Steve Rauch	West Virginia Department of Natural Resources	Randolph; Wetzel	District Wildlife Biologist	304-825-6787	steven.e.rauch@wv.gov
Ben Collier	NRCS	Randolph; Upshur	District Conservationist	304-636-6703 x 305	ben.collier@wv.usda.gov
Jeremy Bennett	NRCS	Randolph; Upshur	District Conservationist	304-457-4516	jeremy.bennett@wv.nrcs.gov
Dustin Adkins	NRCS	Tyler; Wetzel	District Conservationist	304-758-2173 x 1	dustin.adkins@wv.usda.gov
Katie Fitzsimmons	NRCS	Marshall	District Conservationist	304-242-0576 x 108	katie.fitzsimmons@wv.usda.gov

TABLE 5.7.4-1 (continued)

Summary of Federal and State/Commonwealth Agencies and Subject Matter Expert Consultations

Contact Name	Agency/ Organization	County	Title/Role	Phone	Email
Virginia					
Amy Ewing	Virginia Department of Game and Inland Fisheries	Virginia Counties	Environmental Services Biologist/Fish & Wildlife Information Manager	804-367-2211	Amy.Ewing@dgif.virginia.gov
Charles Ivins	NRCS	Augusta; Highland	District Conservationist	540-248-6218 x 122	charles.ivins@va.usda.gov
Charles Simmons	NRCS	Bath	District Conservationist	540-463-7124 x111	charles.simmons@va.usda.gov
Justin Folk	NRCS/Virginia Department of Game and Inland Fisheries	Bath	Private Lands Wildlife Biologist	540-248-6218 x 108	justin.folks@va.usda.gov
Davie Wade Harris	NRCS	Brunswick	District Conservationist	434-848-2145 x 102	davie.harris@va.usda.gov
David Harris	NRCS	Buckingham; Cumberland	District Conservationist	434-983-4757 x 101	david.harris@va.usda.gov
Bryan Poovey	U.S. Fish and Wildlife Service	Chesapeake; Suffolk (City); (Great Dismal Swamp National Wildlife Refuge)	Forestry Scientist	757-986-3705	bryan_poovey@fws.gov
David Bryd	U.S. Fish and Wildlife Service	Great Dismal Swamp NWR	Forestry Scientist	804-824-2412	david_byrd@fws.gov
Robert E. Williams	NRCS	Chesapeake	District Conservationist	757-547-7172 x 102	robert.williams@va.usda.gov
Bob Glennon	NRCS	Eastern Virginia Counties	Private Lands Biologist	757-357-7004 x 126	robert.glennon@va.usda.gov
Anthony Howell	NRCS	Dinwiddie	District Conservationist	804-469-7297 x 106	anthony.howell@va.usda.gov
Harvey Baker	NRCS	Greensville	District Conservationist	434-634-2115 x 109	harvey.baker@va.usda.gov
Jay Jeffreys	Virginia Department of Game and Inland Fisheries	Highland; Nelson	Biologist	540-248-9360	jay.jeffreys@dgif.virginia.gov
Kory Kirkland	NRCS	Nelson	District Conservationist	540-967-0233 x 111	kory.kirkland@va.usda.gov
Jeffray Jones	NRCS	All Counties	State Biologist	804-287-1691	jeffray.jones@va.usda.gov
J.B. Daniel	NRCS	Prince Edward	Agronomist Director	434-392-4171	j.b.daniel@va.usda.gov
Derek Hancock	NRCS	Nottoway; Prince Edward	District Conservationist	434-392-4127 x 101	derek.hancock@va.usda.gov
Yamika Bennett	NRCS	Southampton	District Conservationist	757-653-2532 x 122	yamika.bennett@va.usda.gov
Michael A. Faulk	NRCS	Suffolk (City)	District Conservationist	757-357-7004 x 114	mike.faulk@va.usda.gov
Ryan McCormick	National Park Service		Specialist Coordinator	828-348-3441	

TABLE 5.7.4-1 (continued)

Summary of Federal and State/Commonwealth Agencies and Subject Matter Expert Consultations

Contact Name	Agency/ Organization	County	Title/Role	Phone	Email
J. Christopher Ludwig	DCR	All Counties	Chief Biologist	804-371-6206	Chris.Ludwig@dcr.virginia.gov
Marc Puckett	DGIF	All Counties	QMAP Coordinator	434-392-9645	Marc.Puckett@dgif.virginia.gov
North Carolina					
Renessa Hardy-Brown	NRCS	Cumberland	District Conservationist	910-484-8479	renessa.brown@nc.usda.gov
Terry Best	NRCS	Halifax	District Conservationist	252-583-3481	terry.best@nc.usda.gov
Brian Loadholt	NRCS	Johnston	District Conservationist	919-934-7156	brian.loadholt@nc.usda.gov
Patrick Evens	NRCS	Nash	District Conservationist	252-459-4116 x 124	patrick.evans@nc.usda.gov
Paul Boone	NRCS	Northampton	District Conservationist	252-534-2591	paul.boone@nc.usda.gov
Jeremy Ruston	NRCS	Robeson	District Conservationist	910-739-5478	jeremy.roston@usda.gov
Gavin Thompson	NRCS	Sampson	District Conservationist	910-592-7963	gavin.thompson@nc.usda.gov
David Little	NRCS	Wilson	District Conservationist	252-237-2711	david.little@nc.usda.gov
Pennsylvania					
Chris Droste	Westmoreland Conservation District	Westmoreland	Erosion Control Specialist	724-837-5271	chris@wcdpa.com
Subject Matter Experts					
Mark Fiely	Ernst Seeds	All Counties	Horticulturist	800-873-3321	hortpath@ernstseed.com
Jeremy Hamlington	Roundstone Native Seed	All Counties	Horticulturist	270-531-3034	jeremy@roundstoneseed.com
Bob Glennon	NRCS / The Xerces Society	All Counties	Private Lands Biologist	757-357-7004 x 126	robert.glennon@va.usda.gov
Nancy Lee Adamson	The Xerces Society for Invertebrate Conservation & NRCS East National Technology Support Center	All Counties	Pollinator Conservation Specialist	336-370-3443	nancy@xerces.org

5.7.5.1 Steep to Very Steep Slope Seed Mixes

As described in Sections 5.7.3, the Steep to Very Steep Slope RU includes areas with high erosion potential (e.g., slopes greater than 15 percent). These areas require appropriate seed mixtures and erosion control measures that are able to quickly stabilize disturbed areas. The recommended seed mixes include the use of cool season grasses, which are identified by County in Appendix B.

5.7.5.2 Mountain Physiographic Region Seed Mixes

Excessively to Moderately Well Drained Sites

West Virginia

The proposed Mountain Physiographic Region Seed Mix P-MUDW01 (Tables 5.7.5-1 and 5.7.5-2) was designed to be compatible with the Mountain Physiographic Region RU in areas with slopes of 15 percent or less. The mix is based on selected native grass and forb species suitable for the restoration of excessively to moderately well-drained mountainous areas in West Virginia.

Virginia

The proposed Mountain Physiographic Region Seed Mix P-VABCHNP01 (Tables 5.7.5-3 and 5.7.5-4) was designed to be compatible with the Mountain Physiographic Region RU in areas with slopes of 15 percent or less. The mix is based on selected native grass and forb species suitable for restoration in excessively to moderately well-drained mountainous areas in Virginia.

Somewhat Poorly to Very Poorly Drained Sites

West Virginia

The proposed Mountain Physiographic Region Seed Mix P-MUDW02 (Tables 5.7.5-5 and 5.7.5-6) was designed to be compatible with the Mountain Physiographic Region RU in areas with slopes of 15 percent or less. The mix is based on selected native grasses and forb species suitable for restoration in somewhat poorly to very poorly-drained mountainous areas in West Virginia.

Virginia

The proposed Mountain and Upland Seed Mix P-VABCHNP02 (Tables 5.7.5-7 and 5.7.5-8) was designed to be compatible with the Mountain Physiographic Region RU in areas with slopes of 15 percent or less. The mix is based on selected native grasses and forb species suitable for restoration in somewhat poorly to very poorly-drained mountainous areas in Virginia.

TABLE 5.7.5-1

Seed Mix P-MUDW01: Recommended Mountain Physiological Region
Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in West Virginia [a]

Common Name	Scientific Name	Height (feet)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS) [b]
Little Bluestem	*Schizachyrium scoparium*	2 - 4	Full Sun	0.250
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.250
Tall Dropseed	*Sporobolus compositus*	2 - 3	Full Sun	0.050
Purple Top	*Tridens flavus*	3 - 5	Part Shade	0.058
Indian Grass	*Sorghastrum nutans*	3 - 6	Full Sun	0.167
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.183
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.042
Total	—	—	—	1.0

Sources: Roundstone Native Seed, 2015; Glennon, 2015

[a] Recommended seeding application rate is 8 to 18 pounds per acre.

[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 5.7.5-2

Seed Mix P-MUDW01: Recommended Mountain Physiological Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in West Virginia

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS) [a]
Lance Leaved Coreopsis	*Coreopsis lanceolata*	Yellow	Spring,Summer	0.385
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.146
Common Milkweed	*Asclepias syriaca*	Pink	Spring, Summer	0.128
Goat's Rue	*Tephrosia virginiana*	White/Pink	Spring, Summer	0.128
Partridge Pea	*Cassia fasciculata*	Yellow	Summer	0.745
Slender Mountain Mint	*Pycnanthemum tenuifolium*	White	Summer	0.069
Early Goldenrod	*Solidago juncea*	Yellow	Summer	0.086
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.103
Spiked Blazing Star	*Liatris spicata*	Pink	Summer	0.343
Sneezeweed	*Helenium autumnale*	Yellow	Summer, Fall	0.128
Gray Goldenrod	*Solidago nemoralis*	Yellow	Fall	0.086
Iron Weed	*Vernonia altissima*	Purple	Summer, Fall	0.343
Tall Coreopsis	*Coreopsis tripteris*	Yellow	Summer, Fall	0.051
Total				2.74

Sources: Roundstone Native Seed, 2015; Glennon, 2015

[a] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 5.7.5-3

Seed Mix P-VABCHNP01: Recommended Mountain Physiographic Region
Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Little Bluestem	*Schizachyrium scoparium*	Piedmont (NC) or Suther Germplasm (NC)	8 ounces	3
Broomsedge	*Andropogon virginicus*	—	8 ounces	3
Purple Top	*Tridens flavus*	North Carolina or Kentucky Ecotype	3 ounces	3
Common milkweed	*Asclepias syriaca*	—	3 ounces	0.210

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 5.7.5-4

Seed Mix P-VABCHNP01: Recommended Mountain Physiographic Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
Pea, Partridge (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Susan, Black-eyed (B)	*Rudbeckia hirta*	Early Summer	2	3
Bergamot, Spotted (P)	*Monarda punctata*	Summer	2	3
Bergamot, Wild (P)	*Monarda fistulosa*	Summer	2	3
Beardtongue, Eastern Smooth (P)	*Penstemon laevigatus*	Late Spring	7	3
Penstemon, Talus Slope (P)	*Penstemon digitalis*	Late Spring	5	3
Slender Mountain Mint (P)	*Pycnanthemum tenuifolium*	Late Summer	1	3
New England Aster	*Aster novae-angliae*	Late Summer	2	3
Total	—	—	**64.0 ounces/acre (4.0 lbs/acre)**	**27**

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 5.7.5-5

Seed Mix P-MUMP02: Recommended Mountain Physiographic Region
Grass Seed Mix and Application Rate for Somewhat Poorly to Very Poorly Drained Sites in West Virginia [a]

Common Name	Scientific Name	Height (feet)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.233
Red Top Panicum	*Panicum rigidulum*	2 - 4	Full Sun	0.017
Fowl Manna Grass	*Glyceria striata*	3 - 5	Part Shade	0.008
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.217
Canada Wild Rye	*Elymus canadensis*	2 - 5	Part Shade	0.167
Deer Tongue Grass	*Panicum clandestinum*	2 - 4	Full Sun	0.058
Big Bluestem	*Andropogon gerardii*	4 - 10	Full Sun	0.167
Frank's Sedge	*Carex frankii*	1 - 2	Part Shade	0.042
Fox Sedge	*Carex vulpinoidea*	2 - 3	Part Shade	0.025
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.067
Total	—	–	—	1.0

Sources: Roundstone Native Seed, 2015; Glennon, 2015
[a] Recommended seeding application rate is 8 to 18 pounds per acre.
[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 5.7.5-6

Seed Mix P-MUMP02: Recommended Mountain Physiographic Region
Forb Seed Mix Application Rate for Somewhat Poorly to Very Poorly Drained Sites in West Virginia

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[a]
Ohio Spiderwort	*Tradescantia ohiensis*	Blue	Spring, Summer	0.167
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.083
Butterfly Milkweed	*Asclepias tuberosa*	Orange	Spring, Summer	0.083
Blackeyed Susan	*Rudbeckia hirta*	Yellow	Spring, Summer	0.134
Wild Senna	*Senna marilandica*	Yellow	Summer	0.668
Hoary Mountain Mint	*Pycnanthemum incanum*	White	Summer	0.033
Lupine	*Lupinus perennis*	Blue	Summer	0.501
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.083
Boneset	*Eupatorium perfoliatum*	White	Summer	0.083
Joe-Pye Weed	*Eupatorium fistulosum*	Pink	Summer, Fall	0.125
Showy Tickseed	*Bidens aristosa*	Yellow	Summer, Fall	0.501
Sneezeweed	*Helenium autumnale*	Yellow	Summer, Fall	0.125
Rough Goldenrod	*Solidago rugosa*	Yellow	Fall	0.083
Total	—	—	—	2.67

Sources: Roundstone Native Seed, 2015; Glennon, 2015
[a] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 5.7.5-7

Seed Mix P-VABCHNP02: Recommended Mountain Physiographic Region
Grass Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in Virginia [a]

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Beaked Panicum	*Panicum anceps*	SC or MD Ecotype	4 ounces	3
Redtop Panicum	*Panicum rigidulum*	NC Ecotype	3 ounces	3
Slender Rush	*Juncus tenuis*	—	1 ounce	3

Source: Glennon, 2015; Roundstone Native Seed, 2017.
[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 5.7.5-8

Seed Mix P-VABCHNP02: Recommended Mountain Physiographic Region
Forb Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre	Seeds per Square Foot
New England Aster	*Symphyotrichum puniceum*	Fall	3	3
Bergamot, Wild (P)	*Monarda fistulosa*	Summer	1	3
Ironweed, New York (P)	*Vernonia novaboracensis*	Late Summer	7	3
Rough-stemmed goldenrod	*Solidago rugosa*	Late Summer	3	3
Joe Pye Weed, Spotted (P)	*Eutrochium fistulosus*	Late Summer	2	3
Pea, Partridge (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Rosemallow (P)	*Hibiscus moscheutos*	Summer	2	3
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
Total	—	—	**61.0 ounces/ acre (3.8 lbs/acre)**	**24**

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

Pennsylvania

In Pennsylvania, the SHP pipeline (approximately 3.9 miles) will be collocated with DTI's existing LN-25 pipeline in Westmoreland County. In general, the SHP pipeline will be constructed within and directly adjacent to the existing LN-25 pipeline rights-of-way which is seeded with cool season grasses. As presented in Appendix B, the recommended seed mixtures, rates, and amendments for the SHP were based on existing site conditions and compatibility with existing grasses, which includes the use of cool season grasses. No pollinator species specific to the area were recommended.

5.7.5.3 Piedmont Physiographic Region Seed Mixes

Excessively to Moderately Well Drained Sites

Virginia

The proposed Mountain Physiographic Seed Mix P-VABCHNP01 that is described in Section 5.7.5.2 was designed to also be compatible with the Piedmont Physiographic Region RU in excessively to moderately well drained areas in Virginia.

Somewhat Poorly to Very Poorly Drained Sites

Virginia

The proposed Mountain Physiographic Seed Mix P-VABCHNP02 described in Section 5.7.5.2 was designed to also be compatible with the Piedmont Physiographic Region RU in somewhat poorly to very poorly drained sites in Virginia.

5.7.5.4 Coastal Plain Physiographic Region Seed Mixes

Excessively to Moderately Well Drained Sites

Virginia

The proposed Coastal Plain Seed Mix P-VACSDGS01 (Tables 5.7.5-9 and 5.7.5-10) was designed to be compatible with the Coastal Plain Physiographic Region RU in areas with slopes of 15 percent or less. The mix is based on selected native grass and forb species suitable for restoration in excessively to moderately well drained coastal areas in Virginia.

North Carolina

The proposed Coastal Plain Seed Mix P-CPDW01 (Tables 5.7.5-11 and 5.11.5-12) was designed to be compatible with the Coastal Plain Physiographic Region RU in areas with slopes of 15 percent or less and is based on selected native grass and forb species suitable for restoration in excessively to moderately well drained coastal areas in North Carolina.

Somewhat Poorly to Very Poorly Drained Sites

Virginia

The proposed Coastal Plain Seed Mix P-VACSDGS02 (Tables 5.7.5-13 and 5.7.5-14) was designed to be compatible with the Coastal Plain Physiographic Region RU in areas with slopes of 15 percent or less. The mix is based on selected native grass and forb species suitable for restoration in somewhat poorly to very poorly drained coastal areas in Virginia.

TABLE 5.7.5-9

Seed Mix P-VACSDGS01: Recommended Coastal Plain Physiographic Region
Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Little Bluestem	*Schizachyrium scoparium*	Piedmont (NC) or Suther Germplasm (NC)	8 ounces	3
Splitbeard Bluestem	*Andropogon ternarius*	Virginia Ecotype	8 ounces	3
Common milkweed	*Asclepias syriaca*	—	3 ounces	0.21

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 5.7.5-10

Seed Mix P-VACSDGS01: Recommended Coast Plain Physiographic Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Mountain Mint, Narrowleaf (P)	*Pycnanthemum tenuifolium*	Late Summer	1	3
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
Pea, Partridge (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Susan, Black-eyed (B)	*Rudbeckia hirta*	Early Summer	2	3
Bergamot, Spotted (P)	*Monarda punctata*	Summer	2	3
Beardtongue, Eastern Smooth (P)	*Penstemon laevigatus*	Late Spring	7	3
Penstemon, Talus Slope (P)	*Penstemon digitalis*	Late Spring	5	3
Bergamot, Wild (P)	*Monarda fistulosa*	Summer	2	3
Total	—	—	**65.0 ounces/acre (4.4 lbs/acre)**	**24**

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 5.7.5-11

Seed Mix P-CPDW01: Recommended Coastal Plain Physiographic Region
Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in North Carolina

Common Name	Scientific Name	Height (feet)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Little Bluestem	*Schizachyrium scoparium*	2- 4	Full Sun	0.250
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.250
Tall Dropseed	*Sporobolus compositus*	2 - 3	Full Sun	0.050
Purple Top	*Tridens flavus*	3 - 5	Part Shade	0.058
Indian Grass	*Sorghastrum nutans*	3 - 6	Full Sun	0.167
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.183
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.042
Total	—	—	—	**1.0**

Sources: Roundstone Native Seed, 2017; Glennon, 2017.
[a] Recommended seeding application rate is 8 to 18 pounds per acre.
[b] lbs/acre/PLS = pounds per acre of pure live seed.

TABLE 5.7.5-12

Seed Mix P-CPDW01: Recommended Coastal Plain Physiographic Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in North Carolina

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[a]
Lance Leaved Coreopsis	*Coreopsis lanceolata*	Yellow	Spring, Summer	0.266
Spotted Beebalm	*Monarda punctata*	Pink	Spring, Summer	0.124
Common Milkweed	*Asclepias syriaca*	Pink	Spring, Summer	0.107
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.107
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.124
Partridge Pea	*Cassia fasciculata*	Yellow	Summer	0.621
Spiked Blazing Star	*Liatris spicata*	Pink	Summer	0.222
Lupine	*Lupinus perennis*	Blue	Summer	0.497
Early Goldenrod	*Solidago juncea*	Yellow	Summer	0.160
Starry Silphium	*Silphium asteriscus*	Yellow	Summer, Fall	0.178
Iron Weed	*Vernonia altissima*	Purple	Summer, Fall	0.222
Sneezeweed	*Helenium autumnale*	Yellow	Summer, Fall	0.124
Hairy Mountain Mint	*Pycnanthemum pilosum*	White	Summer, Fall	0.089
Total	—	—	—	**2.84**

Sources: Roundstone Native Seed, 2017; Glennon, 2017.
[a] lbs/acre/PLS = pounds per acre of pure live seed.

TABLE 5.7.5-13

Seed Mix P-VACSDGS02: Recommended Coastal Plant Physiographic Region
Grass Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Panicum, Beaked	*Panicum anceps*	SC or MD Ecotype	4 ounces	3
Panicum, Redtop	*Panicum rigidulum*	NC Ecotype	3 ounces	3

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 5.7.5-14

Seed Mix P-VACSDGS02: Recommended Coastal Plant Physiographic Region
Forb Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate (weight of bulk seed per acre)	Seeds per Square Foot
New England Aster	*Aster novae-angliae*	Fall	3	3
Sneezeweed, Common (P)	*Helenium autumnale*	Fall	2	3
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
New York Ironweed (P)	*Vernonia nova boracensis*	Late Summer	7	3
Goldenrod, Wrinkleleaf (P)	*Solidago rugosa*	Late Summer	2	3
Joe Pye Weed, Spotted (P)	*Eutrochium fistulosus*	Late Summer	2	3
Partridge Pea (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Rosemallow (P)	*Hibiscus moscheutos*	Summer	2	3
Narrowleaf Sunflower (P)	*Helianthus angustifolius*	Late Summer	4	3
Total	—	—	**65.0 ounces/acre (4.1 lbs/acre**	**27**

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

North Carolina

The proposed Coastal Plain Seed Mix P-CPDW02 (Tables 5.7.5-15 and 5.7.5-16) was designed to be compatible with the Coastal Plain Physiographic Region RU in areas with slopes of 15 percent or less and is based on selected native grass and forb species suitable for restoration in somewhat poorly to very poorly drained coastal areas in North Carolina.

TABLE 5.7.5-15

Seed Mix P-CPDW02: Recommended Coastal Plain Physiographic Region
Grass Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in North Carolina [a]

Common Name	Scientific Name	Height (feet)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.233
Red Top Panicum	*Panicum rigidulum*	2 - 4	Full Sun	0.017
Fowl Manna Grass	*Glyceria striata*	3 - 5	Part Shade	0.008
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.217
Deer Tongue Grass	*Panicum clandestinum*	2 - 4	Full Sun	0.058
Big Bluestem	*Andropogon gerardii*	4 - 10	Full Sun	0.167
Frank's Sedge	*Carex frankii*	1 - 2	Part Shade	0.042
Fox Sedge	*Carex vulpinoidea*	2 - 3	Part Shade	0.025
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.067
Total	—	—	—	0.83

Sources: Roundstone Native Seed, 2015; Glennon, 2015

[a] Recommended seeding application rate is 8 to 18 pounds per acre.

[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 5.7.5-16

Seed Mix P-CPDW02: Recommended Coastal Plain Physiographic Region
Forb Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in North Carolina

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[a]
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.169
Butterfly Milkweed	*Asclepias tuberosa*	Orange	Spring, Summer	0.056
Ohio Spiderwort	*Tradescantia ohiensis*	Blue	Spring, Summer	0.084
Blackeyed Susan	*Rudbeckia hirta*	Yellow	Spring, Summer	0.180
Spiked Blazing Star	*Liatris spicata*	Pink	Summer	0.264
Hoary Mountain Mint	*Pycnanthemum incanum*	White	Summer	0.034
Early Goldenrod	*Solidago juncea*	Yellow	Summer	0.113
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.169
Showy Tickseed	*Bidens aristosa*	Yellow	Summer, Fall	0.366
Starry Silphium	*Silphium asteriscus*	Yellow	Summer, Fall	0.113
Narrow-Leaved Sunflower	*Helianthus angustifolius*	Yellow	Summer, Fall	0.113
Joe-Pye Weed	*Eupatorium fistulosum*	Pink	Summer, Fall	0.141
Total	—	—	—	2.84

Sources: Roundstone Native Seed, 2015; Glennon, 2015

[a] lbs/acre/PLS = pounds per acre of pure live seed

5.7.6 Seeding Methods

Seeding may be conducted with the use of a seed drill, a mechanical broadcast seeder, or by hydroseeding. In the absence of requirements to the contrary, the standard application method will be seeding with a seed drill equipped with a cultipacker. In rocky soils or where site conditions may limit the effectiveness of this equipment, other alternatives may be appropriate (e.g., use of a chain drag) to lightly cover seed after application, as approved by an EI. Broadcast or hydroseeding at double the recommended seeding rates may be used in lieu of drilling (see Appendix B for recommendations).

Broadcast seeding will be used for areas with minimal to moderate slopes and will be performed by dry dispersal or wet broadcast seeding. Wet broadcast seeding is an effective treatment for temporary erosion control and may be used when hydroseeding late in the season or on certain site conditions where hydroseeding is not practical. To support successful seed germination, seed will be broadcast once soil compaction has been rectified and soil composition includes proper aeration and water percolation to support plant development. Where seed is broadcast, the seedbed will be restructured with a cultipacker or imprinter after seeding. Once seed is broadcast, Atlantic and DTI will rake the area lightly to encourage plant establishment and minimize the seed that migrates from the site (North Carolina Department of Environment and Natural Resources, 2009).

Hydroseeding involves the mixing of slurry (i.e., seed, water, fertilizer, tackifier, or mulch) in a truck-mounted mixing tank and ground application via a pressurized pump. Hydroseeding is the preferred method of seed dispersal on steep slopes greater than 60 percent, where site conditions require seed adherence to the disturbed soil. Prior to hydroseeding, Atlantic and DTI will scarify the seedbed to facilitate lodging and germination of seed. Tackifiers will be applied where necessary so that seed adheres to soil. Polymer binders, if selected, will be used in accordance with manufacturer’s specifications to ensure proper compatibility with fertilizers and to avoid foaming that might otherwise result from excessive agitation. All chemical components will be mixed and administered in accordance with manufacturer and applicable agency guidelines. In addition, hydroseeding near wetlands or waterbodies will only be conducted in accordance with the FERC Plan and Procedures and other applicable agency regulations.

5.8 SEEDBED AUGMENTATION

5.8.1 Lime and Fertilizer Application

Lime and fertilizer recommendations provided by the various Federal, State/Commonwealth, local and land management and subject matter experts consulted for each County/City are provided in Appendix B. Each county crossed by the Projects may have different fertilization and liming requirements based on the soil characteristics and the proposed seed mix prescriptions. In general, and in accordance with the Plan and Procedures, upland areas will have a fertilizer and pH supplement (i.e., lime) mixed in to the upper two inches of topsoil. No lime or fertilizer will be used within 100 feet of wetlands or waterbodies or within 300 feet of karst features. In upland areas without specific fertilization requirements, Atlantic and DTI will:

- apply 150 pounds per acre of 10-20-20 (or similar) fertilizer;
- apply phosphorus or potassium during the same installation, if required;
- avoid fertilizer drift through restricted application times that exclude periods of high winds or heavy rains; and
- store and mix all fertilizers in upland areas and away from karst features, so as to avoid wetlands, waterbodies, or karst features.

5.8.2 Mulching

Mulching recommendations provided by the various Federal, State/Commonwealth, local and land management agencies, and subject matter experts consulted for each County/City are provided in Appendix B. Each County/City crossed by the Projects may have different mulching requirements based on the landscape characteristics, soil types, and the proposed seed mix prescriptions. In general, and in accordance with the Plan, Atlantic and DTI will apply mulch to slopes immediately after seeding to prevent erosion. In non-forested areas, mulch will be spread uniformly over a minimum of 75 percent of the surface at a rate of 2 tons per acre, or 1 ton per acre if wood chips are used, or per directions from land managing agencies or landowners. In forested areas, if the amount of mulch will likely exceed these parameters due to the shredding of non-merchandisable forest materials cleared from the rights-of-way, Atlantic and DTI will request a variance from FERC prior to applying mulch greater than 1 ton/acre. Mulch materials will be anchored to the soil with stakes or liquid mulch tackifiers. No tackifiers will be used within 100 feet of wetlands and waterbodies or within 300 feet of karst features.

Possible mulch materials and application techniques are described below.

- Salvaged wood materials, including slash and non-merchantable timber, will be retained in forested areas and placed on the rights-of-way after final grading, re-contouring, and seeding is complete. Woody debris is expected to support revegetation while preventing erosion and providing micro-habitat for various species.
- Native wood chip materials will be used in forested systems and will be generated from cleared materials that are chipped and stockpiled on the edge of the rights-of-way. Native wood chips are expected to aid in the successful revegetation of disturbed areas.
- Wood fiber hydromulch may be used in shrubby areas to augment biomass salvaged during clearing. Hydromulch is evenly distributed and absorbs water quickly, which enhances seed survival rates and discourages erosion during regeneration of shrubby species.
- Bonded fiber matrix (BFM), a type of hydromulch designed to control erosion on steep slopes, may also be used where appropriate. BFM slurry contains thermally processed wood fibers (approximately 80 percent), water (approximately

10 percent), and tackifiers and polymer-based binding agents that are quick to dry upon application. BFM is hydraulically applied, which allows for controlled application on steep slopes where access may be difficult. BFM will only be applied to stable slopes where final grading has been completed and water runoff has been diverted from the slope face. Once BFM has had 24 to 48 hours to cure, an erosion-resistant blanket is formed that is flexible, absorbent, and biodegradable, and that will accelerate plant growth. BFM may be used in conjunction with slope breakers and other erosion control devices on slopes longer than 70 feet. BFM application rates will depend on manufacturers specifications, based upon the slope of the disturbed areas.

- Straw or hay that has been certified as weed-free will be used to preserve the soil base in areas where native salvaged material is not available. In areas that are seeded by drill, Atlantic and DTI will apply one bale of clean straw or hay per 1,000 square feet. Where broadcast seeding is used, Atlantic and DTI will apply two bales of clean straw or hay per 1,000 square feet, or in accordance with requirements specified by Federal or State/Commonwealth land managing agencies.

5.8.3 Supplemental Plantings

Where required, Atlantic and DTI may supplement seeding with the planting of tree seedlings or small shrubs. No supplemental plantings are anticipated for maintained areas within the permanent easements for the pipelines. Public lands will be revegetated in accordance with land management objectives and direction from land managing agencies (see Sections 5.0 and 6.0).

5.9 RIPARIAN RESTORATION

Following initial stream bank stabilization, Atlantic and DTI will restore the banks of waterbodies to preconstruction contours to the extent practicable. In steep-slope areas, re-grading may be required to reestablish stable contours capable of supporting preconstruction drainage patterns. Riparian areas will be revegetated with native species across the entire width of the construction corridor. Restoration of riparian areas will be designed to:

- restore stream bank integrity, including both shore crossings up to the ordinary high water mark;
- withstand periods of high flow without increasing erosion and downstream sedimentation; and
- include temporary erosion control fencing, which will remain in place until stream bank and riparian restoration is complete.

Permanent bank stabilization and erosion control devices (e.g., natural structures, rock riprap, and/or large woody debris) will be installed as necessary on steep banks in accordance with permit requirements to permanently stabilize the banks and minimize sediment deposition into waterbodies.

5.9.1 Non-forested Riparian Areas

All disturbed banks and riparian work areas will be seeded as soon as possible after final grading, weather and soil conditions permitting and subject to the recommended seeding dates for the area. Seeding is intended to stabilize the soil, improve the appearance of the area disturbed by construction, and restore native flora. As discussed above, Atlantic and DTI will determine appropriate seeding prescriptions based upon the vegetative community of the disturbed area, and will continue to consult with land managing agencies regarding seeding requirements for riparian areas.

5.9.2 Forested Riparian Areas

Restoration of forested riparian areas will include seeding as discussed above, and may include supplemental plantings of tree seedlings and shrubs. Clearing of riparian trees in forested areas will reduce shade near streams, and may allow for an increase in local water temperature. Large woody debris, where available and appropriate habitat conditions exist, will be placed adjacent to waterbody crossings to add shade and fish habitat. Forested riparian areas will be restored and enhanced using plantings of native shrubs and trees, excluding the permanent easement, which will be retained in an herbaceous state. On a site-specific basis and in consultation with land managing agencies or landowners, Atlantic and DTI will design riparian revegetation with the use of fast growing native trees and shrubs placed closest to the bank top to provide canopy recovery as quickly as possible to shade and overhang the waterbodies. Restoration of forested riparian areas on Federal and State/Commonwealth lands will be determined based upon consultations with the appropriate land managing agencies.

5.10 WETLAND RESTORATION

Atlantic and DTI will employ clearing and construction techniques designed to support regeneration of existing wetland vegetation, including the following:

- clearing vegetation at ground level in all non-forested wetland areas outside of the trench line to leave existing root systems intact to help stabilize soils, preserve existing ground elevations, and promote revegetation through sprouting and from existing seed stocks;
- using equipment mats to prevent soil compaction and allow intact root systems to regrow;
- replacing the topsoil segregated from the trenchline in unsaturated wetlands to promote reestablishment of existing wetland species and preserving the vegetative propagules (i.e., seeds, tubers, rhizomes, and bulbs) within the soil, which will have the potential to germinate or sprout when the topsoil is replaced; and
- limiting the removal of stumps to the trench area in forested wetlands, except where safety considerations necessitate additional stump removal, as retained

stumps will facilitate reestablishment of woody species by enabling re-sprouting from existing root structures.

In accordance with the Procedures, sediment barriers will be installed immediately following clearing activities occurring within wetlands or adjacent upland areas along the pipeline rights-of-way. Where necessary, sediment barriers will be installed across the construction rights-of-way immediately upslope of the wetland boundary to prevent sediment flow into wetlands. Sediment barriers will be properly maintained throughout construction, reinstalled as necessary, and removed after restoration is complete and revegetation has stabilized the disturbed areas.

Seeding of wetlands is not anticipated as wetlands are expected to naturally revegetate. Unless specified by landowners or land managing agencies, revegetation will be monitored annually until wetland revegetation is successful in accordance with the Procedures. Wetland revegetation will be considered successful when vegetation community characteristics are similar to the vegetation in adjacent wetland areas that were not disturbed by construction. As described in the Procedures, restored wetland vegetation will include at least 80 percent of the species targeted for restoration, and the density (i.e., percent cover) and distribution (e.g., microsites and patches) of individual plants will be similar to areas not disturbed by construction. Revegetation requirements appropriate for Federal and State/Commonwealth lands will be determined through consultation with those agencies.

After revegetation, Atlantic and DTI anticipate no permanent impact on emergent wetland vegetation within the rights-of-way. Scrub-shrub and forested wetlands will not be allowed to fully reestablish within portions of the permanent rights-of-way centered over the pipeline trench lines. Atlantic and DTI will periodically remove woody species from wetlands to facilitate post-construction inspections of the permanently maintained rights-of-way. Where the pipelines cross wetlands, Atlantic and DTI will maintain a 10-foot-wide corridor centered over the pipelines in an herbaceous condition, and remove deep rooted trees within a 30-foot-wide corridor centered over the pipelines.

5.11 AGRICULTURAL AREAS

Atlantic and DTI will work with individual landowners to address restoration of active agricultural areas. Generally, agricultural areas will be replanted by the landowner or tenant, unless otherwise requested by the landowner. Anticipated impacts on and restoration of irrigation systems, drain tiles, gates, and other structures are discussed in Resource Report 8.

5.12 EXPOSED BEDROCK

In areas with exposed bedrock or bedrock, Atlantic and DTI will restore the area using crushed rock rather than attempting to revegetate the area.

5.13 UPLAND FOREST

Atlantic and DTI have prepared and will implement a *Timber Removal Plan*, which describes construction and restoration activities in areas where timber is removed. The plan also addresses compensation for loss of merchantable timber as well as elements of timber removal/sale that are unique to public lands. Elements of the plan include:

- completion of a timber cruise to appraise the value of merchantable timber;
- installation of flagging/fencing of timber removal limits, riparian areas, and other exclusion zones prior to timber removal operations;
- identification of access and staging requirements for timber removal, including log landing locations, temporary bridges at waterbody crossings, etc.; and
- identification of timber removal methods (e.g., high line yarder logging, mechanical harvesting, helicopter logging).

Following construction in forested areas, seed mixes, and/or seedlings will be planted in temporary workspace areas in accordance with recommendations from the NRCS, land managing or other applicable agencies, and operators of commercial tree farms. In non-cultivated uplands, including forested areas, the permanent easement for each pipeline will be maintained in an herbaceous state.

6.0 FEDERAL LANDS

The AP-1 mainline will cross approximately 5.5 miles of Federal lands in the Monongahela National Forest and approximately 14.5 miles of Federal lands in the George Washington National Forest, which are administered by the USFS. As described in Atlantic's and DTI's Resource Reports, Federal lands are managed in accordance with various management directives, including standards and guidelines for restoration and revegetation activities. Restoration activities on Federal lands will be in accordance with these standards and guidelines. Additional or site-specific requirements for restoration of Federal lands will be addressed in a Construction, Operations, and Maintenance Plan to be developed in conjunction with USFS staff.

Consultation with USFS staff regarding seed mixes, soil amendments, and application rates, including appropriate cultural practices recommended by USFS staff to be used in the Monongahela National and George Washington National Forest is ongoing. This information will be provided in Appendix B when consultation is complete.

In addition to USFS lands, the AP-1 mainline will also cross approximately 0.1 mile of National Park Service lands along the Blue Ridge Parkway. Atlantic is proposing the use of the horizontal directional drill construction method to install the proposed pipeline under the Blue Ridge Parkway at this location. The horizontal directional drill method will avoid direct impacts on the parkway, including impacts on adjacent vegetation.

7.0 STATE LANDS

In West Virginia, the AP-1 mainline crosses 3.8 miles of the Seneca State Forest in Pocahontas County, West Virginia, and the SHP crosses approximately 3.6 miles of the Lewis Wetzel WMA in Wetzel County, West Virginia. Seneca State Forest is managed by the WV Division of Forestry and the Lewis Wetzel WMA is managed by the West Virginia Department of Natural Resources. The AP-1 mainline crosses 1.2 miles of the James River WMA in Nelson County, Virginia, which is managed by the Virginia Department of Game and Inland Fisheries.

The seed mixes, soils amendments, and application rates, including appropriate cultural practices recommended by the State/Commonwealth staff, for the Lewis Wetzel WMA and James River WMA are provided in Appendix B. In Virginia, the Department of Game and Inland Fisheries has indicated that it may want to be responsible for replanting the rights-of-way on its lands. Consultation with the WV Division of Forestry regarding seed mixes, soil amendments, and application rates is ongoing. This information will be provided in Appendix B when consultation is complete.

8.0 RESTORATION MONITORING AND MAINTENANCE

8.1 MONITORING

The general objectives of the monitoring program will be to determine the status and effectiveness of restoration efforts and to determine locations where additional maintenance may be required. Atlantic and DTI will inspect disturbed areas after the first and second growing seasons to determine the success of revegetation. In agricultural areas, revegetation will be considered successful when the area has been revegetated and is similar to adjacent undisturbed areas of the same field. In all other non-forested areas, revegetation will be considered successful when the density and cover of non-nuisance vegetation is similar to adjacent areas that were not disturbed by construction activities. In Federal and State/Commonwealth forested areas, monitoring activities will be performed until reforestation is determined successful based on pre-defined success criteria, as determined through consultations with Federal and State/Commonwealth land managing agencies.

Atlantic and DTI will continue revegetation efforts until they are successful. Restoration will be considered successful when construction debris is removed, similar vegetative cover or bedrock has been restored, the original surface elevations are restored as closely as practicable to preconstruction contours, the surface condition is similar to adjacent non-disturbed areas, and proper drainage is restored.

8.2 GRAZING DEFERMENTS

Where warranted, Atlantic and DTI will work with landowners or lessees to implement grazing deferment plans (e.g., by fencing off restoration sites) to minimize impacts on emergent vegetation due to grazing.

8.3 PERMANENT RIGHTS-OF-WAY MAINTENANCE

In order to maintain accessibility of the rights-of-way and to accommodate pipeline integrity surveys, vegetation within the permanent easements will be periodically cleared over the pipelines. In accordance with the Plan, in non-cultivated uplands, a 10-foot-wide herbaceous corridor may be maintained annually, as needed. In addition, trees and brush will be cleared over the entire width of the permanent rights-of-way on an as-needed basis not to exceed once every 3 years. In wetlands and riparian areas, the Procedures allow a 10-foot-wide corridor centered over pipelines to be permanently maintained in an herbaceous state. The Procedures also allow for cutting and removing trees greater than 15 feet in height within 15 feet of pipelines in wetlands.

Atlantic and DTI will use mechanical mowing or cutting along their rights-of-way for normal vegetative maintenance. Atlantic and DTI will monitor the rights-of-way for infestations of invasive species that may have been created or exacerbated by construction, restoration, or maintenance activities, and will treat such infestations in consultation with landowners and applicable agencies in accordance with its *Invasive Species Management Plan*.

9.0 ROLES AND RESPONSIBILITIES

9.1 ENVIRONMENTAL INSPECTORS

EIs will have the authority to stop activities that violate environmental conditions of Federal or State/Commonwealth environmental permits and landowner agreements and to order appropriate corrective action. During revegetation and restoration, the EIs will be responsible for:

- ensuring compliance with the requirements of the Plan and Procedures; Atlantic's and DTI's construction, restoration, and mitigation plans; conditions required by permits and other approvals; this Restoration and Rehabilitation Plan; and environmental requirements identified in landowner easement agreements;
- identifying, documenting, and overseeing corrective actions, as necessary, to bring an activity back into compliance;
- verifying that the limits of authorized construction work areas and locations of access roads are visibly marked before clearing;
- verifying the location of restoration sites, and maintaining appropriate signage for boundaries of sensitive resource areas, waterbodies, wetlands, farm improvements (i.e., repair of fences, drain tiles, irrigation systems, or structures), or areas with special restoration requirements;
- monitoring erosion and sediment control devices and soil stabilization measures in construction areas, and identifying additional needs for new controls or maintenance of existing controls;
- verifying that dewatering activities are properly monitored and do not result in the deposition of sand, silt, and/or sediment into sensitive environmental resource areas, including but not limited to wetlands, waterbodies, cultural resource sites, and sensitive species habitats;
- ensuring that subsoil and topsoil are tested in agricultural and residential areas to measure compaction and determine the need for corrective action;

- advising the Construction Inspector when environmental conditions (such as wet or frozen soils) make it advisable to restrict or delay construction activities to avoid topsoil mixing or excessive compaction;

- ensuring restoration of contours and topsoil;

- verifying that soils imported for agricultural or residential use have been certified as free of invasive species and soil pests, unless otherwise approved by the landowner;

- determining the need for and ensuring that erosion controls are properly installed, as necessary, to prevent sediment flow into wetlands, waterbodies, sensitive areas, and onto roads;

- inspecting and ensuring the maintenance of temporary erosion control measures at least:

    - on a daily basis in areas of active construction or equipment operation;

    - on a weekly basis in areas with no construction or equipment operation; and

    - within 24 hours of each 0.5 inch of rainfall.

- ensuring the repair of all ineffective temporary erosion control measures within 24 hours of identification;

- keeping records of compliance or non-compliance with conditions of environmental regulatory permits and approvals, including activities that could result in decertification of organic farms; and

- identifying areas that will require special attention to ensure stabilization and restoration success.

Where appropriate for local resource needs, the role of EIs may be filled by agricultural or horticultural specialists.

9.2 DOCUMENTATION

In accordance with the Plan, Atlantic and DTI will maintain post-construction records of activities performed and will submit quarterly activity reports to the FERC. Reports will document any issues that arise during revegetation, including those identified by the landowner or land managing agency, and corrective actions taken for at least two years following construction. Reports will identify by milepost:

- method of application, application rate, and type of fertilizer, pH modifier, seed, and mulch used;

- acreage treated;
- dates of backfilling and seeding;
- names of landowners requesting special seeding treatment and a description of the follow-up actions;
- the location of subsurface drainage repairs or improvements made during restoration; and
- problem areas, such areas where vegetation did not establish or erosion occurred, and how they were addressed.

10.0 REFERENCES

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Restoration and Rehabilitation Plan

Appendix A
Major Soil Drainage and Slope Classes Crossed by the Projects

TABLE 5.6-1

Atlantic Coast Pipeline and Supply Header Project
Major Soil Drainage and Slope Classes Crossed by the Projects

Project /State or Commonwealth/County	Drainage Class [a]	Crossing Length (miles)		
		Total	0-15% [b]	>16% [b]
ATLANTIC COASTAL PIPELINE				
West Virginia				
Harrison	Excessively to Moderately Well Drained	1.0	0.2	0.8
	Somewhat Poorly to Very Poorly Drained	0.1	<0.1	<0.1
	Total	1.1	0.3	0.8
Lewis	Excessively to Moderately Well Drained	19.8	6.9	12.9
	Null [b/]	0.1	<0.1	0.1
	Total	19.9	6.9	13.0
Upshur	Excessively to Moderately Well Drained	21.5	8.8	12.7
	Somewhat Poorly to Very Poorly Drained	0.6	0.6	<0.1
	Null	0.1	0.1	<0.1
	Total	22.2	9.5	12.7
Randolph	Excessively to Moderately Well Drained	28.6	12.3	16.3
	Somewhat Poorly to Very Poorly Drained	0.3	0.3	0.00
	Null	1.9	1.4	0.5
	Total	30.8	14.0	16.8
Pocahontas	Excessively to Moderately Well Drained	23.4	8.4	15.0
	Somewhat Poorly to Very Poorly Drained	0.8	0.8	<0.1
	Null	<0.1	<0.1	0.00
	Total	24.3	9.3	15.0
Virginia				
Highland	Excessively to Moderately Well Drained	10.5	3.0	7.5
	Somewhat Poorly to Very Poorly Drained	0.1	0.1	0.0
	Null	<0.1	<0.1	0.0
	Total	10.6	3.1	7.5
Bath	Excessively to Moderately Well Drained	20.4	9.6	10.8
	Somewhat Poorly to Very Poorly Drained	1.2	1.2	0.00
	Null	<0.1	<0.1	<0.1
	Total	21.6	10.8	10.8
Augusta	Excessively to Moderately Well Drained	50.4	35.5	14.9
	Somewhat Poorly to Very Poorly Drained	1.9	1.9	<0.1
	Null	2.0	1.1	0.9
	Total	54.3	38.5	15.8
Nelson	Excessively to Moderately Well Drained	26.9	10.3	16.7
	Somewhat Poorly to Very Poorly Drained	0.3	0.3	<0.1
	Null	<0.1	<0.1	0.0
	Total	27.3	10.6	16.7
Buckingham	Excessively to Moderately Well Drained	22.8	20.0	2.7
	Somewhat Poorly to Very Poorly Drained	4.9	4.6	0.3
	Null	<0.1	<0.1	0.0
	Total	27.7	24.7	3.0
Cumberland	Excessively to Moderately Well Drained	8.5	7.8	0.7
	Somewhat Poorly to Very Poorly Drained	0.5	0.5	0.0
	Null	<0.1	<0.1	0.0
	Total	9.1	8.4	0.7

TABLE 5.6-1 (cont'd)

Atlantic Coast Pipeline and Supply Header Project
Major Soil Drainage and Slope Classes Crossed by the Projects

Project /State or Commonwealth/County	Drainage Class [a]	Crossing Length (miles)		
		Total	0-15% [b]	>16% [b]
Prince Edward	Excessively to Moderately Well Drained	5.0	4.1	0.9
	Somewhat Poorly to Very Poorly Drained	0.2	0.2	<0.1
	Null	<0.1	<0.1	0.0
	Total	5.2	4.3	0.9
Nottoway	Excessively to Moderately Well Drained	21.1	19.1	2.0
	Somewhat Poorly to Very Poorly Drained	2.3	2.2	0.1
	Null	<0.1	<0.1	0.0
	Total	23.4	21.3	2.1
Dinwiddie	Excessively to Moderately Well Drained	11.0	10.9	0.1
	Somewhat Poorly to Very Poorly Drained	0.8	0.8	0.0
	Total	11.8	11.7	0.1
Brunswick	Excessively to Moderately Well Drained	21.4	21.2	0.2
	Somewhat Poorly to Very Poorly Drained	1.6	1.6	<0.1
	Total	23.0	22.8	0.2
Greensville	Excessively to Moderately Well Drained	11.4	11.1	0.3
	Somewhat Poorly to Very Poorly Drained	7.1	7.1	0.0
	Null	0.1	0.1	0.0
	Total	18.6	18.3	0.3
Southampton	Excessively to Moderately Well Drained	16.1	16.0	<0.1
	Somewhat Poorly to Very Poorly Drained	10.0	10.0	0.0
	Null	<0.1	<0.1	0.0
	Total	26.1	26.1	<0.1
City of Suffolk	Excessively to Moderately Well Drained	16.2	15.8	0.4
	Somewhat Poorly to Very Poorly Drained	16.4	16.3	0.1
	Null	0.6	0.6	0.0
	Total	33.2	32.7	0.5
City of Chesapeake	Excessively to Moderately Well Drained	0.6	0.6	0.0
	Somewhat Poorly to Very Poorly Drained	9.0	9.0	0.0
	Null	1.7	1.7	0.0
	Total	11.3	11.3	0.0
North Carolina				
Northampton	Excessively to Moderately Well Drained	17.8	17.6	0.2
	Somewhat Poorly to Very Poorly Drained	4.2	4.2	<0.1
	Null	0.1	0.1	0.0
	Total	22.1	21.9	0.2
Halifax	Excessively to Moderately Well Drained	16.8	16.6	0.2
	Somewhat Poorly to Very Poorly Drained	7.5	7.5	<0.1
	Null	0.0	0.0	0.0
	Total	24.3	24.1	0.2
Nash	Excessively to Moderately Well Drained	20.1	19.9	0.2
	Somewhat Poorly to Very Poorly Drained	11.8	11.8	0.0
	Null	<0.1	<0.1	0.0
	Total	31.9	31.7	0.2
Wilson	Excessively to Moderately Well Drained	6.5	6.5	0.0
	Somewhat Poorly to Very Poorly Drained	5.4	5.4	<0.1
	Total	11.9	11.9	<0.1

TABLE 5.6-1 (cont'd)

Atlantic Coast Pipeline and Supply Header Project
Major Soil Drainage and Slope Classes Crossed by the Projects

Project /State or Commonwealth/County	Drainage Class [a]	Crossing Length (miles)		
		Total	0-15% [b]	>16% [b]
Johnston	Excessively to Moderately Well Drained	19.0	19.0	<0.1
	Somewhat Poorly to Very Poorly Drained	19.1	19.1	0.0
	Null	<0.1	<0.1	0.0
	Total	38.1	38.1	<0.1
Sampson	Excessively to Moderately Well Drained	4.7	4.7	0.0
	Somewhat Poorly to Very Poorly Drained	3.1	3.1	0.0
	Total	7.8	7.8	0.0
Cumberland	Excessively to Moderately Well Drained	16.8	16.7	0.1
	Somewhat Poorly to Very Poorly Drained	22.7	22.7	0.0
	Null	0.1	0.1	0.0
	Total	39.6	39.5	0.1
Robeson	Excessively to Moderately Well Drained	9.4	9.4	0.0
	Somewhat Poorly to Very Poorly Drained	13.1	13.1	0.0
	Total	22.5	22.5	0.0
TOTAL		**599.7**	**482.1**	**117.6**
SUPPLY HEADER PROJECT				
Pennsylvania				
Westmoreland	Excessively to Moderately Well Drained	3.8	2.2	1.6
	Somewhat Poorly to Very Poorly Drained	0.1	0.1	0.0
	Total	3.9	2.3	1.6
West Virginia				
Harrison	Excessively to Moderately Well Drained	0.3	0.2	0.1
	Somewhat Poorly to Very Poorly Drained	0.3	0.1	0.2
	Total	0.6	0.3	0.3
Doddridge	Excessively to Moderately Well Drained	22.1	4.2	17.9
	Null	0.1	0.1	<0.1
	Total	22.2	4.3	17.9
Tyler	Excessively to Moderately Well Drained	0.8	0.1	0.7
	Total	0.8	0.1	0.7
Wetzel	Excessively to Moderately Well Drained	10.0	1.2	8.8
	Total	10.0	1.2	8.8
TOTAL		**37.5**	**8.2**	**29.3**
GRAND TOTAL		**637.2**	**490.3**	**146.9**

[a] Null = soil map units with no assigned drainage class.

[b] Slope was determined using available digital elevation model raster data and running the slope analysis tool in ArcGIS: ArcMap. The drainage classes were determined using the SSURGO database.

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Restoration and Rehabilitation Plan

Appendix B
Recommended Seed Mix Prescriptions and Soil Amendments

ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE
Docket Nos. CP15-554-000 &
CP15-554-001

and

DOMINION TRANSMISSION, INC.
SUPPLY HEADER PROJECT
Docket No. CP15-555-000

Recommended Seed Mixes by Milepost

Updated, Rev 5

Prepared by

ERM

May 1, 2017

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LIST OF ACRONYMS AND ABBREVIATIONS

ACP	Atlantic Coast Pipeline
NRCS	Natural Resources Conservation Service
SHP	Supply Header Project
WMA	Wildlife Management Area

1.0 INTRODUCTION

This appendix compiles seed mix prescriptions and soil amendment recommendations provided by Federal and State/Commonwealth agencies, and subject matter experts consulted for the restoration and rehabilitation of the proposed Atlantic Coast Pipeline (ACP) and Supply Header Project (SHP). The recommendations are summarized by county in Attachment A and discussed below.

2.0 ATLANTIC COAST PIPELINE

2.1 WEST VIRGINIA

2.1.1 Harrison, Lewis, Randolph, and Upshur Counties

The following seed mixtures and application rates, seeding dates, soil amendments recommendations, and planting recommendations are for Harrison, Lewis, Randolph, and Upshur counties in West Virginia. These recommendations are based on the collection of correspondences and discussions with Federal and State agencies, including communication with Greg Stone (Natural Resources Conservation Service [NRCS] Acting State Resource Conservationist) and Jeff Griffith (NRCS Conservationist). The tables and lists below provide the specific recommendations for these counties. No specific recommendations were made in these counties regarding tackifiers, mulching, or anchoring of mulch or seed.

Recommended Seed Mixes and Application Rates

TABLE 2.1.1-1

Seed Mix WVHLRU01: Recommended Cool Season Seed Mixture

Seed Mixture	Potentially Suitable Land Use	Common Species Name [a]	Seed Application Rate (lbs/acre/PLS)[b]
1	Pasture or Hay	Orchardgrass	10
		Ladino Clover	2
		Red Clover	3
		Redtop	3
2	Pasture	**Kentucky Bluegrass**	20
		Ladino Clover	2
		Red Clover	3
		Redtop	3
3	Pasture or Hay	Orchardgrass	20
		Redtop	5
		Birdsfoot Trefoil	10

[a] Species in bold are more wildlife-friendly; species in italics are suitable for use in filter strips.
[b] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Seeding Dates

TABLE 2.1.1-2

Harrison, Lewis, Randolph, and Upshur Counties, West Virginia Recommended Seeding Dates for Permanent Cover

Seeding Dates	Suitability
March 1 to April 15	Best seeding period
August 1 to October 1	Best seeding period
December 1 to March 1	Good seeding period (dormant seeding)
April 15 to August 1	High risk (moisture stress likely)
October 1 to December 1	High risk (potential freeze damage to young seedlings)

Recommended Soil Amendments and Application Rates

TABLE 2.1.1-3

Harrison, Lewis, Randolph, and Upshur Counties, West Virginia Recommended Soil Amendments and Application Rates

Soil Amendment Type	Application Rate
Lime	3 tons per acre
Fertilizer [a]	400 pounds per acre

[a] Fertilizer with a 10-20-20 ratio of nitrogen, phosphorus, and potassium is recommended.

Planting Recommendations

- Certified seed is preferred.
- Use proper inoculants prior to seeding for all legumes.
- Amend soil fertility and pH levels to satisfy the needs of the plant species.
- For unprepared seedbeds or seeding outside the optimum timeframes:
  - Add 50 percent more seed to the specified application rate, particularly during the periods of April 15 – August 1, and October 1 – March 1.
  - Double the seed application rate and consider planting an annual small grain like wheat (2 bushels [120 pounds] per acre) to act as a nurse crop.

2.1.2 **Pocahontas County**

The following seed mixtures, application rates, and soil amendment recommendations are for Pocahontas County, West Virginia. The recommendations are based on correspondence and discussions with Iden Gunther (NRCS Conservationist) and Susan Davis (West Virginia Department of Natural Resources). Seed Mix WVPO01 provides seeding recommendations for disturbed areas from the NRCS Critical Area Planting Standard that is commonly used with a high success rate in the County.

Recommended Seed Mixes and Application Rates

TABLE 2.1.2-1

Seed Mix WVPO01: Recommended Cool or Warm Seed Mixes for Pocahontas County, West Virginia

Seed Mixture	Species / Mixture [a]	Seeding Application Rate (lbs/acre/PLS)[b]	Soil Drainage Preference	pH Range
1	Crownvetch	10 – 15	Well – Moderately Well	5.0 – 7.5
	Perennial Ryegrass	20		
2	**KY Bluegrass**	20	Well – Moderately Well	5.5 – 7.5
	Redtop	3		
	Ladino Clover or	2		
	Birdsfoot Trefoil	10		
3	**Timothy**	8	Well - Poorly	5.5 – 7.5
	Birdsfoot Trefoil	8		
4	***Orchardgrass***	10	Well – Moderately Well	5.5 – 7.5
	Ladino Clover	2		
	Redtop	3		
5	***Orchardgrass***	10	Well – Moderately Well	5.5 – 7.5
	Ladino Clover	2		
5	**Birdsfoot Trefoil**	10	Well – Moderately Well	5.5 – 7.5
	Redtop	5		
	Orchardgrass	20		

Source: WVDEP, 2012

[a] Species in bold are more wildlife-friendly; species in italics are suitable for use in filter strips.

[b] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Soil Amendments and Application Rates

TABLE 2.1.2-2

Recommended Lime and Fertilizer Application

pH of Soil [a]	Lime Application Rate (tons/acre)[b]	Fertilizer Application Rate (10-20-20 or equivalent) (lbs/acre)
> 6.0	2	500
5.0 to 6.0	3	
< 5.0	4	

Source: WVDEP, 2012

[a] The pH can be determined with a portable pH testing kit or by sending the soil samples to a soil testing laboratory. When four tons of lime per acre is applied it must be incorporated into the soil by disking, backblading, or tracking up and down the slope.

[b] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Mulch Material and Application Rates

TABLE 2.1.2-3

Recommended Mulch Material Rates and Uses

Material	Minimum Rates Per Acre	Coverage	Remarks
Hay or Straw	2-3 Tons (100 – 150 Bales)	75% - 90%	Subject to wind blowing or washing unless tied down
Wood Fiber, Pulp Fiber, Wood-Cellulose, Recirculated Paper	1,000 – 1,500 lbs	Cover all disturbed areas	Hydroseeding

Source: WVDEP, 2012

Chemical Mulches, Soil Binders, and Tackifiers Recommendations

- Determine mulch-type and its appropriate application rate;
- A wide range of synthetic tackifiers (e.g., spray-on materials) are marketed to stabilize and protect the seeds and soil surfaces. These tackifiers are mixed with water and seed mixtures, and sprayed over the mulch and soils. They may be used alone in some cases as temporary stabilizers, or in conjunction with fiber mulch, straw or hay; and
- Chemical tackifiers, when used alone, do not have the capability to insulate the soil or retain soil moisture as effectively as organic mulches such wood fiber, straw, or hay.

Mulch Anchoring

- Depending on field conditions, mulch anchoring (e.g., mechanical methods or netting) may become necessary due to environmental conditions, including heavy winds or rapid water runoff (e.g., rain or snowmelt).
- Mechanical Anchoring
    - Apply mulch and pull a mulch anchoring tool over the mulch. When a disk is used, set the disk straight and pull across the slope. Mulch material should be tucked into the soil about three inches.
- Mulch Netting
    - Follow manufacturer's recommendations when positioning and stapling mulch netting into the soil.

2.1.3 **Federal Lands**

Monongahela National Forest – Pocahontas County

This section is pending additional consultation with the U.S. Forest Service.

2.1.4 State Lands

Seneca State Forest – Pocahontas County

This section is pending additional consultation with the West Virginia Department of Natural Resources.

2.1.5 Recommended Native Grasses and Pollinators Seed Mixtures, Application Rates, and Non-Native Cover Crop by Physiographical Region

Recommended Seed Mixtures by Geographical Region (Mountain Physiographic Region) and Drainage Class

The following seed mixtures are for the mountain and upland areas of West Virginia. These recommendations are based on discussions with Roundstone Native Seed and Robert Glennon, private lands biologist from the Conservation Management Institute, Virginia Tech and NRCS, and the Xerces Society.

West Virginia Excessively to Moderately Well Drained Sites

TABLE 2.1.5-1

Seed Mix P-MUDW01: Recommended Mountain Physiological Region
Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in West Virginia

Common Name	Scientific Name	Height (feet)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Little Bluestem	*Schizachyrium scoparium*	2 - 4	Full Sun	0.250
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.250
Tall Dropseed	*Sporobolus compositus*	2 - 3	Full Sun	0.050
Purple Top	*Tridens flavus*	3 - 5	Part Shade	0.058
Indian Grass	*Sorghastrum nutans*	3 - 6	Full Sun	0.167
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.183
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.042
Total	—	—	—	**1.0**

Sources: Roundstone Native Seed, 2015; Glennon, 2015
[a] Recommended seeding application rate is 8 to 18 pounds per acre.
[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.1.5-2

Seed Mix P-MUDW01: Recommended Mountain Physiological Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in West Virginia

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[a]
Lance Leaved Coreopsis	*Coreopsis lanceolata*	Yellow	Spring, Summer	0.385
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.146
Common Milkweed	*Asclepias syriaca*	Pink	Spring, Summer	0.128
Goat's Rue	*Tephrosia virginiana*	White/Pink	Spring, Summer	0.128
Partridge Pea	*Cassia fasciculata*	Yellow	Summer	0.745
Slender Mountain Mint	*Pycnanthemum tenuifolium*	White	Summer	0.069
Early Goldenrod	*Solidago juncea*	Yellow	Summer	0.086
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.103
Spiked Blazing Star	*Liatris spicata*	Pink	Summer	0.343
Sneezeweed	*Helenium autumnale*	Yellow	Summer, Fall	0.128
Gray Goldenrod	*Solidago nemoralis*	Yellow	Fall	0.086
Iron Weed	*Vernonia altissima*	Purple	Summer, Fall	0.343
Tall Coreopsis	*Coreopsis tripteris*	Yellow	Summer, Fall	0.051
Total	—	—	—	**2.74**

____

Sources: Roundstone Native Seed, 2015; Glennon, 2015

[b] lbs/acre/PLS = pounds per acre of pure live seed

West Virginia Somewhat Poorly to Very Poorly Drained Sites

TABLE 2.1.5-3

Seed Mix P-MUMP02: Recommended Mountain Physiographic Region
Grass Seed Mix and Application Rate for Somewhat Poorly to Very Poorly Drained Sites in West Virginia

Common Name	Scientific Name	Height (feet)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.233
Red Top Panicum	*Panicum rigidulum*	2 - 4	Full Sun	0.017
Fowl Manna Grass	*Glyceria striata*	3 - 5	Part Shade	0.008
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.217
Canada Wild Rye	*Elymus canadensis*	2 - 5	Part Shade	0.167
Deer Tongue Grass	*Panicum clandestinum*	2 - 4	Full Sun	0.058
Big Bluestem	*Andropogon gerardii*	4 - 10	Full Sun	0.167
Frank's Sedge	*Carex frankii*	1 - 2	Part Shade	0.042
Fox Sedge	*Carex vulpinoidea*	2 - 3	Part Shade	0.025
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.067
Total	—	–	—	**1.0**

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Sources: Roundstone Native Seed, 2015; Glennon, 2015

[a] Recommended seeding application rate is 8 to 18 pounds per acre.

[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.1.5-4

Seed Mix P-MUMP02: Recommended Mountain Physiographic Region
Forb Seed Mix Application Rate for Somewhat Poorly to Very Poorly Drained Sites in West Virginia

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[a]
Ohio Spiderwort	*Tradescantia ohiensis*	Blue	Spring, Summer	0.167
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.083
Butterfly Milkweed	*Asclepias tuberosa*	Orange	Spring, Summer	0.083
Blackeyed Susan	*Rudbeckia hirta*	Yellow	Spring, Summer	0.134
Wild Senna	*Senna marilandica*	Yellow	Summer	0.668
Hoary Mountain Mint	*Pycnanthemum incanum*	White	Summer	0.033
Lupine	*Lupinus perennis*	Blue	Summer	0.501
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.083
Boneset	*Eupatorium perfoliatum*	White	Summer	0.083
Joe-Pye Weed	*Eupatorium fistulosum*	Pink	Summer, Fall	0.125
Showy Tickseed	*Bidens aristosa*	Yellow	Summer, Fall	0.501
Sneezeweed	*Helenium autumnale*	Yellow	Summer, Fall	0.125
Rough Goldenrod	*Solidago rugosa*	Yellow	Fall	0.083
Total	—	—	—	**2.67**

Sources: Roundstone Native Seed, 2015; Glennon, 2015
[a] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Non-Native Temporary Cover Crop Species and Non-Native Grass Cover Mix for Inclusion with Pollinator Mixtures

In areas where the erosion potential is high (e.g., steep slope areas) and/or sites that require stabilization within 30 days of disturbance, non-native temporary cover species in seed mixture P-NNTC, as shown in Table 2.1.5-5, should be used. In areas where erosion is likely to occur on steep slopes prior to the germination of native grasses and forbs, non-native grass mixture P-NNGC should be used in combination with the forb mixtures that are prescribed for non-steep slope areas within the Mountain Physiographic Region of West Virginia. Table 2.1.5-6 provides the specific non-native grass species to be included with the native forb seed mix in these areas.

TABLE 2.1.5-5

Seed Mix P-NNTC: Recommended Mountain Physiographic Region
Non-Native Temporary Cover Crop Species for Steep Slope Areas in West Virginia

Common Name	Scientific Name	Height (Inches)	Sun Exposure	Seeding Application Rate (lbs/acre/PLS)[a]	Seed Mix Planting Season
Brown Top Millet	*Panicum ramosum*	3 - 3.5	Full sun	5.0	Summer
Spring Oats	*Avena sativa*	2 – 2.5	Full sun	30.0	Spring and Fall
Annual Rye Grass	*Lolium multiflorum*	2 – 2.5	Part shade	6.0	Fall and Winter

Source: Roundstone Native Seed, 2015
[a] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.1.5-6

Seed Mix P-NNGC: Recommended Mountain Physiographic Region Non-Native Grass Cover Mix for Steep Slope Areas in West Virginia [a]

Common Name	Scientific Name	Height (Inches)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Fescue	*Festuca arundinacea*	2 - 3	Part Shade	0.300
Timothy	*Phleum pratense*	2 - 4	Part Shade	0.100
Orchard Grass	*Dactylis glomerata*	2 - 3	Part Shade	0.100
Red Top	*Agrostis alba*	2 - 3	Full Sun	0.020
Ladino Clover	*Trifolium repens*	1 - 1.5	Part Shade	0.040
Annual Rye Grass	*Lolium multiflorum*	2 - 2.5	Part Shade	0.170
Creeping Red Fescue	*Festuca rubra*	1 - 2	Full Sun	0.250
Kentucky Bluegrass	*Poa pratensis*	1-2	Full Sun	0.020
Total	—	—	—	**1.0**

Source: Roundstone Native Seed, 2015

[a] Recommended seeding application rate is 30 to 50 pounds per acre.

[b] lbs/acre/PLS = pounds per acre of pure live seed

2.2 VIRGINIA

2.2.1 Augusta, Brunswick, Buckingham, Cumberland, Highland, Bath, Nelson, Nottoway, and Prince Edward Counties

The following erosion control prevention, forage species seed mixtures, and recommended soil amendments are for the Mountain and Piedmont Physiographic Regions of Virginia, which include Augusta, Brunswick, Buckingham, Cumberland, Highland, Nelson, Nottoway, and Prince Edward Counties. These recommendations are based on the U.S. Department of Agriculture-NRCS Virginia Plant Establishment Guide (Jones, et. al., 2014), which was recommended by Federal and Commonwealth agency contacts, including Charles Ivins (NRCS Conservationist), Charles Simmons (NRCS Conservationist), Davie Wade Harris (NRCS Conservationist), Jeffray Jones (State Biologist), J.B. Daniel (NRCS Conservationist), and Derek Hancock (NRCS Conservationist).

Recommended Grass Seed Mixtures, Species, Application Rates, and Planting Dates

Seed Mix VABCHNP01 (Table 2.2.1-1) provides a cool season species list mixture for erosion prevention, while Seed Mix VABCHNP02 (Table 2.2.1-2) provides cool and warm season species mixtures for forage.

TABLE 2.2.1-1

Seed Mix VABCHNP01: Recommended Cool Season Erosion Prevention Species and Seed Mixtures

Seeding Mix	Common Species Name	Virginia Native	Seeding Rate (lbs/acre/PLS)[a] B:broadcast; D:drill (4-9" row)	Plant Depth (inches)	Mountain/Valley/Northern Piedmont: Best Dates	Mountain/Valley/Northern Piedmont: Possible Dates	Southern Piedmont: Best Dates	Southern Piedmont: Possible Dates
Average Last Frost					May 1		Apr 15	
Perennial Grass								
1	Canada wild rye (Elymus canadensis), Virginia wild rye (Elymus virginicus), and Common milkweed (Asclepias syriaca) (use in high velocity and highly erosive situations		B: 60	¼-½	Aug 15-Sep 10; Mar 15-Apr 10	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 20; Mar 1-Apr 1	Aug 25-Nov 1; Feb 15-Apr 15
2	Switchgrass and Common milkweed (Asclepias syriaca)	√	D:10; B:15	¼	Mar 15-Jun 30		Mar 1-Jun15	
Mixtures								
3	Canada wild rye and Virginia wild rye + Virginia lespedeza (Lespedeza virginica), + hairy lespedeza (Lespedeza hirta) + Common milkweed (Asclepias syriaca)		B:40+3	¼	Aug 15-Sep 10; Mar 15-Apr 10	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 20; Mar 1-Apr 1	Aug 25-Nov 1; Feb 15-Apr 15
4	Canada wild rye + Virginia wild rye + Virginia lespedeza + hairy lespedeza + Common milkweed (Asclepias syriaca)		B:40+6	¼	Aug 15-Sep 10; Mar 15-Apr 10	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 20; Mar 1-Apr 1	Aug 25-Nov 1; Feb 15-Apr 15
5	Canada wild rye + Virginia wild rye + Virginia, + hairy lespedeza (Lespedeza hirta) + Common milkweed (Asclepias syriaca)		B:40+10; D:30+8	¼	Mar 1-Apr 15	Mar 1-Apr 15	Feb 15-Apr 1	Feb 15-Apr 1
6	Canada wild rye + Virginia wild rye + Redtop + Common milkweed (Asclepias syriaca)		D/B: 40+10	¼-½	Jul 25-Sep 1; Mar 20-Apr 20	Jul 15-Sep 15; Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25; Feb 15-Mar 31
7	Switchgrass + Red Fescue + Partridge Pea + Common milkweed (Asclepias syriaca)		D/B: 10+15+4	¼	Mar 15-April 30	Mar 15-Jun 30	Mar 1-Apr 15	Feb 15-May 31
8	Switchgrass + Indiangrass + Big Bluestem + Common milkweed (Asclepias syriaca)		D/B: 5 each	¼	Mar 15-Jun 30	Mar 15-Jun 30	Mar 1-Jun 15	Mar 1-Jun 15

TABLE 2.2.1-1

Seed Mix VABCHNP01: Recommended Cool Season Erosion Prevention Species and Seed Mixtures

Seeding Mix	Common Species Name	Virginia Native	Seeding Rate (lbs/acre/PLS)[a] B:broadcast; D:drill (4-9" row)	Plant Depth (inches)	Mountain/Valley/Northern Piedmont		Southern Piedmont	
					Best Dates	Possible Dates	Best Dates	Possible Dates
9	Canada wild rye + Virginia wild rye + Redtop + Virginia lespedeza and hairy lespedeza + Common milkweed (Asclepias syriaca)		D/B: 60+6+10	¼-½	Jul 25-Sep 1; Mar 20-Apr 20	Jul 15-Sep 15; Mar 1-May 15	Aug 25-Sep 15	Aug 25-Oct 25; Feb 15-Mar 31
10	Switchgrass + Deer tongue + Partridge Pea + Common milkweed (Asclepias syriaca)	√	D/B: 8+8+4	¼	Mar 15-April 30	Mar 15-Jun 30	Mar 1-Apr 15	Feb 15-May 31
11	Perennial Ryegrass + Redtop + Common milkweed (Asclepias syriaca)		D:5+2; B:7+3	½-¾	Mar 1-Apr 15	Aug 1-Sep 15	Feb 15-April 1	Aug 15-Oct 1

Source: Jones, et. al., 2014

[a] lbs/acre/PLS = pounds per acre of pure live seed

Note: The Virginia Plant Establishment Guide (Jones, et. al., 2014) provides acceptable seed mixtures and/or plant species rates, seeding dates, and other information that may be needed in the planning of practices and development of specifications for individual sites.

TABLE 2.2.1-2

Seed Mix VABCHNP02: Recommended Cool and Warm Season Forage Species and Seed Mixtures

Seeding Mix	Common Species Name	Virginia Native	Seeding Rate (lbs/acre/PLS) B:broadcast; D:drill (4-9" row)	Plant Depth (inches)	Mountain/Valley/Northern Piedmont [a]		Southern Piedmont	
					Best Dates	Possible Dates	Best Dates	Possible Dates
	Average Last Frost				May 1		Apr 15	
Perennial Grasses [k]								
101	Bermudagrass (Hybrid) [b] Sprigs – 1 bushel = 1.25 ft^3		B:30-40 bushels D:15-20 bushels	2"-4"	Not well adapted	May 1-Jun 15	Apr 15-Jun 1	Apr 1thru Jun 15 or thru Jul if irrigated
102	Bermudagrass [b], Coated Seeds (Common & Cultivars)		B:10-12; D:8-10	¼	Not well adapted	May 1-Jun 15	Apr 15– May 15	Apr 15-Jun 15
103	Big Bluestem [c]	√	B:10-12; D:8-10	¼	Mar 15-Jun 30	Mar 15-Jun 30	Mar 1-Jun 15	Mar 1-Jun 15
104	Bluegrass		B:10-15; D:8-12 4-5 in mixtures	¼	Aug 15-Sep 1; Mar 15-Apr 1	Aug 1-Sep 15; Mar 1-Apr 15	Seed in mixtures Mar 1- Apr 1; Aug 15 - Oct 1	Seed in mixtures Mar 1- Apr 1; Aug 15 - Oct 1
105	Eastern Gamagrass [d] (use non-stratified seed for winter planting and stratified seed for spring plantings)	√	R:8-10	1- 1.5	Nov 15-Feb 15; May 1-May30	Nov 15- Feb 15: May 1-Jun 30	Nov 25-Jan 31; Apr 20- May 15	Nov 25-Jan 31; Apr 15 - Jun 10
106	Indiangrass [c]	√	B:10-12; D:8-10	¼	Mar 15-Jun 30	Mar 15-Jun 30	Mar 1-Jun 15	Mar 1-Jun 15
107	Orchardgrass [e]		B:12-15; D:8-12	¼-½	Aug 20-Sep 10; Mar 15-Apr 1	Aug 15-Oct 1; Mar 1-Apr 15	Aug 25-Sep 15; Mar 1-Apr 1	Aug 25-Oct 25; Mar 1-Apr 15
109	Perennial Ryegrass [e]		D: 12-15 B:20-25; 6-10 in mixtures	¼-½	Aug 20-Sep 10; Mar 15-Apr 1	Aug 15-Sep 25; Mar 1-Apr 15	Not well adapted	Aug 25-Oct 1; Feb 25-April 1
110	Prairiegrass		D:20-25; B:30-35 10-15 in mixtures	¼-½	Aug 15 - Sep 15; Mar 15-Apr 15	Aug 15-Oct 15; Mar 1-Apr 30	Sep 1 - Oct 1; Mar 1-Mar 20	Aug 15-Oct 25; Feb 20-Apr 15
111	Switchgrass [c]	√	B:8-10; D:6-8	¼	Mar 15-Jun 30	Mar 15-Jun 30	Mar 1-Jun 15	Mar 1-Jun 15
112	Tall Fescue		B:20-25; D:15-20	¼-½	Aug 15-Sep 10; Mar 15-Apr 15	Aug 1-Sep 30; Mar 1-Apr 30	Sep 1-Sep 30; Mar 1-Apr 1	Aug 25-Nov 1; Feb 25-Apr 15
113	Timothy		B:10-12; D: 8-10	¼-½	Aug 15-Sep 10; Mar 15-Apr 1	Aug 15-Oct 1; Mar 1-Apr 15	Not well adapted	Not well adapted
Mixtures [k]								
114	Orchardgrass + Alfalfa [f]		B:5+20; D:3+15	¼-½	Aug 15-Sep 1; Mar 15-Apr 1	Aug 1-Sep 15; Mar 1-Apr15	Aug 25-Sep 15; Mar 1-Mar 20	Aug 25-Oct 15; Feb 25-Apr 1

TABLE 2.2.1-2

Seed Mix VABCHNP02: Recommended Cool and Warm Season Forage Species and Seed Mixtures

Seeding Mix	Common Species Name	Virginia Native	Seeding Rate (lbs/acre/PLS) B:broadcast; D:drill (4-9" row)	Plant Depth (inches)	Mountain/Valley/Northern Piedmont [a]		Southern Piedmont	
					Best Dates	Possible Dates	Best Dates	Possible Dates
115	Orchardgrass with 1 or more of the following: Ladino Clover Red Clover Annual Lespedeza		B: 10-12; D:8-10 1-2 4-6 10-12	¼-½	Aug 20-Sep 10; Mar 15-Apr 1	Aug 15-Oct 1; Mar 1-Apr 15	Aug 25-Sep 15; Mar 1-Mar 20	Aug 25-Oct 15; Feb 25-Apr 1
116	Orchardgrass and Timothy with 1 or more of the following: Ladino Clover Red Clover Annual Lespedeza		B: 10-12; D:8-10 B: 4; D:2 1-2 4-6 10-12	¼-½	Aug 20-Sep 10; Mar 15-Apr 1	Aug 15-Oct 1; Mar 1-Apr 15	Aug 25-Sep 15; Mar 1-Mar 20	Aug 25-Oct 15; Feb 25-Apr 1
117	Tall Fescue with 1 or more of the following: Ladino Clover Red Clover Annual Lespedeza		B:20-25; D:15-20 1-2 4-6 10-12	¼-½	Aug 15- Oct 1; Mar 1-Apr 15	Aug 15- Oct 1; Mar 1-Apr 15	Aug 25 - Oct 15; Feb 20-Apr 1	Aug 25 - Oct 15; Feb 20-Apr 1
118	Prairiegrass with 1 or more of the following: Red Clover Alfalfa [f]		B:20-25; D:15-20; 4-6 15	¼-½	Aug 15 - Sep 15; Mar 10-Apr 10	Aug 1-Sep 20; Mar 1-Apr 15	Aug 25 - Sep 15; Mar 1-Mar 20	Aug 15-Oct 15; Feb 25-Apr 1
Annual Grasses [k]								
119	Crabgrass [g]		B:6-8; D:4-6	¼	May 15-May 31	May 1-Jun 30	May 1-May 31	Apr 15-Jun 30
120	Barley		B:140; D:120	1 – 1.5	Aug 15-Sep 15	Aug 10-Sep 30	Aug 25-Sep 15	Aug 15-Sep 30
121	Millet, Pearl		B:30-40; D:15-20	½ - 1	May 15-May 31	May 1-Jun 30	May 1-May 31	Apr 25-Jun 30
122	Millet, German Foxtail, Japanese		B:20-30;D:15-20	¼	May 15-May 31	May 1-Jun 30	May 1-May 31	May 1-Jun 30
123	Oats, Winter [h]		B:80-96; D:65-80	1 – 1.5	Aug 15-Sep 10	Aug 10-Sep 15; Feb 1-Mar 1	Sep 1-Sep 15	Aug 25-Oct 1; Feb 1-Mar 1
124	Oats, Spring		B:80-96; D:65-80	1 – 1.5	Mar 15-Apr 1	Mar 15-Apr 10	Mar 5-Mar 20	Mar 5-Apr 1
125	Rye		B:120-150; D:90-110	1 – 1.5	Aug 15-Aug 31	Aug 15-Oct 25	Aug 25-Sep 15	Aug 20-Oct 31
126	Ryegrass		B:30-40; D:20-30	¼-½	Aug 15-Sep 10	Aug 10-Sep 30	Aug 25-Sep 15	Aug 20-Oct 31
127	Teff [g, i]		B: 6-8; D 5-6	1/8	Jun 1-Jun 15	May 15 - Jul 1	May 20-Jun 10	May 1 - Jul 1
128	Wheat		B:150; D: 120	1 – 1.5	Aug 15-Aug 31	Aug 15-Oct 25	Aug 25-Sep 15	Aug 20-Oct 31
129	Small grain Mix (2 Grains)		Reduce each selection by 50%	1 – 1.5	See dates for small grains.	See dates for small grains.	See dates for small grains.	See dates for small grains.
130	Small grain mixed with annual ryegrass		Reduce Small grain 25% & ryegrass 50%	½ - 1	See dates for grains and ryegrass.		See dates for grains and ryegrass.	
131	Sorghum-Sudangrass		B:30-40; D:20-30	½ - 1	May 15-May 31	May 1-Jun 30	May 1- May 31	Apr 25-Jun 30

TABLE 2.2.1-2

Seed Mix VABCHNP02: Recommended Cool and Warm Season Forage Species and Seed Mixtures

Seeding Mix	Common Species Name	Virginia Native	Seeding Rate (lbs/acre/PLS) B:broadcast; D:drill (4-9" row)	Plant Depth (inches)	Mountain/Valley/Northern Piedmont [a]		Southern Piedmont	
					Best Dates	Possible Dates	Best Dates	Possible Dates
132	Sorghum, Forage		B: 15-20; R:5-10	1 – 1 ½	May 15-May 31	May 1 – Jun 30	May 1–May 31	Apr 25 – Jun 30
133	Sudangrass		B:30-35; D:15-20	½ - 1	May 15 -May 31	May 1 – Jun 30	May 1–May 31	Apr 25 – Jun 30
134	Triticale		B:140-180; D: 120-140	1 – 1.5	Aug 15-Aug 31	Aug 15-Oct 25	Aug 25-Sep 15	Aug 20-Oct 31
Perennial Legumes [k]								
135	Alfalfa [f]		B:20-25; D:15-20	¼	Aug 25-Sep 15; Mar 20–Apr 7	Aug 15-Sep 25; Mar 15-Apr 15	Sep 1-Sep 15; Mar 10-Mar 20	Aug 25-Oct 1; Mar 5-Apr 5
136	Alfalfa (no-till seeding into grass)		D:10-12	¼ - ½	Mar 20–Apr 7	Mar 15-Apr 15	Mar 10-Mar 20	Mar 5-Apr 5
137	Birdsfoot Trefoil (no-till into suppressed grass sod)		D:6-8	¼	Aug 15-Sep 1	Aug1-Sep 15	Not adapted	Not adapted
138	Birdsfoot Trefoil (frost seed onto pasture)		B: 8-10	0	Feb 1-Mar 1	Jan 25-Mar 10	Not adapted	Not adapted
139	Ladino or White Clover (no-till into suppressed grass sod)		D:1-2	¼	Aug 20-Sep 10; Mar 15-Apr 1	Aug 15-Sep 25; Mar 1-Apr 15	Aug 25-Sep 15; Mar 1-Mar 20	Aug 25-Oct 15; Feb 25-Apr 1
140	Ladino or White clover (frost seed onto pasture)		B:1-2	0	Feb 1-Mar 1	Jan 25-Mar 10	Jan 25-Feb 15	Jan 20-Mar 1
141	Red Clover (no-till into suppressed grass sod)		D:4-6	¼ - ½	Aug 20-Sep 10; Mar 15-Apr 1	Aug 15-Sep 25; Mar 1-Apr 15	Aug 25-Sep 15; Mar 1-Mar 20	Aug 25-Oct 15; Feb 25-Apr 1
142	Red Clover (frost seed onto pasture)		B:4-6	0	Feb 1-Mar 1	Jan 25-Mar 10	Jan 25-Feb 15	Jan 20-Mar 1
Annual Legumes [k]								
143	Crimson Clover w/Ryegrass or small grain		B:20; D:15 & reduce small grain by 1/3	¼ - ½	Aug 15-Sep 10	Aug 10-Sep 30	Aug 25-Sep 15	Aug 20-Oct 15
144	Lespedeza, Kobe (Southeast VA) (frost seeded onto pastures)		B:10-15	0	Not adapted	Not adapted	Not well adapted	Not well adapted
145	Lespedeza, Korean (frost seeded onto pastures)		B:10-15	0	Feb 1-Mar 1	Feb 1-Mar 15	Jan 25-Mar 1	Jan 25-Mar 10
146	Hairy Vetch w/ small grain		B: 15; D 10 & reduce small grain by 50%	½ - 1 ½	Aug 15-Aug 31	Aug 15-Sep 15	Aug 25-Sep 15	Aug 20-Oct 1

TABLE 2.2.1-2

Seed Mix VABCHNP02: Recommended Cool and Warm Season Forage Species and Seed Mixtures

Seeding Mix	Common Species Name	Virginia Native	Seeding Rate (lbs/acre/PLS) B:broadcast; D:drill (4-9" row)	Plant Depth (inches)	Mountain/Valley/Northern Piedmont [a] Best Dates	Mountain/Valley/Northern Piedmont [a] Possible Dates	Southern Piedmont Best Dates	Southern Piedmont Possible Dates
Other Species [k]								
147	Chicory (in mixture w/grass & legume)		B: 3-4 D: 1-2	¼ - ½	Apr 15-May5	Apr 1-May 15	Sep 1-Sep 15	Sep 1-Oct 10
148	Brassicas [j] (sow 1-2 of the following in a 50% rate mix of summer or winter annual grasses in late spring or late summer respectively)		B: 2-3 D: 1-2	¼ - ½	May 1 - Jun 30 Aug 1 - Sep 1	May 1 - Jun 30 Aug 1 - Sep 1	Apr 20 - Jun 20 Aug 1 - Sep 10	Apr 20 - Jun 20 Aug 1 - Sep 10
	Rape							
	Kale							
	Turnip							
	Turnip X Rape							
	Radish							

Source: Jones, et. al., 2014

[a] The northern piedmont planting dates may be on the opposite end of the planting range compared to the mountains and valley in Southwest VA.

[b] Sprigged and seeded Bermudagrass have been established in the mountain and valley region of the state but are not well adapted and have a higher chance of winter kill.

[c] Native warm season grass planting date will vary within the planting window depending on dormancy of seed and expected annual grass/weed competition in the field.

[d] Eastern Gama grass can be planted with a corn planter (30" row) or with a drill on approximately 15" row centers (by blocking every other seed tube).

[e] This species tends to be a short lived perennial when planted and managed in monocultures in the piedmont and eastern regions of VA; it seems does better in the mountain and valley regions of the state especially when managed with rotational stocking in a mixed stand with other grasses and legumes.

[f] Fall planted alfalfa should not be no-tilled; alfalfa should be planted in spring 30 days prior to last killing frost and in fall 30-60 days before first killing fros.t

[g] Planting too deep is a common cause of stand failure.

[h] It is generally not recommended to plant oats in the fall west of the Blue Ridge because they will winter kill, however they are sometimes planted late summer and grazed in the fall and early winter.

[i] Not recommended for no-till planting, needs a clean firm seedbed to ensure establishment.

[j] Brassicas are not recommended in a monoculture, they are low in fiber and have highly digestible protein and can cause problems with rumen function; they should be planted mixed with summer or winter annuals to avoid problems (50 percent seeding rate of brassicas and 50 percent annuals).

[k] Add to the mixture or use Canada wild rye (*Elymus canadensis*) and/or Virginia wild rye (*Elymus virginicus*) where possible and practicable.

TABLE 2.2.1-3 Recommended Soil Amendments	
Type	Application Rate
Lime	2 tons/acre
Fertilizer 10-10-10	1,000 lbs/acre

Mulching

The NRCS Conservation Practice Standard - Mulching (Code 484) (NRCS, 2014) provides a general recommendation for mulching in Virginia. Mulching materials should consist of natural/artificial materials that can provide a certain depth/thickness and durability to achieve adequate cover. Mulch should be applied evenly and, if necessary, anchored into the soil. As a minimum, apply manufactured mulches in accordance with the manufacturer's specifications. The Mulch Specifications table provides some general guidelines when using certain mulches.

TABLE 2.2.1-4 Mulch Specifications	
Mulch Type	Suggested Cover
Cereal Grain/Grass Hay	70% Ground Cover
Wood Products (Wood Chips, Bark)	≤ 2-inch thickness
Gravel / Other Inorganic Materials	0.75 to 2-inch diameter / 2-inch thickness

Mulch should be applied to provide adequate protection from erosion, yet allow light and moisture to penetrate into the seedbed. Typical mulching provides 70 percent cover (approximately 2,000 pounds of straw per acre) with the appropriate erosion control measure to hold the seed and straw in place during establishment, depending on slope (NRCS Code 342) (NRCS, 2011). There are several types of mulches that can be used to conserve soil moisture, promote plant growth, and reduce erosion; however, there are also mulches that can have the reverse affect. Consider potential benefit or detrimental effects of mulching to the impacted and surrounding areas.

An operation and maintenance plan should clearly document:

- Purpose of mulch and type;
- Percent cover and/or thickness of mulch material;
- Timing of application;
- Site preparation; and
- Method of anchoring (i.e., netting, tackifiers, etc.).

Recommended Perennial Grasses and Pollinator Seed mixtures, Species, and Rates for Mountainous and Piedmont Regions

The following seed mixtures are for the Mountainous and Piedmont Regions of Virginia. These recommendations are based on discussions and information provided by Robert Glennon, private lands biologist from the Conservation Management Institute, Virginia Tech and NRCS, and the Xerces Society.

TABLE 2.2.1-5

Seed Mix P-VABCHNP01: Recommended Mountain and Piedmont Physiographic Regions
Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Little Bluestem	*Schizachyrium scoparium*	Piedmont (NC) or Suther Germplasm (NC)	8 ounces	3
Broomsedge	*Andropogon virginicus*	—	8 ounces	3
Purple Top	*Tridens flavus*	North Carolina or Kentucky Ecotype	3 ounces	3
Common milkweed	*Asclepias syriaca*	—	3 ounces	0.210

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 2.2.1-6

Seed Mix P-VABCHNP01: Recommended Mountain and Piedmont Physiographic Regions
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
Pea, Partridge (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Susan, Black-eyed (B)	*Rudbeckia hirta*	Early Summer	2	3
Bergamot, Spotted (P)	*Monarda punctata*	Summer	2	3
Bergamot, Wild (P)	*Monarda fistulosa*	Summer	2	3
Beardtongue, Eastern Smooth (P)	*Penstemon laevigatus*	Late Spring	7	3
Penstemon, Talus Slope (P)	*Penstemon digitalis*	Late Spring	5	3
Slender Mountain Mint (P)	*Pycnanthemum tenuifolium*	Late Summer	1	3
New England Aster	*Aster novae-angliae*	Late Summer	2	3
Total	**—**	**—**	**64.0 ounces/acre (4.0 lbs/acre)**	**27**

Source: Glennon, 2017; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 2.2.1-7

Seed Mix P-VABCHNP02: Recommended Mountain and Piedmont Physiographic Regions
Grass Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Beaked Panicum	*Panicum anceps*	SC or MD Ecotype	4 ounces	3
Redtop Panicum	*Panicum rigidulum*	NC Ecotype	3 ounces	3
Slender Rush	*Juncus tenuis*	—	1 ounce	3

Source: Glennon, 2015; Roundstone Native Seed, 2017.
[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 2.2.1-8

Seed Mix P-VABCHNP02: Recommended Mountain and Piedmont Physiographic Regions
Forb Seed Mix and Application Rates Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre	Seeds per Square Foot
New England Aster	*Symphyotrichum puniceum*	Fall	3	3
Bergamot, Wild (P)	*Monarda fistulosa*	Summer	1	3
Ironweed, New York (P)	*Vernonia novaboracensis*	Late Summer	7	3
Rough-stemmed goldenrod	*Solidago rugosa*	Late Summer	3	3
Joe Pye Weed, Spotted (P)	*Eutrochium fistulosus*	Late Summer	2	3
Pea, Partridge (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Rosemallow (P)	*Hibiscus moscheutos*	Summer	2	3
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
Total	—	—	**61.0 ounces/ acre (3.8 lbs/acre)**	**24**

Source: Glennon, 2017. ; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers. Add New York Aster (Symphyotrichum novi-belgii) and narrow- leaf mountain mint (Pycnanthemum tenuifolium) to seed mix in coastal plain sites
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

2.2.2 Federal Lands

George Washington National Forest – Augusta, Bath, and Highland Counties

This section is pending additional consultation with the U.S. Forest Service.

2.2.3 State Lands

James River Wildlife Management Area – Nelson County

The following seed mixtures and application rates recommendations are for the James River WWA in Nelson County, Virginia. The recommendations are based on correspondence and discussions with Virginia Department of Game and Inland Fisheries regional specialist staff (Amy Ewing, environmental services biologist/FWIS Manager, Virginia Department of Game and Inland Fisheries). These seed mixes are considered suitable for planting of the ACP pipeline.

The specialist staff is supportive of the use of native vegetation mixes that stabilize the corridor while providing food and cover for a variety of wildlife.

James River Wildlife Management Area (WMA) Excessively to Moderately Well Drained – Partially Shade Sites

TABLE 2.2.3-1

Seed Mix VJRWMA01: Recommended Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained – Partially Shade Sites [a]

Common Name	Scientific Name	Seed Mix Rate (lbs/acre/PLS)[b]
Autumn bentgrass	*Agrostis perennans*	0.012
Canada Wild Rye	*Elymus canadensis*	0.083
Virginia Wild Rye	*Elymus virginicus*	0.208
Creeping Red Fescue	*Festuca rubra*	0.167
Purple Top	*Tridens flavus*	0.083
Upland Bentgrass	*Agrostis perennans*	0.005
Little Bluestem	*Schizachyrium scoparium*	0.208
Broomsedge	*Andropogon virginicus*	0.033
Beaked Panicum	*Panicum anceps*	0.167
Nimblewill	*Muhlenbergia schreberii*	0.033
Total	**—**	**1.0**

Source: Recommendations provided by the Virginia Department of Game and Inland Forest.
a Recommended seeding application rate is 6.3 to 9.0 pounds per acre.
b lbs/acre/PLS = pounds per acre of pure live seed

James River WMA Excessively to Moderately Well Drained – Wildlife Sites

TABLE 2.2.3-2

Seed Mix VJRWMA02: Recommended Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained – Wildlife Sites [a]

Common Name	Scientific Name	Seed Mix Rate (lbs/acre/PLS)[b]
Big Bluestem	*Andropogon gerardii*	0.070
Indian Grass	*Sorghastrum nutans*	0.070
Little Bluestem	*Schizachyrium scoparium*	0.141
Switchgrass (Blackwell)	*Panicum virgatum*	0.070
Canada Wild Rye	*Elymus canadensis*	0.106
Tall Dropseed	*Sporobolus compositus*	0.070
Purple Top	*Tridens flavus*	0.035
Plains Coreopsis	*Coreopsis tinctoria*	0.019
Violet lespedeza	*Lespedeza frutescen*	0.057
Blackeyed Susan	*Rudbeckia hirta*	0.033
Virginia lespedeza	*Lespedeza virginica*	0.077
Partridge Pea	*Cassia fasciculata*	0.120
Browneyed Susan	*Rudbeckia triloba*	0.025
Maximilian Sunflower	*Helianthus maximiliani*	0.060
Roundhead Lespedeza	*Lespedeza capitata*	0.033
New England Aster	*Aster novae-angliae*	0.012
Total	—	1.0

Source: Recommendations provided by the Virginia Department of Game and Inland Forest.
a Recommended seeding application rate is 6.3 to 9.0 pounds per acre.
b lbs/acre/PLS = pounds per acre of pure live seed.

James River WMA Steep Slope Stabilization Sites

TABLE 2.2.3-3

Seed Mix VJRWMA03: Recommended Grass Seed Mixes and Application Rates for Steep Slopes Stabilization – Sites

Common Name	Scientific Name	Seed Mix Rate (lbs/acre/PLS)[b]
Seed Mix [a]		
Creeping Red Fescue	*Festuca rubra*	0.050
Virginia Wild Rye	*Elymus virginicus*	0.083
Fall Panicum	*Panicum anceps*	0.083
Side Oats Grama	*Bouteloua curtipendula*	0.083
Big Bluestem	*Andropogon gerardii*	0.083
Indian Grass	*Sorghastrum nutans*	0.083
Purple Top	*Tridens flavus*	0.033
Switchgrass	*Panicum virgatum*	0.083
Little Bluestem	*Schizachyrium scoparium*	0.083
Virginia lespedeza	*Lespedeza virginica*	0.025
Lance Leaved Coreopsis	*Coreopsis lanceolata*	0.042
Blackeyed Susan	*Rudbeckia hirta*	0.008
Partridge Pea	*Cassia fasciculata*	0.058
Violet lespedeza	*(Lespedeza frutescens*	0.033
False Sunflower	*Heliopsis helianthoides*	0.042
Showy Tickseed	*Bidens aristosa*	0.042
Maximilian Sunflower	*Helianthus maximiliani*	0.042
Iron Weed	*Vernonia altissima*	0.025
Common Milkweed	*Asclepias syriaca*	0.021
Hairy Mountain Mint	*Pycnanthemum pilosum*	0.003
Gray Goldenrod	*Solidago nemoralis*	0.013
Total	—	1.0
Common Name		Seed Application Rate (lbs/acre/PLS)[b]
Seed Mix		
Buckwheat[c]		15-20
Millet		5-7
Korean lespedeza		5-7
Perennial Ryegrass		5-8
Blackwell switchgrass		3-4

Source: Recommendations provided by the Virginia Department of Game and Inland Forest.
[a] Recommended seeding application rate is 7.4 to 10.7 pounds per acre.
[b] lbs/acre/PLS = pounds per acre of pure live seed.
[c] Buckwheat is somewhat frost sensitive and deepening on the planting date, increase the application rate Korean lespedeza to compensate and decrease or remove the application of buckwheat.

2.2.4 Dinwiddie, Greensville, and Southampton Counties, and Chesapeake and Suffolk Cities (Coastal Plain Region)

The following seed mixtures, site preparation, seeding techniques, and amendments recommendations are for Dinwiddie, Greensville, Suffolk, Southampton, and Chesapeake Counties. These recommendations are based on information provided by Mr. Robert Glennon. NRCS Conservationists in these counties referred to Mr. Robert Glennon's recommendations.

2.2.4.1 Recommended Grass Seed Mixtures, Application Rates, and Planting Dates

Seeding species, cultivars, rates, and planting dates are contained in the table below. The materials identified as "common" do not require a specific cultivar for successful establishment and performance. Nurse crops must be sown at the same time as the perennial cover species to ensure that the site will have quick cover. The temporary cover specifications are intended for use when the site will not be sown to a perennial cover immediately after construction and a temporary cover is needed until the seed can be sown during the proper seeding season.

TABLE 2.2.4-1

Seed Mix VACSDGS01: Recommended Cool and Warm Season Species, Cultivars, Seeding Rates, Seeding Dates, and Temporary Cover

Species	Cultivars	Seeding Application Rate (lbs/acre)	Seeding Dates
Wild rye and lespedeza			
Canada wild rye (Elymus canadensis), and Virginia wild rye (Elymus virginicus)	—	60 pounds broadcast	September 1 – October 31; February 1 – March 31
Canada wild rye and Virginia wild rye Tall Fescue + Virginia lespedeza (Lespedeza virginica), + hairy lespedeza (Lespedeza hirta)	—	40 pounds broadcast	September 1 – October 31; February 1 – March 31
Bermudagrass and Japanese Lespedeza			
Bermudagrass	Common Cheyenne II Pasto Rico Ranchero Frio	10-12 pounds broadcast; 8-10 pounds drilled	April 1 – June 10
Japanese Lespedeza	Kobe	10-12 pounds broadcast or drilled	April 1 – June 10
Nurse Crops (Sow with the Perennial Seed Mixtures for Quick Cover)			
Oats	Common	25-30 pounds broadcast; 20-25 drilled	September 1 – November 15; February 1 – April 20
Rye	Common	35-50 broadcast; 25-40 drilled	September 1 – November 15; February 1 – April 20
Wheat	Common	40-50 broadcast; 30-40 drilled	September 1 – November 15; February 1 – April 20
Millet (Browntop, German, Italian, Foxtail, Proso)	Common	10-15 broadcast; 7-10 drilled	April 20 – August 1
Temporary Crops (Sow on Areas that will not be Seeded Immediately)			
Oats	Common	80-95 broadcast; 65-80 drilled	September 1 – November 15; February 1 – April 20
Rye	Common	120 broadcast; 100 drilled	September 1 – November 15; February 1 – April 20
Wheat	Common	120 broadcast; 100 drilled	September 1 – November 15; February 1 – April 20
Millet (Browntop, German, Italian, Foxtail, Proso	Common	20-30 broadcast; 15-20 drilled	April 20 – August 31

Note: Seeding Rates in Bulk Pounds per Acre – Non-Native Seed Must Have a minimum Germination and Purity to be Sold.

Site Preparation

The soils on the Coastal Plain of Virginia in Dinwiddie, Greensville, Suffolk, and Southampton counties typically have sandy topsoil but have a heavy clay subsoil close to the soil surface. The sandy topsoil must be kept separate during construction to prevent mixing with the subsoil, which will ensure easy till-ability and compaction and allow seeds to sow without restriction. To ensure optimum conditions in the soil for germination and early growth for soils sown to non-native species, the species should be tested, limed, and fertilized according to the soil test recommendations.

Seeding Technique

Seed may be established by broadcasting on a firm seedbed and packing the seed, or by drilling the seed into a firm seedbed and packing the seed. Drilled seed of the perennial seed grass species, legumes, and annual millets should only be placed at a depth of ¼ inch. The nurse crops and temporary cover species oats, rye, and wheat may be broadcast but will perform best if drilled at a one-inch depth.

Mulching

To ensure that the seed will remain in place through germination and growth, seedlings must be mulched. Synthetic or processed mulch must be applied and anchored according to the manufacturer's recommendations. Straw (seed stalks of small grains – usually wheat) may be used as mulch at a rate of 75 to 100 pounds per acre (1.5 to 2.5 tons per acre). The mulch must be anchored with a sprayed on product or netting applied according to the manufacturer's recommendations. It should be noted that hay must not be used as mulch, as hay typically contains weeds that would negatively impact the restoration of the area.

2.2.4.2 Recommended Perennial Grasses and Pollinator Seed Mixtures, Species, and Application Rates for the Coastal Plain Region

The following seed mixtures are for the Coastal Plain Region of Virginia. These recommendations are based on discussions and information provided by Robert Glennon.

TABLE 2.2.4-2

Seed Mix P-VACSDGS01: Recommended Coastal Plain Physiographic Region Grass Mixture for Excessively to Moderately Well Drained Sites In Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Little Bluestem	*Schizachyrium scoparium*	Piedmont (NC) or Suther Germplasm (NC)	8 ounces	3
Splitbeard Bluestem	*Andropogon ternarius*	Virginia Ecotype	8 ounces	3
Common milkweed	*Asclepias syriaca*	—	3 ounces	0.21

Source: Glennon, 2017; Roundstone Native Seed, 2017.

[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 2.2.4-3

Seed Mix P-VACSDGS01: Recommended Coastal Plain Physiographic Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Mountain Mint, Narrowleaf (P)	*Pycnanthemum tenuifolium*	Late Summer	1	3
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
Pea, Partridge (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Susan, Black-eyed (B)	*Rudbeckia hirta*	Early Summer	2	3
Bergamot, Spotted (P)	*Monarda punctata*	Summer	2	3
Beardtongue, Eastern Smooth (P)	*Penstemon laevigatus*	Late Spring	7	3
Penstemon, Talus Slope (P)	*Penstemon digitalis*	Late Spring	5	3
Bergamot, Wild (P)	*Monarda fistulosa*	Summer	2	3
Total	**—**	**—**	**65.0 ounces/acre (4.4 lbs/acre)**	**24**

Source: Glennon, 2017; Roundstone Native Seed, 2017.

[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.

[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 2.2.4-4

Seed Mix P-VACSDGS02: Recommended Coastal Plain Physiographic Region
Grass Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name	Scientific Name	Cultivar or Germplasm	Drilled Seeding Rate [a] (weight of pure live seed (PLS) per acre)	Seeds per Square Foot
Panicum, Beaked	*Panicum anceps*	SC or MD Ecotype	4 ounces	3
Panicum, Redtop	*Panicum rigidulum*	NC Ecotype	3 ounces	3

Source: Glennon, 2017
; Roundstone Native Seed, 2017.

[a] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

TABLE 2.2.4-5

Seed Mix P-VACSDGS02: Recommended Coastal Plain Physiographic Region
Forb Seed Mix Seed and Application Rate Mix for Somewhat Poorly to Very Poorly Drained Sites in Virginia

Common Name [a]	Scientific Name	Flowering Season	Drilled Seeding Rate [b] (ounces/acre - weight of pure live seed (PLS) per acre)	Seeds per Square Foot
New England Aster	*Aster novae-angliae*	Fall	3	3
Sneezeweed, Common (P)	*Helenium autumnale*	Fall	2	3
Showy Tickseed	*Bidens aristosa*	Late Summer	11	3
New York Ironweed (P)	*Vernonia nova boracensis*	Late Summer	7	3
Goldenrod, Wrinkleleaf (P)	*Solidago rugosa*	Late Summer	2	3
Joe Pye Weed, Spotted (P)	*Eutrochium fistulosus*	Late Summer	2	3
Partridge Pea (A)	*Chamaecrista fasciculata*	Mid-Summer	32	3
Rosemallow (P)	*Hibiscus moscheutos*	Summer	2	3
Narrowleaf Sunflower (P)	*Helianthus angustifolius*	Late Summer	4	3
Total	—	—	**65.0 ounces/acre (4.1 lbs/acre**	**27**

Source: Glennon, 2015; Roundstone Native Seed, 2017.
[a] Forb types include (A) for annual flowers, (B) for biennial flowers, and (P) for perennial flowers.
[b] If the broadcast method is more feasible, increase the perennial grasses in the mixture by 50 percent.

2.3 NORTH CAROLINA

2.3.1 Northampton County

The following recommendations of seed mixtures, rates, planting dates, and amendments are for Northampton County, North Carolina. The recommendation is from Paul Boone (NRCS District Conservationist).

Recommended Grass Seed Mixtures, Application Rates, Planting Dates, and Amendments

TABLE 2.3.1-1

Seed Mix NCNO01: Recommended Cool Season Seed Mixture

Common Species Name [a]	Seed Application Rate (lbs/acre/PLS)[b]	Planting Date
Spring (February - March) and Fall (September - November) Seeding		
Tall Fescue mixed with any of the following grains:	60	Feb - Nov
Wheat	60	Oct 25 - Nov 15
Oats and Barley	60	Sept 1 - Oct 15
Rye	60	Sept 15 - Nov 1
Korean Lespedeza	20	March - May
Sercia Lespedeza	20	Oct - May

[a] Recommendations provided by the Northampton County NRCS office District Conservationist.
[b] lbs/acre/PLS = pounds per acre of pure live seed
Note: Apply small grain mulch at 2 tons/acre or check with the NRCS office for alternatives mulches.

TABLE 2.3.1-2

Seed Mix NCNO02: Recommended Warm Season Seed Mixture

Common Species Name [a]	Seed Application Rate (lbs/acre/PLS)	Planting Date
Temporary Cover		
Brown Top Miller	30-40	May 5 – July 5
Japanese Millet	25	May 5 – July 5
Permanent Cover		
Pensacola Bahia	25	March 15 – June 15
Pensacola Bahia mixed with any of the following:	20	March - May
Annual Lespedeza	20	March - May
Kolb Lespedeza	20	March - May
Common Lespedeza	20	March - May
Korean Lespedeza	20	March - May
Bermuda Grass (Hulled)	8-10	April - July
Bermuda Grass		
Hulled Bermunda (up June)	6-10	April – July
Unhulled Bermuda	15-18	January - March

[a] Recommendations provided by the Northampton County NRCS office District Conservationist.

TABLE 2.3.1-3

Recommended Soil Amendments

Type	Application Rate
Lime	2 tons/acre
Fertilizer 10-10-10	1,000 lbs/acre

2.3.2 **Halifax and Wilson Counties**

The following seed mixture, planting dates, and cover crop recommendations are primarily for Wilson County, but are also applicable for Halifax County. The recommendation is from David Little (NRCS District Conservationist).

Recommended Grass Seed Mixtures, Application Rates, Planting Dates, and Cover Crops

TABLE 2.3.2-1

Seed Mix NCHW01: Recommended Cool Season Seed Mixture

Common Species Name [a]	Seed Application Rate (lbs/acre/PLS) [b]	Planting Date
Tall Fescue and White Clover	30-50	Sept 1 – Sept 30 (Coastal Plain)
Cover Crop [a]		
Buckwheat	80	Late Winter-Spring
Oats	180	Late Winter-Spring
Rye	120-180	Late Winter-Spring
Ryegrass	30-40	Late Winter-Spring
Oats and Ryegrass	90	Late Winter-Spring
Oats and Korean Lespedeza	20	Late Winter-Spring
Browntop Miller	30-40	Summer
Rye	120-180	Late Summer/Early Winter
Ryegrass	30-40	Late Summer/Early Winter
Oats (Before Oct 1)	120-180	Late Summer/Early Winter
Barley (Before Oct 15)	120-180	Late Summer/Early Winter
Wheat (After Oct 1)	120-180	Late Summer/Early Winter
Rye and Ryegrass mixture	60 Rye + 20 Ryegrass	Late Summer/Early Winter
Little barley	75-80	Late Summer/Early Winter

[a] Temporary cover vegetation is desirable to minimize erosion and pollution and permanent vegetation cannot be established due to seasons of the year, and where a temporary seeding is needed to control erosion and water pollution prior to the establishment of finished grade or perennial vegetation. The temporary measures should be coordinated with the permanent erosion control measures planned, to assure economical and effective control.

[b] lbs/acre/PLS = pounds per acre of pure live seed

2.3.3 Nash and Johnston Counties

The following species and cover crop seeding application rates, planting dates, and amendments recommendations are for Nash and Johnston counties. The seed mixture recommendations are from correspondence with Patrick Evans (NRCS District Conservationist Nash County) and Brian Loaholt (NRCS District Conservationist). Seed Mix NCNJ01 provides seeding specifications for conservation work.

Recommended Grass Seeding Species, Application Rates, Planting Dates, Cover Crops, and Amendments

TABLE 2.3.3-1

Seed Mix NCNJ01: Recommended Cool Season Grass Seed Mixture

Common Species Name [a]	Seed Application Rate (lbs/acre/PLS)[b]	Planting Date
Tall Fescue	30-40	Sept 1 – Sept 30 (Coastal Plain)
Sorghum (Cover crop) [c]	60-120	—

[a] Recommendations provided by the Nash County NRCS office District Conservationist.

[b] lbs/acre/PLS = pounds per acre of pure live seed

[c] Temporary cover vegetation is desirable to minimize erosion and pollution and permanent vegetation cannot be established due to seasons of the year, and where a temporary seeding is needed to control erosion and water pollution prior to the establishment of finished grade or perennial vegetation. The temporary measures should be coordinated with the permanent erosion control measures planned, to assure economical and effective control.

Notes: Mulch seeded area with small grain straw. Spread evenly over the area at the rate of 1-2 tons/acre. Apply mulch so that about 25 percent of the ground is visible.

TABLE 2.3.3-2

Recommended Lime and Fertilizer Application

Type	Application Rate
Lime	2 tons/acre
Fertilizer - 10-10-10	500 - 700 lbs/acre

2.3.4 Sampson County

The following recommendations for seed mixtures, rates, planting dates, and amendments are for Sampson County. The recommendations are based on correspondence with Gavin Thompson (NRCS District Conservationist) and Susan Davis (West Virginia Department of Natural Resources). Seed Mixes NCSA01 and NCSA02 are NRCS recommended cool and warm season mixtures for disturbed areas. No pollinator species specific to the County were recommended by the Conservationist.

2.3.4.1 Recommended Grass Seed Mixtures, Application Rates, and Planting Dates

TABLE 2.3.4-1

Seed Mix NCSA01: Recommended Cool Season Seed Mixture

Common Species Name [a]	Seeding Application Rate (lbs/acre/PLS)[b]	Planting Date
Tall Fescue or	40-50	Sept - March
Bermudagrass (hull attached)	15	January - March

[a] Recommendations provided by the Sampson County NRCS office District Conservationist. Used Tall Fescue to seed wet spots along the pipeline.

[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.3.4-2

Seed Mix NCSA02: Recommended Warm Season Seed Mixture

Common Species Name	Seeding Application Rate (lbs/acre/PLS)	Planting Date
Bermudagrass (hull removed)	8-10	April – August

[a] Recommendations provided by the Sampson County NRCS office District Conservationist.
[b] lbs/acre/PLS = pounds per acre of pure live seed

2.3.4.2 Recommended Lime and Fertilizer Application

Where soils are relatively uniform and amendments can be incorporated, use appropriate lime and fertilize according to a soils test. In the absence of a soil test, use the recommended lime and fertilizers application rates in the table below.

TABLE 2.3.4-3

Recommended Lime and Fertilizer Application

Type	Application Rate
Lime (dolomite)	1-2 tons/acre
Fertilizer 10-10-10	500 - 800 lbs/acre [a]

Notes: Any seeding should also be mulched with small grain straw or equivalent at a rate of 1 to 2 tons per acre. When mulching, be sure to eave approximately 25 percent of the ground exposed to allow light to penetrate. Mulch should be anchored to prevent loss.

2.3.4.3 Planting Recommendations

Where conventional equipment is used for planting, seed shall be applied uniformly with cultipacker-seeders, drills, seeders or other mechanical seeders. Any equipment that will apply seed uniformly is acceptable. Seeding may be done by hand where it is not practical or feasible to use equipment.

2.3.4.4 Mulching Recommendations

- Mulching is essential on all sites, especially steep, erosive sites where plant establishment may be expected to be difficult.

- Use of dry, unchopped, and unweathered small grain straw or hay-free-seeds (from completing plant species). Spread at the rate of 1-2 tons per acre depending upon the site and season.

- Apply mulch uniformly so that about 25 percent of the ground surface is visible.

- Anchor mulch immediately after placement to minimize loss by water and/or wind.

2.3.5 **Cumberland County**

The following recommended seed mixture, rates, planting dates, cover crop, and amendments are for Cumberland County. The recommendations are from correspondence with Renessa Brown (NRCS District Conservationist). No pollinator species recommendations specific to the County were provided.

2.3.5.1 Recommended Seed Mixtures, Application Rates, and Planting Dates

TABLE 2.3.5-1

Seed Mix NCCU01: Recommended Cool and Warm Season Seed Mixture

Common Species Name [a]	Seeding Application Rate (lbs/acre/PLS)[b]	Planting Date
Common or Hybrid Bernudagrass (hull removed or scarified)	5-7 (drill) 6-8 (broadcast)	April 1 – May 15 (best); April 1 – June 7 (possible)
Cover Crop [c]		
Buckwheat	80	Late Winter-Spring
Oats	180	Late Winter-Spring
Rye	120-180	Late Winter-Spring
Ryegrass	30-40	Late Winter-Spring
Oats and Ryegrass	20 and 90	Late Winter-Spring
Oats and Korean Lespedeza	20 and 90	Late Winter-Spring
Browntop Miller	30-40	Summer
Rye	120-180	Late Summer/Early Winter
Ryegrass	30-40	Late Summer/Early Winter
Oats (Before Oct 1)	180	Late Summer/Early Winter
Barley (Before Oct 15)	120-180	Late Summer/Early Winter
Wheat (After Oct 1)	120-180	Late Summer/Early Winter
Rye and Ryegrass mixture	60 Rye + 20 Ryegrass	Late Summer/Early Winter
Little barley	75-80	Late Summer/Early Winter

[a] Recommendations provided by the Cumberland County NRCS office District Conservationist.

[b] lbs/acre/PLS = pounds per acre of pure live seed

[c] Select from the following table a quick growing grass with high seedling vigor that is suited to the area, When temporary vegetation is desirable to minimize erosion and pollution and permanent vegetation cannot be established due to seasons of the year, and where a temporary seeding is needed to control erosion and water pollution prior to the establishment of finished grade or perennial vegetation. The temporary measures should be coordinated with the permanent erosion control measures planned, to assure economical and effective control.

TABLE 2.3.5-2

Recommended Lime and Fertilizer Application

Planting	Fertilizer Analysis	Fertilizer Rate (lbs/acre)	Lime Rate (lbs/acre)
Perennial Grasses with or without Legumes, Fertilizer no incorporated	10-10-10	10 lbs / 1,000 sq. ft.	46 lbs / 1,000 sq. ft.
Temporary Cover, Fertilizer not incorporated	10-10-10	12 – 16 lbs / 1,000 sq. ft.	92 lbs / 1,000 sq. ft.

TABLE 2.3.5-3

Recommended Mulch Material Rates and Uses

Material	Minimum Rates Per Acre	Coverage	Remarks
Dry unchopped, unweathered small grain straw or hay-free-seeds (of competing plants)	1 – 2 tons/acre	75% (25% of ground is visible)	Evenly spread mulch over the area by hand or blower-type spreading equipment
burlap and pine boughs	—	100%	Secure in place if flowing water is involved
Jute matting	—	100%	May be used in the place of mulch or sod; has the strength to withstand water flow. It is an accepted practice to sow half the seed before placing the matting. Sow the remaining half after the matting is laid.
Barnyard manure and bedding	—	75% (25% of ground is visible)	Do not apply within 50 feet of surface waters
Wood fiber (excelsior)	—	—	Available as mulch material to be blown on after seeding or as a matting to be stapled on steep slopes, waterways, etc.

Source: WVDEP, 2012

2.3.5.2 Planting Recommendations

Mulching should be specified to reduce damage from water run-off and improve moisture conditions for seedlings. Temporary vegetation can be satisfactorily established without the use of mulch.

2.3.6 Robeson County

The following seed mixture, rates, and planting date recommendations are for Robeson County. The recommendation comes from Jeremy Ruston (NRCS District Conservationist).

Recommended Grass Seed Mixtures

TABLE 2.3.6-1

Seed Mix NCRO01: Recommended Warm Season Seed Mixture

Common Species Name [a]	Seeding Rate (lbs/acre/PLS)[b]	Planting Date
Switchgrass (Carthage or Cave-In-Rock cultivars)	1	April 1 – May 15
Little Bluestem	1.5	April 1 – May 15
Indian Grass	1	April 1 – May 15

[a] Recommendations provided by the Robeson County NRCS office District Conservationist.
[b] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Pollinator Seed Mixtures

TABLE 2.3.6-2

Seed Mix P-NCRO01: Recommended Pollinator Seed Mixture

Common Name	Scientific Name	Bloom Period	Sun	Soil	Seeding Application Seed Rate (lbs/acre/PLS)[a]
Lanceleaf coreopsis	*Coreopsis lanceolata*	April – June	Full – Shade	Dry – Moist	0.3
Wrinkleleaf goldenrod	*Solidago rugosa*	Late Summer	Full to Partial shade	Moist	
Purple coneflower	*Echinacea purpurea*	April – September	Full to Partial shade	Dry	

Source: Recommendations provided by the Roberson County NRCS office District Conservationist.
[a] lbs/acre/PLS = pounds per acre of pure live seed

2.3.7 Recommended Native Grass and Pollinator Seed Mixtures, Application Rates, and Non-Native Cover Crop by Physiographical Region (Coastal Plain)

The following seed mixtures are for the Coastal Plan Region. These recommendations are from discussions with Roundstone Native Seed and Robert Glennon.

Recommended Seed Mixtures by Geographical Region (Coastal Plain) and Drainage Class

TABLE 2.3.7-1

Seed Mix P-CPDW01: Recommended Coastal Plain Physiographic Region Grass Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in North Carolina [a]

Common Name	Scientific Name	Height (Inches)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Little Bluestem	*Schizachyrium scoparium*	2- 4	Full Sun	0.250
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.250
Tall Dropseed	*Sporobolus compositus*	2 - 3	Full Sun	0.050
Purple Top	*Tridens flavus*	3 - 5	Part Shade	0.058
Indian Grass	*Sorghastrum nutans*	3 - 6	Full Sun	0.167
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.183
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.042
Total	—	—	—	**1.0**

Sources: Roundstone Native Seed, 2017; Glennon, 2017.
[a] Recommended seeding application rate is 8 to 18 pounds per acre.
[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.3.7-2

Seed Mix P-CPDW01: Recommended Coastal Plain Physiographic Region
Forb Seed Mix and Application Rates for Excessively to Moderately Well Drained Sites in North Carolina

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[b]
Lance Leaved Coreopsis	*Coreopsis lanceolata*	Yellow	Spring, Summer	0.266
Spotted Beebalm	*Monarda punctata*	Pink	Spring, Summer	0.124
Common Milkweed	*Asclepias syriaca*	Pink	Spring, Summer	0.107
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.107
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.124
Partridge Pea	*Cassia fasciculata*	Yellow	Summer	0.621
Spiked Blazing Star	*Liatris spicata*	Pink	Summer	0.222
Lupine	*Lupinus perennis*	Blue	Summer	0.497
Early Goldenrod	*Solidago juncea*	Yellow	Summer	0.160
Starry Silphium	*Silphium asteriscus*	Yellow	Summer, Fall	0.178
Iron Weed	*Vernonia altissima*	Purple	Summer, Fall	0.222
Sneezeweed	*Helenium autumnale*	Yellow	Summer, Fall	0.124
Hairy Mountain Mint	*Pycnanthemum pilosum*	White	Summer, Fall	0.089
Total	—	—	—	**2.84**

Sources: Roundstone Native Seed, 2017; Glennon, 2017.
[a] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.3.7-3

Seed Mix P-CPDW02: Recommended Coastal Plain Physiographic Region
Grass Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in North Carolina [a]

Common Name	Scientific Name	Height (Inches)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Switchgrass	*Panicum virgatum*	3 - 7	Full Sun	0.233
Red Top Panicum	*Panicum rigidulum*	2 - 4	Full Sun	0.017
Fowl Manna Grass	*Glyceria striata*	3 - 5	Part Shade	0.008
Virginia Wild Rye	*Elymus virginicus*	2 - 4	Full Sun	0.217
Deer Tongue Grass	*Panicum clandestinum*	2 - 4	Full Sun	0.058
Big Bluestem	*Andropogon gerardii*	4 - 10	Full Sun	0.167
Frank's Sedge	*Carex frankii*	1 - 2	Part Shade	0.042
Fox Sedge	*Carex vulpinoidea*	2 - 3	Part Shade	0.025
Fall Panicum	*Panicum anceps*	2 - 4	Part Shade	0.067
Total	—	—	—	**0.83**

Sources: Roundstone Native Seed, 2017; Glennon, 2017.
[a] Recommended seeding application rate is 8 to 18 pounds per acre.
[b] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.3.7-4

Seed Mix P-CPDW02: Recommended Coastal Plain Physiographic Region Forb Seed Mix and Application Rates for Somewhat Poorly to Very Poorly Drained Sites in North Carolina

Common Name	Scientific Name	Color	Bloom Period	Seed Application Rate (lbs/acre/PLS)[a]
Smooth Beardtongue	*Penstemon digitalis*	White	Spring	0.169
Butterfly Milkweed	*Asclepias tuberosa*	Orange	Spring, Summer	0.056
Ohio Spiderwort	*Tradescantia ohiensis*	Blue	Spring, Summer	0.084
Blackeyed Susan	*Rudbeckia hirta*	Yellow	Spring, Summer	0.180
Spiked Blazing Star	*Liatris spicata*	Pink	Summer	0.264
Hoary Mountain Mint	*Pycnanthemum incanum*	White	Summer	0.034
Early Goldenrod	*Solidago juncea*	Yellow	Summer	0.113
Bergamot	*Monarda fistulosa*	Lavender	Summer	0.169
Showy Tickseed	*Bidens aristosa*	Yellow	Summer, Fall	0.366
Starry Silphium	*Silphium asteriscus*	Yellow	Summer, Fall	0.113
Narrow-Leaved Sunflower	*Helianthus angustifolius*	Yellow	Summer, Fall	0.113
Joe-Pye Weed	*Eupatorium fistulosum*	Pink	Summer, Fall	0.141
Total	—	—	—	**1.80**

Sources: Roundstone Native Seed, 2017; Glennon, 2017.
[a] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Non-native Temporary Cover Crop Species and Non-native Grass Cover

Use of non-native temporary cover species (P-NNTC) on all plantings where erosion potential is high or where the site must be vegetated within 30 days is recommended. Furthermore, use the non-native grass mixes (P-NNGC) with the forb mixes where slope is steep for native species to germinate and where erosion potential is high.

TABLE 2.3.7-5

Seed Mix P-NNTC: Recommended Non-native Temporary Cover Crop Species

Common Name	Scientific Name	Height (Inches)	Sun Exposure	Seeding Application Rate (lbs/acre/PLS)[a]
For Summer Use in Native Mixes				
Brown Top Millet	*Panicum ramosum*	3 - 3.5	Full sun	5.0
For Spring and Fall Use in Native Mixes				
Spring Oats	*Avena sativa*	2 – 2.5	Full sun	30.0
For Fall and Winter Use in Native Mixes				
Annual Rye Grass	*Lolium multiflorum*	2 – 2.5	Part shade	6.0

Source: Roundstone Native Seed, 2015
[a] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 2.3.7-6

Seed Mix P-NNGC: Recommended Non-native Grass Cover Mix [a]

Common Name	Scientific Name	Height (Inches)	Sun Exposure	Seed Mix Rate (lbs/acre/PLS)[b]
Fescue	*Festuca arundinacea*	2 - 3	Part Shade	0.300
Timothy	*Phleum pratense*	2 - 4	Part Shade	0.100
Orchard Grass	*Dactylis glomerata*	2 - 3	Part Shade	0.100
Red Top	*Agrostis alba*	2 - 3	Full Sun	0.020
Ladino Clover	*Trifolium repens*	1 - 1.5	Part Shade	0.040
Annual Rye Grass	*Lolium multiflorum*	2 - 2.5	Part Shade	0.170
Creeping Red Fescue	*Festuca rubra*	1 - 2	Full Sun	0.250
Kentucky Bluegrass	*Poa pratensis*	1-2	Full Sun	0.020
Total	—	—	—	**1.0**

Source: Roundstone Native Seed, 2015

[a] Recommended seeding application rate is 30 to 50 pounds per acre.

[b] lbs/acre/PLS = pounds per acre of pure live seed

3.0 SUPPLY HEADER PROJECT

3.1 WEST VIRGINIA

3.1.1 Wetzel and Tyler Counties

The following recommended seed mixtures, rates, and amendments are primarily for Tyler County but also include a portion of Wetzel County, West Virginia. The recommendation is from correspondence with Dustin Adkins (NRCS District Conservationist). The recommendation is for the area starting at Mile 23 (estimated portion in Tyler County) through Mockingbird Hill (Wetzel County). No pollinator species specific to the County were recommended by the Conservationist.

Recommended Seed Mixtures, Application Rates, Planting Dates, and Amendments

TABLE 3.1.1-1

Seed Mix WVWE01: Recommended Cool Season Seed Mixture

Seed Mixture	Common Species Name	Seed Rate (lbs/acre/PLS)[a]
1	Orchard Grass	8
	Ladino Clover	2
2	White Clover	2
	Orchardgrass	5
	Kentucky Bluegrass	5
3	Red Clover	4
	Alsike Clover	2
	Orchardgrass	4

[a] lbs/acre/PLS = pounds per acre of pure live seed

TABLE 3.1.1-2

Recommended Seeding Dates for Permanent Cover

Planting Dates	Suitability
March 1 to April 15	Best seeding periods.
August 1 to October 1	
December 1 to March 1	Good seeding period. Dormant seeding.
April 15 to August 1	**HIGH RISK** – moisture stress likely.
October 1 to December 1	**HIGH RISK** – freeze damage to young seedlings.

Source: WVDEP, 2012

TABLE 3.1.1-3

Recommended Lime and Fertilizer Application for Permanent Seeding

pH of Soil	Lime (tons/ acre)	Fertilizer (10-20-20 or equivalent) (lbs/acre)
> 6.0	2	500
5.0 to 6.0	3	
< 5.0	4	

Recommended Lime and Fertilizer Application

Lime should be applied to all permanent seedlings. Once pH is known, use the information in the above Table to determine the amount (tons) of lime to use onsite. For the best results, apply the lime and fertilizer at the time of the seedbed preparation. The recommended lime and fertilizer application for temporary seeding in the absence of a soil test is provided in the below table.

TABLE 3.1.1-4

Recommended Lime and Fertilizer Application for Temporary Seeding (Absent of a Soil Test)

Species	Nitrogen (N) (lbs/acre)	Phosphorus (P_2O_5) (lbs/acre)	Potassium (K_2O) (lbs/acre)	Recommendations (per acre)
Cool Season Grass	40	80	80	400 lbs 10-20-20
Cool Season Grass & Legume	30	60	60	300 lbs 10-20-20
Temporary Cover	40	40	40	200 lbs 19-19-19

Source: WVDEP, 2012

3.1.2 **State Lands**

Lewis Wetzel Wildlife Management Area – Wetzel County

The following seed mixtures, application rates, and soil amendments recommendations are for the Lewis Wetzel WMA in Wetzel County, West Virginia. The recommendations are based on correspondence and discussions with the West Virginia Department of Natural Resources (Steve Rauch, District Wildlife Biologist), which recommended the use of the seed mixtures and soil amendments discussed in the West Virginia Enhancing Wildlife Habitat on Oil and Gas Infrastructure booklet (West Virginia Department of Natural Resources, 2015).

Recommended Seed Mixtures and Application Rates

The following planting recommendations are intended to enhance early successional stage habitat found along access roads and pipelines.

TABLE 3.1.2-1

Seed Mix WVLWWMA01: Recommended Grass Seed Mixes and Application Rates

Common Species Name	Scientific Name	Seeding Application Rate (lbs/acre/PLS)[a]
Perennial, Cool Season Seed Mix [b]		
Ladino White Clover [c]	*Trifolium repens*	4
Mammoth Red Clover [c]	*Trifolium pratense*	5
Forage Clover	*Cichorium intybus*	2
Winter Wheat [d]	*Triticum aestivum*	50
Perennial, Cool Season, Slopes Seed Mix [e]		
Ladino White Clover [c]	*Trifolium repens*	8
Red Clover [c]	*Trifolium pratense*	5
Birdsfoot Trefoil [c]	*Lotus corniculatus*	8
Orchardgrass	*Dactylis glomerata*	15
Winter Wheat [d]	*Triticum aestivum*	50

Source: WVDRN, 2015

[a] lbs/acre/PLS = pounds per acre of pure live seed

[b] Ideal for use in areas where the landscape is generally flat and where the objective is to have vegetative cover for pollinator species and wildlife habitat for turkey/grouse broods, and forage for deer

[b] Herbaceous legumes must be treated with the appropriate inoculant before seeding.

[d] Autumn planting: September 1 through October 15 or substitute annual rye. Spring planting: substitute oats at the same rate between February 15 and March 15, and retain the other species as listed.

[e] Ideal for sloped areas, as grasses are typically added to cool season mixes to provide habitat and erosion control measures.

Recommended Lime and Fertilizer Application

Application of soil amendments should be based on soil test recommendations. In the absence of a soil test, fertilizer and lime should be applied at the rates shown in Table 3.1.2-2.

TABLE 3.1.2-2

Recommended Lime and Fertilizer Application

Type	Application Rate
Lime	3 tons/acre
Fertilizer - 10-20-20	600 lbs/acre

Source: WVDRN, 2015

3.1.3 **Doddridge and Harrison Counties**

The following recommended seed mixtures, planting dates, and amendments are for Doddridge and Harrison counties. These recommendations are based on the collection of correspondences with federal and state agencies, including Greg Stone (NRCS Acting State Resource Conservationist), Jeff Griffith (NRCS District Conservationist). No pollinator species specific to the County were recommended by the Conservationists.

Recommended Seed Mixtures and Application Rates

TABLE 3.1.3-1

Seed Mix WVDH01: Recommended Cool Season Seed Mixtures

Seed Mixture	Common Species Name [a]	Seed Application Rate (lbs/acre/PLS)[b]	Suitable Land Use
1	Orchardgrass	10	Pasture or Hay
	Ladino Clover	2	
	Red Clover	3	
	Redtop	3	
2	**Kentucky Bluegrass**	20	Pasture
	Ladino Clover	2	
	Red Clover	3	
	Redtop	3	Pasture or Hay
3	Orchardgrass	20	
	Redtop	5	
	Birdsfoot Trefoil	10	

[a] Species in bold are more wildlife-friendly; species in italics are suitable for use in filter strips.
[b] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Seeding Dates for Permanent Cover and Amendments

TABLE 3.1.3-2

Recommended Seeding Dates for Permanent Cover

Planting Dates	Suitability
March 1 to April 15	Best seeding periods.
August 1 to October 1	
December 1 to March 1	Good seeding period. Dormant seeding.
April 15 to August 1	**HIGH RISK** – moisture stress likely.
October 1 to December 1	**HIGH RISK** – freeze damage to young seedlings.

TABLE 3.1.3-3

Recommended Lime and Fertilizer Application

Type	Application Rate
Lime	3 tons/acre
Fertilizer - 10-20-20	400 lbs/acre

Planting Recommendations

- Certified seed is preferred.
- All legumes should be planted with proper inoculants prior to seeding.
- Soil fertility and pH level will be amended to satisfy the needs of the plant species planned.
- For unprepared seedbeds or seeding outside the optimum timeframes:

- o Add 50 percent more seed to the specified rate, particularly during the periods of April 15 – August 1, and October 1 – March 1.
- o Double the seeding rate and consider planning an annual small grain like wheat (2 bushels [120 pounds] per acre) to act as a nurse crop.

3.1.4 **Recommended Native Grasses and Pollinators Seed Mixtures, Application Rates, and Non-Native Cover Crop by Physiographical Region**

Use the same recommended pollinator seed mixtures, non-native temporary cover, and non-native grass cover as indicted in Section 2.1.5 for the ACP in West Virginia.

3.2 PENNSYLVANIA

3.2.1 **Westmoreland County**

Seed mixtures, rates, and amendments were selected based on appropriate site conditions and recommendations from Christopher Droste (Conservation District) and adapted from the Pennsylvania Department of Environmental Protection Erosion and Sediment Pollution Control Program Manual. No pollinator species specific to the County were recommended by the Conservationist.

Recommended Seed Mixtures and Application Rates

TABLE 3.2.1-1

Seed Mix PAWE01: Recommended Cool Season Seed Mixture

Common Species Name	Seeding Application Rate (lbs/acre/PLS)[b] Most Sites	Adverse Sites
Birdsfoot trefoil [a], plus	6	10
-Tall fescue	30	35

[a] For Birdsfoot trefoil use empire variety. For slopes > 33 percent (3H:1V), add perennial rye at 20 lbs/acre. For planting outside March 1 - October 15, use winter oats at 90 lbs/acre and winter rye at 56 lbs/acre.

[b] lbs/acre/PLS = pounds per acre of pure live seed

Recommended Soil Amendments

TABLE 3.2.1-2

Soil Amendment Application Rate Equivalents [a]

Soil Amendment	Per Acre	Per 1,000 Square feet (lbs)	Per 1,000 square Yard (lbs)	Notes
Agricultural lime	7.5 tons	300	3100	Or as per soil test; may not be required in agricultural fields
20-20-20 fertilizer	1,000 lbs	25	210	Or as per soil test; may not be required in agricultural fields

[a] For agricultural or private lands, contractor will use rates above unless otherwise specified by landowner.

TABLE 3.2.1-3

Recommended Mulch Type and Rates

Mulch Type	Per Acre (tons)	Per 1000 Square Feet (lbs)	Per 1000 Square Yard (lbs)	Notes
Straw	3	140	1240	Either wheat or oat straw, free of weeds, not chopped or finely broken
Hay	3	140	1240	Timothy, mixed clover and timothy or other native forage grasses
Wood Chips	4-6	185-275	1650-2500	May prevent germination of grasses and legumes
Hydromulch	1	47	415	See limitations below

Shredded paper hydromulch should not be used in slopes steeper than 5 percent. Wood fiber hydromulch may be applied on steeper slopes provided a tackifier is used. The application rate for any hydromulch should be 2,000 pounds per acre at a minimum.

4.0 REFERENCES

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Attachment A
Summary of Seed Mixes by County for the
Atlantic Coast Pipeline and Supply Header Project

ATTACHMENT A

Summary of Seed Mixtures by County for the Atlantic Coast Pipeline and Supply Header Project

Approximate Milepost Range	County and State	Suggested Cool Season Seed Mix Number [a]	Suggested Warm Season Seed Mix Number [a]	Suggested Pollinator Seed Mix Number [a]	Federal, State/Commonwealth, or local Agency/ Subject Matter Expert Contact Information
Atlantic Coast Pipeline					
Spread 1 (AP-1)					
0.0–29.1	Harrison, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District Conservationist - Jeff Griffith (304) 624-9232 ext. 11; jeff.griffith@wv.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Lewis, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District Conservationist - Jeff Griffith (304) 624-9232 ext. 110; jeff.griffith@wv.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Upshur, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	Acting State Conservationist - Greg Stone (304) 284-7579; greg.stone@wv.usda.gov. Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 2 (AP-1)					
29.1–50.6	Upshur, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	Acting State Conservationist - Greg Stone (304) 284-7579; greg.stone@wv.usda.gov,Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Randolph, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District (1) Wildlife Biologist - Steve Rauch (304) 825-6787; Steven.E.Rauch@wv.gov.
Spread 2 A (AP-1)					
50.6-65.3	Randolph, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District (1) Wildlife Biologist - Steve Rauch (304) 825-6787; Steven.E.Rauch@wv.gov
Spread 3 (AP-1)					
65.3-79.2	Randolph, WV	WVHLRU01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District (1) Wildlife Biologist - Steve Rauch (304) 825-6787; Steven.E.Rauch@wv.gov
	Pocahontas, WV	WVPO01	WVPO01; P-MUDW01 or MUMP02; P-NNTC or P-NNGC	P-MUDW01 or MUMP02; P-NNTC or P-NNGC	District Conservationist - Iden Gunther (304) 255-9225; idun.guenther@wv.usda.gov. Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 3A (AP-1)					
79.2-91.3					
	Pocahontas, WV	WVPO01	WVPO01; P-MUDW01 or MUMP02; P-NNTC or P-NNGC	P-MUDW01 or MUMP02; P-NNTC or P-NNGC	District Conservationist - Iden Gunther (304) 255-9225; idun.guenther@wv.usda.gov. Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.

ATTACHMENT A

Summary of Seed Mixtures by County for the Atlantic Coast Pipeline and Supply Header Project

Approximate Milepost Range	County and State	Suggested Cool Season Seed Mix Number [a]	Suggested Warm Season Seed Mix Number [a]	Suggested Pollinator Seed Mix Number [a]	Federal, State/Commonwealth, or local Agency/ Subject Matter Expert Contact Information
	Highland, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - Charles Ivins (540) 248-6218 ext. 122; charles.ivins@va.usda.gov, Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov.
Spread 4 (AP-1)					
91.3–125.9	Highland, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - Charles Ivins (540) 248-6218 ext. 122; charles.ivins@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov.
	Bath, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist – Charles Simmons; charles.simmons@va.usda.gov, Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov.
	Augusta, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - Charles Ivins (540) 248-6218 ext. 122; charles.ivins@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
Spread 5 (AP-1)					
125.9–183.3	Augusta, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - Charles Ivins (540) 248-6218 ext. 122; charles.ivins@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Nelson, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	State Biologist - Jeffray Jones (804) 287-1691; Jeffray.Jones@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
Spread 6 (AP-1)					
183.3–239.6	Nelson, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	State Biologist - Jeffray Jones (804) 287-1691; Jeffray.Jones@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Nelson, VA; James River WWA	VJRWMA01; VJRWMA02; or VJRWMA03	VJRWMA01; VJRWMA02; or VJRWMA03		Environmental Services Biologists – Amy Ewing (804) 367-2211; Amy.Ewing@dgif.virginia.gov
	Buckingham, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - David Harris (434) 983-4757 x 101; david.harris@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Cumberland. VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - David Harris (434) 983-4757 x 101; david.harris@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Prince Edward, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - J.B. Daniel (434) 392-4171; j.b.daniel@va.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Nottoway, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov

ATTACHMENT A

Summary of Seed Mixtures by County for the Atlantic Coast Pipeline and Supply Header Project

Approximate Milepost Range	County and State	Suggested Cool Season Seed Mix Number [a]	Suggested Warm Season Seed Mix Number [a]	Suggested Pollinator Seed Mix Number [a]	Federal, State/Commonwealth, or local Agency/ Subject Matter Expert Contact Information
Spread 7 (AP-1)					
239.6–300.1	Nottoway, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Dinwiddie, VA	VACSDGS01	VACSDGS01	P-VACSDGS01 or P-VACSDGS02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Brunswick, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Greensville, VA	VACSDGS01	VACSDGS01	P-VACSDGS01 or P-VACSDGS02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Northampton, NC	NCNO01	NCNO02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Paul Boone (252) 534-2591; paul.boone@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 8 (AP-2)					
0.0–61.6	Northampton, NC	NCNO01	NCNO02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Paul Boone (252) 534-2591; paul.boone@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Halifax, NC	NCHW01	P-CPDW01 or P-CPMP02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist -David Little (252) 237-2711; David.Little@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Nash, NC	NCNJ01	P-CDW01 or P-CPMP02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Patrick Evans (252) 459-4116; patrick.evans@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 9 (AP-2)					
61.6–61.6	Nash, NC	NCNJ01	P-CPDW01 or P-CPMP02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Patrick Evans (252) 459-4116; patrick.evans@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Roundstone Native Seed (270) 234-7160.
	Wilson, NC	NCHW01	P-CPDW01 or P-CPMP02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist -David Little (252) 237-2711; David.Little@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Johnston, NC	NCNJ01	P-CDW01 or P-CPMP02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Brian Loadholt (919) 934-7156; brian.loadholt@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.

ATTACHMENT A

Summary of Seed Mixtures by County for the Atlantic Coast Pipeline and Supply Header Project

Approximate Milepost Range	County and State	Suggested Cool Season Seed Mix Number [a]	Suggested Warm Season Seed Mix Number [a]	Suggested Pollinator Seed Mix Number [a]	Federal, State/Commonwealth, or local Agency/ Subject Matter Expert Contact Information
	Sampson, NC	NCSA01	NCSA02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Gavin Thompson (910) 592-7963; gavin.thompson@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Cumberland, NC	NCCU01	NCCU01	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Renessa Hardy-Brown (910) 484-8479; renessa.brown@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 10 (AP-2)					
61.5–183.0	Cumberland, NC	NCCU01	NCCU01	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Renessa Hardy-Brown (910) 484-8479; renessa.brown@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Robeson, NC	P-CPDW01 or P-CPMP02	NCRO01	P-CPDW01, P-CPMP02, or P-NCRO01; P-NNTC or P-NNGC	District Conservationist - Jeremy Roston (910) 739-5478; jeremy.roston@usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 11 (AP-3)					
0.0–83.0	Northampton, NC	NCNO01	NCNO02	P-CPDW01 or P-CPMP02; P-NNTC or P-NNGC	District Conservationist - Paul Boone (252) 534-2591; paul.boone@nc.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Greensville, VA	VACSDGS01	VACSDGS01	P-VACSDGS01 or P-VACSDGS02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Southampton, VA	VACSDGS01	VACSDGS01	P-VACSDGS01 or P-VACSDGS02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
	Suffolk, VA	VACSDGS01	VACSDGS01	P-VACSDGS01 or P-VACSDGS02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov
Spread 12 (AP-4; AP-5)					
0.0–0.4; 0.0-1.1	Brunswick, VA	VABCHNP01	VABCHNP02	P-VABCHNP01 or P-VABCHNP02	District Conservationist - Davie Wade Harris (434) 848-2145 ext. 102; davie.harris@va.usda.gov
	Greensville, VA	VACSDGS01	VACSDGS01	P-VACSDGS01 or P-VACSDGS02	Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov

ATTACHMENT A

Summary of Seed Mixtures by County for the Atlantic Coast Pipeline and Supply Header Project

Approximate Milepost Range	County and State	Suggested Cool Season Seed Mix Number [a]	Suggested Warm Season Seed Mix Number [a]	Suggested Pollinator Seed Mix Number [a]	Federal, State/Commonwealth, or local Agency/ Subject Matter Expert Contact Information
Supply Header Project					
Spread 13 (TL-635)					
0.0–33.6	Wetzel, WV	WVWE01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District Conservationist - Dustin Adkins (304) 758-2173; dustin.adkins@wv.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Wetzel, WV; Lewis Wetzel WMA	WVLWWMA01			District Wildlife Biologist - Steve Rauch (304)825-6787; steven.e.rauch@wv.gov
	Doddridge, WV	WVDH01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	Acting State Conservationist - Greg Stone (304) 284-7579; greg.stone@wv.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Tyler, WV	WVWE01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	District Conservationist - Dustin Adkins (304) 758-2173; dustin.adkins@wv.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
	Harrison, WV	WVDH01	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	P-MUDW01 or P-MUMP02; P-NNTC or P-NNGC	Acting State Conservationist - Greg Stone (304) 284-7579; greg.stone@wv.usda.gov. Private Lands Biologist - Bob Glennon (757) 357-7004, ext. 126; Robert.Glennon@va.usda.gov. Roundstone Native Seed (270) 234-7160.
Spread 14 (TL-636)					
0.0–3.9	Westmoreland, PA	PAWE01	None Recommended	None Recommended	Westmoreland Conservation District, Christopher Droste, Senior Erosion Control Specialist (724) 837-5271; chris@wcdpa.com.

[a] Tables describing each seed mix are located within the text of Appendix A.

ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE

and

DOMINION TRANSMISSION, INC.
SUPPLY HEADER PROJECT

Restoration and Rehabilitation Plan

Appendix C
Recommended Seed Mixes by Milepost
(to be provided prior to construction)

APPENDIX S

Agricultural Cost Share Conservation Areas

Appendix S

Agricultural Cost Share Conservation Areas within Virginia

County	Latitude	Longitude	BMP ID	Practice Type[1]
Highland County	38.28494107	-79.74621201	49136	WP-2A
Highland County	38.28494107	-79.74621201	49110	WP-2A
Highland County	38.22071218	-79.70223802	49016	CP-22
Highland County	38.22071218	-79.70223802	49017	CRFR-3
Highland County	38.22071218	-79.70223802	49039	SL-6
Bath County	38.17001343	-79.66104889	139264	SL-6
Bath County	38.16526247	-79.65984552	49456	SL-1
Bath County	38.16479893	-79.65871253	49457	SL-1
Bath County	38.13407156	-79.61249462	49308	CP-22
Bath County	38.13407156	-79.61249462	49309	CRFR-3
Bath County	38.13407156	-79.61249462	49310	SL-6
Bath County	38.09734096	-79.51967591	48908	FR-1
Bath County	38.09734096	-79.51967591	48909	FR-3
Bath County	38.10347366	-79.50761414	178719	SL-6
Bath County	38.11646587	-79.49989794	39253	CP-22
Bath County	38.11646587	-79.49989794	39254	CRFR-3
Bath County	38.11646587	-79.49989794	39255	SL-6
Bath County	38.12537324	-79.49172978	49390	SL-1
Bath County	38.12942022	-79.49107604	49389	SL-1
Bath County	38.13427998	-79.48355963	49387	SL-1
Augusta County	38.24938202	-79.33409119	231253	SL-8B
Augusta County	38.28042603	-79.17675018	231902	SL-8B
Augusta County	38.27169235	-79.1730627	39814	CP-22
Augusta County	38.27169235	-79.1730627	39815	SL-6
Augusta County	38.26892986	-79.16754248	39812	CP-22
Augusta County	38.26892986	-79.16754248	39813	SL-6
Augusta County	38.27239609	-79.16718292	223273	CP-22
Augusta County	38.27239609	-79.16718292	223275	CRFR-3
Augusta County	38.27239609	-79.16718292	223276	CRSL-6
Augusta County	38.18313599	-79.15982819	161902	SL-6
Augusta County	38.18373489	-79.15433502	160677	SL-6
Augusta County	38.19766235	-79.14598084	124280	LE-1T
Augusta County	38.11946106	-79.13977814	208529	SL-6
Augusta County	38.11148071	-79.11851501	119320	SL-1
Augusta County	38.10711837	-79.11735081	40960	FR-1
Augusta County	38.07004597	-79.05872955	40421	WQ-4
Augusta County	38.06938078	-79.05664971	39227	CRFR-3
Augusta County	38.06938078	-79.05664971	39444	CP-22
Augusta County	38.06938078	-79.05664971	39445	SL-6
Augusta County	38.03054428	-79.0182724	5119	WQ-4
Augusta County	38.03167916	-79.0094308	39101	CRFR-3
Augusta County	38.03167916	-79.0094308	39322	CP-22
Nelson County	37.82169724	-78.81558228	166655	SL-6
Buckingham County	37.53968048	-78.61242676	179332	LE-1T
Buckingham County	37.54304427	-78.61053035	61431	CP-22
Buckingham County	37.44728943	-78.5030504	61785	CP-22
Buckingham County	37.44728943	-78.5030504	61784	CRFR-3
Buckingham County	37.44728943	-78.5030504	61783	SL-6
Buckingham County	37.43597031	-78.48266602	227809	SL-7
Buckingham County	37.4125084	-78.46050762	61527	CP-22

Appendix S

Agricultural Cost Share Conservation Areas within Virginia

County	Latitude	Longitude	BMP ID	Practice Type[1]
Buckingham County	37.4125084	-78.46050762	61526	CRFR-3
Buckingham County	37.4125084	-78.46050762	61525	SL-6
Buckingham County	37.40871266	-78.45664806	61238	CP-22
Buckingham County	37.40871266	-78.45664806	61237	CRFR-3
Buckingham County	37.41096389	-78.4565719	61236	SL-6
Cumberland County	37.37597906	-78.41163864	61743	LE-1T
Cumberland County	37.37522894	-78.40866085	61352	CP-22
Cumberland County	37.37522894	-78.40866085	61351	CRFR-3
Cumberland County	37.37340328	-78.40759456	61350	SL-6
Cumberland County	37.3733909	-78.40703041	61361	CP-22
Cumberland County	37.3733909	-78.40703041	61360	CRFR-3
Cumberland County	37.32531738	-78.32090759	230933	SL-1
Cumberland County	37.32814407	-78.32062531	144113	SL-1
Cumberland County	37.32857132	-78.31963348	117054	FR-1
Cumberland County	37.32474833	-78.3189963	61588	SL-6
Cumberland County	37.32195663	-78.30764008	164342	CCI-SE-1
Prince Edward County	37.30680847	-78.28314972	108150	SL-6
Prince Edward County	37.3066597	-78.28259277	108153	CRSL-6
Prince Edward County	37.30644989	-78.28234863	108151	CP-22
Prince Edward County	37.30640793	-78.28233337	108152	CRFR-3
Nottoway County	37.25846863	-78.18582916	161521	FR-1
Nottoway County	37.25315857	-78.16517639	154120	WQ-4
Nottoway County	37.25333786	-78.16505432	138410	WQ-4
Nottoway County	37.14148331	-78.01461029	143905	SL-1
Nottoway County	37.14112473	-78.01112366	137162	FR-1
Nottoway County	37.1330121	-77.96712762	62985	SL-6
Nottoway County	37.1330121	-77.96712762	62983	SL-6
Nottoway County	37.13123984	-77.96593294	62984	SL-6
Nottoway County	37.12084961	-77.91753387	208636	SL-6
Dinwiddie County	37.11429955	-77.86709908	17526	WP-4C
Dinwiddie County	37.00909046	-77.83574486	17904	SL-6
Dinwiddie County	37.03451463	-77.83146398	17684	SL-1
Dinwiddie County	37.03496839	-77.83095255	17552	SL-1
Greensville County	36.65485001	-77.58078003	227669	SL-8B
Greensville County	36.64987564	-77.57558441	218333	SL-8B
Greensville County	36.61894226	-77.53320313	227505	SL-8B
Greensville County	36.5770344	-77.52851736	20934	CP-21
Greensville County	36.5770344	-77.52851736	20935	WQ-1
Southampton County	36.56680085	-77.28134932	20451	WP-4
Southampton County	36.58278275	-77.23579407	222287	SL-8B
Southampton County	36.58528137	-77.23194122	214382	SL-8B
Southampton County	36.58666992	-77.22829437	222304	SL-8B
Southampton County	36.58561325	-77.22797394	222288	SL-8B
Southampton County	36.58587265	-77.22688293	222289	SL-8B
Southampton County	36.58444214	-77.22664642	222290	SL-8B
Southampton County	36.58510971	-77.22509766	224318	SL-8B
Southampton County	36.58394623	-77.22185516	224322	SL-8B
Southampton County	36.59467316	-77.20809174	224288	SL-8B
Southampton County	36.59809875	-77.20211029	183392	SL-6
Southampton County	36.60088146	-77.19388766	22398	WP-3

Appendix S

Agricultural Cost Share Conservation Areas within Virginia

County	Latitude	Longitude	BMP ID	Practice Type[1]
Southampton County	36.60521698	-77.18889618	224870	SL-8B
Southampton County	36.60366058	-77.18481445	222134	SL-8B
Southampton County	36.60465622	-77.18241119	222138	SL-8B
Southampton County	36.61142349	-77.17645264	224291	SL-8B
Southampton County	36.61037445	-77.17596436	224300	SL-8B
Southampton County	36.61234665	-77.17429352	224295	SL-8B
Southampton County	36.629673	-77.1439209	217761	SL-8B
Southampton County	36.63484955	-77.13848114	225026	SL-8B
Southampton County	36.63381195	-77.13816071	225027	SL-8B
Southampton County	36.63649368	-77.13772583	215173	SL-8B
Southampton County	36.63964844	-77.0918045	213814	SL-8B
Southampton County	36.63907623	-77.08894348	213659	SL-8B
Southampton County	36.63570786	-77.085289	213947	SL-8B
Southampton County	36.63773346	-77.08287048	213942	SL-8B
Southampton County	36.64189148	-77.08113098	213817	SL-8B
Southampton County	36.63824081	-77.07996368	213943	SL-8B
Southampton County	36.6398735	-77.07852936	213940	SL-8B
Southampton County	36.63860321	-77.07611084	213946	SL-8B
Southampton County	36.64048386	-77.07487488	213941	SL-8B
Southampton County	36.6373558	-77.03378296	224237	SL-8B
Southampton County	36.63496017	-77.02060699	224203	SL-8B
Southampton County	36.63360977	-77.02054596	224205	SL-8B
Southampton County	36.62848625	-77.01071633	21010	CP-21
Southampton County	36.62848625	-77.01071633	21011	WQ-1
Southampton County	36.63844541	-76.98171718	21442	CP-22
Southampton County	36.63844541	-76.98171718	21443	CRFR-3
Southampton County	36.64523795	-76.96233935	21422	CP-21
Southampton County	36.64523795	-76.96233935	21423	WQ-1
Southampton County	36.64095747	-76.93196486	20312	CP-21
Southampton County	36.64095747	-76.93196486	20313	WQ-1
City of Suffolk	36.67939763	-76.73920728	59982	SL-1
City of Suffolk	36.71559826	-76.71674682	59601	CP-21
City of Suffolk	36.71559826	-76.71674682	59671	CRLF-1
City of Suffolk	36.71559826	-76.71674682	59600	WQ-1
City of Suffolk	36.76386261	-76.68712616	230964	SL-8B
City of Suffolk	36.76226425	-76.68557739	232268	SL-8H
City of Suffolk	36.78076172	-76.66472626	232267	SL-8H
City of Suffolk	36.79058075	-76.65029144	230268	SL-8B
City of Suffolk	36.79394913	-76.63909912	212434	SL-8B
City of Suffolk	36.79595566	-76.62844086	212442	SL-8B
City of Suffolk	36.79616547	-76.62794495	212441	SL-8B
City of Suffolk	36.79376602	-76.62299347	212443	SL-8B
City of Suffolk	36.79581039	-76.60713079	59184	WP-1
City of Suffolk	36.79879761	-76.60551453	230967	SL-8B
City of Suffolk	36.79560089	-76.60223389	231019	SL-8B

Appendix S

Agricultural Cost Share Conservation Areas within Virginia

County	Latitude	Longitude	BMP ID	Practice Type[1]
City of Suffolk	36.80052948	-76.59979248	231021	SL-8B

1- Long Term Continuous No-Till Planting Systems (CCI-CNT), Filter Strip (CP-21), Riparian Forest Buffer (CP-22), Riparian Forest Buffer (CRFR-3), Buffer Length Recording (CRLF-1), Stream Exclusion (CRSL-6), Reforestation of Erodible Crop and Pastureland (FR-1), Woodland Buffer Filter Area (FR-3), Livestock Exclusion with Riparian Buffers for TMDL Implementation (LE-1T), Permanent Vegetative Cover on Cropland (SL-1), Stream Exclusion with Grazing Land Management (SL-6), Extension of CREP Watering System (SL-7), Small Grain Cover Crop for Nutrient and Residue Management (SL-8B), Harvestable Cover Crop (SL-8H), Sediment Retention, Erosion or Water Control Structure (WP-1), Streambank Stabilization (WP-2A), Sod Waterway (WP-3), Animal Waste Control Facility (WP-4), Composting Facility (WP-4C).

APPENDIX T

HDD Plan

ATLANTIC COAST PIPELINE, LLC
ATLANTIC COAST PIPELINE

and

DOMINION TRANSMISSION, INC.
SUPPLY HEADER PROJECT

Supplemental Filing
January 10, 2017

HDD Design Report

HDD Design Report, Revision 2
Atlantic Coast Pipeline Project

December 14, 2016

Prepared for

Dominion

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Table of Contents

Atlantic Coast Pipeline Project
HDD Design Report, Revision 2

1. Introduction

1.1 Scope of Report

This report provides background information associated with design drawings produced by J. D. Hair & Associates, Inc. (JDH&A) for nineteen obstacle crossings on Dominion's Atlantic Coast Pipeline (ACP) Project that are proposed for installation by horizontal directional drilling (HDD). The table below provides a list of the crossings that are addressed in this report along with their diameters and horizontal lengths.

Crossing	Pipe Diameter	Horizontal Length
Interstate 79	42 inches	2,869 feet
Blue Ridge Parkway	42 inches	4,639 feet
James River	42 inches	2,965 feet
Roanoke River	36 inches	1,559 feet
Fishing Creek	36 inches	1,822 feet
Swift Creek	36 inches	1,629 feet
Tar River	36 inches	1,516 feet
Contentnea Creek	36 inches	1,327 feet
Little River	36 inches	1,446 feet
Cape Fear River	36 inches	1,654 feet
Nottaway River	20 inches	1,678 feet
Blackwater River	20 inches	2,234 feet
Lake Prince	20 inches	1,952 feet
Western Branch Reservoir	20 inches	1,464 feet
Nansemond River Tributary	20 inches	3,435 feet
Nansemond River	20 inches	4,127 feet
Interstate 64	20 inches	2,039 feet
Route 17	20 inches	2,951 feet
Elizabeth River	20 inches	1,730 feet

Table 1. Proposed HDD Crossings on the ACP Project

While the primary function of this report is to present design drawings, calculations, and opinions of feasibility for each of the proposed HDD crossings on the ACP Project, general information about the HDD construction method has also been included to provide a more thorough understanding of both project-specific considerations and standard industry practices.

1.2 Information Provided by Others

In producing the design drawings described in the previous section, JDH&A has relied upon the following information provided by others.

1.2.1 Base Survey Data

AutoCAD base files for each of the proposed crossing locations were provided by GAI Consultants, Canonsburg, Pennsylvania. These files present the results of the topographic and bathymetric surveys completed at the sites, providing grade elevations along the proposed HDD alignments and information about existing features in the vicinity of the proposed crossings.

1.2.2 Subsurface Information

Subsurface information at each of the crossing locations was provided by Geosyntec Consultants, Richmond, Virginia in crossing-specific Geotechnical Site Investigation Reports. In addition to the report text, boring logs, and laboratory testing data that were provided, Geosyntec's reports included geotechnical parameters for the soils encountered in each boring. This information was used by JDH&A to analyze the potential for drilling fluid circulation loss due to hydrofracture at each HDD crossing location.

1.2.3 Pipe Specifications and Operating Information

Line pipe specifications and maximum operating pressures applicable to the proposed crossings were provided by Ron Baker of Dominion in an email dated December 10, 2015. Installation and operating temperatures were assumed by JDH&A for the sake of analysis.

2. Horizontal Directional Drilling

2.1 Process Description

Installation of a pipeline by HDD is generally accomplished in three phases as indicated in Figure 1. First, a small diameter pilot hole is drilled along a designed directional path. Next, the pilot hole is enlarged to a diameter that will accommodate the pipeline to be installed. Finally, the pipeline is pulled into the enlarged hole.

2.1.1 Pilot Hole

Pilot hole directional control is achieved by using a non-rotating drill string with an asymmetrical leading edge. The asymmetry of the leading edge creates a steering bias while the non-rotating aspect of the drill string allows the steering bias to be held in a specific position while drilling. If a change in direction is required, the drill string is rolled so that the direction of bias is the same as the desired change in direction. Leading edge asymmetry is typically accomplished with either a bent sub or a bent motor housing located behind the bit.

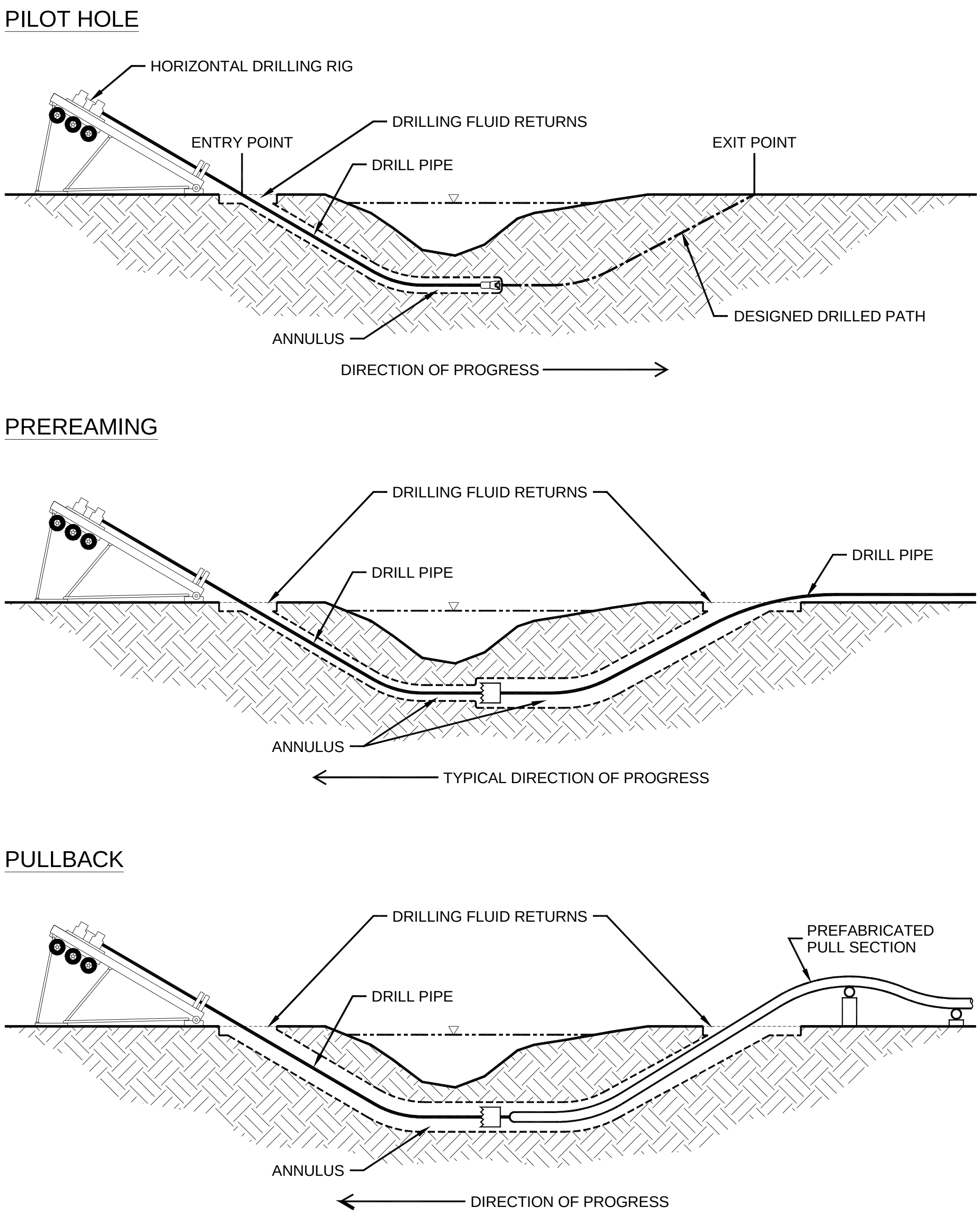

Figure 1. The HDD Process

In soft soils, drilling progress is achieved by hydraulic cutting with a jet nozzle. If hard zones are encountered, the drill string may be rotated to drill without directional control until the hard zone has been penetrated. Mechanical cutting action required for harder soils and rock is provided by a mud motor which converts hydraulic energy from drilling fluid to mechanical energy at the drill bit. This allows for bit rotation without drill string rotation.

The path of the pilot hole is monitored during drilling using a steering tool positioned near the bit. The steering tool provides continuous readings of the inclination and azimuth at the leading edge of the drill string. These readings, in conjunction with measurements of the distance drilled, are used to calculate the horizontal and vertical coordinates of the steering tool relative to the initial entry point on the surface. The path of the pilot hole can also be determined with a surface monitoring system that induces an artificial magnetic field using a wire placed on the surface. Measurements of this magnetic field's properties by instruments in the steering tool allow the position of the steering tool to be determined using triangulation. This provides data that can be used to correct downhole survey inaccuracy that results from inconsistencies in the earth's magnetic field.

2.1.2 Prereaming

Enlarging the pilot hole is accomplished using prereaming passes prior to pipe installation. Reaming tools generally consist of a circular array of cutters and drilling fluid jets and are often custom made by contractors for a particular hole size or type of soil. These tools are attached to the drill string and rotated and drawn along the pilot hole. Drill pipe is added behind the tools as they progress along the drilled path to ensure that a string of pipe is always maintained in the drilled hole.

2.1.3 Pullback

Pipe installation is accomplished by attaching a pipeline pull section behind a reaming assembly at the exit point, then pulling the reaming assembly and pull section back to the drilling rig. This is undertaken after completion of prereaming or, for smaller diameter lines in soft soils, directly after completion of the pilot hole. A swivel is utilized to connect the pull section to the reaming assembly to minimize torsion transmitted to the pipe. The pull section is supported using some combination of roller stands and pipe handling equipment to minimize tension and prevent damage to the pipe.

2.2 HDD Feasibility Considerations

The technical feasibility of an HDD installation can be determined by comparing it to past installations in three basic parameters: drilled length, pipe diameter, and subsurface conditions. These three parameters work in combination to limit what can be achieved at a given location. With pipe diameters ranging from 20 to 42 inches and horizontal drilled lengths ranging from 1,327 to 4,639 feet, all of the potential HDD installations on the ACP Project are within current HDD industry capabilities in terms of both length and diameter. However, while length and diameter are key components in an HDD installation's feasibility, technical feasibility is primarily limited by subsurface conditions. The material characteristic that most frequently prevents successful HDD installations is large grain content in the form of cobbles and boulders. Other conditions that can negatively impact HDD feasibility include poor rock quality, excessive rock strength and hardness, solution cavities in bedrock, and artesian groundwater pressure.

Soils consisting principally of coarse-grained material present a serious restriction on the feasibility of HDD. Coarse material cannot be readily fluidized by the drilling fluid and is too unstable to be cut and removed in a drilling fluid stream as is the case with a crossing in competent rock. A boulder or cluster of cobbles will remain in the drilled path and present an obstruction to a bit, reamer, or pipeline. Such obstructions must be mechanically displaced during hole enlargement. Displacement may be radially outward into voids formed by the entrainment of finer grained material. However, naturally dense, high gravel percentage soils contain little entrainable material, therefore voids sufficient to permit passage by larger diameter reamers or pipe may not develop. Coarse material may also migrate to low spots along the drilled path forming impenetrable blocks. An HDD installation through poor quality (extensively fractured or jointed) rock can present the same problems as coarse granular deposits. Cutting a hole through such materials may cause the overlying rock to fall in creating obstructions during subsequent passes.

Exceptionally strong and hard rock will hamper all phases of an HDD project. Experience has shown that competent rock with unconfined compressive strengths as high as 50,000 psi can be negotiated with today's technology. However, entry of such materials at depth can be problematic as the drill string may tend to deflect rather than penetrate. Extremely slow penetration rates in hard rock and frequent stoppages to replace worn bits and reamers can result in extended construction durations and corresponding increases in construction cost. Excessive rock hardness can also lead to tool failures downhole resulting from premature wear and drill pipe failures due to excessive torque.

Penetration of solution cavities found in karstic limestone formations can allow the drill string to deflect substantially, especially during pilot hole drilling when the drill string is in compression. Continued rotation of a drill string subjected to excessive deflection can result in failure of the drill pipe due to low-cycle fatigue. Penetration of an artesian aquifer on an HDD installation can result in a sustained inflow of groundwater and fine soils into the drilled hole. This can cause several serious problems including drilling fluid storage and disposal issues, degradation of the drilling fluid, deterioration of the hole, and stuck pipe or downhole tools.

2.3 Workspace Requirements

2.3.1 Rig Side

A typical large horizontal drilling spread can be moved onto a site in seven to ten tractor-trailer loads. A workspace of 250 feet by 200 feet is adequate for most operations. The locations of the principal components of the spread (rig ramp, drill pipe, and control trailer) are fixed by the entry point. The rig ramp must be positioned in line with the drilled segment and typically less than 25 feet back from the entry point. The control cab and drill pipe must be positioned adjacent to the rig.

The horizontal drilling rig workspace must be cleared and graded level. Equipment is typically supported on the ground surface, although timber mats may be used where soft ground is encountered. A typical horizontal drilling rig site plan is shown in Figure 2. Where possible, we recommend obtaining workspaces of similar dimensions to accommodate HDD rig side operations on the ACP Project.

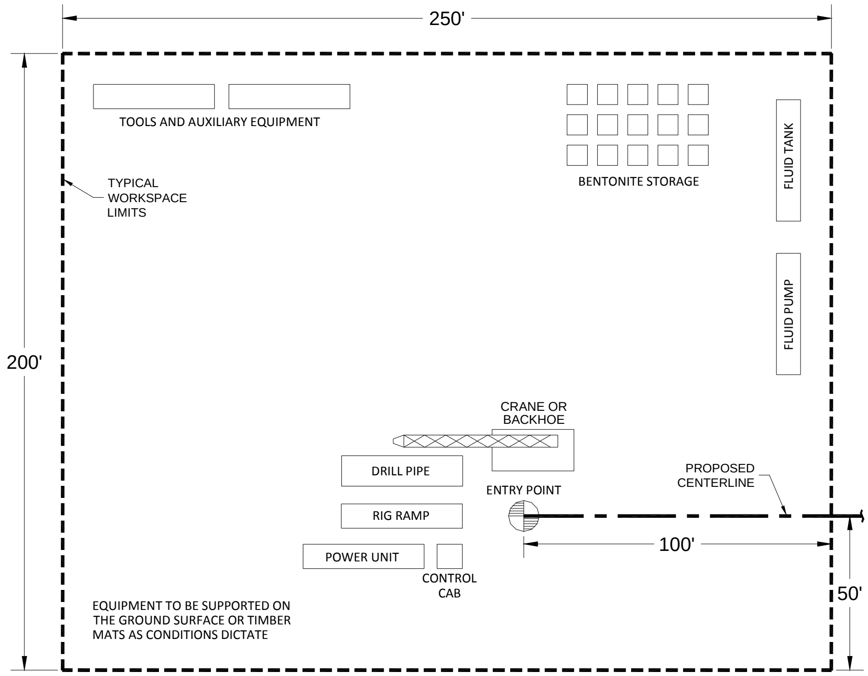

Figure 2. Typical Horizontal Drilling Rig Site Plan

2.3.2 Pipe Side

Pull section fabrication is accomplished using the same construction methods used to lay a pipeline; therefore, similar workspace is required. The drilled segment exit point controls the location of pull section fabrication workspace. Space must be available to allow the pipe to be fed into the drilled hole. It is preferable to have workspace aligned with the drilled segment extending back from the exit point the length of the pull section plus approximately 200 feet. This will allow the pull section to be prefabricated in one continuous length prior to installation. If space is not available, the pull section may be fabricated in two or more sections which are welded together during installation. It should be noted that delays associated with joining multiple pipe strings during pullback can increase the risk of the pipe becoming stuck in the hole.

Workspace for pull section fabrication should generally be around 100 feet wide; similar to what is required for conventional pipeline construction. Additional temporary workspace should be provided in the immediate vicinity of the exit point to facilitate personnel and equipment supporting drilling operations. Pull section workspace must be cleared but need not be graded level. Equipment is typically supported on the ground surface. Timber mats may be used where soft ground is encountered. A typical pull section fabrication site plan is shown in Figure 3. Where possible, we recommend obtaining workspaces of similar dimensions to accommodate HDD pipe side operations on the ACP Project.

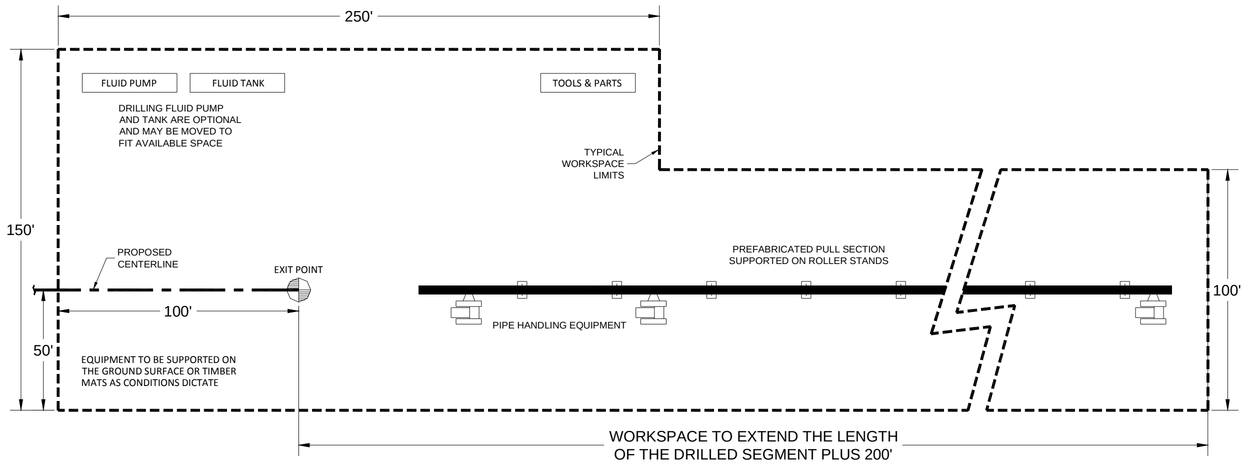

Figure 3. Typical Pull Section Fabrication Site Plan

2.4 Drilling Fluid

2.4.1 Introduction

Drilling fluid is used in all phases of the HDD process and typically consists of fresh water obtained at the crossing location, high-yield bentonite, and excavated soil or rock cuttings that accumulate as HDD operations progress. Typical HDD drilling fluids are composed of less than 2% high yield bentonite by volume. Drilling fluid serves several critical functions in HDD pipeline installation including hydraulic excavation of the soil along the drilled path, transmission of hydraulic power to a downhole motor that turns the bit, removal of soil or rock cuttings from the hole, stabilization of the hole, and reduction of friction between the pipe and the wall of the hole.

2.4.2 Inadvertent Returns

HDD involves the subsurface discharge of drilling fluid. Once discharged downhole, drilling fluid is uncontrolled and will flow in the path of least resistance. This can result in dispersal into the surrounding soils or discharge to the surface at some random location, which may not be a critical problem in an undeveloped location. However, in an urban environment or a high profile recreational area, inadvertent returns can be a major problem. In addition to the obvious public nuisance, drilling fluid flow can buckle streets or wash out embankments.

Drilling parameters may be adjusted to maximize drilling fluid circulation and minimize the risk of inadvertent returns. However, the possibility of lost circulation and inadvertent returns cannot be eliminated. Contingency plans addressing possible remedial action should be made in advance of construction and regulatory bodies should be informed.

Inadvertent returns are more likely to occur in less permeable soils with existing flow paths. Examples are slickensided clay or fractured rock structures. Coarse grained, permeable soils exhibit a tendency to absorb circulation losses. Manmade features, such as exploratory boreholes or piles, may also serve as conduits to the surface for drilling fluid. An example of an inadvertent drilling fluid return is shown in Figure 4.

Figure 4. Inadvertent Drilling Fluid Return

Research projects have been conducted in an attempt to identify the mechanisms that cause inadvertent returns and develop analytical methods for use in predicting their occurrence. Efforts have centered on predicting the point at which hydraulic fracture of the native soils will occur. These programs have met with limited success in providing a reliable prediction method. Engineering judgment and experience must be applied in utilizing the hydrofracture model to predict the occurrence, or nonoccurrence, of inadvertent returns.

2.4.3 Assessment of the Potential for Hydraulic Fracture

Hydraulic fracture, also known as hydrofracture, is a phenomenon that occurs when drilling fluid pressure in the annular space of the drilled hole exceeds the strength of the surrounding soil mass, resulting in deformation, cracking, and fracturing. The fractures may then serve as flow conduits for drilling fluid allowing the fluid to escape into the formation and possibly up to the ground surface. Drilling fluid that makes its way to the ground surface is known as an inadvertent drilling fluid return or, more commonly, a “frac-out.”

Although hydrofracture may be one mechanism by which inadvertent drilling fluid returns occur, it is not the only one. In fact, it is thought that inadvertent returns due to true hydrofracture occur in only a small percentage of cases.[1] Drilling fluid flows in the path of least resistance. Ideally, the path of least resistance is through the annulus of the drilled hole and back to the fluid containment pits at the HDD endpoints. However, the path of least resistance may also be through naturally occurring subsurface features such as fissures in the soil, shrinkage cracks, or porous deposits of gravel. Drilling fluid may also flow to the surface along existing piers, piles, utility poles, or other structures.

The risk of hydrofracture can be determined by comparing the confining capacity of the subsurface (formation limit pressure) to the annular pressure necessary to conduct HDD operations. If the anticipated drilling fluid pressure in the annulus exceeds the estimated formation limit pressure, there is a potential that inadvertent drilling fluid returns will occur as a result of hydrofracture.

The formation limit pressures for the proposed HDD crossings on the ACP Project were calculated using the “Delft Method” as described in an Army Corps of Engineers publication titled *Recommended Guidelines for Installation of Pipelines beneath Levees using Horizontal Directional Drilling*.[2] The Delft Method assumes uniform soil conditions in the soil column above the point on the drilled path that is being analyzed and requires engineering judgement with respect to the selection of the geotechnical parameters that are used in the associated equations. As noted previously, the geotechnical parameters used in our analysis were provided by Geosyntec Consultants. The estimated minimum annular pressure necessary for HDD pilot hole operations was calculated using the Bingham Plastic Model, which is described in Chapter 4 of the Society of Petroleum Engineers’ *Applied Drilling Engineering*.[3]

The formation limit pressures were calculated over the length of each proposed HDD crossing on the ACP Project and compared to the estimated annular pressures necessary for HDD operations. A graphical summary of the results for each crossing is provided in the Appendix. In reviewing this information, it should be noted that a factor of safety has not been applied to the formation limit pressure. As a result, the point at which the estimated annular pressure exceeds the formation limit pressure is the theoretical point at which plastic yielding and cracking reaches the ground surface resulting in an inadvertent drilling fluid return.

Table 2 presents a summary of the hydrofracture risk at each crossing location based on the calculation method described above.

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[1] Bennett, R.D. and K. Wallin. “Step by Step Evaluation of Hydrofracture Risks for HDD Projects.” Presentation, North American Society for Trenchless Technology, NoDig Conference, Grapevine, TX, 2008.

[2] Kimberlie Staheli et al, *Recommended Guidelines for Installation of Pipelines beneath Levees using Horizontal Directional Drilling* (prepared for U.S. Army Corps of Engineers, April 1998).

[3] *Applied Drilling Engineering*, Society of Petroleum Engineers, Richardson, Texas, A. T. Bourgoyne, Jr. [et al], 1991

Crossing	Risk of Hydrofracture	Notes
Interstate 79	Unknown	No geotechnical information available
Blue Ridge Parkway	Low	
James River	Low	
Roanoke River	Low	
Fishing Creek	Low	
Swift Creek	Low	
Tar River	Low	
Contentnea Creek	Unknown	No geotechnical information available
Little River	Low	
Cape Fear River	Low	
Nottaway River	Low	
Blackwater River	Moderate	Predicted annular pressure approaches formation limit pressure beneath river
Lake Prince	Low	
Western Branch Reservoir	Low-Moderate	Safety factor less than 2 below lake
Nansemond River Tributary	High	Predicted annular pressure exceeds formation limit pressure beneath river
Nansemond River	Moderate-High	Predicted annular pressure exceeds formation limit pressure at eastern water’s edge
Interstate 64	Low	
Route 17	Moderate-High	Predicted annular pressure exceeds formation limit pressure beneath pond
Elizabeth River	Low	

Table 2. Summary of Hydrofracture Risk by Crossing

2.5 Design Criteria

2.5.1 Drilled Path Centerline

Drilled path designs for segments to be installed by HDD are defined by the following six parameters: 1) entry point, 2) exit point, 3) entry angle, 4) exit angle, 5) P.I. elevation, and 6) radius of curvature. The relationship of these parameters to each other is illustrated in Figure 5.

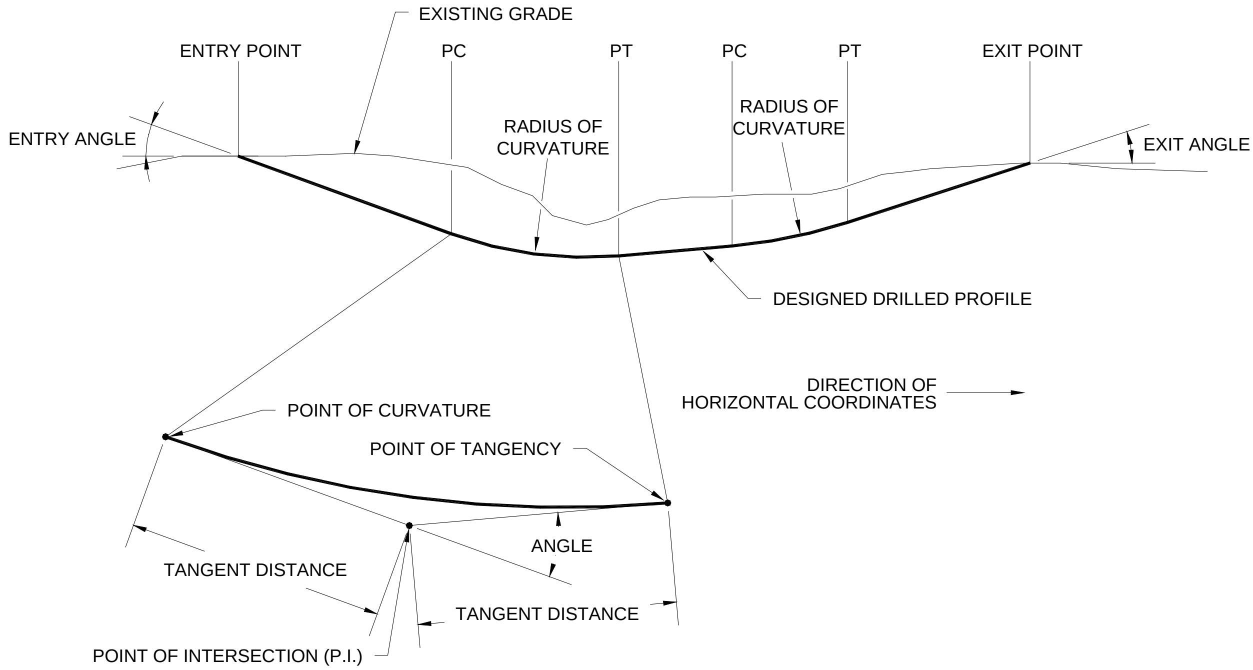

Figure 5. HDD Design Terminology

2.5.2 Entry and Exit Points

The entry and exit points are the endpoints of the designed drilled segment on the ground surface. The drilling rig is positioned at the entry point and the pipeline is pulled into the drilled hole from the exit point. The relative locations of the entry and exit points, and consequently the direction of pilot hole drilling and pullback, should be established by the site's geotechnical and topographical conditions. The following criteria were considered when selecting entry and exit point locations on the ACP Project: 1) steering precision and drilling effectiveness are greater near the drilling rig; 2) drilling fluid returns to the rig are enhanced if the entry point is lower than the exit point; 3) pullback operations are enhanced if there is sufficient workspace in line with the drilled path to allow the pull section to be fabricated in one continuous string. It is also important to recognize that the position of the drilling rig may be changed during construction to facilitate HDD operations and that a dual rig scenario may be employed during both the pilot hole and prereaming if deemed beneficial. In a dual rig scenario, drilling rigs are positioned at both ends of the drilled segment and work in tandem.

2.5.3 Entry and Exit Angles

Entry angles for drilled segments on the ACP Project were set at 10 degrees with the horizontal while exit angles were held between 8 and 10 degrees to facilitate breakover support during pullback. These angles are consistent with HDD industry standards.[4]

[4] *Manual of Practice No. 108, Pipeline Design for Installation by Horizontal Directional Drilling, Second Edition* (Reston, VA: American Society of Civil Engineers, 2014), 14.

2.5.4 P.I. Elevation

The P.I. elevation defines the depth of cover that the HDD installation will provide. Typically, HDD crossings are designed to provide no less than 25 feet of cover beneath critical obstacles.[5] This aids in reducing inadvertent drilling fluid returns and provides a margin for error with regard to downhole survey calculations. Due to the sensitive nature of the HDD segments on the ACP Project, the drilled profiles were designed to provide a minimum vertical clearance of 40 feet where possible in order to further reduce the risk of inadvertent drilling fluid returns. At some of the crossing locations, this clearance was either reduced or increased slightly due to site-specific concerns.

2.5.5 Radius of Curvature

The design radius of curvature for the HDD segments on the ACP Project was set at 2,000 feet for the 20-inch crossings, 3,600 feet for the 36-inch crossings, and 4,200 feet for the 42-inch crossings. These values are consistent with the HDD industry standard design radius of 1,200 times the nominal outside diameter of the pipe to be installed.[6] This relationship has been developed over a period of years in the HDD industry and is based on experience with constructability as opposed to any theoretical analysis.

3 Analysis of Installation and Operating Loads and Stresses

3.1 Installation Loads and Stresses

During HDD installation, a pipeline segment is subjected to tension, bending, and external pressure as it is pulled through a prereamed hole. The stresses in the pipe and its potential for failure are a result of the interaction of these loads.[7,8] In order to determine if a given pipe specification is adequate, HDD installation loads must first be estimated so that the stresses resulting from these loads can be calculated. A thorough design process requires examination of the stresses that result from each individual installation loading condition as well as an examination of the combined stresses that result from the interaction of these loads.

3.2 HDD Pulling Load Estimates

Calculation of the approximate tensile load required to install a pipeline by HDD is relatively complicated due to the fact that the geometry of the drilled path must be considered along with the properties of the pipe being installed and the subsurface conditions. Assumptions and simplifications are required. A method to accomplish this is presented in *Installation of Pipelines*

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[5] *Manual of Practice No. 108,* 16.
[6] *Manual of Practice No. 108,* 16.
[7] Fowler, J.R. and C.G. Langner. "Performance Limits for Deepwater Pipelines." Presentation, OTC 6757, 23rd Annual Offshore Technology Conference, Houston, TX, May 6-9, 1991.
[8] Loh, J.T. "A Unified Design Procedure for Tubular Members." Presentation, OTC 6310, 22nd Annual Offshore Technology Conference, Houston, TX, May 7-10, 1990.

by Horizontal Directional Drilling, An Engineering Design Guide, published by the Pipeline Research Council International (PRCI).[9]

The PRCI Method involves modeling the drilled path as a series of segments to define its shape and properties during installation. The individual loads acting on each segment are then resolved to determine a resultant tensile load for each segment. The estimated force required to install the entire pull section in the reamed hole is equal to the sum of the tensile loads acting on all of the defined segments. When utilizing the PRCI Method, pulling loads are affected by numerous variables, many of which are dependent upon site-specific conditions and individual contractor practices. These include prereaming diameter, hole stability, removal of cuttings, soil and rock properties, drilling fluid properties, and the effectiveness of buoyancy control measures.[10] It is also important to keep in mind that the PRCI Method considers pulling tension, pipe bending, and external pressure. It does not consider point loads that may result from subsurface conditions such as a rock ledge or boulder. Indeed, we know of no way to analyze potential point loads that may develop due to subsurface conditions. Although this type of damage is relatively rare, several cases have been observed in the last few years where pipelines suffered damage in the form of dents or pipe deformation due to point loads encountered during HDD installation.

Pulling load calculations for each of the proposed HDD crossings on the ACP Project were based on an assumed worst-case installation model in which the pilot hole is drilled up to 40 feet longer and 30 feet deeper than the designed path with a radius of curvature equal to two-thirds of the design radius. A conservative drilling fluid density of 12 pounds per gallon was assumed for the sake of analysis. For the 36 inch and 42-inch crossings, pulling load calculations were performed based on two scenarios: 1.) the pull sections being full of water for buoyancy control purposes, which is typical on large diameter crossings to reduce pulling loads, and 2.) the pull sections being installed empty to provide conservative results with regard to installation stresses. For the 20-inch crossings, only an empty pipe scenario was considered since buoyancy control measures are not typically employed for steel pipe less than 30 inches in diameter.

Our installation stress calculations indicated no violations of applicable stress criteria. As a result, it is our opinion that the proposed line pipe specifications are suitable for installation by HDD. This conclusion is based on three assumptions: 1) that the actual drilled paths will not exceed the lengths or depths of the worst-case models analyzed; 2) that the HDD contractor will not employ any improper construction procedures; and 3) that problematic subsurface conditions will not be encountered.

Table 3 provides a summary of the estimated pulling loads for each crossing based on the scenarios described above. Copies of our complete installation stress calculation spreadsheets are provided in the Appendix.

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[9] *Installation of Pipelines by Horizontal Directional Drilling, An Engineering Design Guide* (Arlington, VA: Pipeline Research Council International, Inc., 2008), 26-36.
[10] *Manual of Practice No. 108*, 22.

Crossing	Estimated Pulling Load with Buoyancy Control	Estimated Pulling Load without Buoyancy Control
Interstate 79	199,089 lbs.	430,756 lbs.
Blue Ridge Parkway	286,742 lbs.	979,838 lbs.
James River	187,844 lbs.	459,458 lbs.
Roanoke River	78,434 lbs.	287,363 lbs.
Fishing Creek	92,546 lbs.	323,050 lbs.
Swift Creek	82,857 lbs.	289,047 lbs.
Tar River	76,371 lbs.	277,573 lbs.
Contentnea Creek	66,579 lbs.	249,090 lbs.
Little River	67,335 lbs.	265,977 lbs.
Cape Fear River	83,086 lbs.	305,472 lbs.
Nottaway River	N/A	107,890 lbs.
Blackwater River	N/A	138,721 lbs.
Lake Prince	N/A	122,924 lbs.
Western Branch Reservoir	N/A	93,043 lbs.
Nansemond River Tributary	N/A	207,053 lbs.
Nansemond River	N/A	240,879 lbs.
Interstate 64	N/A	126,012 lbs.
Route 17	N/A	175,267 lbs.
Elizabeth River	N/A	109,466 lbs.

Table 3. Estimated HDD Pulling Loads

3.3 Operating Loads and Stresses

As with a pipeline installed by conventional methods, a pipeline installed by HDD will be subjected to internal pressure, thermal expansion, and external pressure during normal operation. A welded pipeline installed by HDD will also be subjected to elastic bending. The operating loads imposed on a pipeline installed by either of these methods are addressed in Chapter 5 of *Installation of Pipelines by Horizontal Directional Drilling, An Engineering Design Guide*.[11]

With one exception, the operating stresses in a pipeline installed by HDD are not materially different from those experienced by pipelines installed by cut and cover techniques. As a result, past procedures for calculating and limiting stresses can be applied. However, unlike a cut and cover installation in which the pipe is bent to conform to the ditch, a pipeline installed by HDD

[11] *Installation of Pipelines by Horizontal Directional Drilling, An Engineering Design Guide*, 24-26.

will contain elastic bends. Bending stresses imposed by the HDD installation process should be checked in combination with other operating stresses to evaluate if acceptable limits are exceeded. Other longitudinal and hoop stresses that should be considered will result from internal pressure and thermal expansion or contraction.

3.4 Project-Specific Operating Stress Calculations

The results of the operating stress calculations for each proposed pipe diameter are provided in the Appendix. Calculations were performed based on both the design radius and the specified minimum radius and, like the installation stress calculations, did not indicate any violations of applicable stress criteria. Specific information used in the calculations is provided below.

<u>20-inch Crossings</u>

Outside Diameter	20.00 inches
Wall Thickness	0.411 inches
Grade	API 5L X-70
Maximum Operating Pressure	1,440 psig
Minimum Installation Temperature	55 °F
Maximum Operating Temperature	125 °F

<u>36-inch Crossings</u>

Outside Diameter	36.00 inches
Wall Thickness	0.741 inches
Grade	API 5L X-70
Maximum Operating Pressure	1,440 psig
Minimum Installation Temperature	55 °F
Maximum Operating Temperature	125 °F

<u>42-inch Crossings</u>

Outside Diameter	42.00 inches
Wall Thickness	0.864 inches
Grade	API 5L X-70
Maximum Operating Pressure	1,440 psig
Minimum Installation Temperature	55 °F
Maximum Operating Temperature	125 °F

4 Crossing-Specific Summaries

4.1 42-inch Interstate 79 Crossing

The proposed HDD crossing of Interstate 79 has a horizontal drilled length of 2,869 feet and an outside diameter of 42 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

To date, we have not been provided with a geotechnical report for this crossing. However, based on subsurface information obtained on a previous project located roughly 3 miles to the northwest, we anticipate that the Interstate 79 crossing will be placed in bedrock consisting primarily of shale and/or limestone. At this point, we have no reason to believe that the rock at the Interstate 79 crossing would be adverse. Therefore, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of Interstate 79 and that the crossing can be completed successfully.

4.2 42-inch Blue Ridge Parkway Crossing

The proposed HDD crossing of the Blue Ridge Parkway has a horizontal drilled length of 4,639 feet and an outside diameter of 42 inches. This combination of length and diameter falls within the limits of current HDD industry capabilities. Pipe diameters up to 42 inches have been installed over lengths exceeding 7,000 feet and HDD crossings involving 42-inch diameter pipe over lengths on the order of 5,000 feet are fairly common.

The geotechnical site investigation report produced by Geosyntec presents the results of a geologic desktop study, two exploratory borings, and a geophysical survey conducted at the Blue Ridge Parkway crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter surficial alluvium containing gravel, cobbles and boulders in a sandy silt to clay matrix underlain by granodiorite bedrock of the Pedlar Formation and metamorphosed Basalt of the Catoctin Formation. Upon completion of the boring on the southeast end of the crossing in which bedrock was not encountered, there was a concern that the adverse alluvium may be so extensive that the feasibility of the proposed HDD installation would be questionable. However, the results of the boring on the northwest end of the crossing and the subsequent geophysical survey indicate that the adverse alluvial soils are not as extensive as initially feared. Based on that information, it is believed that bedrock can be reached within 90 to 130 feet of both HDD endpoints which will allow for large diameter surface casings to be set from the endpoints to competent rock. The ability to set surface casings through the adverse soils significantly reduces the risk of the proposed HDD installation.

The proposed HDD crossing will be complicated by the challenging topography at the site, which is likely to require some amount of excavation at both ends of the crossing to create level work areas for the HDD equipment. Also, since the product pipe will be laid downhill from the proposed exit point, it is anticipated that several cranes will be needed to handle the pipe and support it as it is lifted during pullback to be aligned with the reamed hole. However, the need for excavations and cranes does not cause any concern with regard to technical feasibility. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the Blue Ridge Parkway and that the crossing can be completed successfully.

4.3 42-inch James River Crossing

The proposed HDD crossing of the James River has a horizontal drilled length of 2,965 feet and an outside diameter of 42 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of one exploratory boring conducted at the James River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter less than 20 feet of overburden soils (lean clay overlying silty gravel), underlain by weak shale and moderate to strong, excellent quality sandstone . Aside from the relatively thin layer of gravel overlying bedrock, these conditions are generally favorable for HDD installation. However, it should be noted that it would be advisable to obtain at least one additional boring on either end of the crossing to allow for a more comprehensive assessment of the subsurface conditions.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the James River and that the crossing can be completed successfully.

4.4 36-inch Roanoke River Crossing

The proposed HDD crossing of the Roanoke River has a horizontal drilled length of 1,559 feet and an outside diameter of 36 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Roanoke River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter primarily clay, sand, and silt, with a slight potential for partially weathered rock or competent bedrock at the low point of the crossing. Aside from possibly encountering bedrock at depth, which could be problematic, these are favorable conditions for HDD installation. If rock is encountered during the pilot hole, Dominion may wish to consider increasing the "up" tolerance (which currently allows being up to 5 feet above the designed profile) so that bedrock can be avoided.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the Roanoke River and that the crossing can be completed successfully.

4.5 36-inch Fishing Creek Crossing

The proposed HDD crossing of Fishing Creek has a horizontal drilled length of 1,822 feet and an outside diameter of 36-inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Fishing Creek crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter alluvial overburden consisting of silty/clayey sand and fat clay with gravel, underlain by 20 to 35 feet of decomposed bedrock generally described as very dense silty and clayey sand, underlain by granite bedrock. On the south end of the crossing, the granite is generally competent and strong, with unconfined compressive strengths ranging from around 15,000 to 30,000 psi. On the north end of the crossing, the granite is described as completely to moderately weathered, with low recovery, low RQDs, and compressive strengths ranging from around 4,000 to 10,000 psi.

The HDD crossing of Fishing Creek has been designed with entry and exit tangents extending to bedrock, and we do not expect the alluvium or the decomposed bedrock (very dense sand) to be problematic. The fact that the granite on the south end of the crossing is competent and strong while the granite on the north end is highly weathered could present challenges during HDD operations, but we believe those challenges will not present insurmountable problems for skilled contractors. It should be noted that the relatively high strength of the competent bedrock will result in low production rates for pilot hole drilling and prereaming, which will increase both the duration and cost of HDD operations in comparison to crossings placed through alluvial soils or soft rock. Nonetheless, HDD installations of similar diameters have been completed through comparable subsurface conditions. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of Fishing Creek and that the crossing can be completed successfully.

4.6 36-inch Swift Creek Crossing

The proposed HDD crossing of Swift Creek has a horizontal drilled length of 1,629 feet and an outside diameter of 36-inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Swift Creek crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter around 50 feet of overburden on the west end of the crossing and 15 feet of overburden on the east end consisting primarily of silty/clayey sand with some gravel. The overburden soils on the west end of the crossing are underlain by amphibolite and granite bedrock while the overburden on the east end is underlain almost exclusively by granite. In general, the granite is competent, strong, and hard with compressive strengths approaching 40,000 psi and Mohs hardness values ranging from 4.5 to 9 while the amphibolite is of lower strength and quality.

As currently designed, the entry tangent on the west end of the crossing does not extend to bedrock, which is generally preferable for entry of the bit into rock and also in the event that installation of surface casing is necessary. As result, the HDD contractor may choose to drill the pilot hole from east to west, eventually moving the rig to the west end of the crossing for pullback. It may also be worth considering extending the entry tangent to bedrock, but we haven't done that as it would require increasing the length of the crossing. The high strength and hardness of the granite at this location will result in low production rates and relatively high construction cost in comparison to crossings placed through alluvial soils or soft rock. However, HDD installations of similar diameters have been completed through comparable subsurface conditions. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of Swift Creek and that the crossing can be completed successfully.

4.7 36-inch Tar River Crossing

The proposed HDD crossing of the Tar River has a horizontal drilled length of 1,516 feet and an outside diameter of 36-inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Tar River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter 25 to 35 feet of overburden consisting primarily of clayey and silty sand with gravel underlain by phyllite bedrock on the south end of the crossing and rhyolite, breccia, and phyllite bedrock on the north end. On the south end of the crossing, the upper 60 feet or so of the phyllite bedrock is moderately to completely weathered and soft with extremely low compressive strengths, while at greater depths (corresponding roughly to the lowest point of the designed crossing) the hardness and compressive strength of the bedrock increases significantly. On the north end of the crossing, the bedrock properties are more uniform, having mostly fair to excellent RQD's and compressive strengths generally ranging from 3,000 to 7,000 psi.

Like the Swift Creek crossing, the entry tangent on the north end of the Tar River crossing does not extend to bedrock. Considering that the rhyolite bedrock at the rock/soil interface beneath the north bank is substantially softer and weaker than the granite encountered at Swift Creek, we anticipate that skilled contractors will not have much difficulty entering bedrock. However, if problems are encountered either in the overburden soils or at the rock/soil interface, the entry angle could be reduced to 8 degrees so that a surface casing could be set to bedrock. While placement through bedrock at this location will certainly result in slower production rates and higher costs than crossings placed through alluvial soils, production rates on the Tar River crossing should be significantly higher than in the granite expected at the Fishing Creek and Swift Creek crossings. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the Tar River and that the crossing can be completed successfully.

4.8 36-inch Contentnea Creek Crossing

The proposed HDD crossing of Contentnea Creek has a horizontal drilled length of 1,327 feet and an outside diameter of 36-inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

To date, we have not been provided with a geotechnical report for this crossing. Based on the subsurface conditions at the Tar River crossing to the north and the Little River crossing to the south, we anticipate that the Contentnea Creek crossing will be placed in bedrock. However, since the bedrock at those crossing locations differs substantially, we're not sure what to expect. Nonetheless, we have no reason to believe that the rock at the Contentnea Creek location would be any more adverse than any of the other proposed HDD crossing locations. Therefore, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of Contentnea Creek and that the crossing can be completed successfully.

4.9 36-inch Little River Crossing

The proposed HDD crossing of the Little River has a horizontal drilled length of 1,446 feet and an outside diameter of 36-inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Little River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter 15 to 25 feet of silty sand and sandy clay with gravel overlying siltstone bedrock. The quality of the siltstone varies significantly and the unconfined compressive strengths generally range from 3,000 to 15,000 psi with an 18,672 psi value at the bottom of boring LR B-2. In general, the rock is soft with typical Mohs hardness values of 2.5 to 3.5.

Despite the fact that some of the compressive strengths obtained in Boring LR B-2 are relatively high, sedimentary rock such as siltstone is generally a favorable medium for installation of an HDD crossing. Placement through siltstone will result in slower production rates and higher costs than crossings placed through alluvial soils, but production rates on the Little River crossing should be significantly higher than in the granite expected at Fishing Creek and Swift Creek. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion’s proposed HDD crossing of the Little River and that the crossing can be completed successfully.

4.10 36-inch Cape Fear River Crossing

The proposed HDD crossing of the Cape Fear River has a horizontal drilled length of 1,654 feet and an outside diameter of 36-inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Cape Fear River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter primarily lean clay and clayey sand, which are favorable conditions for HDD installation.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion’s proposed HDD crossing of the Cape Fear River and that the crossing can be completed successfully.

4.11 20-inch Nottaway River Crossing

The proposed HDD crossing of the Nottaway River has a horizontal drilled length of 1,678 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Nottaway River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter mostly sand and clayey sand over its entire length, which are favorable conditions for HDD installation. The only notable coarse material in the borings was a possible boulder at a depth of 48 feet on the west side of the crossing and a sample containing 15.3 percent gravel at a depth of 23 to 25 feet on the east side of the crossing. Otherwise only trace amounts of gravel were encountered.

While subsurface conditions that include boulders can be problematic for an HDD installation, it is reassuring that there was only one possible boulder encountered by the borings and that the geotechnical report provided no other indication that boulders are expected. As a result, we do not believe that boulders are a significant concern at this location. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the Nottaway River and that the crossing can be completed successfully.

4.12 20-inch Blackwater River Crossing

The proposed HDD crossing of the Blackwater River has a horizontal drilled length of 2,234 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Blackwater River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter surficial sand and silt underlain by fat clay, which are favorable conditions for HDD installation. While it should be noted that the calculations we have completed for this crossing indicate a moderate risk of inadvertent drilling fluid returns as a result of hydrofracture, that risk does not necessarily impact the technical feasibility of the proposed crossing.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the Blackwater River and that the crossing can be completed successfully.

4.13 20-inch Lake Prince Crossing

The proposed HDD crossing of Lake Prince has a horizontal drilled length of 1,952 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Lake Prince crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter sand and clayey sand, which are favorable conditions for HDD installation.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of Lake Prince and that the crossing can be completed successfully.

4.14 20-inch Western Branch Reservoir Crossing

The proposed HDD crossing of the Western Branch Reservoir has a horizontal drilled length of 1,464 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Western Branch Reservoir crossing site. In general, the boring logs indicate that the proposed HDD crossing is anticipated to encounter mainly sand and silt with some clay beneath both banks, underlain by clay directly beneath the river. These conditions are favorable for HDD installation.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of Western Branch Reservoir and that the crossing can be completed successfully.

4.15 20-inch Nansemond River Tributary Crossing

The proposed HDD crossing of the Nansemond River Tributary has a horizontal drilled length of 3,435 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Nansemond River Tributary crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter loose/soft sand, silt, and clay, which are favorable conditions for HDD installation. While it should be noted that the calculations we have completed for this crossing indicate a high risk of inadvertent drilling fluids in the mud flats and waterway as a result of hydrofracture, that risk does not necessarily impact the technical feasibility of the proposed crossing. In an attempt to reduce the potential for inadvertent returns at this location, we lowered the design elevation as much as possible without placing it below the termination depths of the borings. However, there is a still a significant risk of inadvertent returns at this location. It may be possible to mitigate the risk of inadvertent returns at this location by drilling a portion of the pilot hole from the western end of the crossing.

The proposed HDD crossing will be complicated by the fact that there is not sufficient space available for the pipeline pull section to be fabricated and staged in one complete length. As a result, it is envisioned that two tie-in welds will be required during pullback. Stoppages to make tie-in welds will increase the risk of getting stuck during pullback, especially considering the loose/soft nature of the anticipated soils. However, we don't believe this will ultimately prevent a competent HDD contractor from installing the crossing. Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion's proposed HDD crossing of the Nansemond River Tributary and that the crossing can be completed successfully.

4.16 20-inch Nansemond River Crossing

The proposed HDD crossing of the Nansemond River has a horizontal drilled length of 4,127 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Nansemond River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter loose/soft sand, silt, and clay, which are favorable conditions for HDD installation. While it should be noted that the calculations we have completed for this crossing indicate a moderate to high risk of inadvertent drilling fluids on the eastern edge of the mud flats as a result of hydrofracture, that risk does not necessarily impact the technical feasibility of the proposed crossing. We investigated lowering the design elevation by 26 feet in order to reduce the potential for inadvertent returns, but based on our calculations that change didn’t help. It may be possible to mitigate the risk of inadvertent returns at this location by drilling a portion of the pilot hole from the eastern end of the crossing.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion’s proposed HDD crossing of the Nansemond River and that the crossing can be completed successfully.

4.17 20-inch Interstate 64 Crossing

The proposed HDD crossing of Interstate 64 has a horizontal drilled length of 2,039 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of two exploratory borings conducted at the Interstate 64 crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter surficial clay overlying sand with silt and silty sand, which are favorable conditions for HDD installation.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion’s proposed HDD crossing of Interstate 64 and that the crossing can be completed successfully.

4.18 20-inch Route 17 Crossing

The proposed HDD crossing of Route 17 has a horizontal drilled length of 2,951 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of three exploratory borings conducted at the Route 17 crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter alternating layers of clay and sand overlying a layer of medium dense sand though which the majority of the crossing will be placed. These conditions are favorable for HDD installation. While it should be noted that the calculations we have completed for this crossing indicate a moderate to high risk of inadvertent drilling fluid returns as a result of hydrofracture in the pond to the west of the exit point, that risk does not necessarily impact the technical feasibility of the proposed crossing. It may be possible to mitigate the risk of inadvertent returns in the pond by drilling a portion of the pilot hole from the eastern end of the crossing.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion’s proposed HDD crossing of Route 17 and that the crossing can be completed successfully.

4.19 20-inch Elizabeth River Crossing

The proposed HDD crossing of the Elizabeth River has a horizontal drilled length of 1,730 feet and an outside diameter of 20 inches. This combination of length and diameter falls well within the limits of current HDD industry capabilities.

The geotechnical site investigation report produced by Geosyntec presents the results of three exploratory borings conducted at the Elizabeth River crossing site. In general, the geotechnical investigation found that the proposed HDD crossing is anticipated to encounter primarily silty sand and clayey sand, which are favorable conditions for HDD installation. The borings also encountered occasional wood fragments, gravel, and weathered rock fragments.

It should be noted that the depths of the sheet piling along the eastern water’s edge and the wood pilings in the river are not known. While the crossing has been designed at a depth that we anticipate will clear the existing pilings, there is a risk that the pilings could be encountered by the contractor’s downhole tools during HDD operations. If so, the crossing may need to be redesigned and installed at a greater depth.

Based on these considerations, it is our opinion that knowledgeable HDD contractors will submit fixed price, lump sum bids to install Dominion’s proposed HDD crossing of the Elizabeth River and that the crossing can be completed successfully.

APPENDIX

Operating Stress

Supporting Information

- Operating stress analysis, 20-inch crossings (1 page)
- Operating stress analysis, 36-inch crossings (1 page)
- Operating stress analysis, 42-inch crossings (1 page)

Operating Stress Analysis

PROJECT: Dominion Atlantic Coast Pipeline
20" Crossings
Installation and operating temperatures assumed

Pipe Properties				
	Design Radius (2,000')		Specified Min. Radius (1,350')	
Pipe Outside Diameter =	20.000	in	20.000	in
Wall Thickness =	0.411	in	0.411	in
Specified Minimum Yield Strength =	70,000	psi	70,000	psi
Young's Modulus =	2.9E+07	psi	2.9E+07	psi
Moment of Inertia =	1213.22	in^4	1213.22	in^4
Pipe Face Surface Area =	25.29	in^2	25.29	in^2
Diameter to Wall Thickness Ratio, D/t =	49		49	
Poisson's Ratio =	0.3		0.3	
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	6.5E-06	in/in/°F
Pipe Weight in Air =	85.99	lb/ft	85.99	lb/ft
Pipe Interior Volume =	2.01	ft^3/ft	2.01	ft^3/ft
Pipe Exterior Volume =	2.18	ft^3/ft	2.18	ft^3/ft
Operating Parameters				
Maximum Allowable Operating Pressure =	1,440	psig	1,440	psig
Radius of Curvature =	2,000	ft	1,350	ft
Installation Temperature =	55	°F	55	°F
Operating Temperature =	125	°F	125	°F
Groundwater Table Head =	0	ft	0	ft
Operating Stress Check	Scenario 1		Scenario 2	
Hoop Stress =	35,036	psi	35,036	psi
% SMYS =	50%		50%	
Longitudinal Stress from Internal Pressure =	10,511	psi	10,511	psi
% SMYS =	15%		15%	
Longitudinal Stress from Temperature Change =	-13,195	psi	-13,195	psi
% SMYS =	19%		19%	
Longitudinal Stress from Bending =	12,083	psi	17,901	psi
% SMYS =	17%		26%	
Net Longitudinal Stress (taking bending in tension) =	9,399	psi	15,217	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	13%	ok	22%	ok
Net Longitudinal Stress (taking bending in compression) =	-14,767	psi	-20,585	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	21%	ok	29%	ok
Combined Stress (NLS w/bending in tension) - Max. Shear Stress Theory =	25,637	psi	19,819	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	37%	ok	28%	ok
Combined Stress (NLS w/bending in compression) - Max. Shear Stress Theory =	49,804	psi	55,622	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	71%	ok	79%	ok
Combined Stress (NLS w/bending in tension) - Max. Distortion Energy Theory =	31,410	psi	30,430	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	45%	ok	43%	ok
Combined Stress (NLS w/bending in compression) - Max. Distortion Energy Theory =	44,306	psi	48,709	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	63%	ok	70%	ok

7/27/2016

Operating Stress Analysis

PROJECT: Dominion Atlantic Coast Pipeline
36" Crossings
Installation and operating temperatures assumed

Pipe Properties				
	Design Radius (3,600')		Specified Min. Radius (2,400')	
Pipe Outside Diameter =	36.000	in	36.000	in
Wall Thickness =	0.741	in	0.741	in
Specified Minimum Yield Strength =	70,000	psi	70,000	psi
Young's Modulus =	2.9E+07	psi	2.9E+07	psi
Moment of Inertia =	12755.22	in^4	12755.22	in^4
Pipe Face Surface Area =	82.08	in^2	82.08	in^2
Diameter to Wall Thickness Ratio, D/t =	49		49	
Poisson's Ratio =	0.3		0.3	
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	6.5E-06	in/in/°F
Pipe Weight in Air =	279.04	lb/ft	279.04	lb/ft
Pipe Interior Volume =	6.50	ft^3/ft	6.50	ft^3/ft
Pipe Exterior Volume =	7.07	ft^3/ft	7.07	ft^3/ft
Operating Parameters				
Maximum Allowable Operating Pressure =	1,440	psig	1,440	psig
Radius of Curvature =	3,600	ft	2,400	ft
Installation Temperature =	55	°F	55	°F
Operating Temperature =	125	°F	125	°F
Groundwater Table Head =	0	ft	0	ft
Operating Stress Check	Scenario 1		Scenario 2	
Hoop Stress =	34,980	psi	34,980	psi
% SMYS =	50%		50%	
Longitudinal Stress from Internal Pressure =	10,494	psi	10,494	psi
% SMYS =	15%		15%	
Longitudinal Stress from Temperature Change =	-13,195	psi	-13,195	psi
% SMYS =	19%		19%	
Longitudinal Stress from Bending =	12,083	psi	18,125	psi
% SMYS =	17%		26%	
Net Longitudinal Stress (taking bending in tension) =	9,382	psi	15,424	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	13%	ok	22%	ok
Net Longitudinal Stress (taking bending in compression) =	-14,784	psi	-20,826	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	21%	ok	30%	ok
Combined Stress (NLS w/bending in tension) - Max. Shear Stress Theory =	25,597	psi	19,556	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	37%	ok	28%	ok
Combined Stress (NLS w/bending in compression) - Max. Shear Stress Theory =	49,764	psi	55,806	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	71%	ok	80%	ok
Combined Stress (NLS w/bending in tension) - Max. Distortion Energy Theory =	31,360	psi	30,364	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	45%	ok	43%	ok
Combined Stress (NLS w/bending in compression) - Max. Distortion Energy Theory =	44,264	psi	48,845	psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	63%	ok	70%	ok

7/27/2016

Operating Stress Analysis

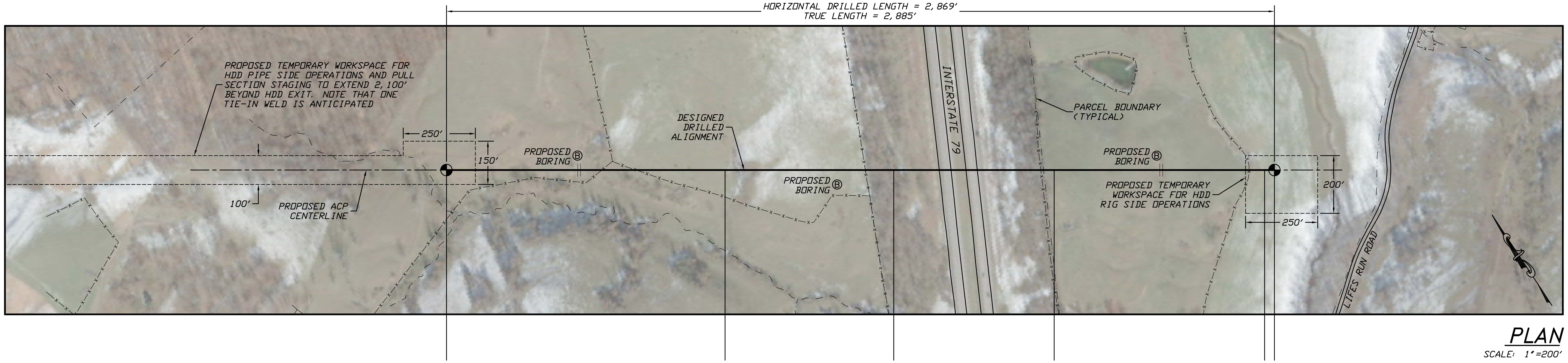
PROJECT: Dominion Atlantic Coast Pipeline
42" Crossings
Installation and operating temperatures assumed

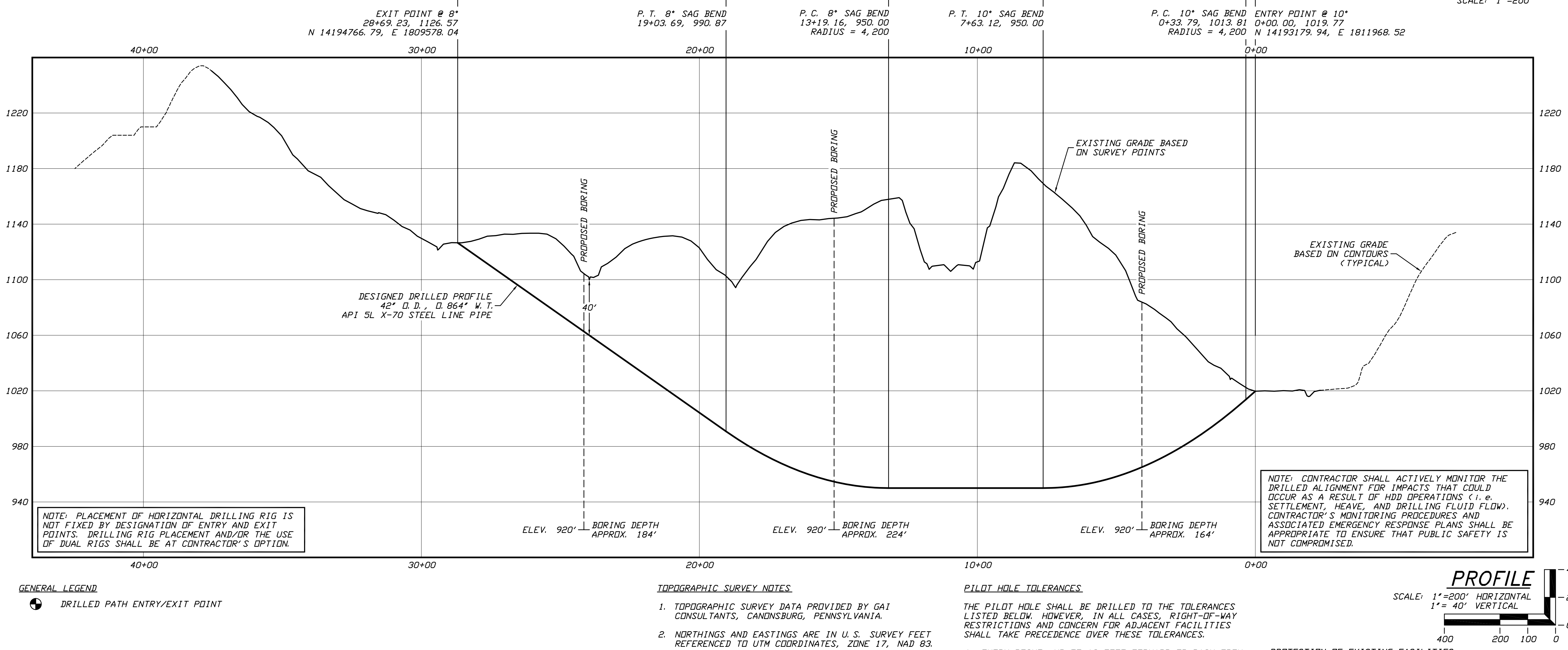
Pipe Properties		
	Design Radius (4,200')	Specified Min. Radius (2,800')
Pipe Outside Diameter =	42.000 in	42.000 in
Wall Thickness =	0.864 in	0.864 in
Specified Minimum Yield Strength =	70,000 psi	70,000 psi
Young's Modulus =	2.9E+07 psi	2.9E+07 psi
Moment of Inertia =	23617.82 in^4	23617.82 in^4
Pipe Face Surface Area =	111.66 in^2	111.66 in^2
Diameter to Wall Thickness Ratio, D/t =	49	49
Poisson's Ratio =	0.3	0.3
Coefficient of Thermal Expansion =	6.5E-06 in/in/°F	6.5E-06 in/in/°F
Pipe Weight in Air =	379.58 lb/ft	379.58 lb/ft
Pipe Interior Volume =	8.85 ft^3/ft	8.85 ft^3/ft
Pipe Exterior Volume =	9.62 ft^3/ft	9.62 ft^3/ft
Operating Parameters		
Maximum Allowable Operating Pressure =	1,440 psig	1,440 psig
Radius of Curvature =	4,200 ft	2,800 ft
Installation Temperature =	55 °F	55 °F
Operating Temperature =	125 °F	125 °F
Groundwater Table Head =	0 ft	0 ft
Operating Stress Check	Scenario 1	Scenario 2
Hoop Stress =	35,000 psi	35,000 psi
% SMYS =	50%	50%
Longitudinal Stress from Internal Pressure =	10,500 psi	10,500 psi
% SMYS =	15%	15%
Longitudinal Stress from Temperature Change =	-13,195 psi	-13,195 psi
% SMYS =	19%	19%
Longitudinal Stress from Bending =	12,083 psi	18,125 psi
% SMYS =	17%	26%
Net Longitudinal Stress (taking bending in tension) =	9,388 psi	15,430 psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	13% ok	22% ok
Net Longitudinal Stress (taking bending in compression) =	-14,778 psi	-20,820 psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	21% ok	30% ok
Combined Stress (NLS w/bending in tension) - Max. Shear Stress Theory =	25,612 psi	19,570 psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	37% ok	28% ok
Combined Stress (NLS w/bending in compression) - Max. Shear Stress Theory =	49,778 psi	55,820 psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	71% ok	80% ok
Combined Stress (NLS w/bending in tension) - Max. Distortion Energy Theory =	31,378 psi	30,381 psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	45% ok	43% ok
Combined Stress (NLS w/bending in compression) - Max. Distortion Energy Theory =	44,279 psi	48,859 psi
Limited to 90% of SMYS by ASME B31.8 (2010) B31.4 (2012) =	63% ok	70% ok

Interstate 79

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)





GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,800 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

PRELIMINARY

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
42-INCH PIPELINE CROSSING OF INTERSTATE 79
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: LEWIS COUNTY, WEST VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
ACM/LKB	11/29/16	JSP	JSP	SHOWN FOR D-SIZED PLOT	INTERSTATE 79	P0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP1-14

Interstate 79 P0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	LKB
Crossing :	42" Interstate 79 Crossing	Date :	11/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 2,400' radius) with 12 ppg mud and BC		

Line Pipe Properties			
Pipe Outside Diameter =	42.000	in	
Wall Thickness =	0.864	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	23617.82	in^4	
Pipe Face Surface Area =	111.66	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	379.58	lb/ft	
Pipe Interior Volume =	8.85	ft^3/ft	
Pipe Exterior Volume =	9.62	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	551.97	lb/ft	
Displaced Mud Weight =	863.59	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,508	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,636	psi	Yes
Allowable Bending Stress, F_b =	45,636	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,800	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,444	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,016	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,200	psi	

Interstate 79 P0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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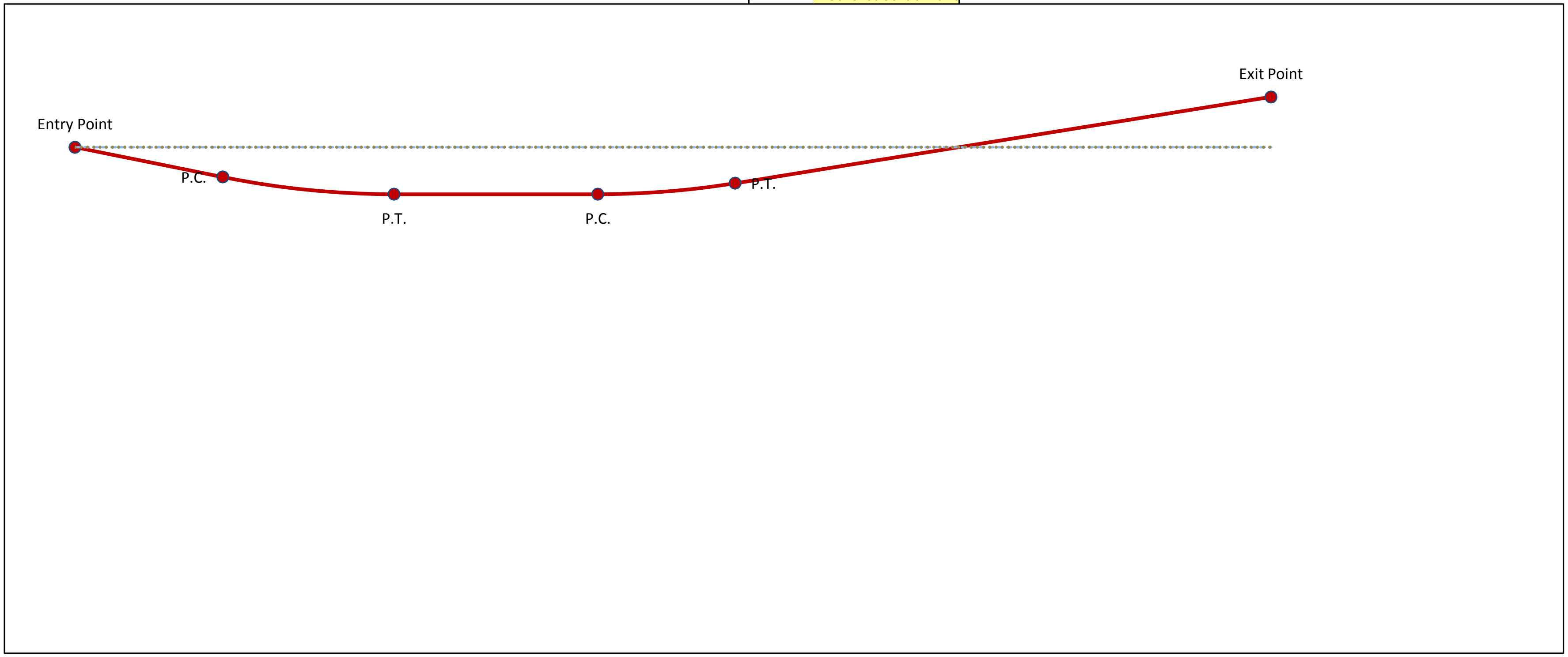
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	1019.77	10.00				199,089
Entry Tangent						364.58		
Entry Sag Bend	PC	349.04	956.46					173,034
	PI	555.82	920.00	10.00	2400	418.88	155,414	
	PT	765.80	920.00				0	137,794
Bottom Tangent				0.00		495.79		
Exit Sag Bend	PC	1261.58	920.00					108,060
	PI	1429.41	920.00	8.00	2400	335.10	93,483	
	PT	1595.60	943.36				0	78,906
Exit Tangent						1316.44		
Exit Point		2899.23	1126.57	8.00	Above Ground Load			0
Drilling Mud			1019.77	(Graph = ········)				
Ballast			1019.77	(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	42.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	379.6	lb/ft	Ballast Weight / ft Pipe, W_b =	552.0	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	863.6	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	1316.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	379.6	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	148,451	lb	
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	0	lb	Fluidic drag is calculated as zero unless entire segment is submerged in drilling fluid. Please reference Step 2, Drilled Path Input
Axial Segment Weight = $W_e\ L \sin\theta$ =	-69,545	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**78,906**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	93,483	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

$h = R\ [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	2,707	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	3.8E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	151.54	
$U = (12\ L) / j$ =	1.49		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	29,129	lb
Bending Frictional Drag = $2\ \mu\ N$ =	17,478	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	13,265	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	-1,589	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**29,154**	**lb**			
Total Pulling Load =	**108,060**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	495.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	10,109	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	19,625	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**29,734**	**lb**
Total Pulling Load =	**137,794**	**lb**

Interstate 79 P0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 155,414 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = 68.0 lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ = 9.13 ft

$j = [(E\,I) / T]^{1/2}$ = 2,099

$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ = 1.2E+06

$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ = 382.49

$U = (12\,L) / j$ = 2.39

$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ = 26,963 lb

Bending Frictional Drag = $2\,\mu\,N$ = 16,178 lb

Fluidic Drag = $12\,\pi\,D\,L\,C_d$ = 16,581 lb

Axial Segment Weight = $W_e\,L\sin\theta$ = 2,481 lb

Pulling Load on Entry Sag Bend = 35,240 lb
Total Pulling Load = 173,034 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 364.6 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = 68.0 lb/ft

Frictional Drag = $W_e\,L\,\mu\cos\theta$ = 7,321 lb

Fluidic Drag = $12\,\pi\,D\,L\,C_d$ = 14,432 lb

Axial Segment Weight = $W_e\,L\sin\theta$ = 4,303 lb

Pulling Load on Entry Tangent = 26,055 lb
Total Pulling Load = 199,089 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	1,783	ok	0	ok	0	ok	0.03	ok	0.00	ok
	1,550	ok	0	ok	292	ok	0.02	ok	0.00	ok
PC										
	1,550	ok	21,146	ok	292	ok	0.49	ok	0.17	ok
	1,234	ok	21,146	ok	461	ok	0.48	ok	0.18	ok
PT										
	1,234	ok	0	ok	461	ok	0.02	ok	0.01	ok
	968	ok	0	ok	461	ok	0.02	ok	0.00	ok
PC										
	968	ok	21,146	ok	461	ok	0.48	ok	0.17	ok
	707	ok	21,146	ok	353	ok	0.47	ok	0.16	ok
PT										
	707	ok	0	ok	353	ok	0.01	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Interstate 79 P0 Installation Stress Analysis (worst-case).xlsm

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Project Information				
Project :	Dominion Atlantic Coast Pipeline		User :	LKB
Crossing :	42" Interstate 79 Crossing		Date :	11/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 2,400' radius) with 12 ppg mud and no BC			

Line Pipe Properties			
Pipe Outside Diameter =	42.000	in	
Wall Thickness =	0.864	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	23617.82	in^4	
Pipe Face Surface Area =	111.66	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	379.58	lb/ft	
Pipe Interior Volume =	8.85	ft^3/ft	
Pipe Exterior Volume =	9.62	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	551.97	lb/ft	
Displaced Mud Weight =	863.59	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,508	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,636	psi	Yes
Allowable Bending Stress, F_b =	45,636	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,800	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,444	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,016	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,200	psi	

Interstate 79 P0 Installation Stress Analysis (worst-case).xlsm

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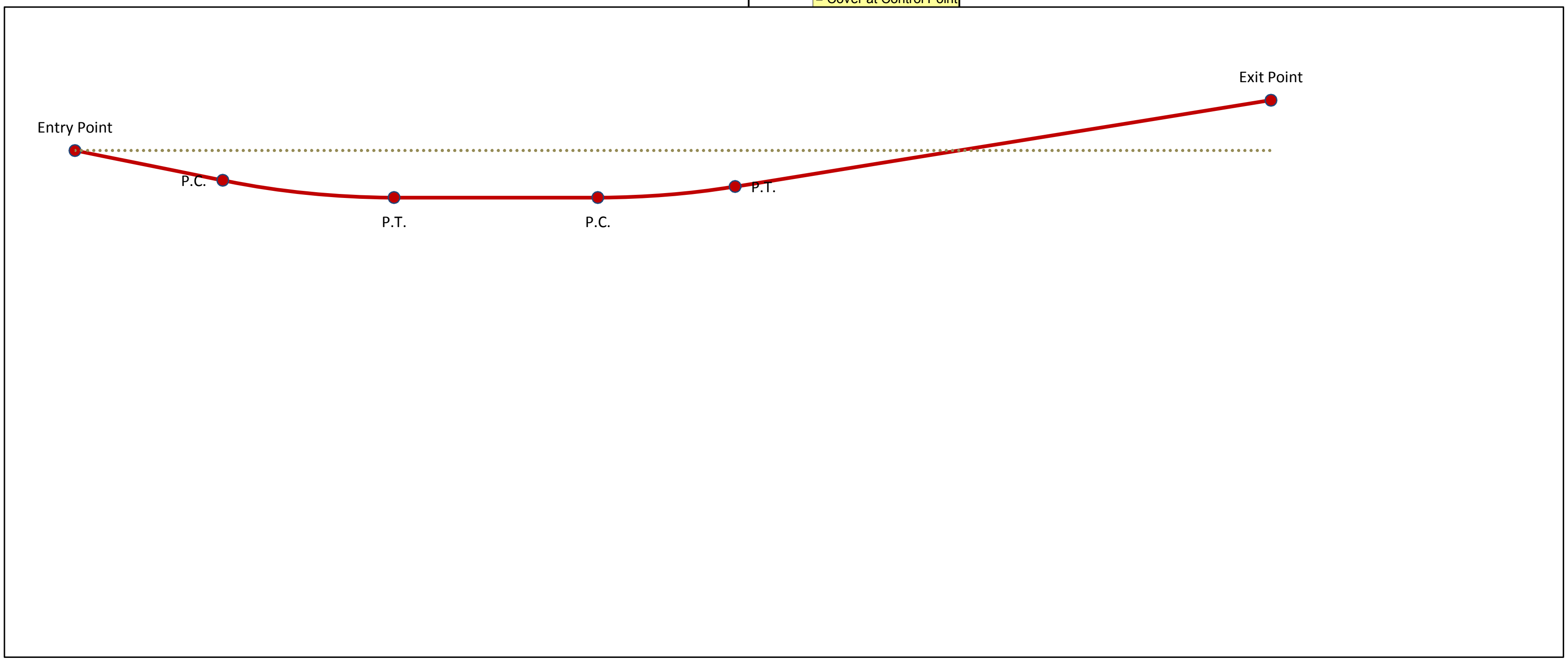
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	1019.77	10.00				430,756
Entry Tangent						364.58		
Entry Sag Bend	PC	349.04	956.46					394,833
	PI	555.82	920.00	10.00	2400	418.88	339,178	
	PT	765.80	920.00				0	283,523
Bottom Tangent				0.00		495.79		
Exit Sag Bend	PC	1261.58	920.00					191,908
	PI	1429.41	920.00	8.00	2400	335.10	135,407	
	PT	1595.60	943.36				0	78,906
Exit Tangent						1316.44		
Exit Point		2899.23	1126.57	8.00	Above Ground Load			0
Drilling Mud			1019.77	(Graph = • • • • • • • • •)				
Ballast				(Graph = – – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Interstate 79 P0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	42.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	379.6	lb/ft	Ballast Weight / ft Pipe, W_b =	552.0	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	863.6	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	1316.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	379.6	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	148,451	lb	
Fluidic Drag = 12 π D L C_d =	0	lb	Fluidic drag is calculated as zero unless entire segment is submerged in drilling fluid. Please reference Step 2, Drilled Path Input
Axial Segment Weight = W_e L sinθ =	-69,545	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**78,906**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	135,407	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

h = R [1 - cos(α/2)] =	5.85	ft	$j = [(E I) / T]^{1/2}$ =	2,249	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	5.1E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	203.12	
U = (12 L) / j =	1.79		N = [(T h) - W_e cosθ (Y/144)] / (X / 12) =	147,372	lb
Bending Frictional Drag = 2 μ N =	88,423	lb			
Fluidic Drag = 12 π D L C_d =	13,265	lb			
Axial Segment Weight = W_e L sinθ =	11,314	lb			
Pulling Load on Exit Sag Bend =	**113,002**	**lb**			
Total Pulling Load =	**191,908**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	495.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

Frictional Drag = W_e L μ =	71,990	lb
Fluidic Drag = 12 π D L C_d =	19,625	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**91,615**	**lb**
Total Pulling Load =	**283,523**	**lb**

Interstate 79 P0 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	339,178	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E I) / T]^{1/2}$ =	1,421	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	1.8E+06		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	586.29	
$U = (12 L) / j$ =	3.54		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	187,331	lb
Bending Frictional Drag = $2 \mu N$ =	112,399	lb			
Fluidic Drag = $12 \pi D L C_d$ =	16,581	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-17,670	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**111,310**	**lb**			
Total Pulling Load =	**394,833**	**lb**			

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L =	364.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	52,134	lb	
Fluidic Drag = $12 \pi D L C_d$ =	14,432	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-30,642	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**35,923**	**lb**	
Total Pulling Load =	**430,756**	**lb**	

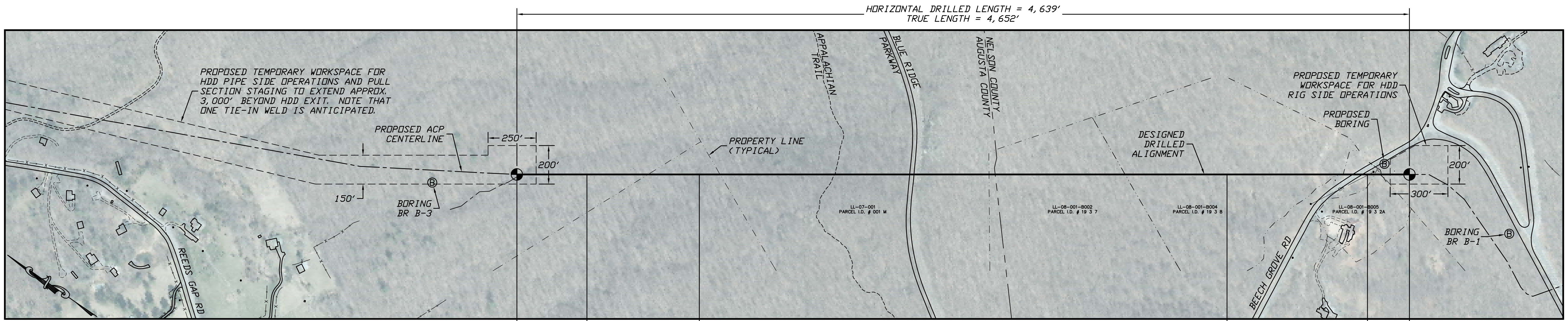
Summary of Calculated Stress vs. Allowable Stress

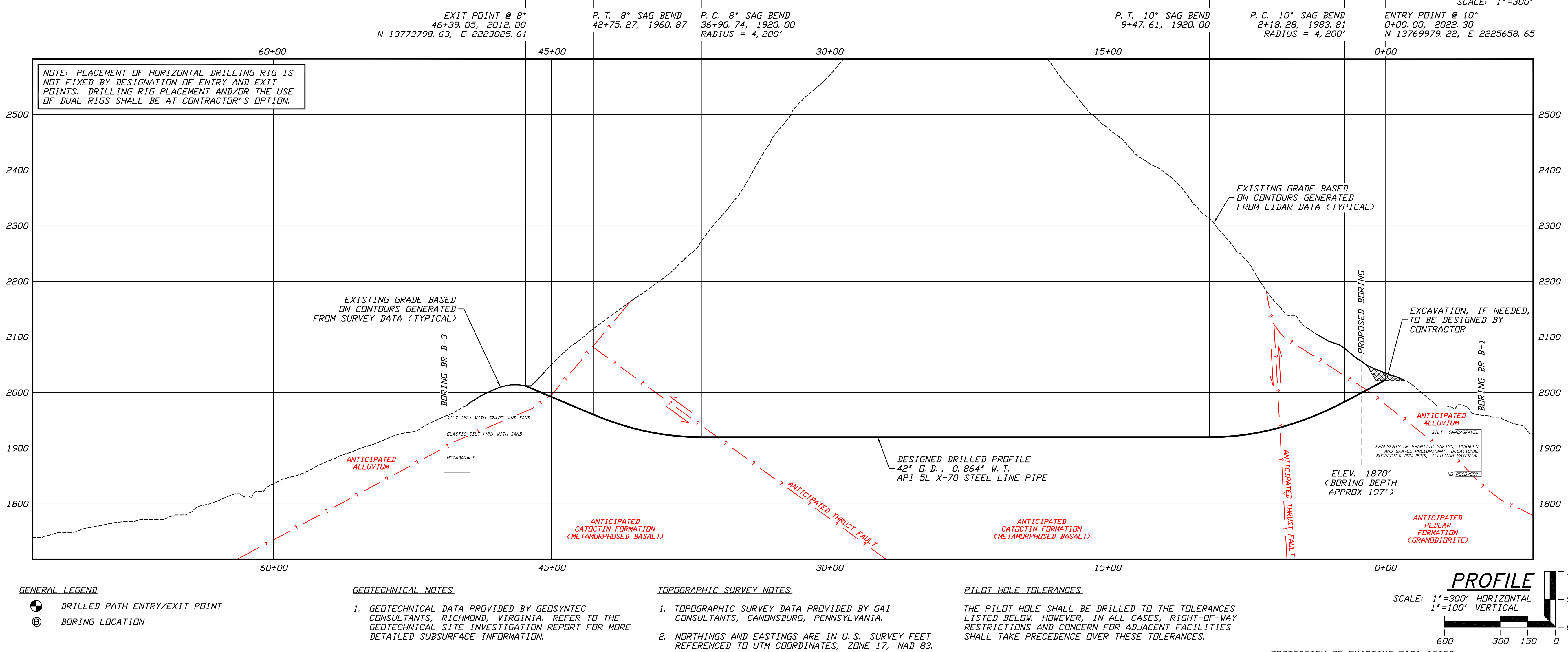
	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,858	ok	0	ok	0	ok	0.06	ok	0.00	ok
	3,536	ok	0	ok	959	ok	0.06	ok	0.03	ok
PC										
	3,536	ok	21,146	ok	959	ok	0.52	ok	0.24	ok
	2,539	ok	21,146	ok	1512	ok	0.50	ok	0.26	ok
PT										
	2,539	ok	0	ok	1512	ok	0.04	ok	0.05	ok
	1,719	ok	0	ok	1512	ok	0.03	ok	0.05	ok
PC										
	1,719	ok	21,146	ok	1512	ok	0.49	ok	0.25	ok
	707	ok	21,146	ok	1158	ok	0.47	ok	0.21	ok
PT										
	707	ok	0	ok	1158	ok	0.01	ok	0.03	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Blue Ridge Parkway

Supporting Information

- Plan & profile drawing presenting HDD crossing design (2 pages, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)





GENERAL LEGEND

- DRILLED PATH ENTRY/EXIT POINT
- BORING LOCATION

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.
2. STRATIFICATION LINES AND SUBSURFACE MATERIAL DESCRIPTIONS SHOWN ON THIS DRAWING HAVE BEEN SIMPLIFIED FOR PRESENTATION PURPOSES.
3. THE ANTICIPATED SUBSURFACE CONDITIONS SHOWN IN RED ARE BASED ON A GENERAL GEOLOGIC PROFILE INCLUDED IN THE GEOTECHNICAL SITE INVESTIGATION REPORT AS FIGURE 4.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 15 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,800 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
42-INCH PIPELINE CROSSING OF THE BLUE RIDGE PARKWAY
BY HORIZONTAL DIRECTIONAL DRILLING

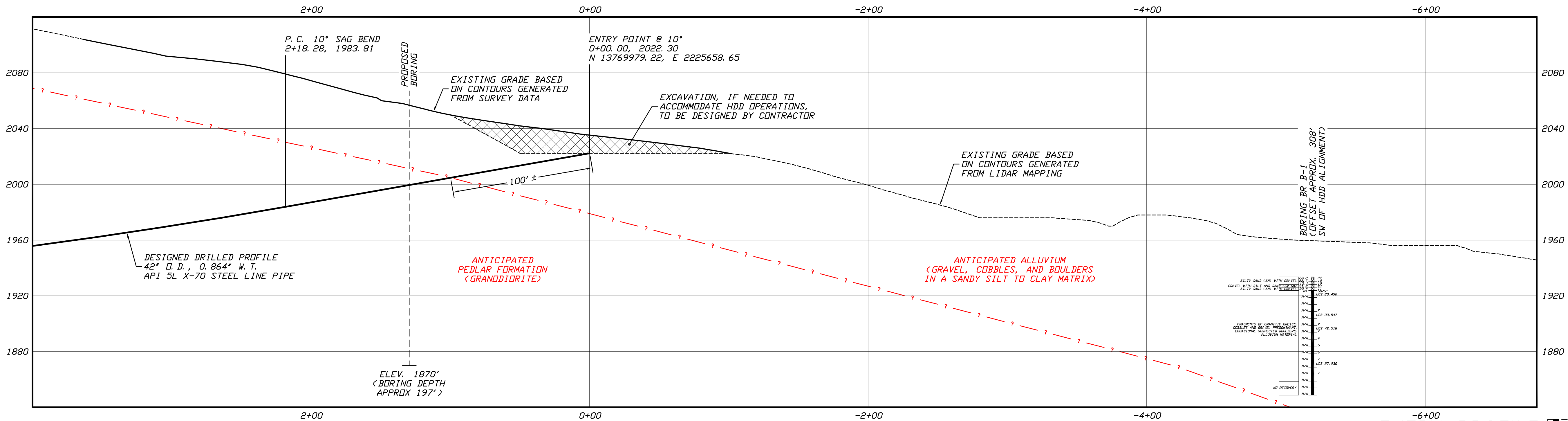
LOCATION: AUGUSTA COUNTY & NELSON COUNTY, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	05/19/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	BR PARKWAY 1	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

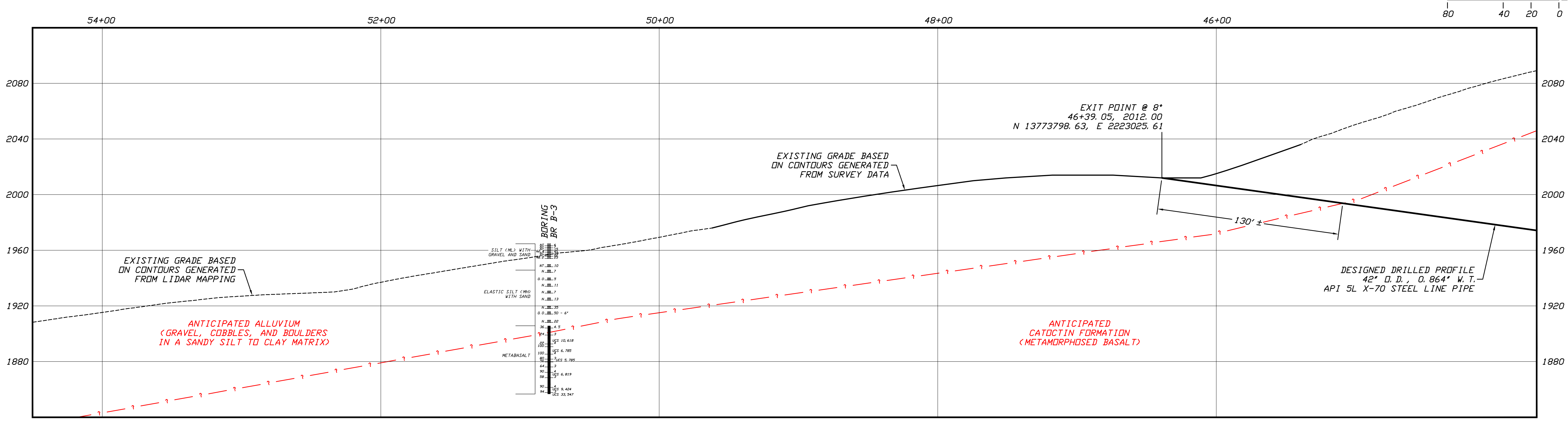
Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508
MILE POST
AP1-158



ENTRY PROFILE

SCALE: 1"=40' HORIZONTAL
1"=40' VERTICAL



EXIT PROFILE

SCALE: 1"=40' HORIZONTAL
1"=40' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

SPLIT SPOON SAMPLE

53 N 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES — PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 6 — MOHS HARDNESS
— ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

GEOTECHNICAL NOTES (CONTINUED)

4. STRATIFICATION LINES AND SUBSURFACE MATERIAL DESCRIPTIONS SHOWN ON THIS DRAWING HAVE BEEN SIMPLIFIED FOR PRESENTATION PURPOSES.
5. THE ANTICIPATED SUBSURFACE CONDITIONS SHOWN IN RED ARE BASED ON A GENERAL GEOLOGIC PROFILE INCLUDED IN THE GEOTECHNICAL SITE INVESTIGATION REPORT AS FIGURE 4.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

ENTRY/EXIT PROFILES - NATURAL SCALE
42-INCH PIPELINE CROSSING OF THE BLUE RIDGE PARKWAY
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: AUGUSTA COUNTY & NELSON COUNTY, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	05/19/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	BR PARKWAY 2	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer

2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP1-158

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	42" Blue Ridge Parkway Crossing	Date :	2/9/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 2,800' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	42.000	in	
Wall Thickness =	0.864	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	23617.82	in^4	
Pipe Face Surface Area =	111.66	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	379.58	lb/ft	
Pipe Interior Volume =	8.85	ft^3/ft	
Pipe Exterior Volume =	9.62	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	551.97	lb/ft	
Displaced Mud Weight =	863.59	lb/ft	

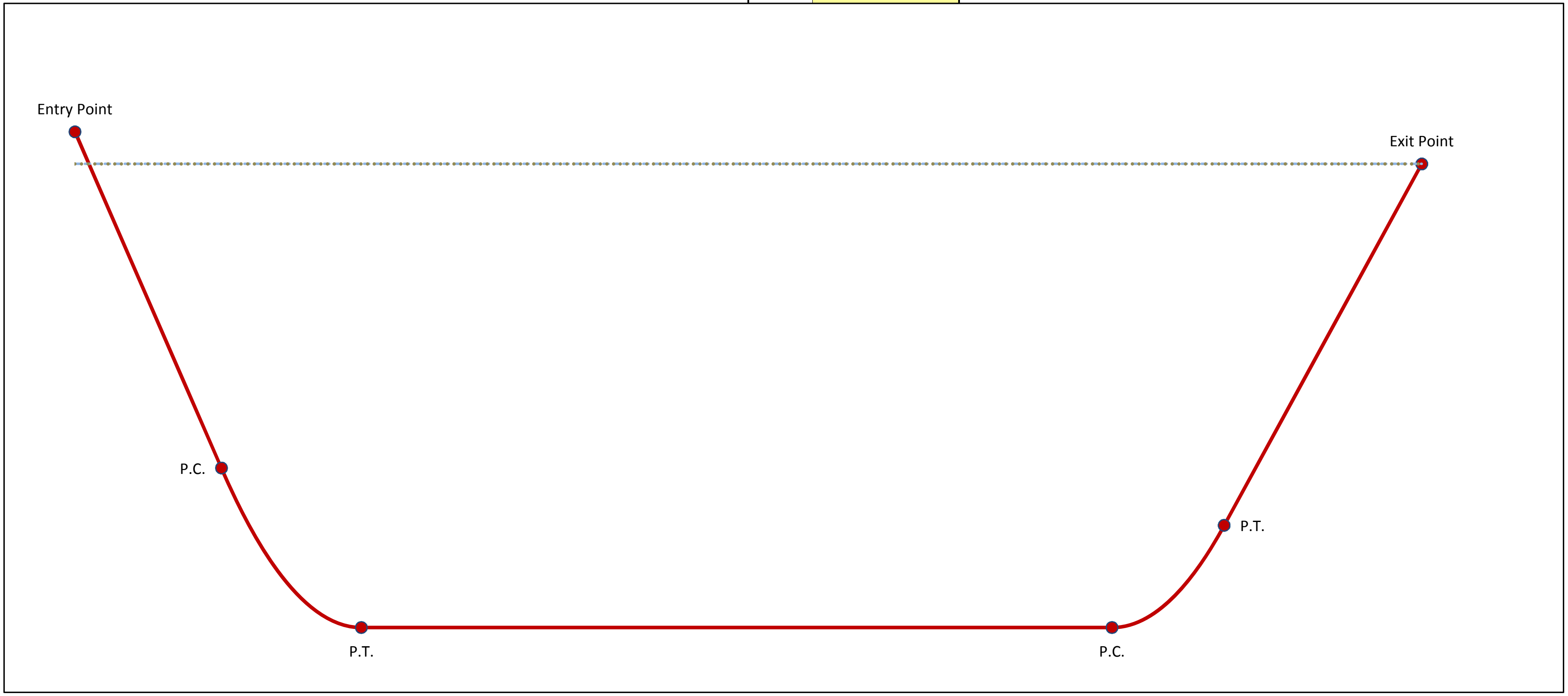
Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,508	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,636	psi	Yes
Allowable Bending Stress, F_b =	45,636	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,800	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,444	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,016	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,200	psi	

Blue Ridge Parkway R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	2022.30	10.00				286,742
Entry Tangent						516.92		
Entry Sag Bend	PC	499.06	1932.54					249,800
	PI	740.31	1890.00	10.00	2800	488.69	231,351	
	PT	985.28	1890.00				0	212,902
Bottom Tangent				0.00		2607.73		
Exit Sag Bend	PC	3593.01	1890.00					56,508
	PI	3788.81	1890.00	8.00	2800	390.95	45,691	
	PT	3982.70	1917.25				0	34,874
Exit Tangent						693.10		
Exit Point		4669.05	2013.71	8.00	Above Ground Load			0
Drilling Mud			2013.71	(Graph = ·········)				
Ballast			2013.71	(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	42.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	379.6	lb/ft	Ballast Weight / ft Pipe, W_b =	552.0	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	863.6	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	693.1	ft	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\, L\, \mu \cos\theta$ =	13,994	lb	
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	27,436	lb	
Axial Segment Weight = $W_e\, L \sin\theta$ =	-6,556	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**34,874**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	391.0	ft	Average Tension, T =	45,691	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,800	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	6.82	ft	$j = [(E\, I) / T]^{1/2}$ =	3,872	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	3.7E+05		$X = (3\,L) - [\,(j / 2) \tanh(U/2)\,]$ =	125.16	
$U = (12\,L) / j$ =	1.21		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$	13,353	lb
Bending Frictional Drag = $2\,\mu\,N$ =	8,012	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	15,476	lb			
Axial Segment Weight = $W_e\,L \sin\theta$ =	-1,853	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**21,634**	**lb**			
Total Pulling Load =	**56,508**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	2607.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

Frictional Drag = $W_e\,L\,\mu$ =	53,170	lb
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	103,225	lb
Axial Segment Weight = $W_e\,L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**156,395**	**lb**
Total Pulling Load =	**212,902**	**lb**

Blue Ridge Parkway R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	488.7	ft	Average Tension, T =	231,351	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,800	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	10.65	ft	$j = [(E\ I) / T]^{1/2}$ =	1,721	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.4E+06		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	660.90	
$U = (12 L) / j$ =	3.41		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	24,431	lb
Bending Frictional Drag = $2 \mu N$ =	14,659	lb			
Fluidic Drag = $12 \pi D L C_d$ =	19,344	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	2,895	lb			
Pulling Load on Entry Sag Bend =	**36,898**	**lb**			
Total Pulling Load =	**249,800**	**lb**			

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L =	516.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	10,379	lb
Fluidic Drag = $12 \pi D L C_d$ =	20,462	lb
Axial Segment Weight = $W_e L \sin\theta$ =	6,101	lb
Pulling Load on Entry Tangent =	**36,942**	**lb**
Total Pulling Load =	**286,742**	**lb**

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	2,568	ok	0	ok	0	ok	0.04	ok	0.00	ok
	2,237	ok	0	ok	375	ok	0.04	ok	0.01	ok
PC										
	2,237	ok	18,125	ok	375	ok	0.43	ok	0.14	ok
	1,907	ok	18,125	ok	571	ok	0.43	ok	0.15	ok
PT										
	1,907	ok	0	ok	571	ok	0.03	ok	0.01	ok
	506	ok	0	ok	571	ok	0.01	ok	0.01	ok
PC										
	506	ok	18,125	ok	571	ok	0.41	ok	0.13	ok
	312	ok	18,125	ok	445	ok	0.40	ok	0.12	ok
PT										
	312	ok	0	ok	445	ok	0.00	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Blue Ridge Parkway R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

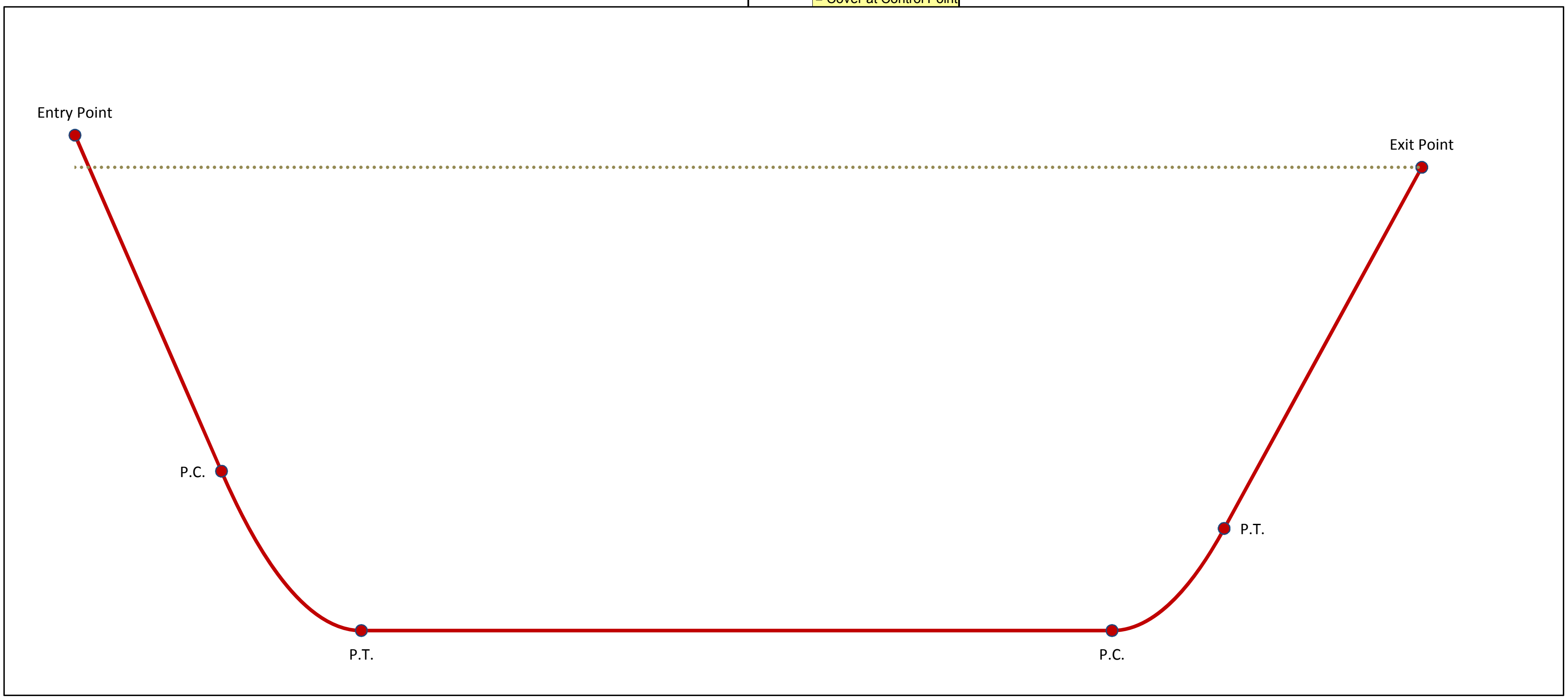
Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	42" Blue Ridge Parkway Crossing	Date :	2/9/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 2,800' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	42.000	in	
Wall Thickness =	0.864	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	23617.82	in^4	
Pipe Face Surface Area =	111.66	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	379.58	lb/ft	
Pipe Interior Volume =	8.85	ft^3/ft	
Pipe Exterior Volume =	9.62	ft^3/ft	
HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	551.97	lb/ft	
Displaced Mud Weight =	863.59	lb/ft	
Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,508	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,636	psi	Yes
Allowable Bending Stress, F_b =	45,636	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,800	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,444	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,016	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,200	psi	

Blue Ridge Parkway R0 Installation Stress Analysis (worst-case).xlsm
J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	2022.30	10.00				979,838
Entry Tangent						516.92		
Entry Sag Bend	PC	499.06	1932.54					928,905
	PI	740.31	1890.00	10.00	2800	488.69	855,318	
	PT	985.28	1890.00				0	781,730
Bottom Tangent				0.00		2607.73		
Exit Sag Bend	PC	3593.01	1890.00					299,856
	PI	3788.81	1890.00	8.00	2800	390.95	236,820	
	PT	3982.70	1917.25				0	173,784
Exit Tangent						693.10		
Exit Point		4669.05	2013.71	8.00	Above Ground Load			0
Drilling Mud			2013.71	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

Blue Ridge Parkway R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	42.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	379.6	lb/ft	Ballast Weight / ft Pipe, W_b =	552.0	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	863.6	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	693.1	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	99,660	lb
Fluidic Drag = $12 \pi D L C_d$ =	27,436	lb
Axial Segment Weight = $W_e L \sin\theta$ =	46,688	lb
Pulling Load on Exit Tangent =	**173,784**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	391.0	ft	Average Tension, T =	236,820	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,800	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	6.82	ft	$j = [(E\,I) / T]^{1/2}$ =	1,701	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	1.2E+06		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	423.90	
$U = (12\,L) / j$ =	2.76		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$	162,328	lb
Bending Frictional Drag = $2\,\mu\,N$ =	97,397	lb			
Fluidic Drag = $12 \pi D L C_d$ =	15,476	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	13,200	lb			
Pulling Load on Exit Sag Bend =	**126,072**	**lb**			
Total Pulling Load =	**299,856**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	2607.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

Frictional Drag = $W_e L \mu$ =	378,650	lb
Fluidic Drag = $12 \pi D L C_d$ =	103,225	lb
Axial Segment Weight = $W_e L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**481,875**	**lb**
Total Pulling Load =	**781,730**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 488.7 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 855,318 lb
Radius of Curvature, R = 2,800 ft
Effective Weight, $W_e = W + W_b - W_m$ = -484.0 lb/ft

h = R [1 - cos(α/2)] = 10.65 ft

$j = [(E\ I) / T]^{1/2}$ = 895

$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 3.6E+06

X = (3 L) - [(j / 2) tanh(U/2)] = 1019.92

U = (12 L) / j = 6.55

$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ = 247,408 lb

Bending Frictional Drag = 2 μ N = 148,445 lb

Fluidic Drag = 12 π D L C_d = 19,344 lb

Axial Segment Weight = W_e L sinθ = -20,615 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 147,174 lb
Total Pulling Load = 928,905 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 516.9 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -484.0 lb/ft

Frictional Drag = W_e L μ cosθ = 73,917 lb

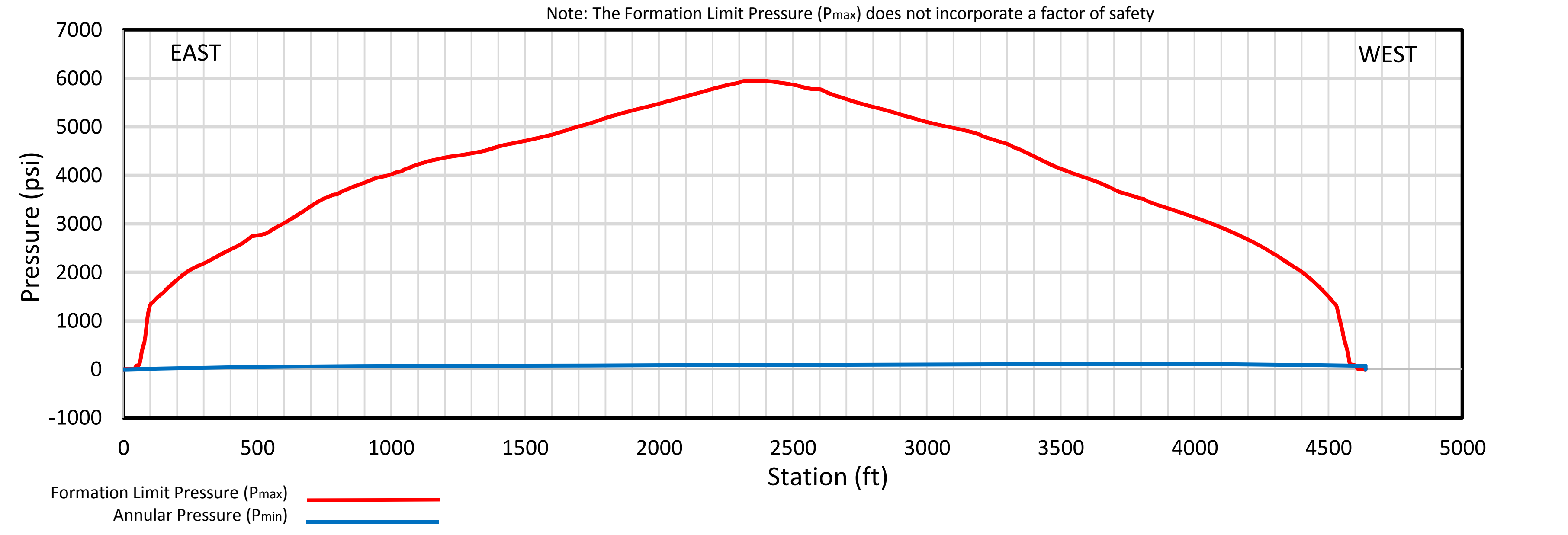
Fluidic Drag = 12 π D L C_d = 20,462 lb

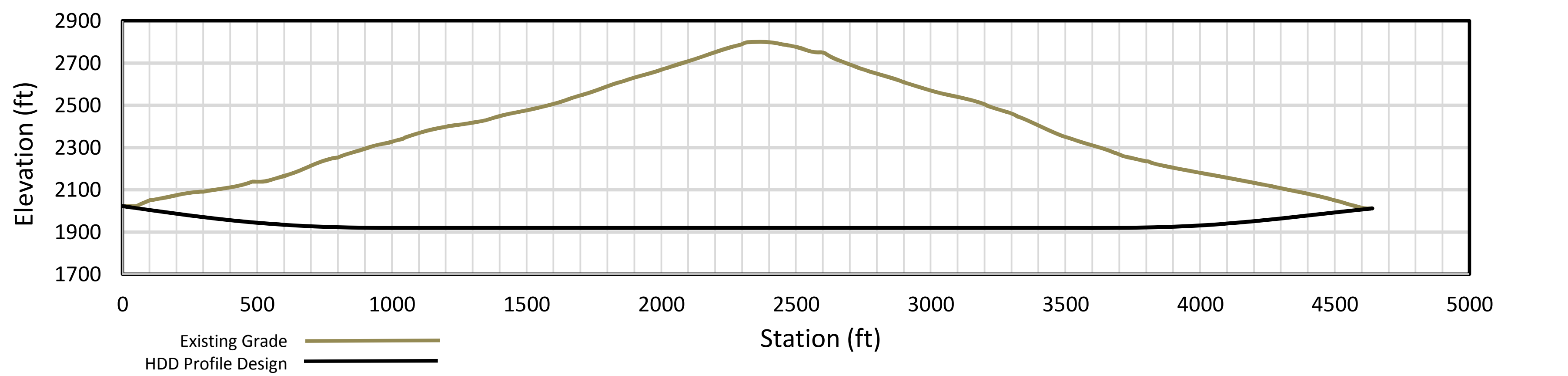
Axial Segment Weight = W_e L sinθ = -43,445 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 50,934 lb
Total Pulling Load = 979,838 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	8,775	ok	0	ok	0	ok	0.14	ok	0.02	ok
	8,319	ok	0	ok	1230	ok	0.13	ok	0.06	ok
PC										
	8,319	ok	18,125	ok	1230	ok	0.53	ok	0.29	ok
	7,001	ok	18,125	ok	1874	ok	0.51	ok	0.32	ok
PT										
	7,001	ok	0	ok	1874	ok	0.11	ok	0.10	ok
	2,686	ok	0	ok	1874	ok	0.04	ok	0.07	ok
PC										
	2,686	ok	18,125	ok	1874	ok	0.44	ok	0.25	ok
	1,556	ok	18,125	ok	1461	ok	0.42	ok	0.20	ok
PT										
	1,556	ok	0	ok	1461	ok	0.02	ok	0.04	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

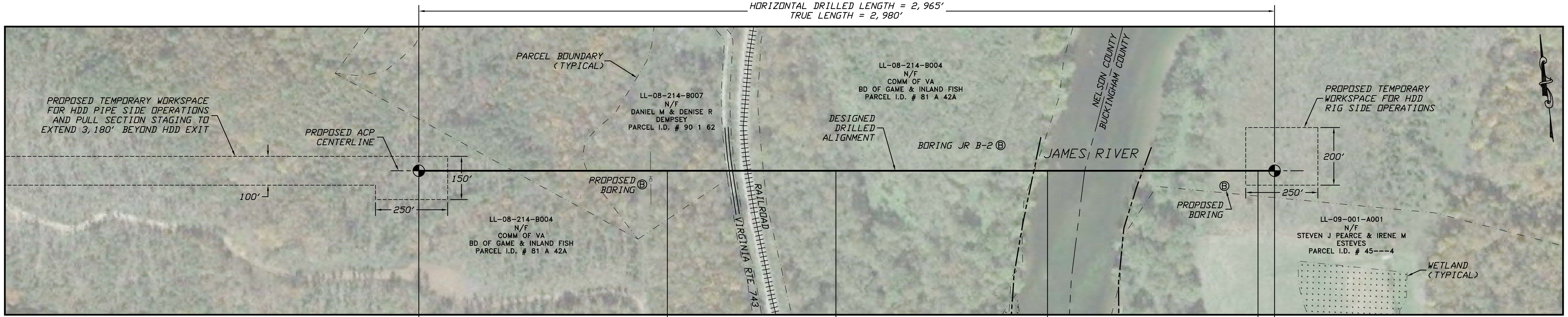
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
42-INCH BLUE RIDGE PARKWAY CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 7/26/2016 Revision: 0

James River

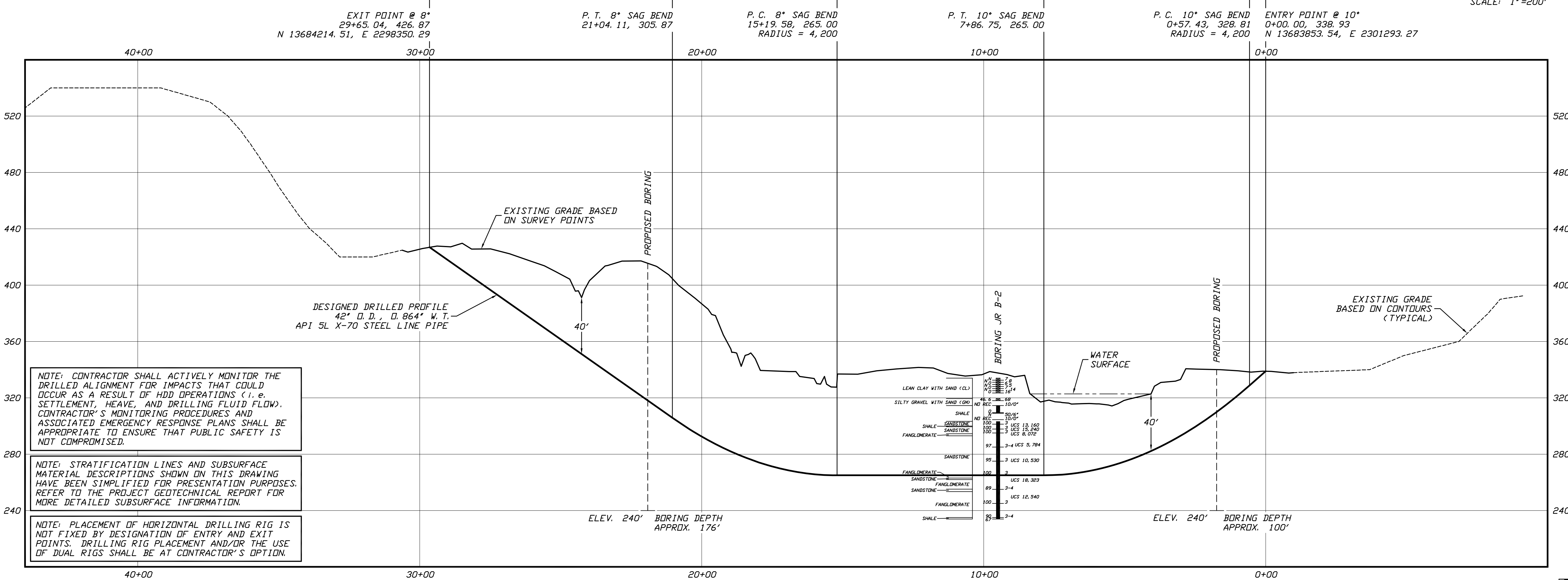
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=200'



NOTE: CONTRACTOR SHALL ACTIVELY MONITOR THE DRILLED ALIGNMENT FOR IMPACTS THAT COULD OCCUR AS A RESULT OF HDD OPERATIONS (i.e. SETTLEMENT, HEAVE, AND DRILLING FLUID FLOW). CONTRACTOR'S MONITORING PROCEDURES AND ASSOCIATED EMERGENCY RESPONSE PLANS SHALL BE APPROPRIATE TO ENSURE THAT PUBLIC SAFETY IS NOT COMPROMISED.

NOTE: STRATIFICATION LINES AND SUBSURFACE MATERIAL DESCRIPTIONS SHOWN ON THIS DRAWING HAVE BEEN SIMPLIFIED FOR PRESENTATION PURPOSES. REFER TO THE PROJECT GEOTECHNICAL REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.

NOTE: PLACEMENT OF HORIZONTAL DRILLING RIG IS NOT FIXED BY DESIGNATION OF ENTRY AND EXIT POINTS. DRILLING RIG PLACEMENT AND/OR THE USE OF DUAL RIGS SHALL BE AT CONTRACTOR'S OPTION.

PROFILE

SCALE: 1"=200' HORIZONTAL
1"= 40' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

Ⓑ BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 6 — MOHS HARDNESS
— ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT DATED JUNE 2016 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,800 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE 42-INCH PIPELINE CROSSING OF THE JAMES RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: BUCKINGHAM & NELSON COUNTIES, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
ACM	07/27/16	DLB	JSP	SHOWN FOR D-SIZED PLOT	JAMES RIVER	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP1-184

James River P5 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	42" James River Crossing	Date :	2/9/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 2,800' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	42.000	in	
Wall Thickness =	0.864	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	23617.82	in^4	
Pipe Face Surface Area =	111.66	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	379.58	lb/ft	
Pipe Interior Volume =	8.85	ft^3/ft	
Pipe Exterior Volume =	9.62	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	551.97	lb/ft	
Displaced Mud Weight =	863.59	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,508	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,636	psi	Yes
Allowable Bending Stress, F_b =	45,636	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,800	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,444	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,016	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,200	psi	

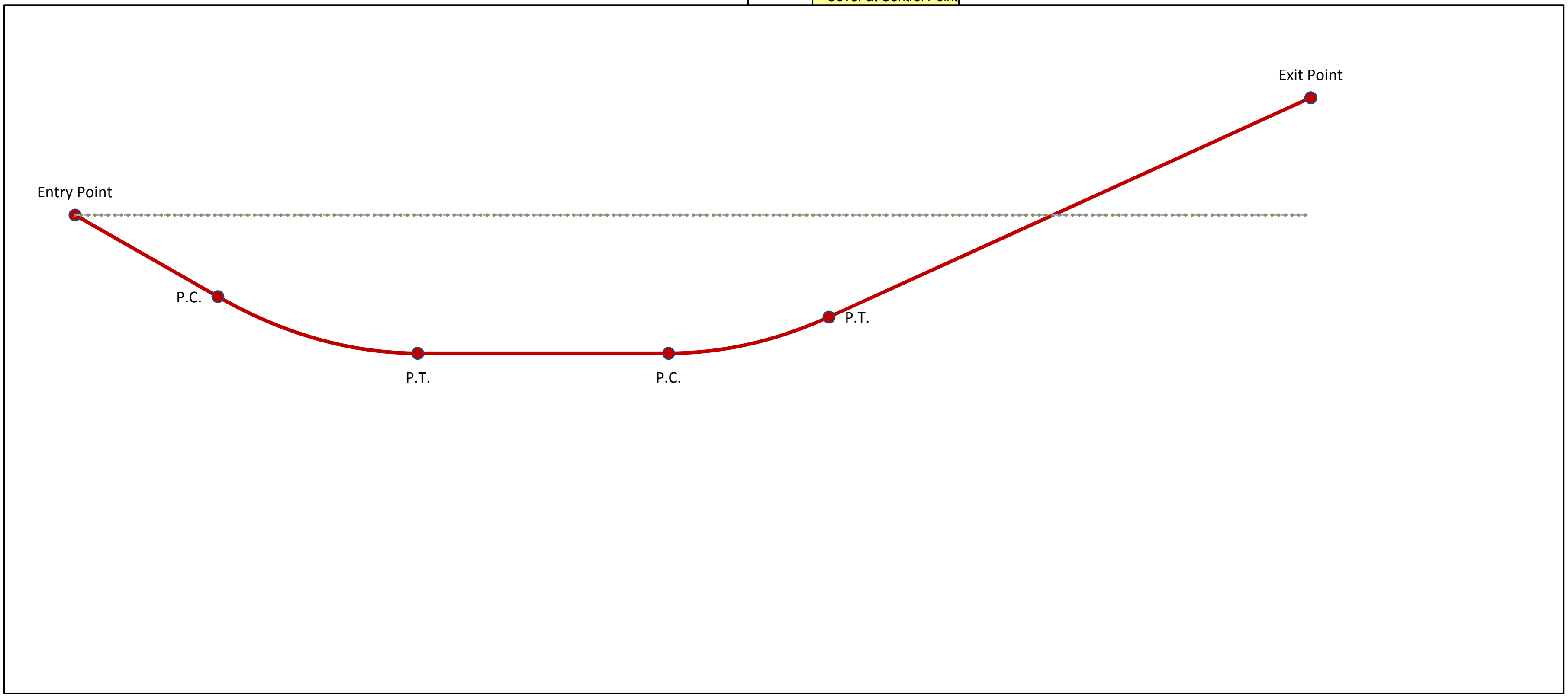
James River P5 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	338.89	10.00				187,844
Entry Tangent						353.31		
Entry Sag Bend	PC	337.94	277.54					162,594
	PI	579.19	235.00	10.00	2800	488.69	146,785	
	PT	824.16	235.00				0	130,975
Bottom Tangent				0.00		609.86		
Exit Sag Bend	PC	1434.02	235.00					94,399
	PI	1629.81	235.00	8.00	2800	390.95	82,649	
	PT	1823.70	262.25				0	70,899
Exit Tangent						1182.85		
Exit Point		2995.04	426.87	8.00	Above Ground Load			0
Drilling Mud			338.89	(Graph = ·········)				
Ballast			338.89	(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



James River P5 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	42.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	379.6	lb/ft	Ballast Weight / ft Pipe, W_b =	552.0	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	863.6	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	1182.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	379.6	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	133,386	lb	
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	0	lb	Fluidic drag is calculated as zero unless entire segment is submerged in drilling fluid. Please reference Step 2, Drilled Path Input
Axial Segment Weight = $W_e\ L \sin\theta$ =	-62,487	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**70,899**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	391.0	ft	Average Tension, T =	82,649	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,800	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	6.82	ft	$j = [(E\ I) / T]^{1/2}$ =	2,879	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	6.0E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	205.24	
$U = (12\ L) / j$ =	1.63		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	16,464	lb
Bending Frictional Drag = $2\ \mu\ N$ =	9,879	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	15,476	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	-1,853	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**23,501**	**lb**			
Total Pulling Load =	**94,399**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	609.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	68.0	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	12,435	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	24,141	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**36,575**	**lb**
Total Pulling Load =	**130,975**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 488.7 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °
Average Tension, T = 146,785 lb
Radius of Curvature, R = 2,800 ft
Effective Weight, $W_e = W + W_b - W_m$ = 68.0 lb/ft

$h = R [1 - \cos(\alpha/2)]$ = 10.65 ft
$j = [(E I) / T]^{1/2}$ = 2,160
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 1.9E+06
$X = (3 L) - [(j / 2) \tanh(U/2)]$ = 520.17
$U = (12 L) / j$ = 2.71
$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ = 15,634 lb
Bending Frictional Drag = $2 \mu N$ = 9,381 lb
Fluidic Drag = $12 \pi D L C_d$ = 19,344 lb
Axial Segment Weight = $W_e L \sin\theta$ = 2,895 lb

Pulling Load on Entry Sag Bend = 31,620 lb
Total Pulling Load = 162,594 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 353.3 ft
Entry Angle, θ = 10.0 °
Effective Weight, $W_e = W + W_b - W_m$ = 68.0 lb/ft

Frictional Drag = $W_e L \mu \cos\theta$ = 7,094 lb
Fluidic Drag = $12 \pi D L C_d$ = 13,985 lb
Axial Segment Weight = $W_e L \sin\theta$ = 4,170 lb

Pulling Load on Entry Tangent = 25,250 lb
Total Pulling Load = 187,844 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	1,682	ok	0	ok	0	ok	0.03	ok	0.00	ok
	1,456	ok	0	ok	283	ok	0.02	ok	0.00	ok
PC										
	1,456	ok	18,125	ok	283	ok	0.42	ok	0.13	ok
	1,173	ok	18,125	ok	480	ok	0.42	ok	0.13	ok
PT										
	1,173	ok	0	ok	480	ok	0.02	ok	0.01	ok
	845	ok	0	ok	480	ok	0.01	ok	0.00	ok
PC										
	845	ok	18,125	ok	480	ok	0.41	ok	0.13	ok
	635	ok	18,125	ok	354	ok	0.41	ok	0.12	ok
PT										
	635	ok	0	ok	354	ok	0.01	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	42" James River Crossing	Date :	2/9/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 2,800' radius) with 12 ppg mud and no BC		

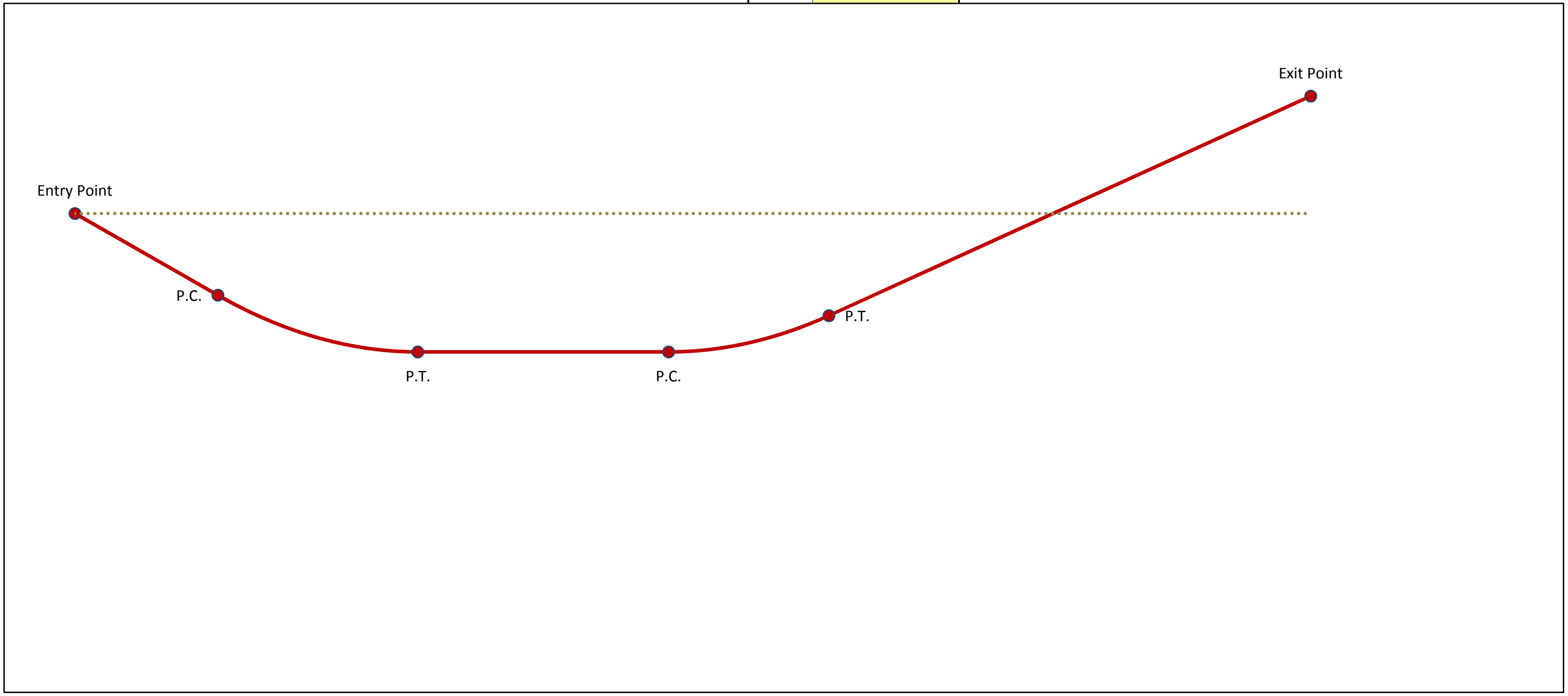
Line Pipe Properties			
Pipe Outside Diameter =	42.000	in	
Wall Thickness =	0.864	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	23617.82	in^4	
Pipe Face Surface Area =	111.66	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	379.58	lb/ft	
Pipe Interior Volume =	8.85	ft^3/ft	
Pipe Exterior Volume =	9.62	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	551.97	lb/ft	
Displaced Mud Weight =	863.59	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,508	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,636	psi	Yes
Allowable Bending Stress, F_b =	45,636	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,800	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,444	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,016	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,800	psi	
Allowable Hoop Buckling Stress, F_{hc}/1.5 =	7,200	psi	

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	338.89	10.00				459,458
Entry Tangent						353.31		
Entry Sag Bend	PC	337.94	277.54					424,645
	PI	579.19	235.00	10.00	2800	488.69	364,718	
	PT	824.16	235.00				0	304,791
Bottom Tangent				0.00		609.86		
Exit Sag Bend	PC	1434.02	235.00					192,096
	PI	1629.81	235.00	8.00	2800	390.95	131,497	
	PT	1823.70	262.25				0	70,899
Exit Tangent						1182.85		
Exit Point		2995.04	426.87	8.00	Above Ground Load			0
Drilling Mud			338.89	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



James River P5 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	42.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	379.6	lb/ft	Ballast Weight / ft Pipe, W_b =	552.0	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	863.6	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	1182.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	379.6	lb/ft
Exit Angle, θ =	8.0	º			

Frictional Drag = $W_e L \mu \cos\theta$ =	133,386	lb	
Fluidic Drag = $12 \pi D L C_d$ =	0	lb	Fluidic drag is calculated as zero unless entire segment is submerged in drilling fluid. Please reference Step 2, Drilled Path Input
Axial Segment Weight = $W_e L \sin\theta$ =	-62,487	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**70,899**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	391.0	ft	Average Tension, T =	131,497	lb
Segment Angle with Horizontal, θ =	-8.0	º	Radius of Curvature, R =	2,800	ft
Deflection Angle, α =	-4.0	º	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	6.82	ft	$j = [(E I) / T]^{1/2}$ =	2,282	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	8.5E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	290.74	
$U = (12 L) / j$ =	2.06		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$	154,204	lb
Bending Frictional Drag = $2 \mu N$ =	92,522	lb			
Fluidic Drag = $12 \pi D L C_d$ =	15,476	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	13,200	lb			
Pulling Load on Exit Sag Bend =	**121,198**	**lb**			
Total Pulling Load =	**192,096**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	609.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

Frictional Drag = $W_e L \mu$ =	88,554	lb
Fluidic Drag = $12 \pi D L C_d$ =	24,141	lb
Axial Segment Weight = $W_e L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**112,694**	**lb**
Total Pulling Load =	**304,791**	**lb**

James River P5 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	488.7	ft	Average Tension, T =	364,718	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,800	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	10.65	ft	$j = [(E\,I) / T]^{1/2}$ =	1,370	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	2.9E+06		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	799.61	
$U = (12\,L) / j$ =	4.28		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	201,875	lb
Bending Frictional Drag = $2\,\mu\,N$ =	121,125	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	19,344	lb			
Axial Segment Weight = $W_e\,L\sin\theta$ =	-20,615	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**119,854**	**lb**			
Total Pulling Load =	**424,645**	**lb**			

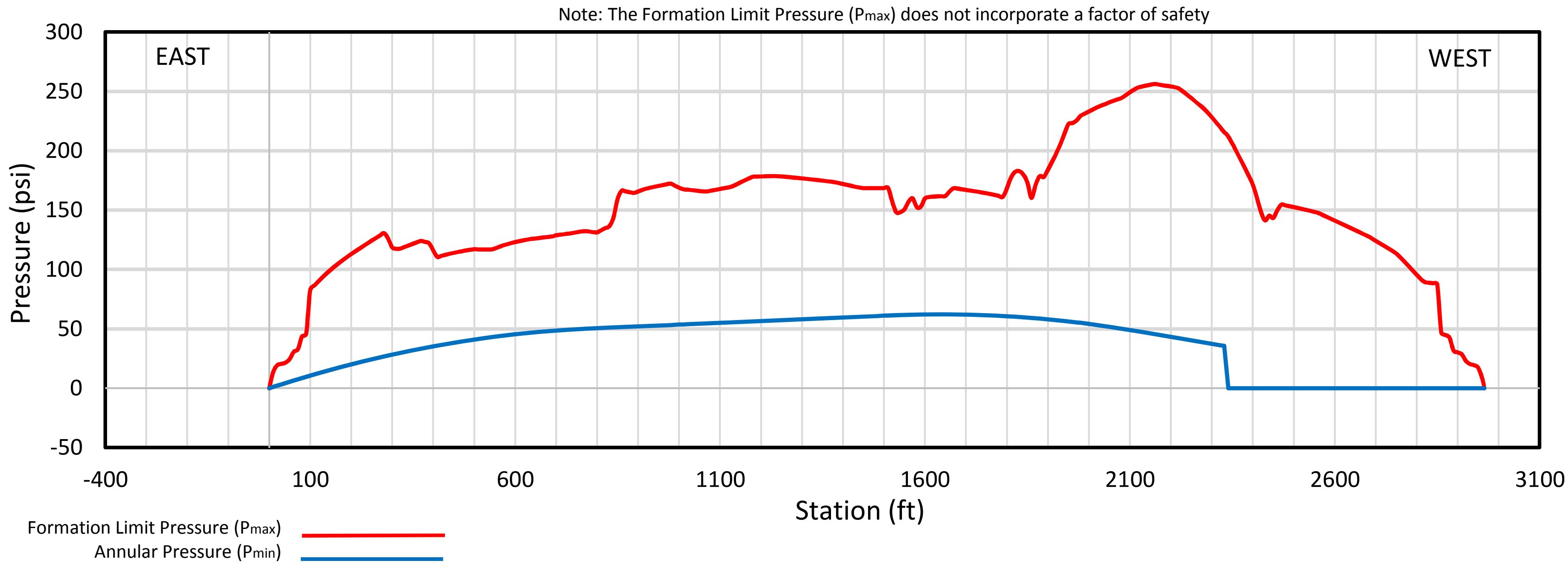
Entry Tangent - Summary of Pulling Load Calculations

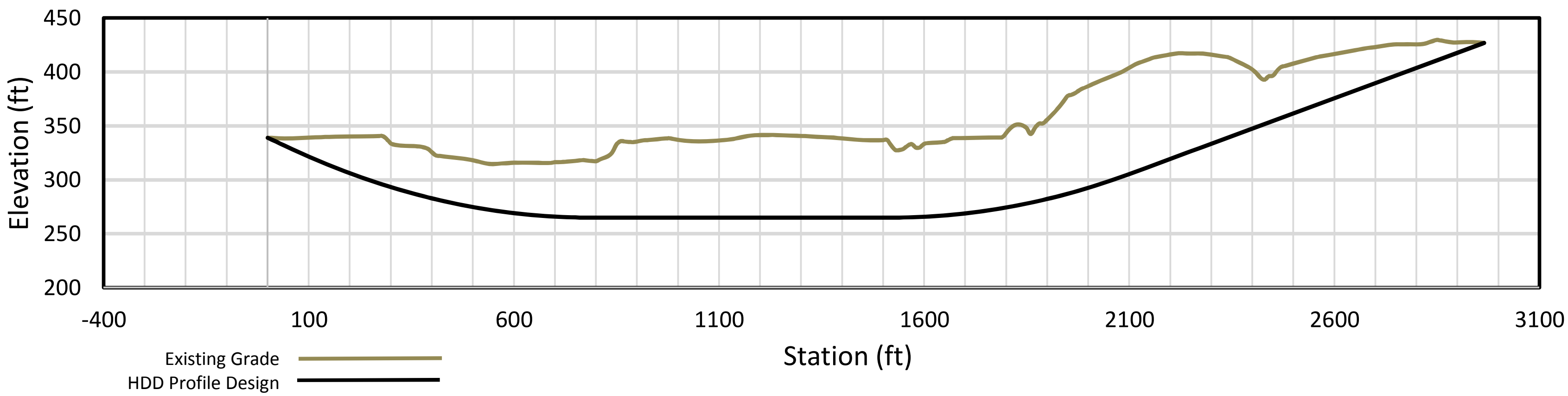
Segment Length, L =	353.3	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-484.0	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu\cos\theta$ =	50,522	lb	
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	13,985	lb	
Axial Segment Weight = $W_e\,L\sin\theta$ =	-29,695	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**34,813**	**lb**	
Total Pulling Load =	**459,458**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	4,115	ok	0	ok	0	ok	0.07	ok	0.01	ok
	3,803	ok	0	ok	930	ok	0.06	ok	0.02	ok
PC										
	3,803	ok	18,125	ok	930	ok	0.46	ok	0.19	ok
	2,730	ok	18,125	ok	1574	ok	0.44	ok	0.22	ok
PT										
	2,730	ok	0	ok	1574	ok	0.04	ok	0.05	ok
	1,720	ok	0	ok	1574	ok	0.03	ok	0.05	ok
PC										
	1,720	ok	18,125	ok	1574	ok	0.42	ok	0.21	ok
	635	ok	18,125	ok	1161	ok	0.41	ok	0.16	ok
PT										
	635	ok	0	ok	1161	ok	0.01	ok	0.03	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
42-INCH JAMES RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

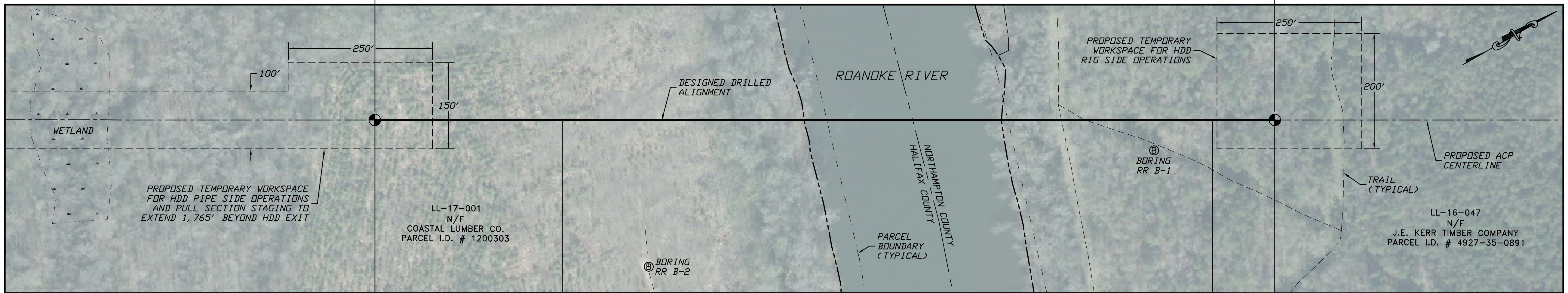
Date: 7/26/2016 Revision: 0

Roanoke River

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)

HORIZONTAL DRILLED LENGTH = 1,559'
TRUE LENGTH = 1,568'



PLAN

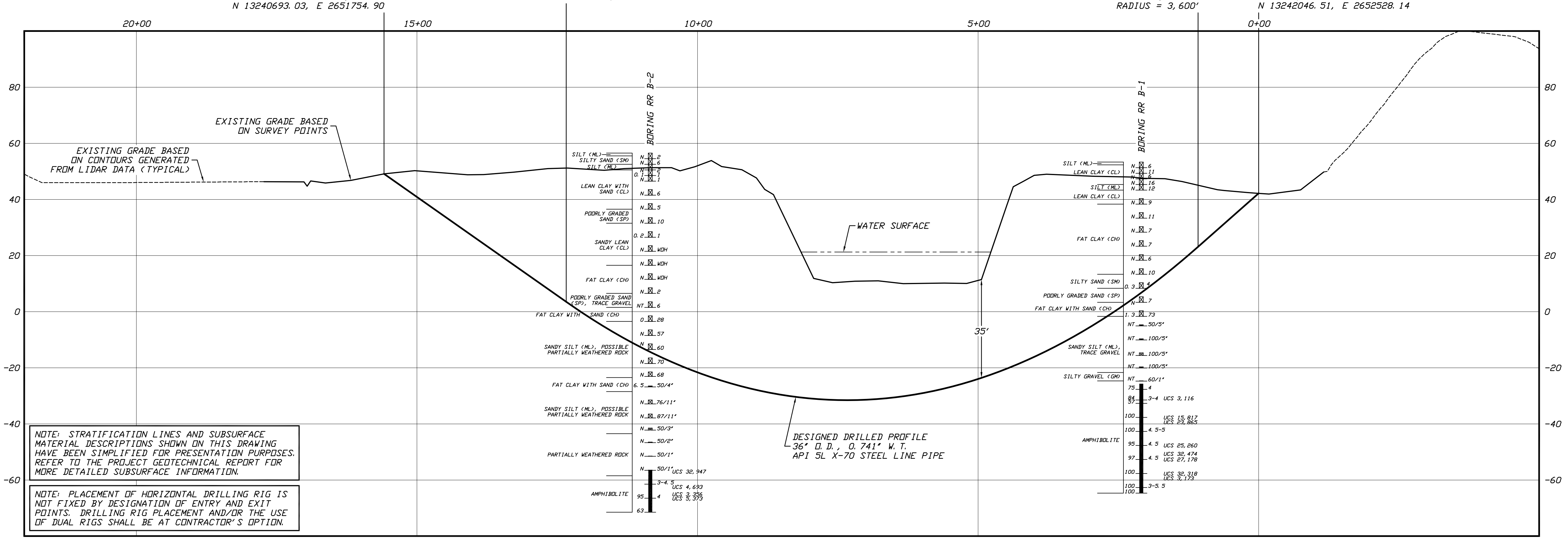
SCALE: 1"=100'

EXIT POINT @ 8°
15+58.78, 49.14
N 13240693.03, E 2651754.90

P.T. 18° SAG BEND
12+33.96, 3.48

P.C. 18° SAG BEND
1+07.81, 23.14
RADIUS = 3,600'

ENTRY POINT @ 10°
0+00.00, 42.15
N 13242046.51, E 2652528.14



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 6 — MOHS HARDNESS
— ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 20 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
36-INCH PIPELINE CROSSING OF THE ROANOKE RIVER
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: HALIFAX & NORTHAMPTON COUNTIES, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	06/17/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	ROANOKE	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

SHEET NO.
AP2-10

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	36" Roanoke River Crossing	Date :	7/22/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 18' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

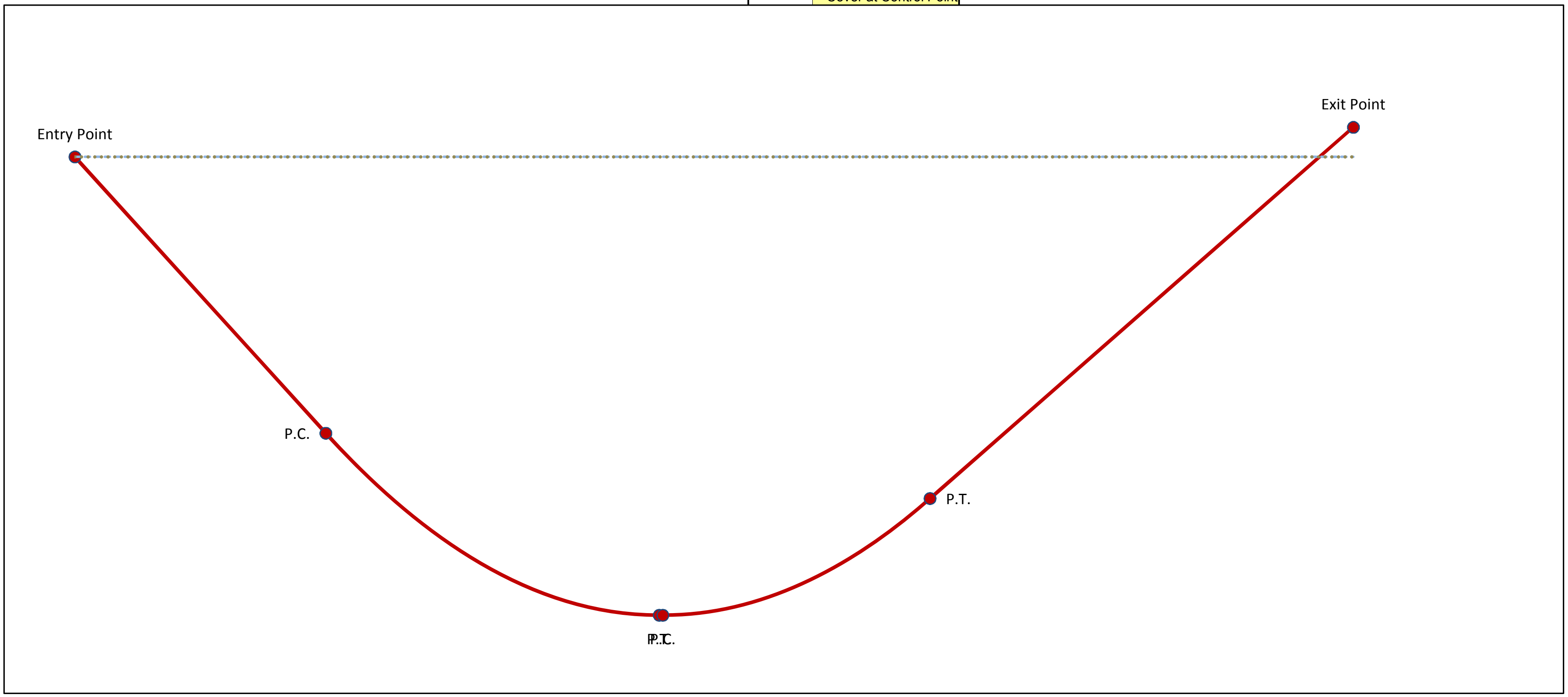
Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, F_{hc}/1.5 =	7,208	psi	

Roanoke River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	42.00	10.00				78,434
Entry Tangent						318.74		
Entry Sag Bend	PC	303.90	-13.35					60,133
	PI	510.68	-49.81	10.00	2400	418.88	49,854	
	PT	720.65	-49.81				0	39,574
Bottom Tangent				0.00		4.70		
Exit Sag Bend	PC	725.36	-49.81					39,344
	PI	893.18	-49.81	8.00	2400	335.10	30,855	
	PT	1059.37	-26.45				0	22,366
Exit Tangent						534.61		
Exit Point		1588.78	47.95	8.00	Above Ground Load			0
Drilling Mud			42.00	(Graph =)				
Ballast			42.00	(Graph =)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	534.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	7,952	lb	
Fluidic Drag = $12 \pi D L C_d$ =	18,139	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-3,725	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**22,366**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	30,855	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	3,462	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.5E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	99.59	
$U = (12\ L) / j$ =	1.16		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$	11,298	lb
Bending Frictional Drag = $2 \mu N$ =	6,779	lb			
Fluidic Drag = $12 \pi D L C_d$ =	11,370	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-1,170	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**16,978**	**lb**			
Total Pulling Load =	**39,344**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	4.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = $W_e L \mu$ =	71	lb
Fluidic Drag = $12 \pi D L C_d$ =	160	lb
Axial Segment Weight = $W_e L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**230**	**lb**
Total Pulling Load =	**39,574**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	49,854	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E I) / T]^{1/2}$ =	2,724	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	8.3E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	266.28	
$U = (12 L) / j$ =	1.85		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	7,531	lb
Bending Frictional Drag = $2 \mu N$ =	4,519	lb			
Fluidic Drag = $12 \pi D L C_d$ =	14,212	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	1,828	lb			
Pulling Load on Entry Sag Bend =	**20,559**	**lb**			
Total Pulling Load =	**60,133**	**lb**			

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L =	318.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	4,715	lb
Fluidic Drag = $12 \pi D L C_d$ =	10,815	lb
Axial Segment Weight = $W_e L \sin\theta$ =	2,771	lb
Pulling Load on Entry Tangent =	**18,301**	**lb**
Total Pulling Load =	**78,434**	**lb**

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	956	ok	0	ok	0	ok	0.02	ok	0.00	ok
	733	ok	0	ok	255	ok	0.01	ok	0.00	ok
PC										
	733	ok	18,125	ok	255	ok	0.41	ok	0.12	ok
	482	ok	18,125	ok	424	ok	0.40	ok	0.12	ok
PT										
	482	ok	0	ok	424	ok	0.01	ok	0.00	ok
	479	ok	0	ok	424	ok	0.01	ok	0.00	ok
PC										
	479	ok	18,125	ok	424	ok	0.40	ok	0.12	ok
	272	ok	18,125	ok	316	ok	0.40	ok	0.12	ok
PT										
	272	ok	0	ok	316	ok	0.00	ok	0.00	ok
Exit Point	0	ok	0	ok	-27	ok	0.00	ok	0.00	ok

Roanoke River R0 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	36" Roanoke River Crossing	Date :	2/12/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (58' longer and 20' deeper than design with a 2,400' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, F_{hc}/1.5 =	7,208	psi	

Roanoke River R0 Installation Stress Analysis (worst-case).xlsm

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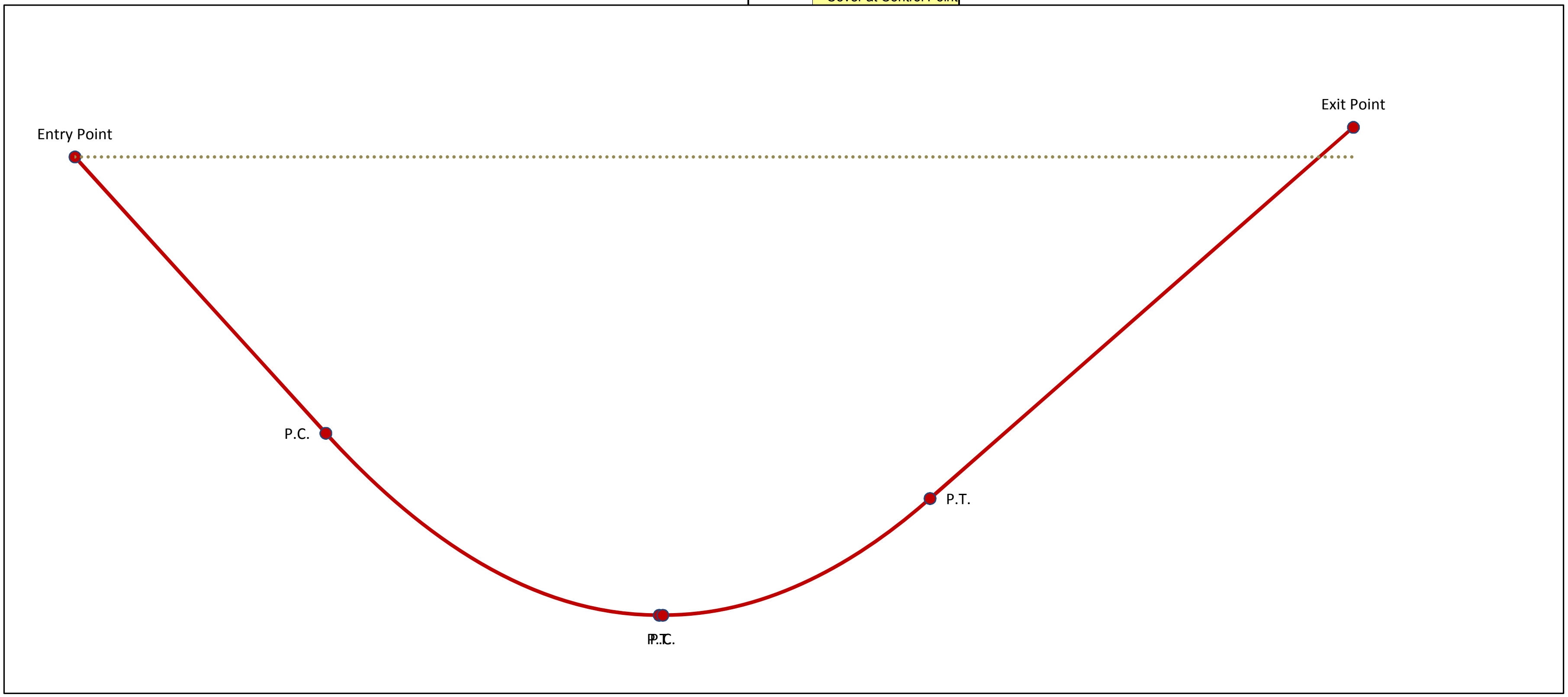
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	42.00	10.00				287,363
Entry Tangent						318.74		
Entry Sag Bend	PC	303.90	-13.35					262,750
	PI	510.68	-49.81	10.00	2400	418.88	223,422	
	PT	720.65	-49.81				0	184,094
Bottom Tangent				0.00		4.70		
Exit Sag Bend	PC	725.36	-49.81					183,432
	PI	893.18	-49.81	8.00	2400	335.10	142,235	
	PT	1059.37	-26.45				0	101,037
Exit Tangent						534.61		
Exit Point		1588.78	47.95	8.00	Above Ground Load			0
Drilling Mud			42.00	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Step 2, Drilled Path Input

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Roanoke River R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	534.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	56,452	lb
Fluidic Drag = 12 π D L C_d =	18,139	lb
Axial Segment Weight = W_e L sinθ =	26,446	lb
Pulling Load on Exit Tangent =	**101,037**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	142,235	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

h = R [1 - cos(α/2)] =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	1,613	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	8.0E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	322.05	
U = (12 L) / j =	2.49		N = [(T h) - W_e cosθ (Y/144)] / (X / 12)	104,529	lb
Bending Frictional Drag = 2 μ N =	62,717	lb			
Fluidic Drag = 12 π D L C_d =	11,370	lb			
Axial Segment Weight = W_e L sinθ =	8,309	lb			
Pulling Load on Exit Sag Bend =	**82,396**	**lb**			
Total Pulling Load =	**183,432**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	4.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = W_e L μ =	502	lb
Fluidic Drag = 12 π D L C_d =	160	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**661**	**lb**
Total Pulling Load =	**184,094**	**lb**

Roanoke River R0 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	223,422	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E I) / T]^{1/2}$ =	1,287	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.0E+06		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	638.65	
$U = (12 L) / j$ =	3.91		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	129,034	lb
Bending Frictional Drag = $2 \mu N$ =	77,420	lb			
Fluidic Drag = $12 \pi D L C_d$ =	14,212	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-12,976	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**78,656**	**lb**			
Total Pulling Load =	**262,750**	**lb**			

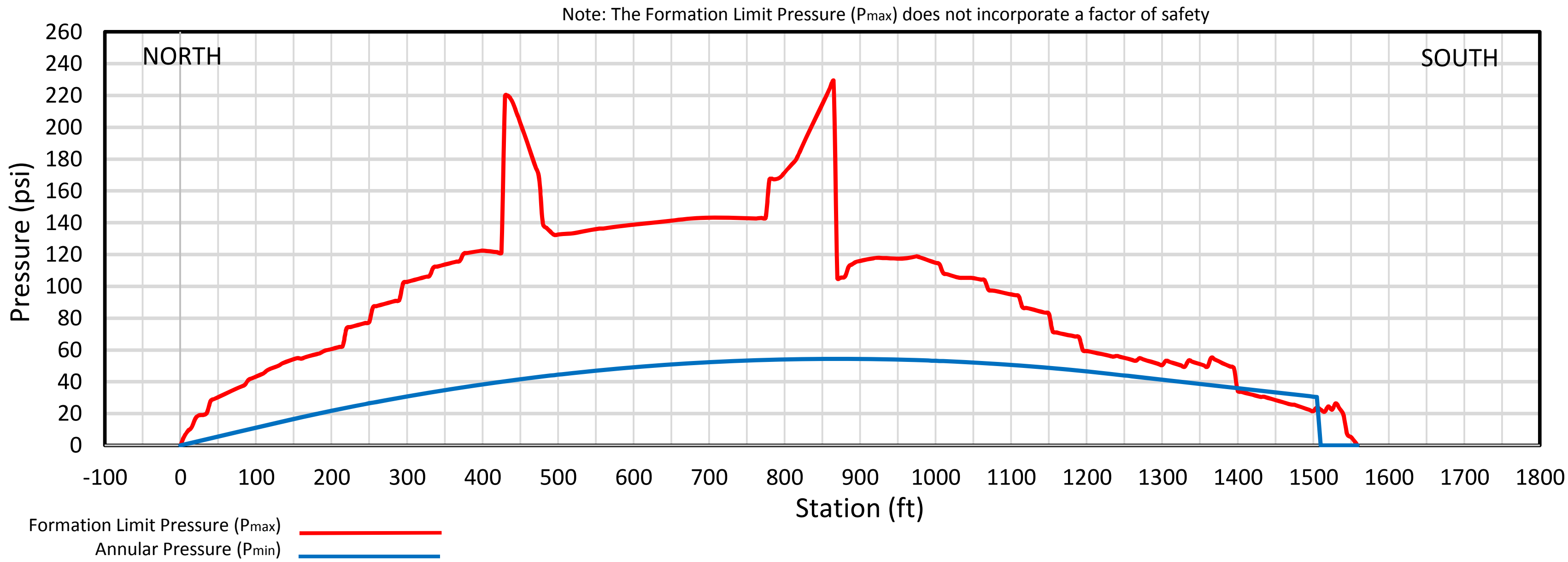
Entry Tangent - Summary of Pulling Load Calculations

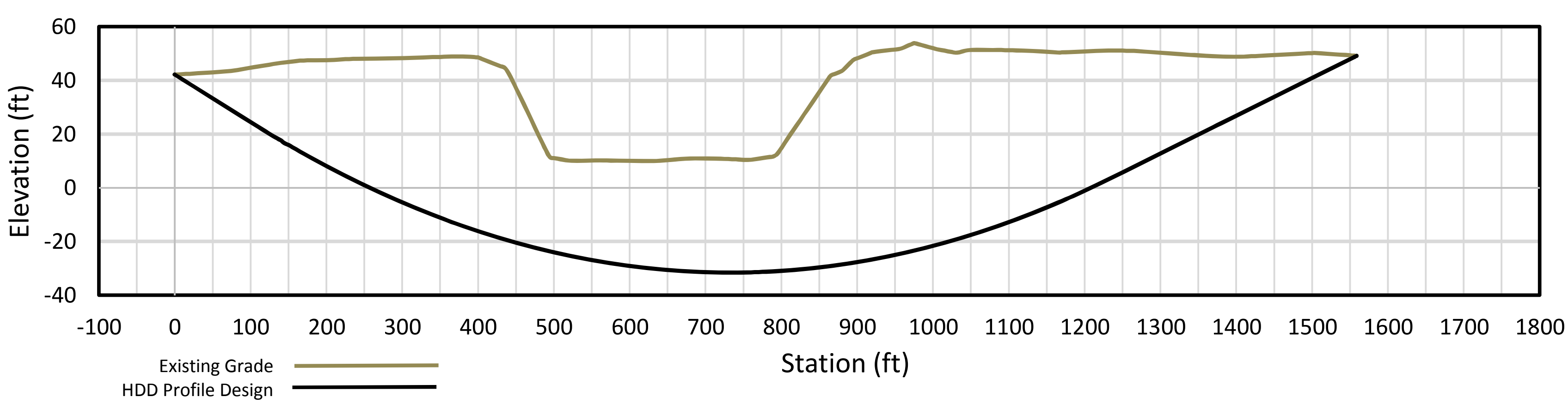
Segment Length, L =	318.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	33,472	lb	
Fluidic Drag = $12 \pi D L C_d$ =	10,815	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-19,673	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**24,613**	**lb**	
Total Pulling Load =	**287,363**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,501	ok	0	ok	0	ok	0.06	ok	0.00	ok
	3,201	ok	0	ok	838	ok	0.05	ok	0.02	ok
PC										
	3,201	ok	18,125	ok	838	ok	0.45	ok	0.18	ok
	2,243	ok	18,125	ok	1390	ok	0.43	ok	0.20	ok
PT										
	2,243	ok	0	ok	1390	ok	0.04	ok	0.04	ok
	2,235	ok	0	ok	1390	ok	0.04	ok	0.04	ok
PC										
	2,235	ok	18,125	ok	1390	ok	0.43	ok	0.20	ok
	1,231	ok	18,125	ok	1037	ok	0.42	ok	0.16	ok
PT										
	1,231	ok	0	ok	1037	ok	0.02	ok	0.02	ok
Exit Point	0	ok	0	ok	-90	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
36-INCH ROANOKE RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

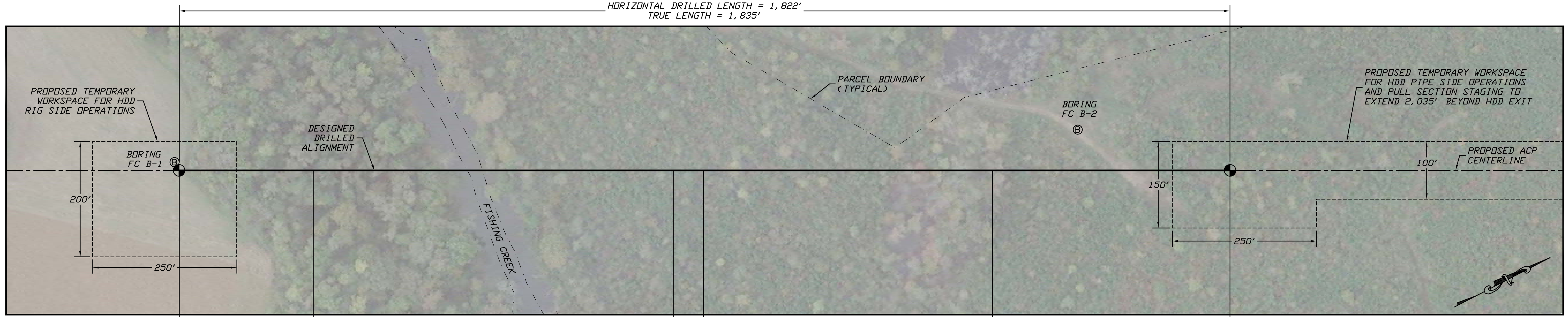
Date: 5/31/2016

Revision: 0

Fishing Creek

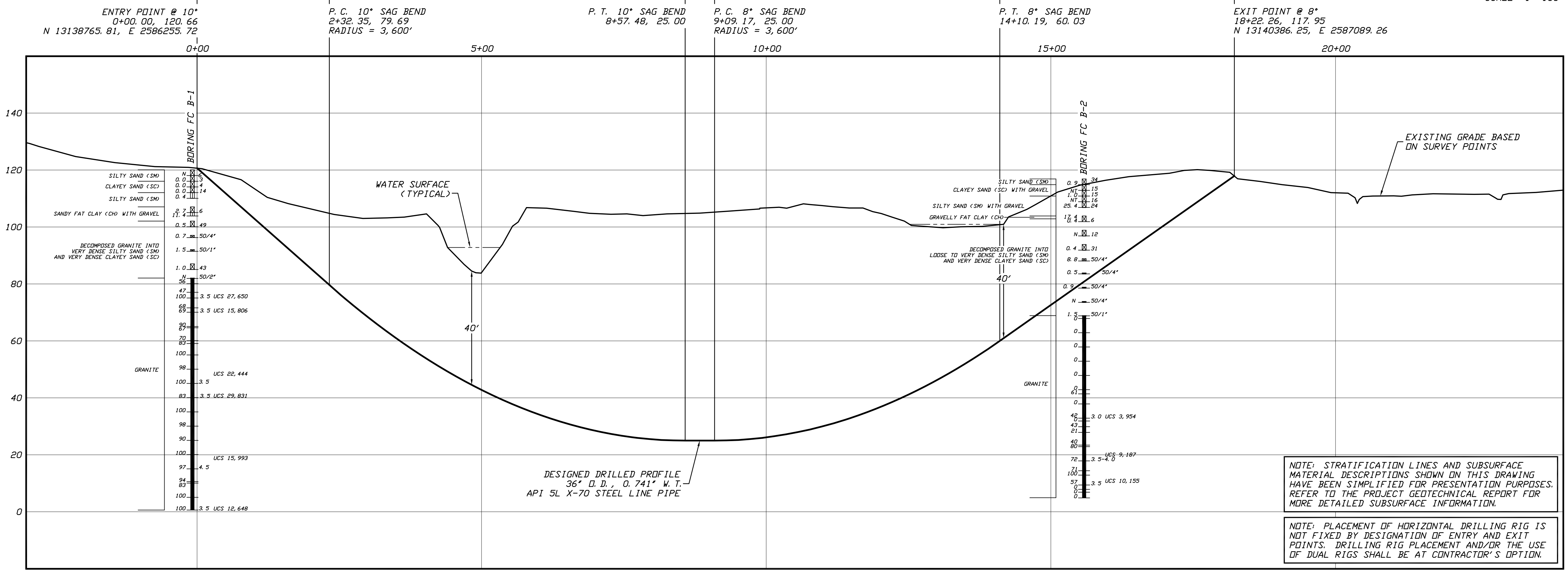
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=100'



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

SHELBY TUBE SAMPLE

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 6 — MOHS HARDNESS
— ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RALEIGH, NORTH CAROLINA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT DATED SEPTEMBER 2016 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 20 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
36-INCH PIPELINE CROSSING OF FISHING CREEK
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: HALIFAX & NASH COUNTIES, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN/LKB	10/07/16	DMP/ACM	JSP	SHOWN FOR D-SIZED PLOT	FISHING CREEK	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

AP2-034

Fishing Creek P1 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Fishing Creek Crossing	Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 20' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Fishing Creek P1 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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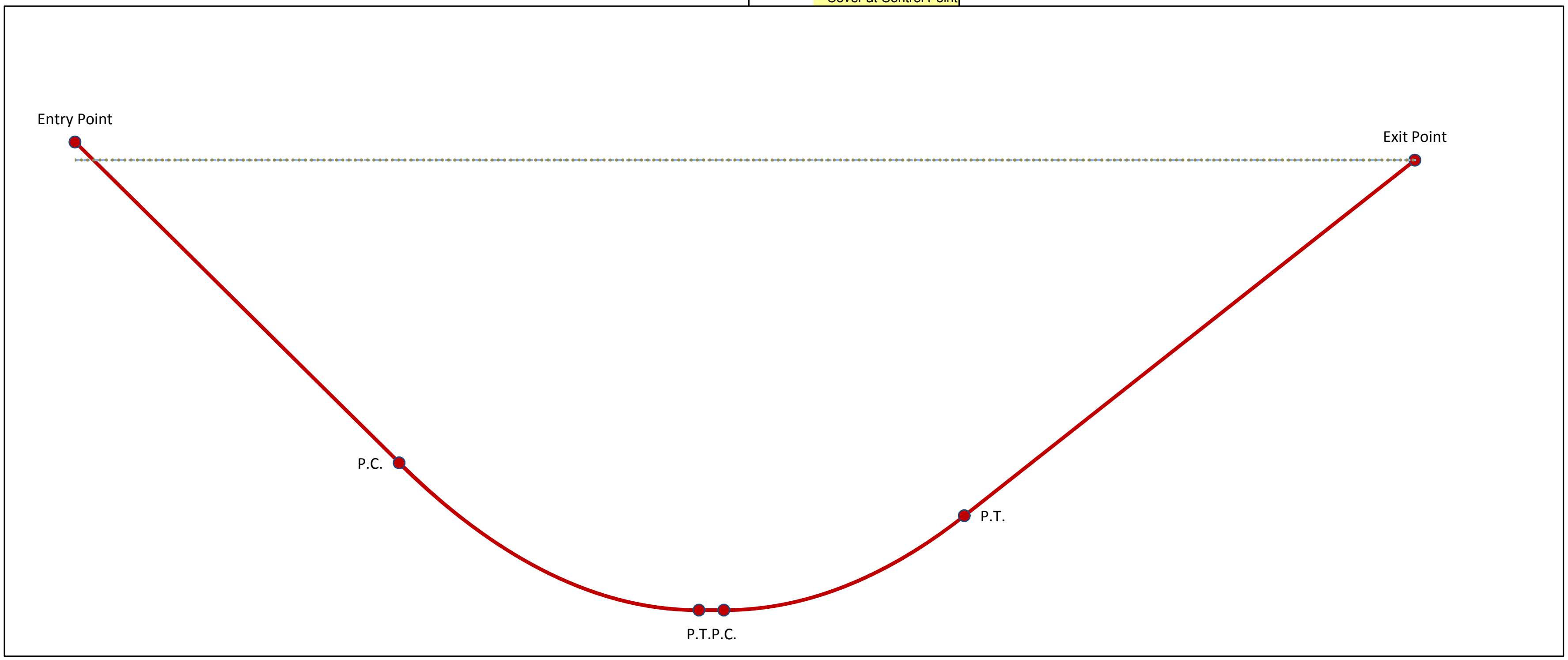
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	120.87	10.00				92,546
Entry Tangent						457.30		
Entry Sag Bend	PC	440.35	41.46					66,290
	PI	647.13	5.00	10.00	2400	418.88	55,822	
	PT	857.10	5.00				0	45,354
Bottom Tangent				0.00		34.75		
Exit Sag Bend	PC	891.85	5.00					43,653
	PI	1059.68	5.00	8.00	2400	335.10	35,058	
	PT	1225.87	28.36				0	26,463
Exit Tangent						632.55		
Exit Point		1852.26	116.39	8.00	Above Ground Load			0
Drilling Mud			116.39	(Graph = ········)				
Ballast			116.39	(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

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Fishing Creek P1 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	632.5	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	9,409	lb	
Fluidic Drag = $12 \pi D L C_d$ =	21,462	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-4,408	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**26,463**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	35,058	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E I) / T]^{1/2}$ =	3,248	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.8E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	111.36	
$U = (12 L) / j$ =	1.24		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	11,652	lb

Bending Frictional Drag = $2 \mu N$ =	6,991	lb	
Fluidic Drag = $12 \pi D L C_d$ =	11,370	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-1,170	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Sag Bend =	**17,190**	**lb**	
Total Pulling Load =	**43,653**	**lb**	

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	34.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = $W_e L \mu$ =	522	lb
Fluidic Drag = $12 \pi D L C_d$ =	1,179	lb
Axial Segment Weight = $W_e L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**1,701**	**lb**
Total Pulling Load =	**45,354**	**lb**

Fishing Creek P1 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	55,822	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E\,I) / T]^{1/2}$ =	2,574	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	9.0E+05		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	289.42	
$U = (12\,L) / j$ =	1.95		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	8,159	lb
Bending Frictional Drag = $2\,\mu\,N$ =	4,895	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	14,212	lb			
Axial Segment Weight = $W_e\,L \sin\theta$ =	1,828	lb			
Pulling Load on Entry Sag Bend =	**20,935**	**lb**			
Total Pulling Load =	**66,290**	**lb**			

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L =	457.3	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu \cos\theta$ =	6,765	lb
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	15,516	lb
Axial Segment Weight = $W_e\,L \sin\theta$ =	3,976	lb
Pulling Load on Entry Tangent =	**26,257**	**lb**
Total Pulling Load =	**92,546**	**lb**

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	1,128	ok	0	ok	0	ok	0.02	ok	0.00	ok
	808	ok	0	ok	346	ok	0.01	ok	0.00	ok
PC										
	808	ok	18,125	ok	346	ok	0.41	ok	0.12	ok
	553	ok	18,125	ok	514	ok	0.41	ok	0.13	ok
PT										
	553	ok	0	ok	514	ok	0.01	ok	0.01	ok
	532	ok	0	ok	514	ok	0.01	ok	0.01	ok
PC										
	532	ok	18,125	ok	514	ok	0.41	ok	0.13	ok
	322	ok	18,125	ok	406	ok	0.40	ok	0.12	ok
PT										
	322	ok	0	ok	406	ok	0.01	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Fishing Creek P1 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Fishing Creek Crossing	Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 20' deeper than design with a 2,400' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Fishing Creek P1 Installation Stress Analysis (worst-case).xlsm

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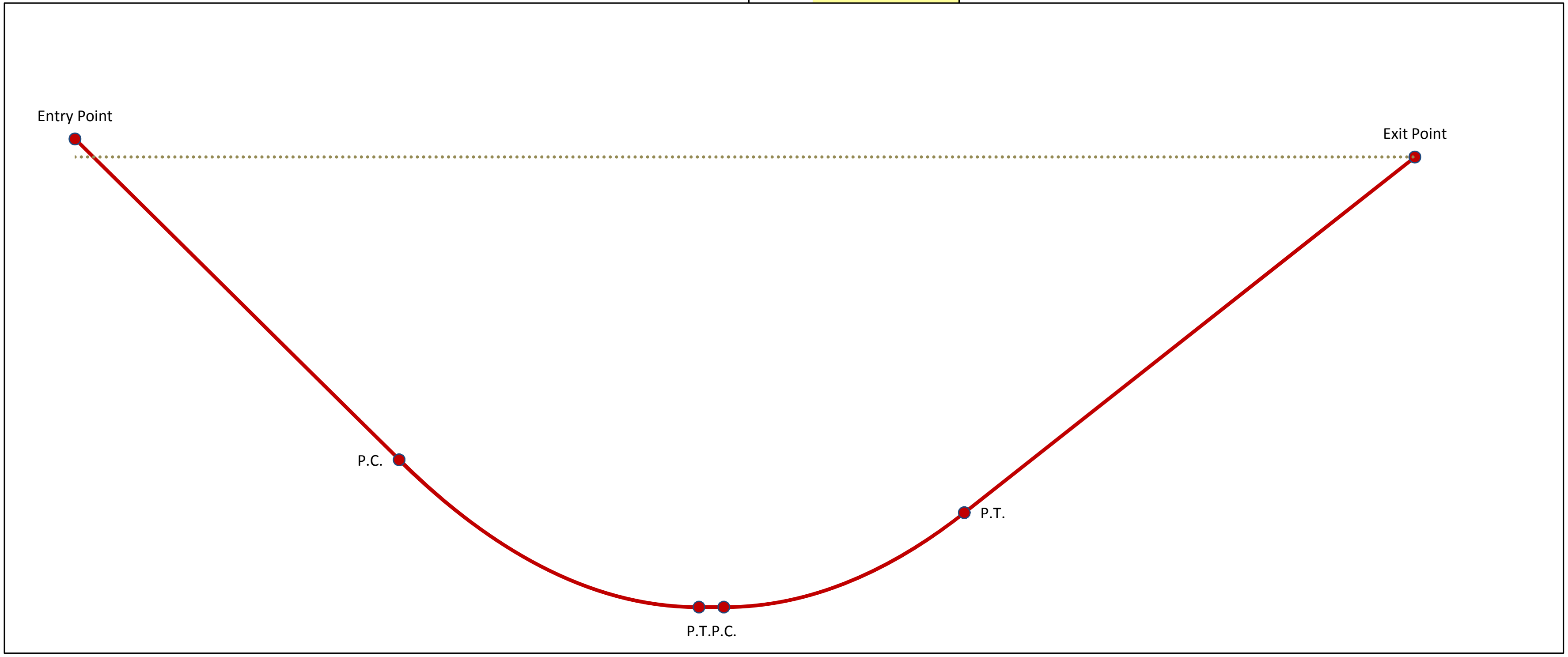
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	120.87	10.00				323,050
Entry Tangent						457.30		
Entry Sag Bend	PC	440.35	41.46					287,738
	PI	647.13	5.00	10.00	2400	418.88	247,725	
	PT	857.10	5.00				0	207,712
Bottom Tangent				0.00		34.75		
Exit Sag Bend	PC	891.85	5.00					202,827
	PI	1059.68	5.00	8.00	2400	335.10	161,186	
	PT	1225.87	28.36				0	119,546
Exit Tangent						632.55		
Exit Point		1852.26	116.39	8.00			Above Ground Load	0
Drilling Mud			116.39	(Graph = ········)				
Ballast				(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

9:41 AM10/10/2016

Fishing Creek P1 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	632.5	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	66,793	lb
Fluidic Drag = 12 π D L C_d =	21,462	lb
Axial Segment Weight = W_e L sinθ =	31,291	lb
Pulling Load on Exit Tangent =	**119,546**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	161,186	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

h = R [1 - cos(α/2)] =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	1,515	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	8.6E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	347.42	
U = (12 L) / j =	2.65		N = [(T h) - W_e cosθ (Y/144)] / (X / 12) =	106,005	lb
Bending Frictional Drag = 2 μ N =	63,603	lb			
Fluidic Drag = 12 π D L C_d =	11,370	lb			
Axial Segment Weight = W_e L sinθ =	8,309	lb			
Pulling Load on Exit Sag Bend =	**83,281**	**lb**			
Total Pulling Load =	**202,827**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	34.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = W_e L μ =	3,706	lb
Fluidic Drag = 12 π D L C_d =	1,179	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**4,885**	**lb**
Total Pulling Load =	**207,712**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 247,725 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

h = R [1 - cos(α/2)] = 9.13 ft

j = $[(E I) / T]^{1/2}$ = 1,222

Y = $[18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 2.0E+06

X = (3 L) - [(j / 2) tanh(U/2)] = 665.31

U = (12 L) / j = 4.11

N = [(T h) - W_e cosθ (Y/144)] / (X / 12) = 131,318 lb

Bending Frictional Drag = 2 μ N = 78,791 lb

Fluidic Drag = 12 π D L C_d = 14,212 lb

Axial Segment Weight = W_e L sinθ = -12,976 lb

Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 80,027 lb
Total Pulling Load = 287,738 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 457.3 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

Frictional Drag = W_e L μ cosθ = 48,022 lb

Fluidic Drag = 12 π D L C_d = 15,516 lb

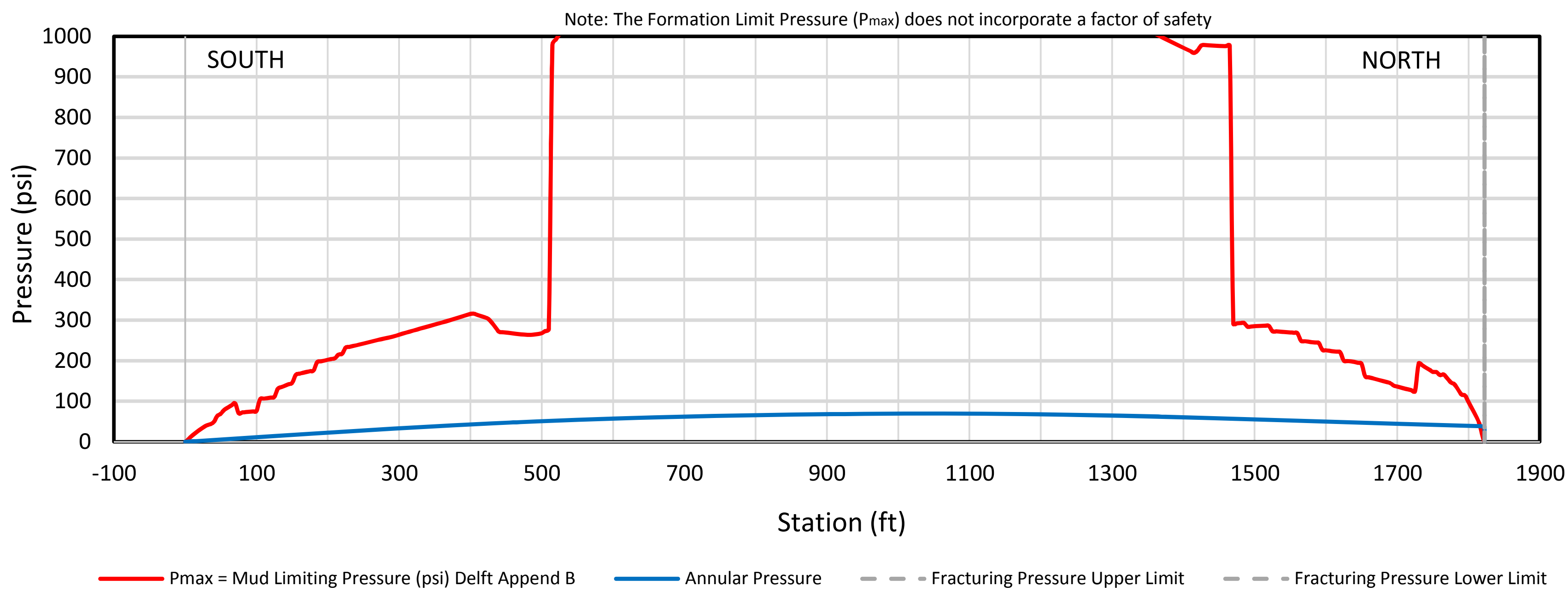
Axial Segment Weight = W_e L sinθ = -28,225 lb

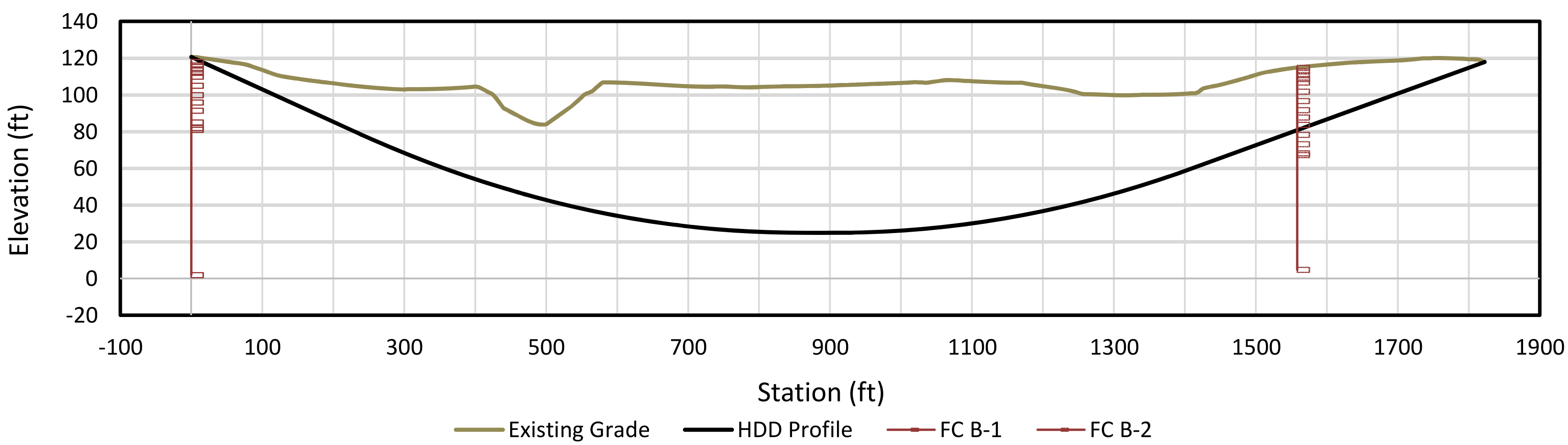
Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 35,312 lb
Total Pulling Load = 323,050 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,936	ok	0	ok	0	ok	0.06	ok	0.00	ok
	3,506	ok	0	ok	1135	ok	0.06	ok	0.03	ok
PC										
	3,506	ok	18,125	ok	1135	ok	0.45	ok	0.20	ok
	2,531	ok	18,125	ok	1687	ok	0.44	ok	0.23	ok
PT										
	2,531	ok	0	ok	1687	ok	0.04	ok	0.06	ok
	2,471	ok	0	ok	1687	ok	0.04	ok	0.06	ok
PC										
	2,471	ok	18,125	ok	1687	ok	0.44	ok	0.23	ok
	1,456	ok	18,125	ok	1333	ok	0.42	ok	0.19	ok
PT										
	1,456	ok	0	ok	1333	ok	0.02	ok	0.04	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

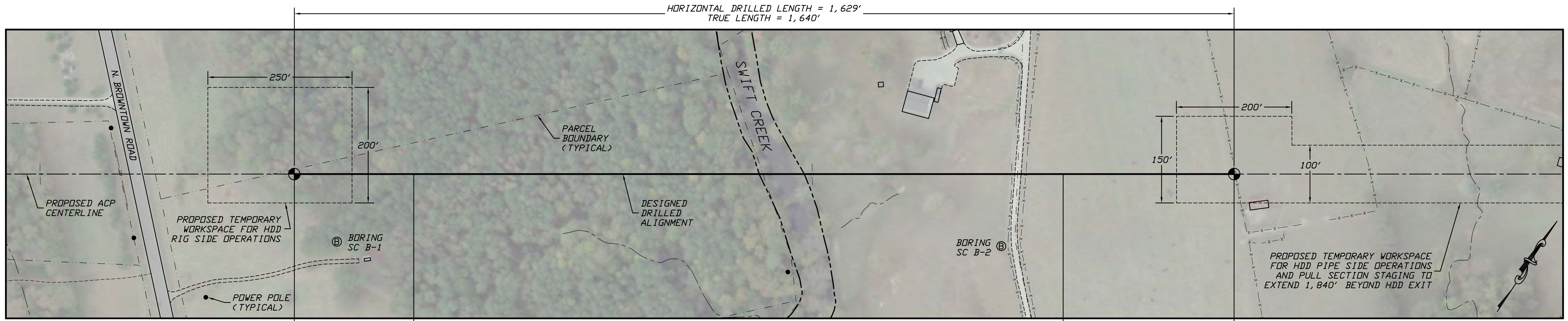
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
FISHING CREEK CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 9/26/2016 Revision: 0

Swift Creek

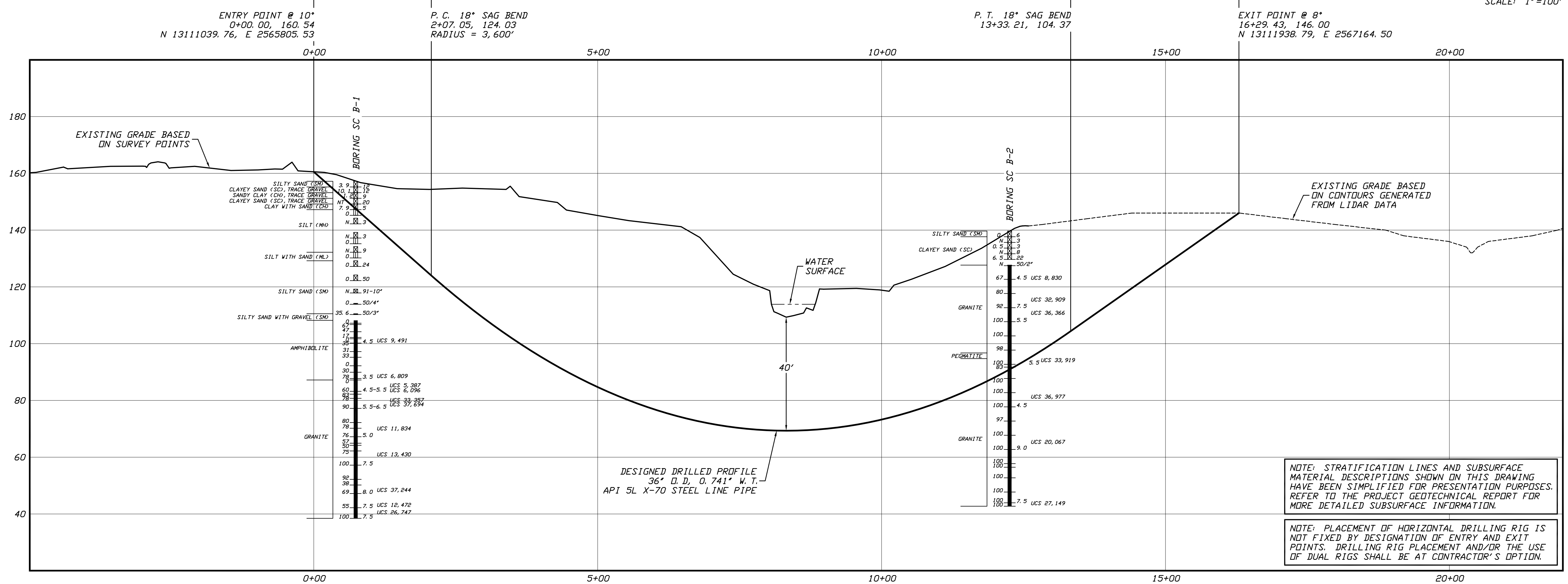
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=100'



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

SHELBY TUBE SAMPLE

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 6 — MOHS HARDNESS
ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RALEIGH, NORTH CAROLINA. REFER TO THE PROJECT GEOTECHNICAL REPORT DATED SEPTEMBER 2016 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 15 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
36-INCH PIPELINE CROSSING OF SWIFT CREEK
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: NASH COUNTY, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
ACM/KMN	10/07/16	KMN/LKB	JSP	SHOWN FOR D-SIZED PLOT	SWIFT CREEK	0

NO.	DATE	REVISION DESCRIPTION	BY	CHKD	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP2-041

Swift Creek R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	JSP
Crossing :	36" Swift Creek Crossing	Date :	10/10/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 15' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

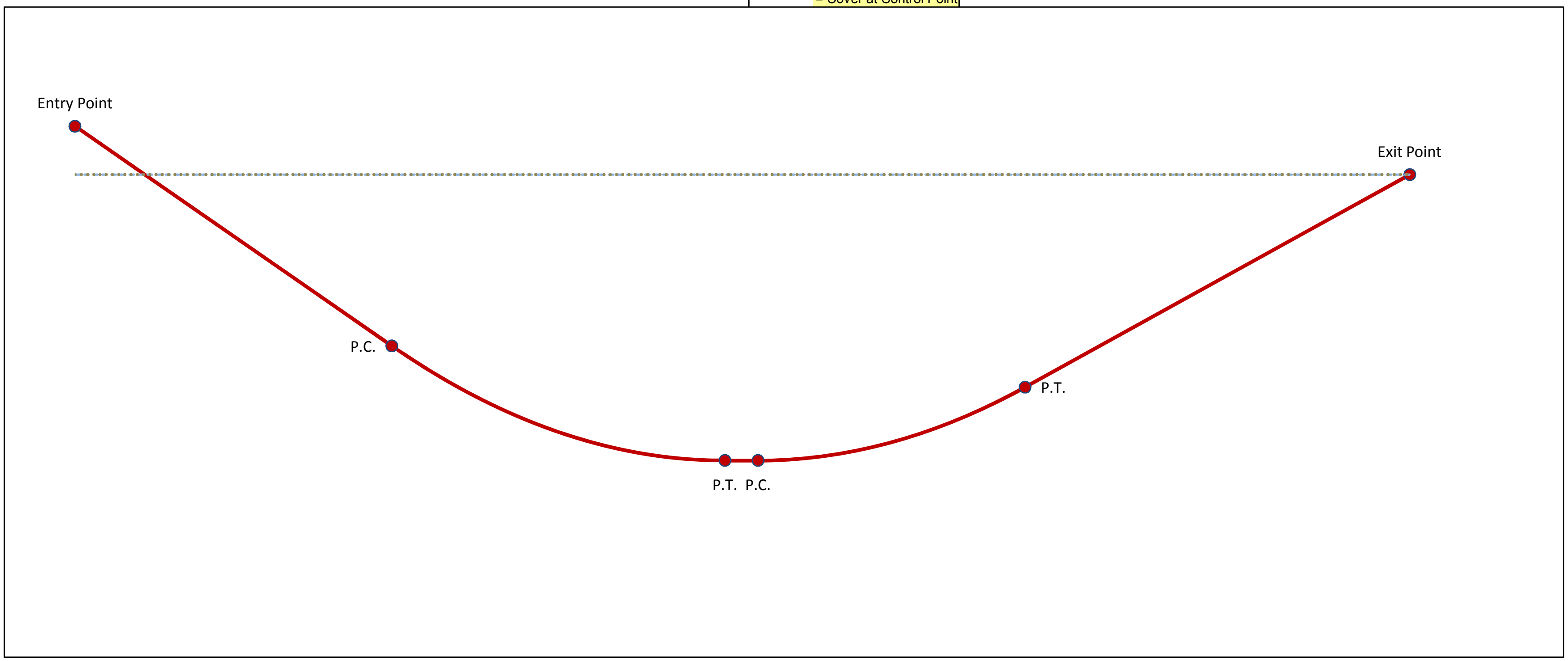
Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Swift Creek R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	160.66	10.00				82,857
Entry Tangent						402.36		
Entry Sag Bend	PC	386.24	90.79					59,755
	PI	593.03	54.33	10.00	2400	418.88	49,487	
	PT	803.00	54.33				0	39,219
Bottom Tangent				0.00		41.25		
Exit Sag Bend	PC	844.25	54.33					37,200
	PI	1012.07	54.33	8.00	2400	335.10	28,764	
	PT	1178.26	77.69				0	20,328
Exit Tangent						485.89		
Exit Point		1659.43	145.31	8.00	Above Ground Load			0
Drilling Mud			145.31	(Graph = ········)				
Ballast			145.31	(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	485.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	7,228	lb	
Fluidic Drag = 12 π D L C_d =	16,486	lb	
Axial Segment Weight = W_e L sinθ =	-3,386	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**20,328**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	28,764	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E I) / T]^{1/2}$ =	3,586	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.3E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	93.59	
$U = (12 L) / j$ =	1.12		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	11,122	lb
Bending Frictional Drag = 2 μ N =	6,673	lb			
Fluidic Drag = 12 π D L C_d =	11,370	lb			
Axial Segment Weight = W_e L sinθ =	-1,170	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**16,872**	**lb**			
Total Pulling Load =	**37,200**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	41.2	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = W_e L μ =	620	lb
Fluidic Drag = 12 π D L C_d =	1,400	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**2,019**	**lb**
Total Pulling Load =	**39,219**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 49,487 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = 50.1 lb/ft

$h = R [1 - \cos(\alpha/2)]$ = 9.13 ft

$j = [(E I) / T]^{1/2}$ = 2,734

$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 8.3E+05

$X = (3 L) - [(j / 2) \tanh(U/2)]$ = 264.81

$U = (12 L) / j$ = 1.84

$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ = 7,492 lb

Bending Frictional Drag = $2 \mu N$ = 4,495 lb

Fluidic Drag = $12 \pi D L C_d$ = 14,212 lb

Axial Segment Weight = $W_e L \sin\theta$ = 1,828 lb

Pulling Load on Entry Sag Bend = 20,536 lb
Total Pulling Load = 59,755 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 402.4 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = 50.1 lb/ft

Frictional Drag = $W_e L \mu \cos\theta$ = 5,952 lb

Fluidic Drag = $12 \pi D L C_d$ = 13,652 lb

Axial Segment Weight = $W_e L \sin\theta$ = 3,498 lb

Pulling Load on Entry Tangent = 23,102 lb
Total Pulling Load = 82,857 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	1,009	ok	0	ok	0	ok	0.02	ok	0.00	ok
	728	ok	0	ok	252	ok	0.01	ok	0.00	ok
PC										
	728	ok	18,125	ok	252	ok	0.41	ok	0.12	ok
	478	ok	18,125	ok	420	ok	0.40	ok	0.12	ok
PT										
	478	ok	0	ok	420	ok	0.01	ok	0.00	ok
	453	ok	0	ok	420	ok	0.01	ok	0.00	ok
PC										
	453	ok	18,125	ok	420	ok	0.40	ok	0.12	ok
	248	ok	18,125	ok	312	ok	0.40	ok	0.12	ok
PT										
	248	ok	0	ok	312	ok	0.00	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Swift Creek R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	JSP
Crossing :	36" Swift Creek Crossing	Date :	10/10/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 15' deeper than design with a 2,400' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

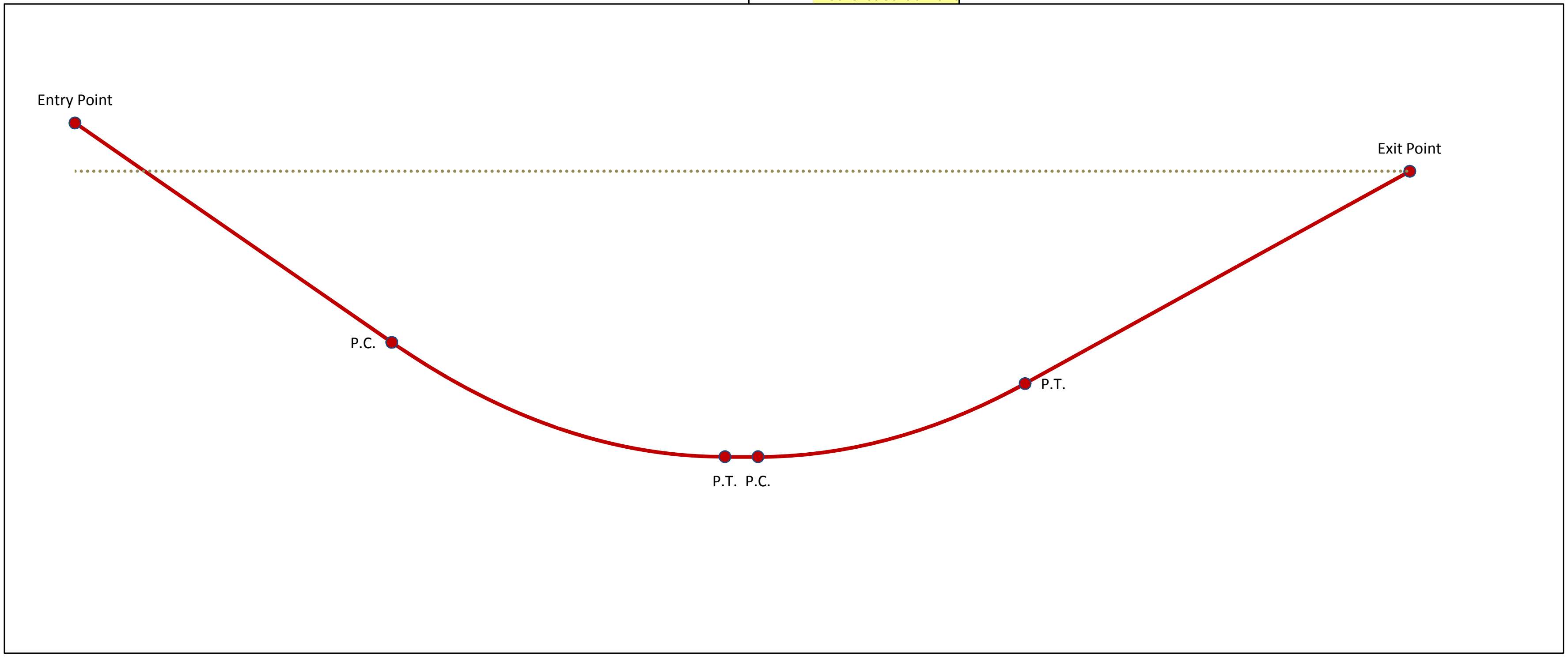
HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Swift Creek R0 Installation Stress Analysis (worst-case).xlsm
J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	160.66	10.00				289,047
Entry Tangent						402.36		
Entry Sag Bend	PC	386.24	90.79					257,977
	PI	593.03	54.33	10.00	2400	418.88	218,780	
	PT	803.00	54.33				0	179,583
Bottom Tangent				0.00		41.25		
Exit Sag Bend	PC	844.25	54.33					173,785
	PI	1012.07	54.33	8.00	2400	335.10	132,807	
	PT	1178.26	77.69				0	91,830
Exit Tangent						485.89		
Exit Point		1659.43	145.31	8.00	Above Ground Load			0
Drilling Mud			145.31	(Graph = ········)				
Ballast				(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
			= Cover at Control Point



Step 2, Drilled Path Input

Swift Creek R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	485.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	51,308	lb
Fluidic Drag = 12 π D L C_d =	16,486	lb
Axial Segment Weight = W_e L sinθ =	24,036	lb
Pulling Load on Exit Tangent =	**91,830**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	132,807	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

h = R [1 - cos(α/2)] =	5.85	ft	$j = [(E I) / T]^{1/2}$ =	1,669	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	7.7E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	308.46	
U = (12 L) / j =	2.41		N = [(T h) - W_e cosθ (Y/144)] / (X / 12) =	103,794	lb
Bending Frictional Drag = 2 μ N =	62,276	lb			
Fluidic Drag = 12 π D L C_d =	11,370	lb			
Axial Segment Weight = W_e L sinθ =	8,309	lb			
Pulling Load on Exit Sag Bend =	**81,955**	**lb**			
Total Pulling Load =	**173,785**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	41.2	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = W_e L μ =	4,398	lb
Fluidic Drag = 12 π D L C_d =	1,400	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**5,798**	**lb**
Total Pulling Load =	**179,583**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 218,780 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ = 9.13 ft

$j = [(E\ I) / T]^{1/2}$ = 1,300

$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ = 1.9E+06

$X = (3\ L) - [\ (j\ /\ 2)\ \tanh(U/2)\ ]$ = 633.17

$U = (12\ L) / j$ = 3.87

$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ = 128,598 lb

Bending Frictional Drag = $2\ \mu\ N$ = 77,159 lb

Fluidic Drag = $12\ \pi\ D\ L\ C_d$ = 14,212 lb

Axial Segment Weight = $W_e\ L \sin\theta$ = -12,976 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 78,394 lb
Total Pulling Load = 257,977 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 402.4 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

Frictional Drag = $W_e\ L\ \mu \cos\theta$ = 42,252 lb

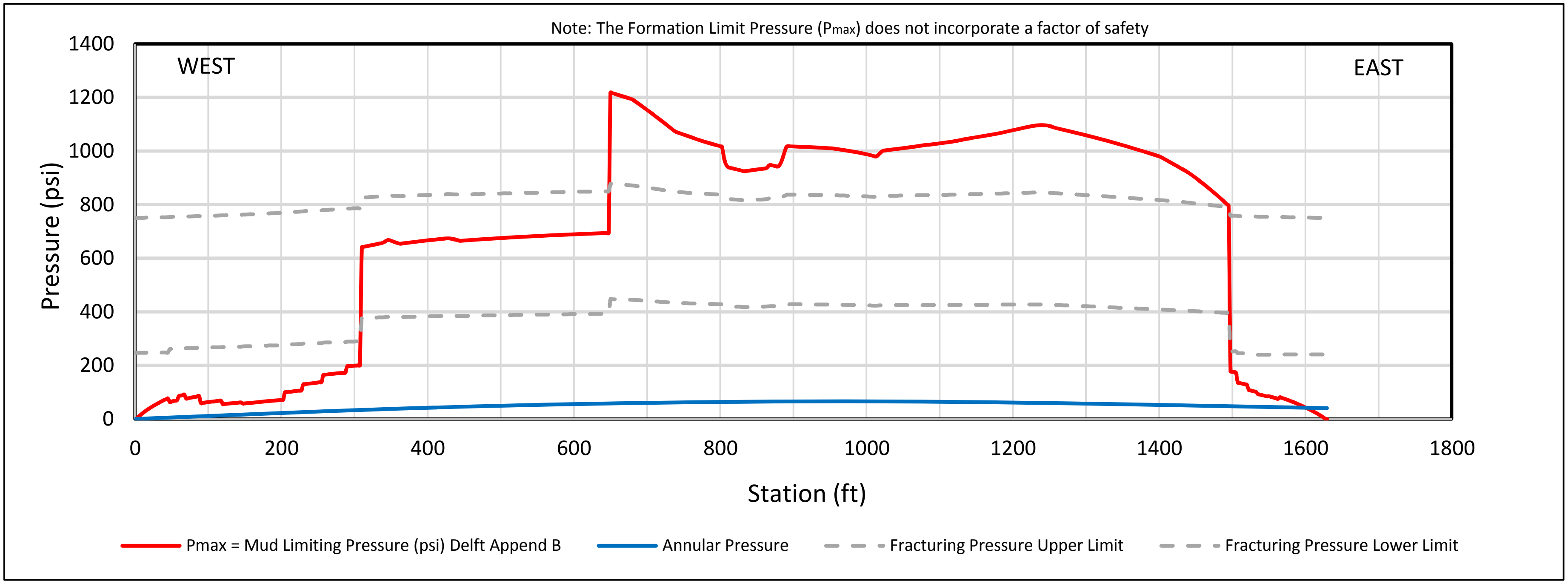
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ = 13,652 lb

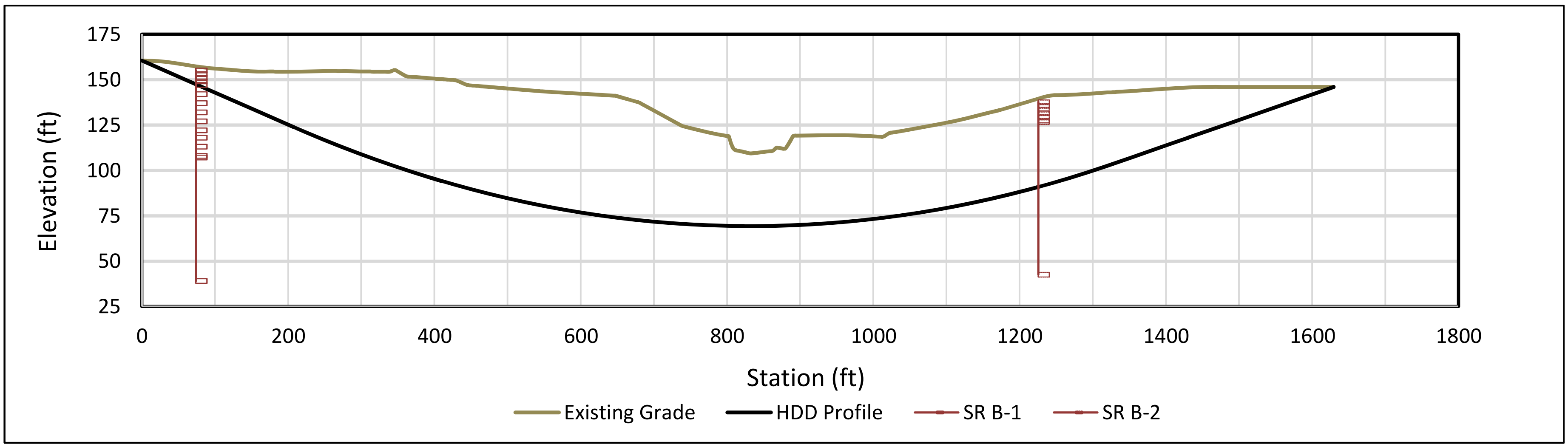
Axial Segment Weight = $W_e\ L \sin\theta$ = -24,834 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 31,070 lb
Total Pulling Load = 289,047 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,522	ok	0	ok	0	ok	0.06	ok	0.00	ok
	3,143	ok	0	ok	826	ok	0.05	ok	0.02	ok
PC										
	3,143	ok	18,125	ok	826	ok	0.45	ok	0.18	ok
	2,188	ok	18,125	ok	1378	ok	0.43	ok	0.20	ok
PT										
	2,188	ok	0	ok	1378	ok	0.03	ok	0.04	ok
	2,117	ok	0	ok	1378	ok	0.03	ok	0.04	ok
PC										
	2,117	ok	18,125	ok	1378	ok	0.43	ok	0.20	ok
	1,119	ok	18,125	ok	1024	ok	0.41	ok	0.16	ok
PT										
	1,119	ok	0	ok	1024	ok	0.02	ok	0.02	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





HYDROFRACTURE EVALUATION

FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE

SWIFT CREEK CROSSING

BY HORIZONTAL DIRECTIONAL DRILLING

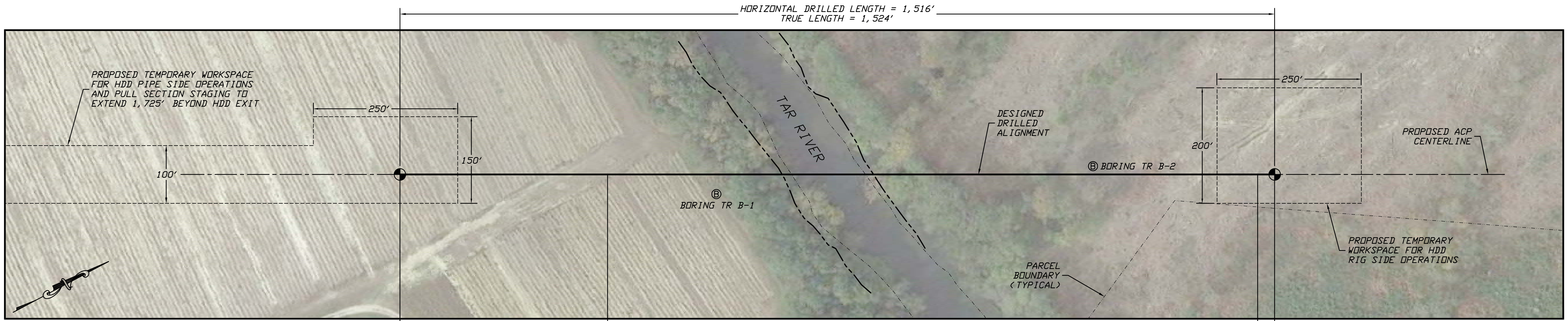
J.D.Hair&Associates, Inc.

Date: 9/23/2016 Revision: 0

Tar River

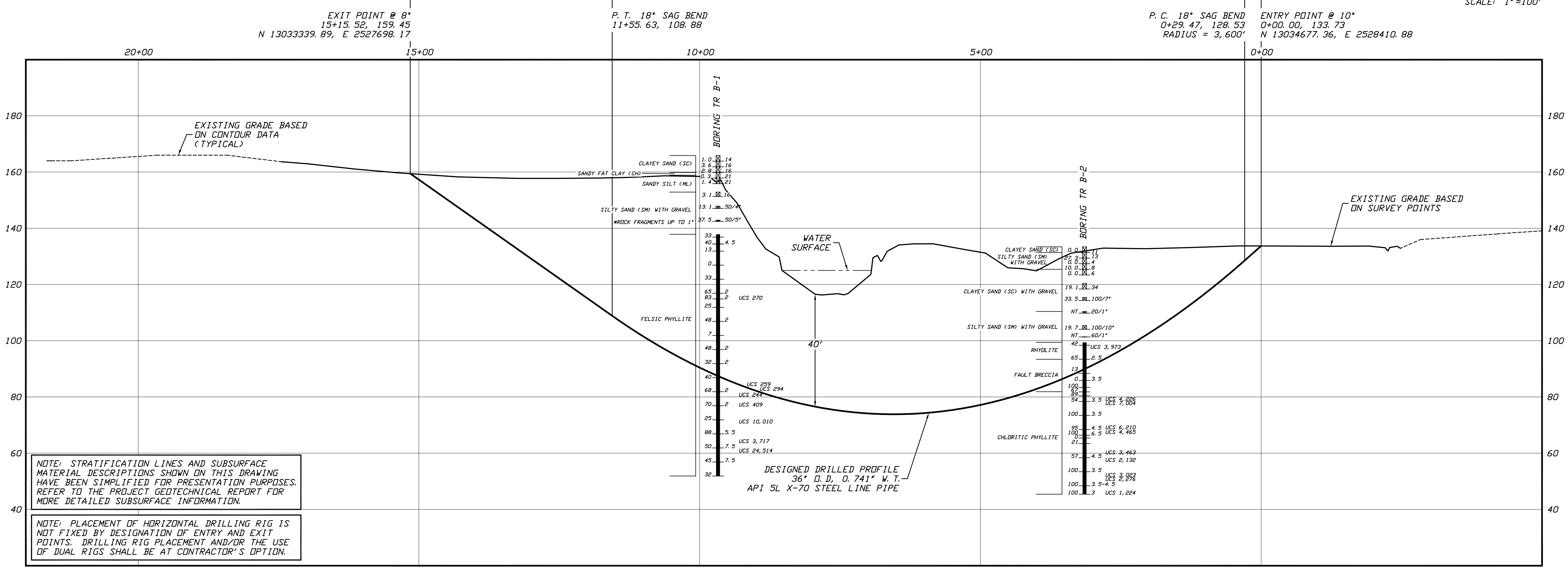
<u>Supporting Information</u>

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=100'



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

Ⓑ BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 6 — MOHS HARDNESS
— ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RALEIGH, NORTH CAROLINA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT DATED SEPTEMBER 2016 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 20 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE 36-INCH PIPELINE CROSSING OF THE TAR RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: NASH COUNTY, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
ACM/LKB	10/06/16	KMN	JSP	SHOWN FOR D-SIZED PLOT	TAR RIVER	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP2-060

Tar River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Tar River Crossing	Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 17' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

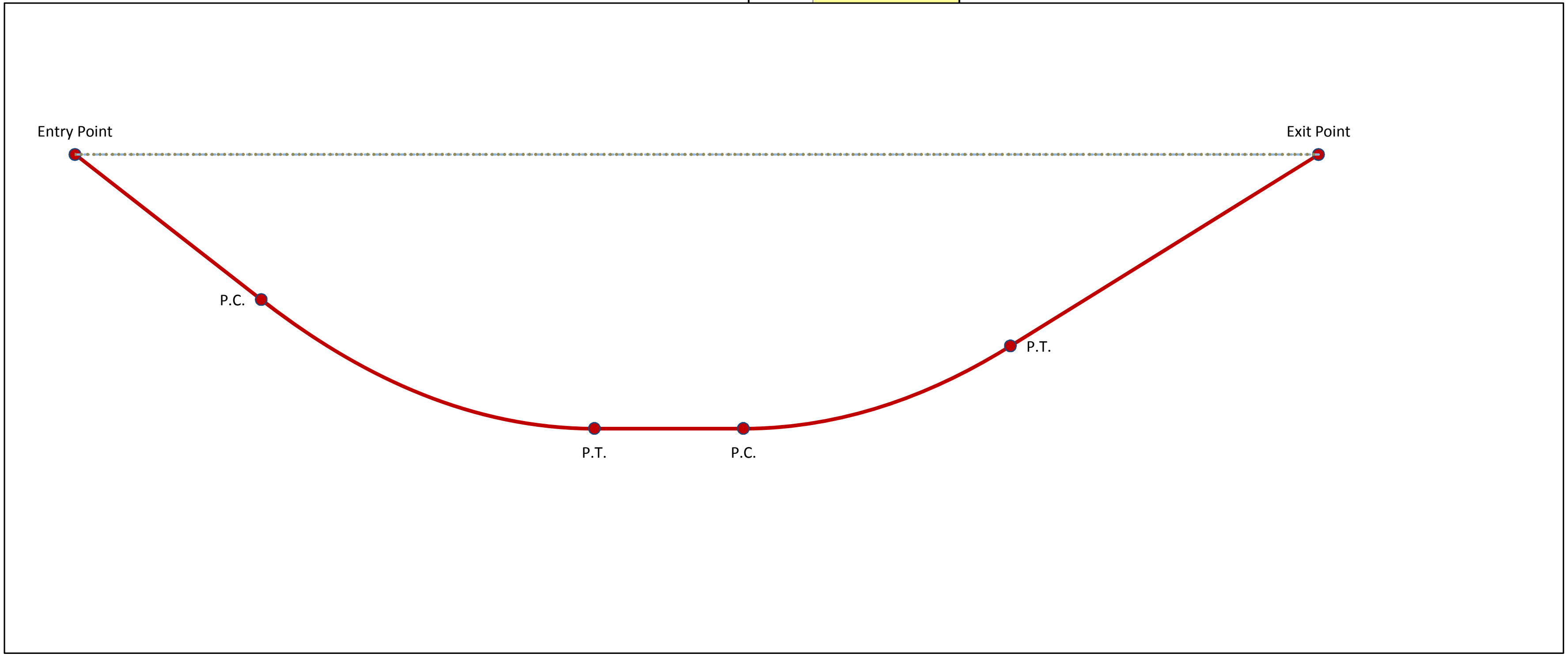
HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Tar River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm
J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	133.72	10.00				76,371
Entry Tangent						236.50		
Entry Sag Bend	PC	222.91	92.65					62,792
	PI	429.69	56.19	10.00	2400	418.88	52,431	
	PT	639.67	56.19				0	42,070
Bottom Tangent				0.00		186.37		
Exit Sag Bend	PC	826.04	56.19					32,947
	PI	993.87	56.19	8.00	2400	335.10	24,616	
	PT	1160.06	79.55				0	16,285
Exit Tangent						389.25		
Exit Point		1545.52	133.72	8.00			Above Ground Load	0
Drilling Mud			133.72	(Graph = ·········)				
Ballast			133.72	(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

Tar River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	389.3	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	5,790	lb	
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	13,207	lb	
Axial Segment Weight = $W_e\ L \sin\theta$ =	-2,713	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**16,285**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	24,616	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R\ [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	3,876	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	2.0E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	81.40	
$U = (12\ L) / j$ =	1.04		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	10,772	lb
Bending Frictional Drag = $2\ \mu\ N$ =	6,463	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	11,370	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	-1,170	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**16,663**	**lb**			
Total Pulling Load =	**32,947**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	186.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	2,800	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	6,324	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**9,123**	**lb**
Total Pulling Load =	**42,070**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 52,431 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = 50.1 lb/ft

$h = R [1 - \cos(\alpha/2)]$ = 9.13 ft

$j = [(E I) / T]^{1/2}$ = 2,656

$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 8.6E+05

$X = (3 L) - [(j / 2) \tanh(U/2)]$ = 276.44

$U = (12 L) / j$ = 1.89

$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ = 7,802 lb

Bending Frictional Drag = $2 \mu N$ = 4,681 lb

Fluidic Drag = $12 \pi D L C_d$ = 14,212 lb

Axial Segment Weight = $W_e L \sin\theta$ = 1,828 lb

Pulling Load on Entry Sag Bend = 20,722 lb
Total Pulling Load = 62,792 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 236.5 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = 50.1 lb/ft

Frictional Drag = $W_e L \mu \cos\theta$ = 3,499 lb

Fluidic Drag = $12 \pi D L C_d$ = 8,024 lb

Axial Segment Weight = $W_e L \sin\theta$ = 2,056 lb

Pulling Load on Entry Tangent = 13,579 lb
Total Pulling Load = 76,371 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	930	ok	0	ok	0	ok	0.01	ok	0.00	ok
	765	ok	0	ok	190	ok	0.01	ok	0.00	ok
PC										
	765	ok	18,125	ok	190	ok	0.41	ok	0.12	ok
	513	ok	18,125	ok	358	ok	0.41	ok	0.12	ok
PT										
	513	ok	0	ok	358	ok	0.01	ok	0.00	ok
	401	ok	0	ok	358	ok	0.01	ok	0.00	ok
PC										
	401	ok	18,125	ok	358	ok	0.40	ok	0.12	ok
	198	ok	18,125	ok	250	ok	0.40	ok	0.11	ok
PT										
	198	ok	0	ok	250	ok	0.00	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Tar River R0 Installation Stress Analysis (worst-case).xlsm

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Project Information				
Project :	Dominion Atlantic Coast Pipeline	User :	ACM	
Crossing :	36" Tar River Crossing	Date :	9/29/2016	
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 18' deeper than design with a 2,400' radius) with 12 ppg mud and no BC			
Line Pipe Properties				
Pipe Outside Diameter =	36.000	in		
Wall Thickness =	0.741	in		
Specified Minimum Yield Strength =	70,000	psi		
Young's Modulus =	2.9E+07	psi		
Moment of Inertia =	12755.22	in^4		
Pipe Face Surface Area =	82.08	in^2		
Diameter to Wall Thickness Ratio, D/t =	49			
Poisson's Ratio =	0.3			
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F		
Pipe Weight in Air =	279.04	lb/ft		
Pipe Interior Volume =	6.50	ft^3/ft		
Pipe Exterior Volume =	7.07	ft^3/ft		
HDD Installation Properties				
Drilling Mud Density =	12.0	ppg		
=	89.8	lb/ft^3		
Ballast Density =	62.4	lb/ft^3		
Coefficient of Soil Friction =	0.30			
Fluid Drag Coefficient =	0.025	psi		
Ballast Weight =	405.51	lb/ft		
Displaced Mud Weight =	634.48	lb/ft		
Installation Stress Limits				
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi		
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No	
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No	
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes	
Allowable Bending Stress, F_b =	45,639	psi		
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi		
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes	
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No	
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No	
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No	
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi		
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi		

Tar River R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	133.72	10.00				277,573
Entry Tangent						236.50		
Entry Sag Bend	PC	222.91	92.65					259,310
	PI	429.69	56.19	10.00	2400	418.88	220,076	
	PT	639.67	56.19				0	180,842
Bottom Tangent			.	0.00		186.37		
Exit Sag Bend	PC	826.04	56.19					154,645
	PI	993.87	56.19	8.00	2400	335.10	114,105	
	PT	1160.06	79.55				0	73,565
Exit Tangent						389.25		
Exit Point		1545.52	133.72	8.00	Above Ground Load			0
Drilling Mud			133.72	(Graph = ········)				
Ballast				(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
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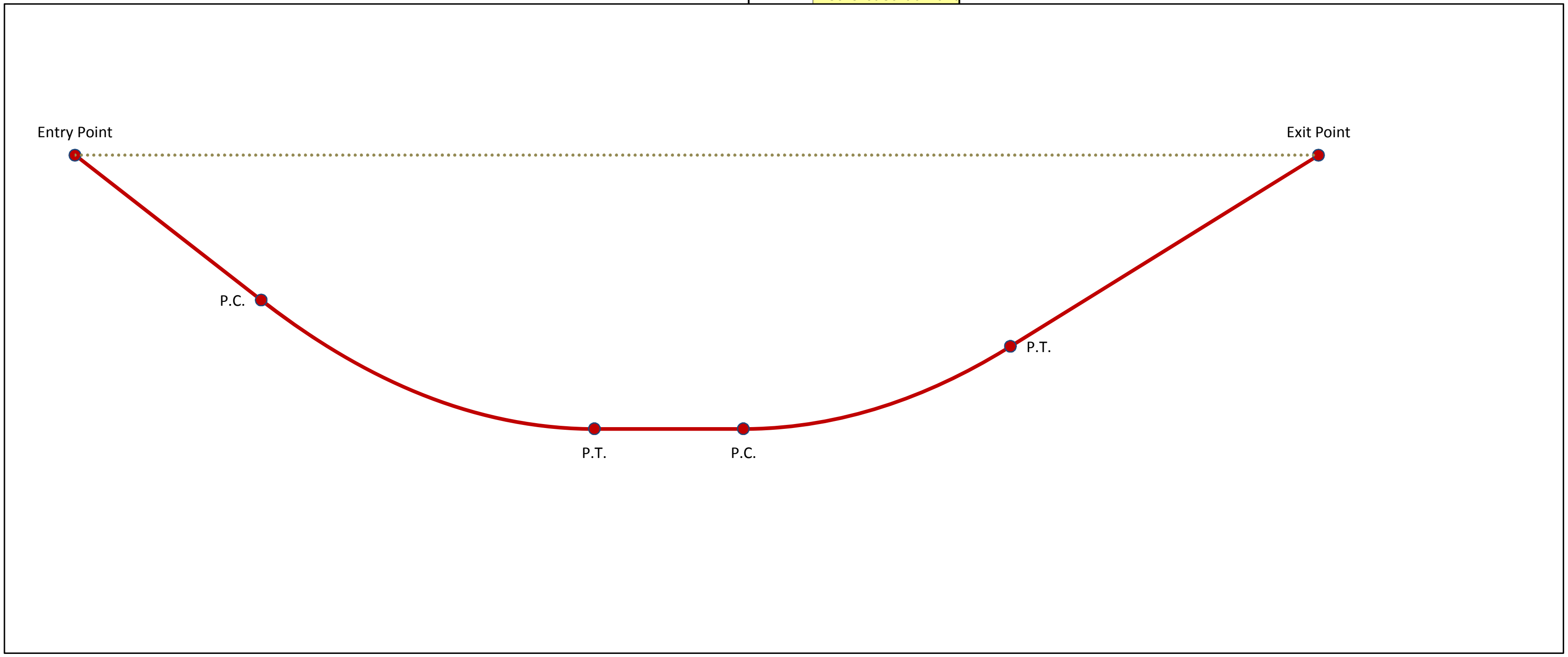
9			
10			
1			Control Point
		= Cover at Control Point	



Tar River R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	389.3	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	8.0	º			

Frictional Drag = W_e L μ cosθ =	41,103	lb
Fluidic Drag = 12 π D L C_d =	13,207	lb
Axial Segment Weight = W_e L sinθ =	19,255	lb
Pulling Load on Exit Tangent =	**73,565**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	114,105	lb
Segment Angle with Horizontal, θ =	-8.0	º	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	º	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

h = R [1 - cos(α/2)] =	5.85	ft	$j = [(E I) / T]^{1/2}$ =	1,800	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	7.0E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	279.33	
U = (12 L) / j =	2.23		N = [(T h) - W_e cosθ (Y/144)] / (X / 12) =	102,336	lb
Bending Frictional Drag = 2 μ N =	61,402	lb			
Fluidic Drag = 12 π D L C_d =	11,370	lb			
Axial Segment Weight = W_e L sinθ =	8,309	lb			
Pulling Load on Exit Sag Bend =	**81,080**	**lb**			
Total Pulling Load =	**154,645**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	186.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = W_e L μ =	19,873	lb
Fluidic Drag = 12 π D L C_d =	6,324	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**26,197**	**lb**
Total Pulling Load =	**180,842**	**lb**

Tar River R0 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft

Segment Angle with Horizontal, θ = 10.0 °

Deflection Angle, α = 5.0 °

Average Tension, T = 220,076 lb

Radius of Curvature, R = 2,400 ft

Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

h = R [1 - cos(α/2)] = 9.13 ft

$j = [(E\ I) / T]^{1/2}$ = 1,296

$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ = 2.0E+06

X = (3 L) - [(j / 2) tanh(U/2)] = 634.72

U = (12 L) / j = 3.88

N = [(T h) - W_e cosθ (Y/144)] / (X / 12) = 128,719 lb

Bending Frictional Drag = 2 μ N = 77,232 lb

Fluidic Drag = 12 π D L C_d = 14,212 lb

Axial Segment Weight = W_e L sinθ = -12,976 lb

Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 78,468 lb

Total Pulling Load = 259,310 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 236.5 ft

Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

Frictional Drag = W_e L μ cosθ = 24,836 lb

Fluidic Drag = 12 π D L C_d = 8,024 lb

Axial Segment Weight = W_e L sinθ = -14,597 lb

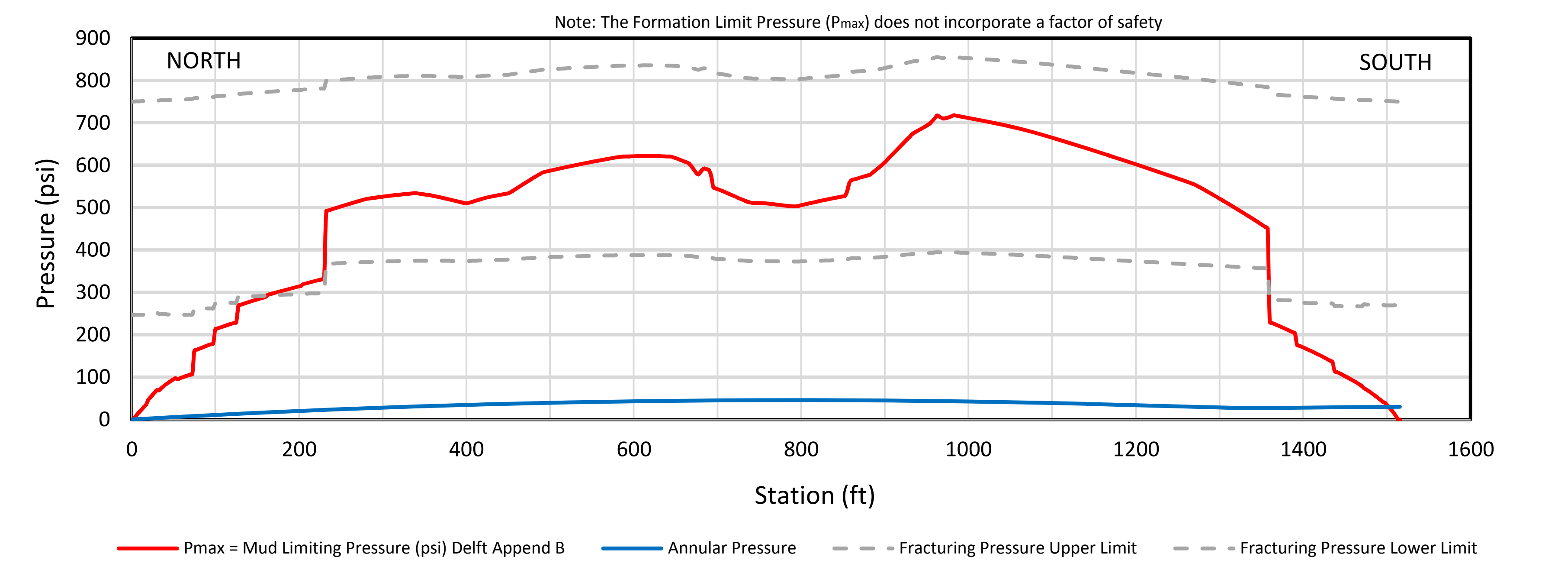
Negative value indicates axial weight applied in direction of installation

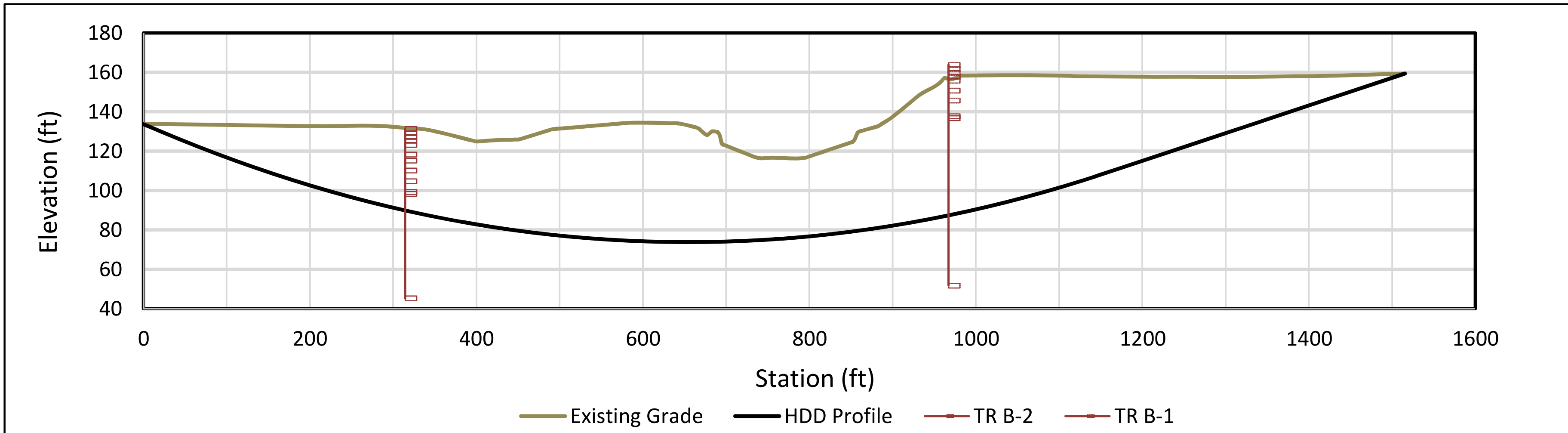
Pulling Load on Entry Tangent = 18,263 lb

Total Pulling Load = 277,573 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,382	ok	0	ok	0	ok	0.05	ok	0.00	ok
	3,159	ok	0	ok	622	ok	0.05	ok	0.01	ok
PC										
	3,159	ok	18,125	ok	622	ok	0.45	ok	0.17	ok
	2,203	ok	18,125	ok	1174	ok	0.43	ok	0.19	ok
PT										
	2,203	ok	0	ok	1174	ok	0.03	ok	0.03	ok
	1,884	ok	0	ok	1174	ok	0.03	ok	0.03	ok
PC										
	1,884	ok	18,125	ok	1174	ok	0.43	ok	0.18	ok
	896	ok	18,125	ok	820	ok	0.41	ok	0.15	ok
PT										
	896	ok	0	ok	820	ok	0.01	ok	0.01	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

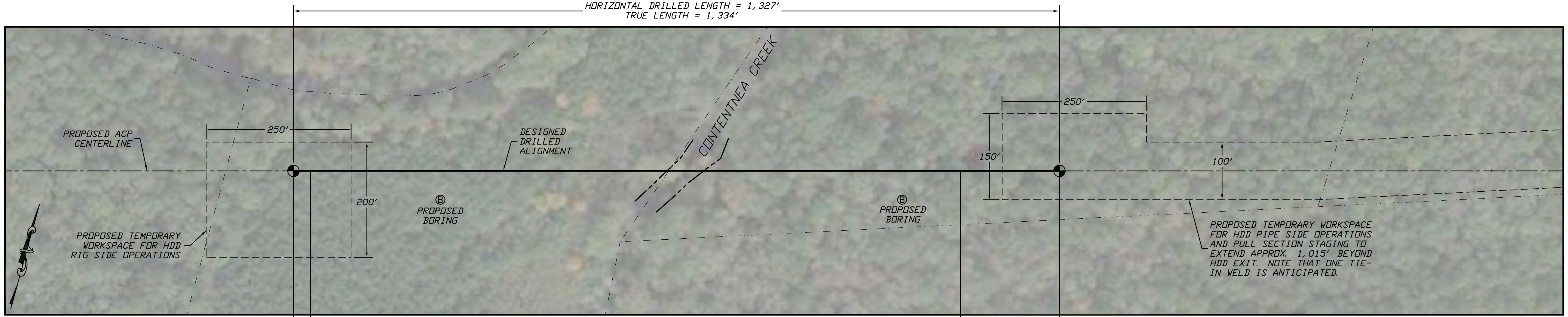
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
TAR RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

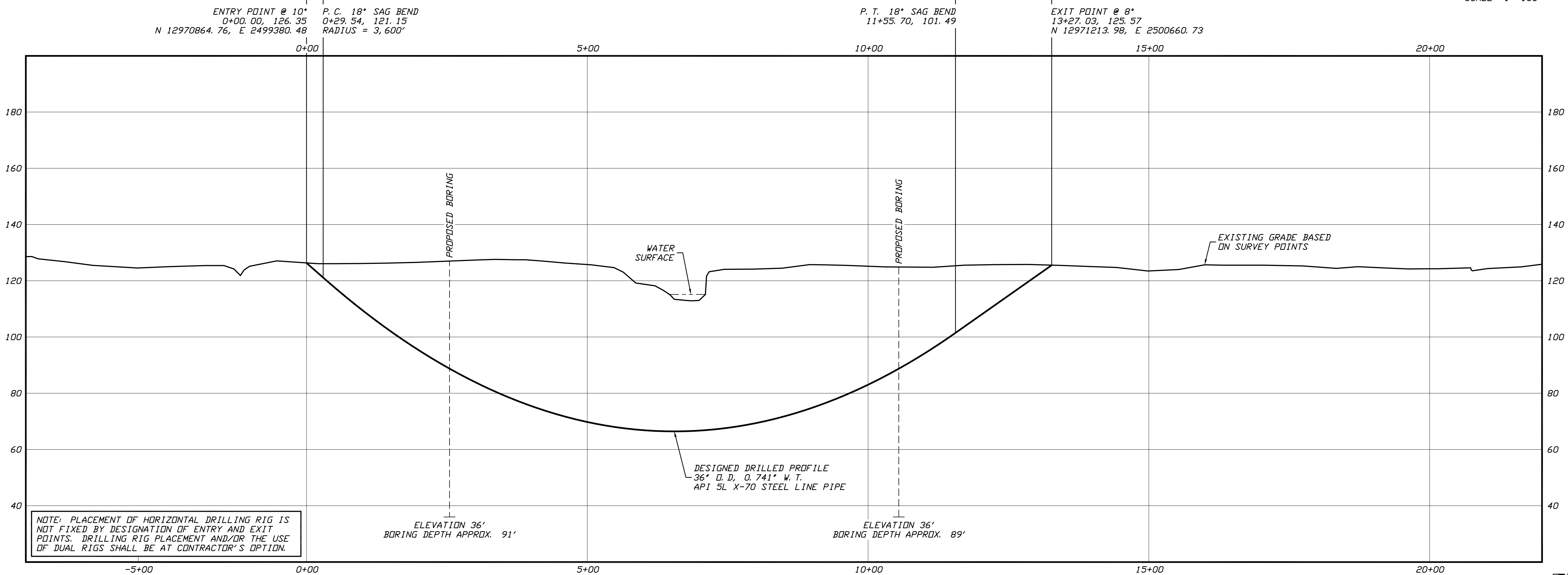
Date: 9/23/2016
Revision: 0

Contentnea Creek

Supporting Information

- Preliminary plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)





PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

200 100 50 0

GENERAL LEGEND

⊕ DRILLED PATH ENTRY/EXIT POINT

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 15 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

PRELIMINARY

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
36-INCH PIPELINE CROSSING OF CONTENTNEA CREEK BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: WILSON COUNTY, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
ACM	07/25/16	KMN	JSP	SHOWN FOR D-SIZED PLOT	CONTENTNEA CREEK	P2

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.
P2	09/20/16	MODIFY TEMP. WORKSPACE AS DIRECTED BY DOMINION	JSP	KMN	JSP
P1	08/10/16	UPDATE DESIGN BASED ON SURVEY DATA FROM GAI	KMN	ACM	JSP

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO. Dominion\1508

MILE POST AP2-074

Contentnea Creek P2 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Contentnea Creek Crossing	Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 18' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Contentnea Creek P2 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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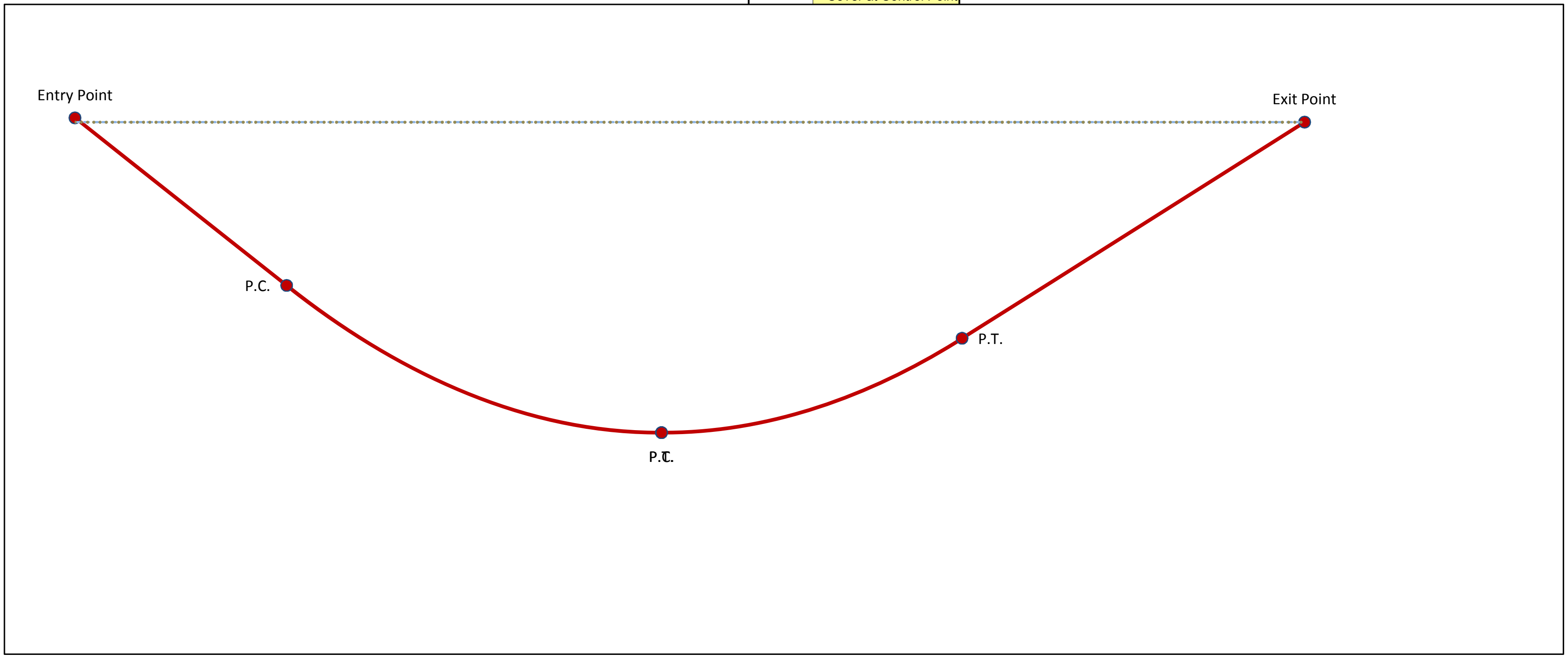
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		0.00	126.35	10.00				66,579
Entry Tangent						238.75		
Entry Sag Bend	PC	235.12	84.89					52,871
	PI	441.91	48.43	10.00	2400	418.88	42,814	
	PT	651.88	48.43				0	32,757
Bottom Tangent				0.00		0.37		
Exit Sag Bend	PC	652.25	48.43					32,739
	PI	820.07	48.43	8.00	2400	335.10	24,412	
	PT	986.26	71.79				0	16,086
Exit Tangent						384.51		
Exit Point		1367.03	125.30	8.00	Above Ground Load			0
Drilling Mud			125.30	(Graph = ········)				
Ballast			125.30	(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Contentnea Creek P2 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	384.5	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	5,720	lb	
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	13,046	lb	
Axial Segment Weight = $W_e\ L \sin\theta$ =	-2,679	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**16,086**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	24,412	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R\ [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	3,893	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	2.0E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	80.79	
$U = (12\ L) / j$ =	1.03		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	10,755	lb
Bending Frictional Drag = $2\ \mu\ N$ =	6,453	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	11,370	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	-1,170	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**16,652**	**lb**			
Total Pulling Load =	**32,739**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	6	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	12	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**18**	**lb**
Total Pulling Load =	**32,757**	**lb**

Contentnea Creek P2 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	42,814	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E\,I) / T]^{1/2}$ =	2,939	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	7.4E+05		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	237.13	
$U = (12\,L) / j$ =	1.71		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	6,790	lb
Bending Frictional Drag = $2\,\mu\,N$ =	4,074	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	14,212	lb			
Axial Segment Weight = $W_e\,L\sin\theta$ =	1,828	lb			
Pulling Load on Entry Sag Bend =	**20,114**	**lb**			
Total Pulling Load =	**52,871**	**lb**			

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L =	238.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu\cos\theta$ =	3,532	lb
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	8,101	lb
Axial Segment Weight = $W_e\,L\sin\theta$ =	2,076	lb
Pulling Load on Entry Tangent =	**13,708**	**lb**
Total Pulling Load =	**66,579**	**lb**

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	811	ok	0	ok	0	ok	0.01	ok	0.00	ok
	644	ok	0	ok	187	ok	0.01	ok	0.00	ok
PC										
	644	ok	18,125	ok	187	ok	0.41	ok	0.12	ok
	399	ok	18,125	ok	355	ok	0.40	ok	0.12	ok
PT										
	399	ok	0	ok	355	ok	0.01	ok	0.00	ok
	399	ok	0	ok	355	ok	0.01	ok	0.00	ok
PC										
	399	ok	18,125	ok	355	ok	0.40	ok	0.12	ok
	196	ok	18,125	ok	247	ok	0.40	ok	0.11	ok
PT										
	196	ok	0	ok	247	ok	0.00	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Contentnea Creek P2 Installation Stress Analysis (worst-case).xlsm

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Project Information				
Project :	Dominion Atlantic Coast Pipeline		User :	ACM
Crossing :	36" Contentnea Creek Crossing		Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 18' deeper than design with a 2,400' radius) with 12 ppg mud and no BC			

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

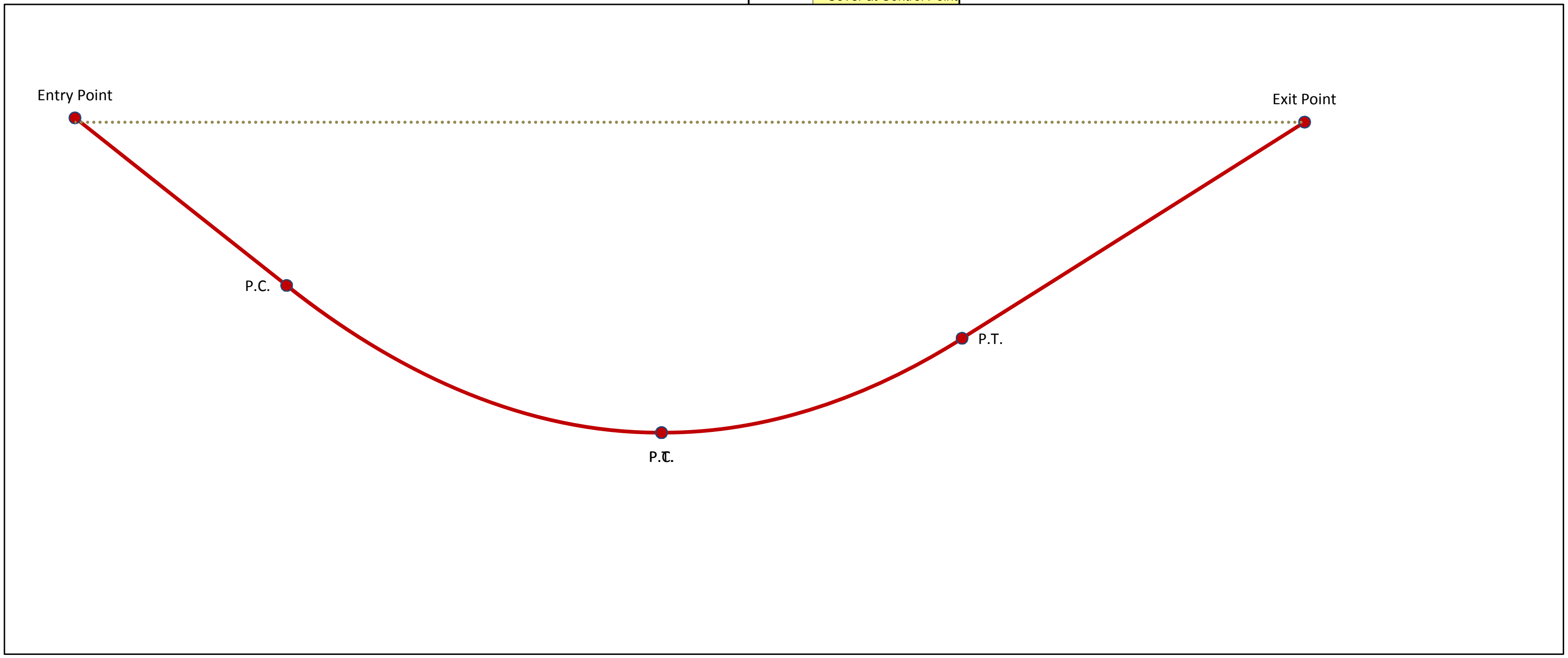
HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, F_{hc}/1.5 =	7,208	psi	

Contentnea Creek P2 Installation Stress Analysis (worst-case).xlsm
J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		0.00	126.35	10.00				249,090
Entry Tangent						238.75		
Entry Sag Bend	PC	235.12	84.89					230,654
	PI	441.91	48.43	10.00	2400	418.88	192,206	
	PT	651.88	48.43				0	153,758
Bottom Tangent				0.00		0.37		
Exit Sag Bend	PC	652.25	48.43					153,706
	PI	820.07	48.43	8.00	2400	335.10	113,188	
	PT	986.26	71.79				0	72,669
Exit Tangent						384.51		
Exit Point		1367.03	125.30	8.00	Above Ground Load			0
Drilling Mud			125.30	(Graph = ········)				
Ballast				(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

Contentnea Creek P2 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	384.5	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	40,602	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	13,046	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	19,021	lb
Pulling Load on Exit Tangent =	**72,669**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	113,188	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

$h = R\ [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	1,808	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	6.9E+05		$X = (3\ L) - [\ (j\ /\ 2) \tanh(U/2)\ ]$ =	277.82	
$U = (12\ L) / j$ =	2.22		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	102,264	lb
Bending Frictional Drag = $2\ \mu\ N$ =	61,359	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	11,370	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	8,309	lb			
Pulling Load on Exit Sag Bend =	**81,037**	**lb**			
Total Pulling Load =	**153,706**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	39	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	12	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**52**	**lb**
Total Pulling Load =	**153,758**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 192,206 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

h = R [1 - cos(α/2)] = 9.13 ft

$j = [(E\ I) / T]^{1/2}$ = 1,387

$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ = 1.8E+06

X = (3 L) - [(j / 2) tanh(U/2)] = 599.07

U = (12 L) / j = 3.62

N = [(T h) - W_e cosθ (Y/144)] / (X / 12) = 126,100 lb

Bending Frictional Drag = 2 μ N = 75,660 lb

Fluidic Drag = 12 π D L C_d = 14,212 lb

Axial Segment Weight = W_e L sinθ = -12,976 lb

Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 76,896 lb
Total Pulling Load = 230,654 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 238.8 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

Frictional Drag = W_e L μ cosθ = 25,072 lb

Fluidic Drag = 12 π D L C_d = 8,101 lb

Axial Segment Weight = W_e L sinθ = -14,736 lb

Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 18,436 lb
Total Pulling Load = 249,090 lb

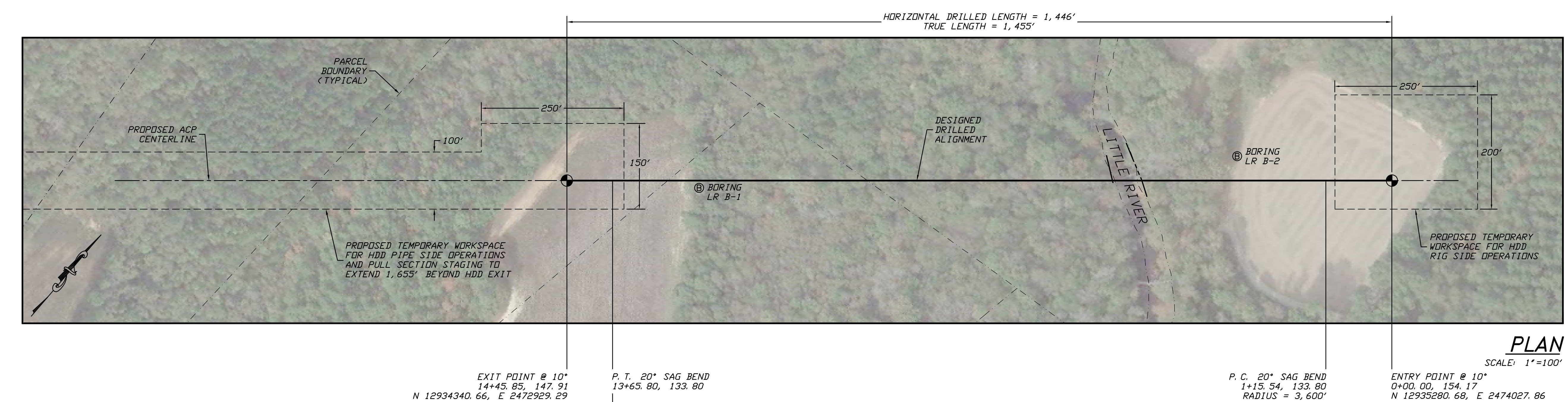
Summary of Calculated Stress vs. Allowable Stress

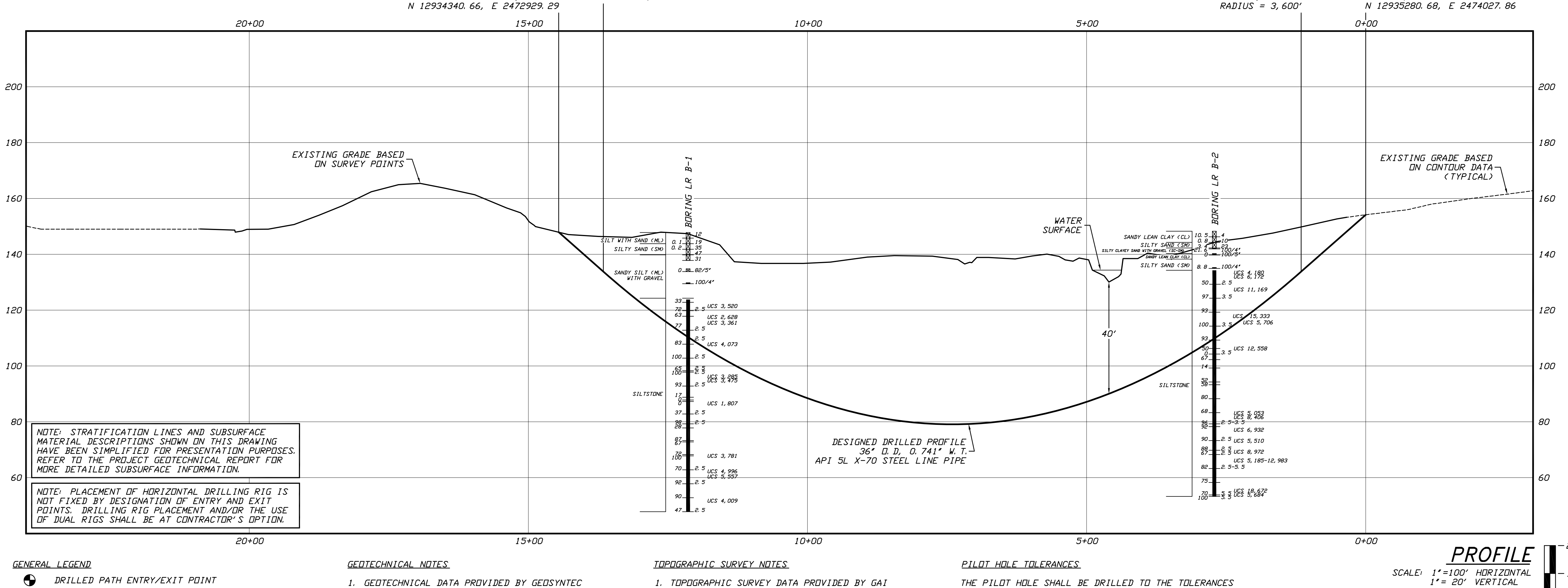
	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,035	ok	0	ok	0	ok	0.05	ok	0.00	ok
	2,810	ok	0	ok	612	ok	0.04	ok	0.01	ok
PC										
	2,810	ok	18,125	ok	612	ok	0.44	ok	0.16	ok
	1,873	ok	18,125	ok	1164	ok	0.43	ok	0.18	ok
PT										
	1,873	ok	0	ok	1164	ok	0.03	ok	0.03	ok
	1,873	ok	0	ok	1164	ok	0.03	ok	0.03	ok
PC										
	1,873	ok	18,125	ok	1164	ok	0.43	ok	0.18	ok
	885	ok	18,125	ok	810	ok	0.41	ok	0.15	ok
PT										
	885	ok	0	ok	810	ok	0.01	ok	0.01	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Little River

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)





GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 / 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES — PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

CORE BARREL SAMPLE

UCS 6,250 — UNCONFINED COMPRESSIVE STRENGTH (PSI)
53 / 6 — MOHS HARDNESS — ROCK QUALITY DESIGNATION (PERCENT)

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE DRAFT GEOTECHNICAL SITE INVESTIGATION REPORT DATED SEPTEMBER 2016 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 20 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
36-INCH PIPELINE CROSSING OF THE LITTLE RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: JOHNSTON COUNTY, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
ACM/LKB	09/29/16	JSP	JSP	SHOWN FOR D-SIZED PLOT	LITTLE RIVER	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP2-083

Little River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Little River Crossing	Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 22' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Little River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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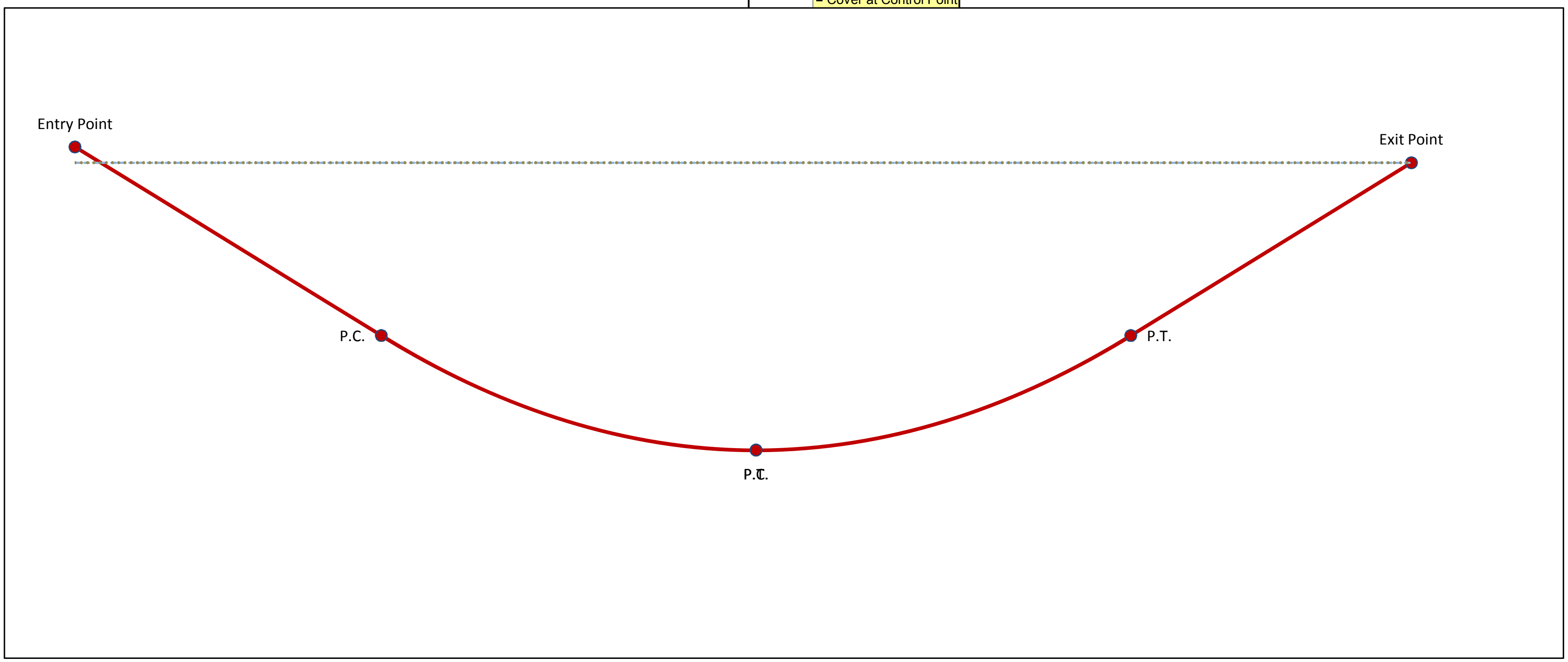
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	154.41	10.00				67,335
Entry Tangent						345.69		
Entry Sag Bend	PC	330.44	94.38					47,487
	PI	537.22	57.92	10.00	2400	418.88	37,595	
	PT	747.19	57.92				0	27,703
Bottom Tangent				0.00		0.04		
Exit Sag Bend	PC	747.24	57.92					27,701
	PI	957.21	57.92	10.00	2400	418.88	20,188	
	PT	1163.99	94.38				0	12,675
Exit Tangent						316.67		
Exit Point		1475.85	149.37	10.00	Above Ground Load			0
Drilling Mud			149.37	(Graph = ·········)				
Ballast			149.37	(Graph = - - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	316.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	10.0	°			

Frictional Drag = W_e L μ cosθ =	4,684	lb	
Fluidic Drag = 12 π D L C_d =	10,744	lb	
Axial Segment Weight = W_e L sinθ =	-2,753	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**12,675**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	20,188	lb
Segment Angle with Horizontal, θ =	-10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E I) / T]^{1/2}$ =	4,281	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	4.0E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	126.93	
$U = (12 L) / j$ =	1.17		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	4,402	lb
Bending Frictional Drag = 2 μ N =	2,641	lb			
Fluidic Drag = 12 π D L C_d =	14,212	lb			
Axial Segment Weight = W_e L sinθ =	-1,828	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**15,025**	**lb**			
Total Pulling Load =	**27,701**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = W_e L μ =	1	lb
Fluidic Drag = 12 π D L C_d =	1	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**2**	**lb**
Total Pulling Load =	**27,703**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 37,595 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = 50.1 lb/ft

$h = R [1 - \cos(\alpha/2)]$ = 9.13 ft

$j = [(E I) / T]^{1/2}$ = 3,137

$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 6.7E+05

$X = (3 L) - [(j / 2) \tanh(U/2)]$ = 214.10

$U = (12 L) / j$ = 1.60

$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ = 6,240 lb

Bending Frictional Drag = $2 \mu N$ = 3,744 lb

Fluidic Drag = $12 \pi D L C_d$ = 14,212 lb

Axial Segment Weight = $W_e L \sin\theta$ = 1,828 lb

Pulling Load on Entry Sag Bend = 19,784 lb
Total Pulling Load = 47,487 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 345.7 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = 50.1 lb/ft

Frictional Drag = $W_e L \mu \cos\theta$ = 5,114 lb

Fluidic Drag = $12 \pi D L C_d$ = 11,729 lb

Axial Segment Weight = $W_e L \sin\theta$ = 3,006 lb

Pulling Load on Entry Tangent = 19,849 lb
Total Pulling Load = 67,335 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	820	ok	0	ok	0	ok	0.01	ok	0.00	ok
	579	ok	0	ok	254	ok	0.01	ok	0.00	ok
PC										
	579	ok	18,125	ok	254	ok	0.41	ok	0.12	ok
	338	ok	18,125	ok	422	ok	0.40	ok	0.12	ok
PT										
	338	ok	0	ok	422	ok	0.01	ok	0.00	ok
	337	ok	0	ok	422	ok	0.01	ok	0.00	ok
PC										
	337	ok	18,125	ok	422	ok	0.40	ok	0.12	ok
	154	ok	18,125	ok	254	ok	0.40	ok	0.11	ok
PT										
	154	ok	0	ok	254	ok	0.00	ok	0.00	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok

Little River R0 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Little River Crossing	Date :	9/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 22' deeper than design with a 2,400' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Little River R0 Installation Stress Analysis (worst-case).xlsm

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		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	154.41	10.00				265,977
Entry Tangent						345.69		
Entry Sag Bend	PC	330.44	94.38					239,283
	PI	537.22	57.92	10.00	2400	418.88	200,598	
	PT	747.19	57.92				0	161,914
Bottom Tangent				0.00		0.04		
Exit Sag Bend	PC	747.24	57.92					161,908
	PI	957.21	57.92	10.00	2400	418.88	112,726	
	PT	1163.99	94.38				0	63,543
Exit Tangent						316.67		
Exit Point		1475.85	149.37	10.00			Above Ground Load	0
Drilling Mud			149.37	(Graph = ········)				
Ballast				(Graph = – – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
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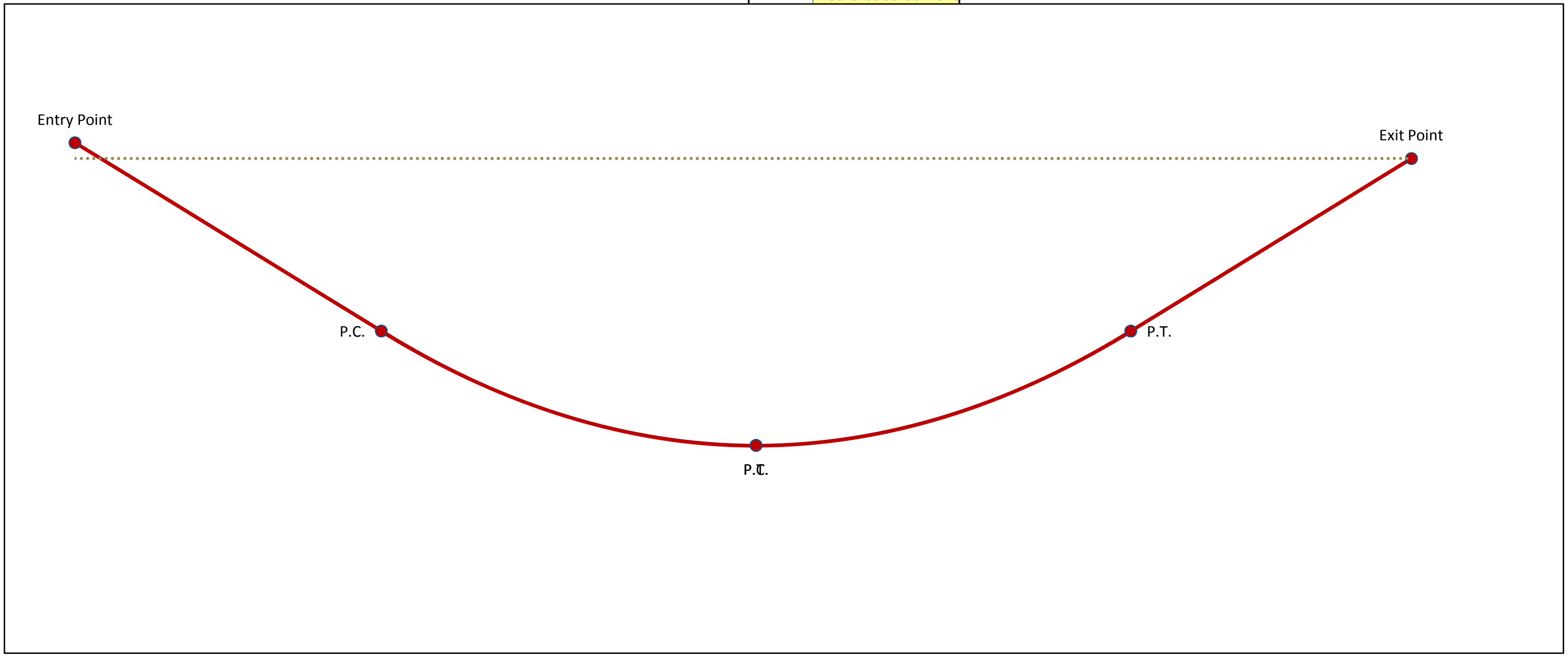
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Little River R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	316.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	10.0	°			

Frictional Drag = $W_e\ L\ \mu\ \cos\theta$ =	33,254	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	10,744	lb
Axial Segment Weight = $W_e\ L\ \sin\theta$ =	19,545	lb
Pulling Load on Exit Tangent =	**63,543**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	112,726	lb
Segment Angle with Horizontal, θ =	-10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

$h = R\ [1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E\ I) / T]^{1/2}$ =	1,811	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	1.4E+06		$X = (3\ L) - [\ (j / 2)\ \tanh(U/2)\ ]$ =	457.23	
$U = (12\ L) / j$ =	2.77		$N = [(T\ h) - W_e\ \cos\theta\ (Y/144)] / (X / 12)$ =	118,626	lb
Bending Frictional Drag = $2\ \mu\ N$ =	71,176	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	14,212	lb			
Axial Segment Weight = $W_e\ L\ \sin\theta$ =	12,976	lb			
Pulling Load on Exit Sag Bend =	**98,364**	**lb**			
Total Pulling Load =	**161,908**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	5	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	1	lb
Axial Segment Weight = $W_e\ L\ \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**6**	**lb**
Total Pulling Load =	**161,914**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	200,598	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E\,I) / T]^{1/2}$ =	1,358	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	1.9E+06		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	610.38	
$U = (12\,L) / j$ =	3.70		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	126,889	lb
Bending Frictional Drag = $2\,\mu\,N$ =	76,133	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	14,212	lb			
Axial Segment Weight = $W_e\,L\sin\theta$ =	-12,976	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**77,369**	**lb**			
Total Pulling Load =	**239,283**	**lb**			

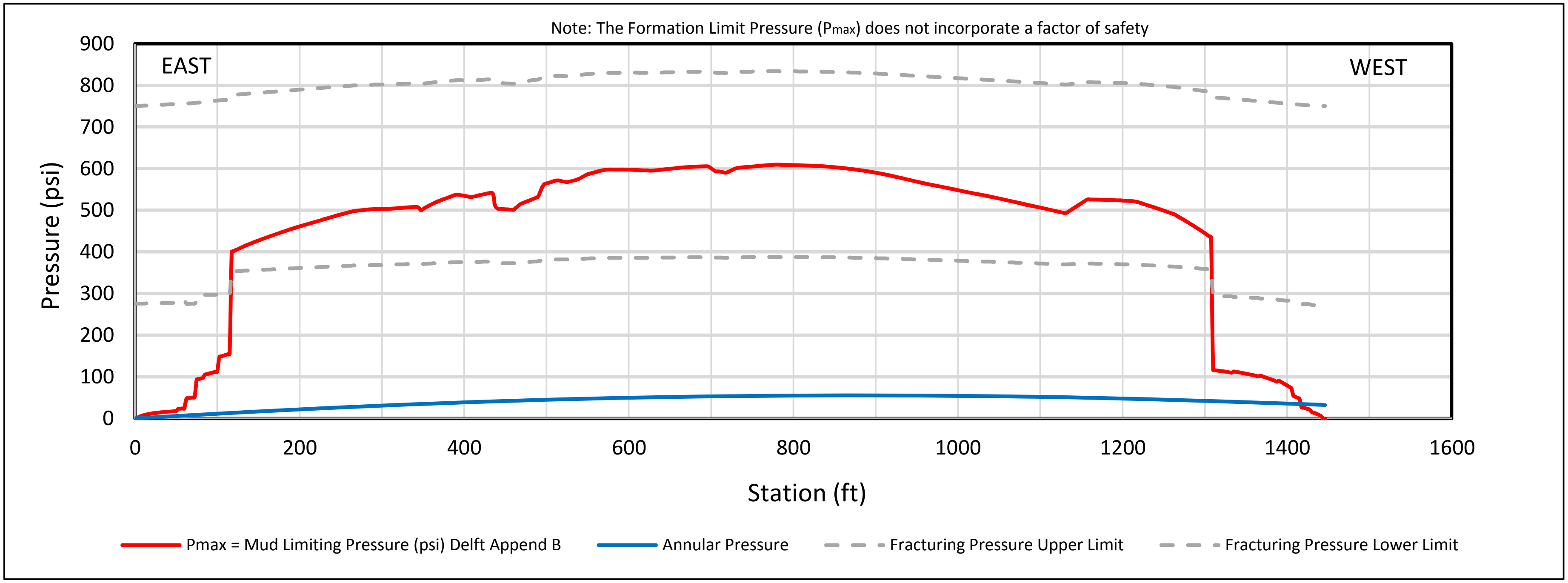
Entry Tangent - Summary of Pulling Load Calculations

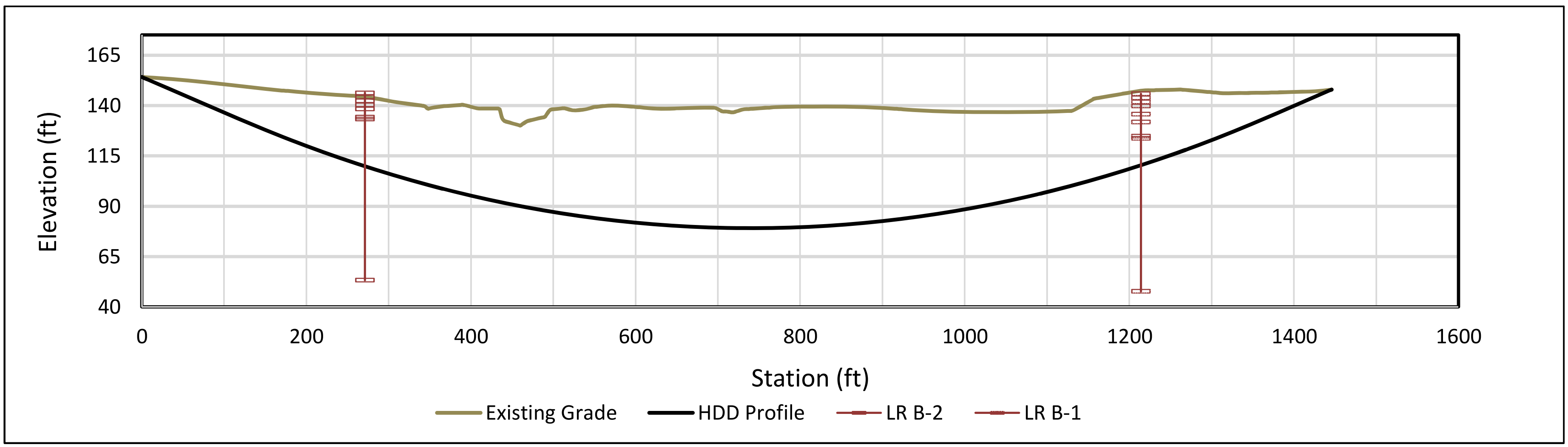
Segment Length, L =	345.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu\cos\theta$ =	36,302	lb	
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	11,729	lb	
Axial Segment Weight = $W_e\,L\sin\theta$ =	-21,337	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**26,694**	**lb**	
Total Pulling Load =	**265,977**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,240	ok	0	ok	0	ok	0.05	ok	0.00	ok
	2,915	ok	0	ok	833	ok	0.05	ok	0.02	ok
PC										
	2,915	ok	18,125	ok	833	ok	0.44	ok	0.17	ok
	1,973	ok	18,125	ok	1385	ok	0.43	ok	0.20	ok
PT										
	1,973	ok	0	ok	1385	ok	0.03	ok	0.04	ok
	1,973	ok	0	ok	1385	ok	0.03	ok	0.04	ok
PC										
	1,973	ok	18,125	ok	1385	ok	0.43	ok	0.20	ok
	774	ok	18,125	ok	833	ok	0.41	ok	0.15	ok
PT										
	774	ok	0	ok	833	ok	0.01	ok	0.01	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
LITTLE RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

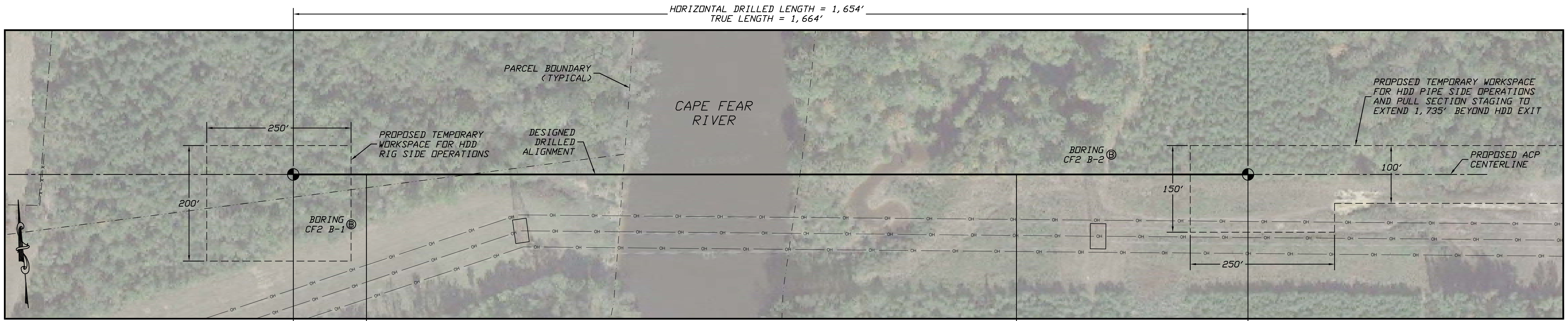
Date: 9/26/2016 Revision: 0

J.D.Hair&Associates, Inc.

Cape Fear River

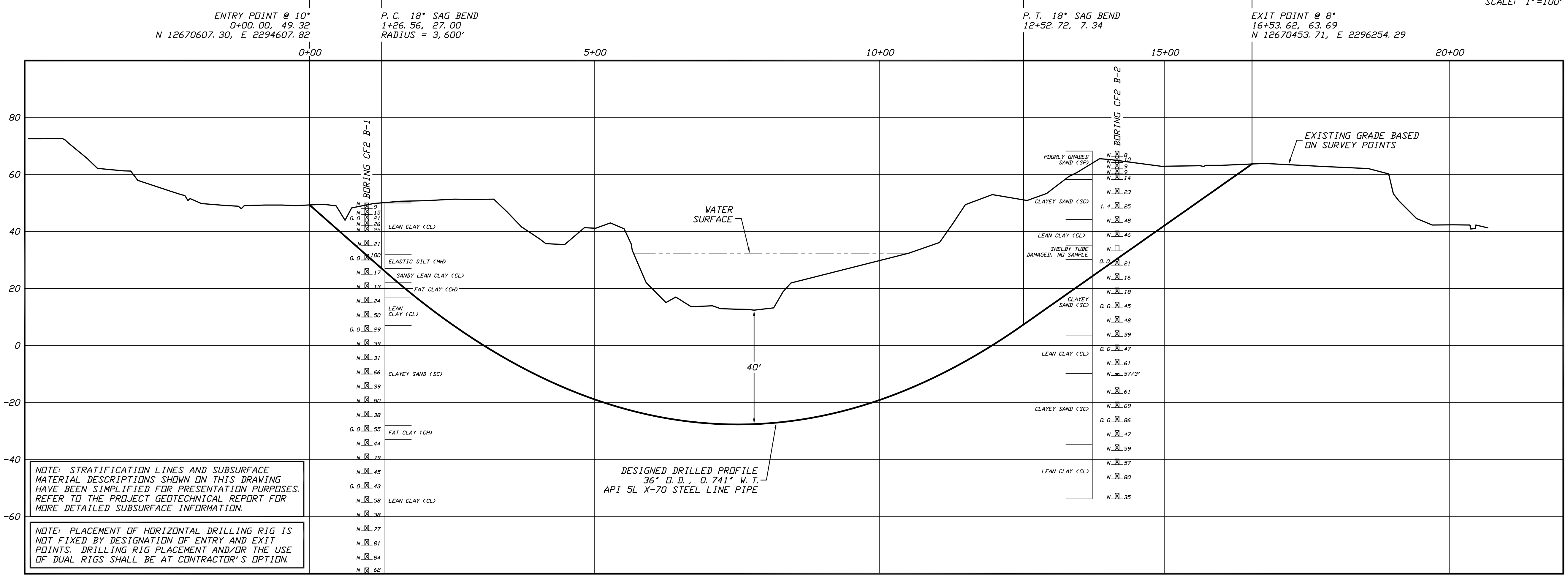
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, with buoyancy control (4 pages)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=100'



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

SHELBY TUBE SAMPLE

53 — PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT DATED JUNE 2016 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 20 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 2,400 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
36-INCH PIPELINE CROSSING OF THE CAPE FEAR RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: CUMBERLAND COUNTY, NORTH CAROLINA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN/ACM	08/18/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	CAPE FEAR	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP2-006A

Cape Fear River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	36" Cape Fear River Crossing	Date :	7/22/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 18' deeper than design with a 2,400' radius) with 12 ppg mud with BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, F_{hc}/1.5 =	7,208	psi	

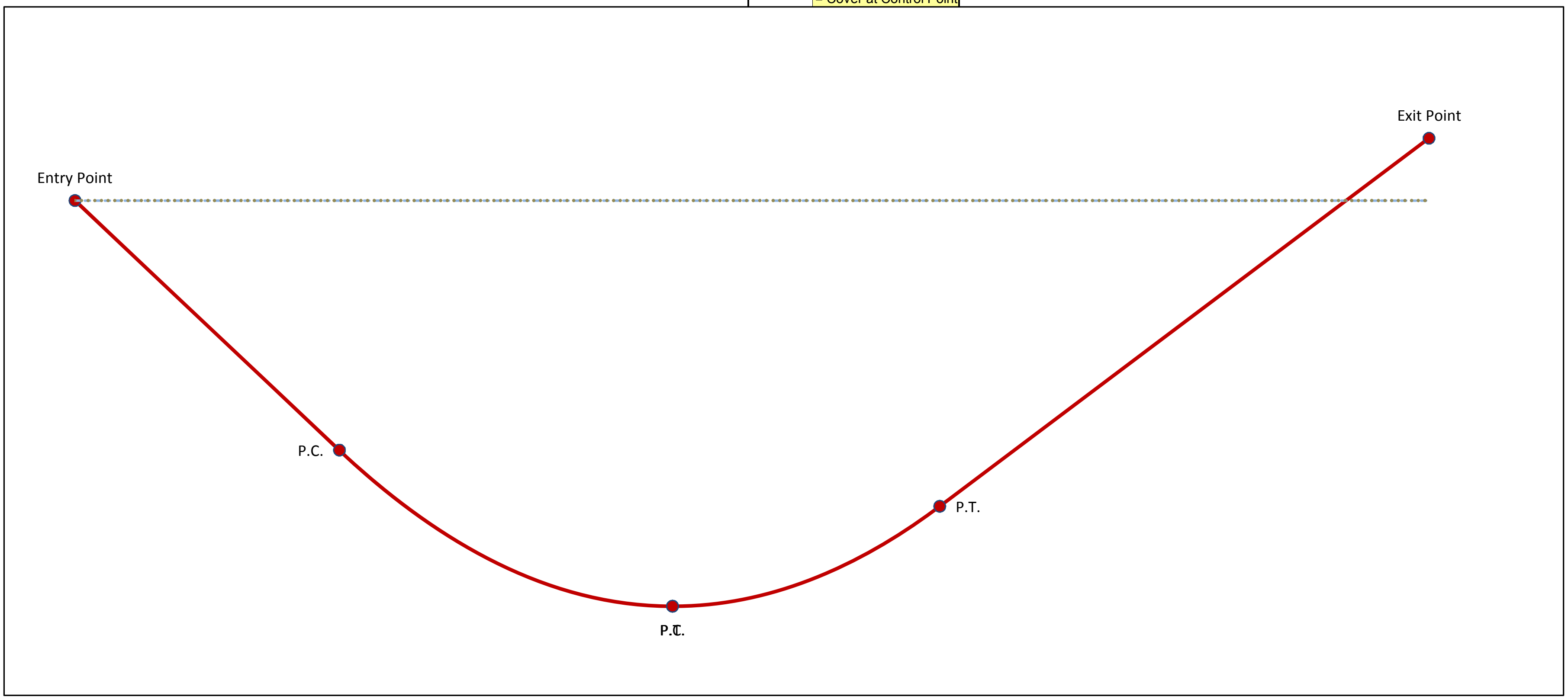
Cape Fear River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	49.22	10.00				83,086
Entry Tangent						335.90		
Entry Sag Bend	PC	320.80	-9.11					63,800
	PI	527.58	-45.57	10.00	2400	418.88	53,408	
	PT	737.55	-45.57				0	43,016
Bottom Tangent				0.00		0.03		
Exit Sag Bend	PC	737.59	-45.57					43,015
	PI	905.41	-45.57	8.00	2400	335.10	34,435	
	PT	1071.60	-22.21				0	25,856
Exit Tangent						618.03		
Exit Point		1683.62	63.80	8.00	Above Ground Load			0
Drilling Mud			49.22	(Graph = ········)				
Ballast			49.22	(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Cape Fear River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	618.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	9,193	lb	
Fluidic Drag = $12 \pi D L C_d$ =	20,969	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-4,307	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Exit Tangent =	**25,856**	**lb**	

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	34,435	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.85	ft	$j = [(E I) / T]^{1/2}$ =	3,277	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.7E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	109.64	
$U = (12 L) / j$ =	1.23		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	11,599	lb
Bending Frictional Drag = $2 \mu N$ =	6,960	lb			
Fluidic Drag = $12 \pi D L C_d$ =	11,370	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-1,170	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Exit Sag Bend =	**17,159**	**lb**			
Total Pulling Load =	**43,015**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

Frictional Drag = $W_e L \mu$ =	1	lb
Fluidic Drag = $12 \pi D L C_d$ =	1	lb
Axial Segment Weight = $W_e L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**2**	**lb**
Total Pulling Load =	**43,016**	**lb**

Cape Fear River R0 Installation Stress Analysis (worst-case) - with buoyancy.xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	418.9	ft	Average Tension, T =	53,408	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	9.13	ft	$j = [(E\,I) / T]^{1/2}$ =	2,632	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	8.8E+05		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	280.22	
$U = (12\,L) / j$ =	1.91		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	7,905	lb
Bending Frictional Drag = $2\,\mu\,N$ =	4,743	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	14,212	lb			
Axial Segment Weight = $W_e\,L\sin\theta$ =	1,828	lb			
Pulling Load on Entry Sag Bend =	**20,783**	**lb**			
Total Pulling Load =	**63,800**	**lb**			

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L =	335.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	50.1	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu\cos\theta$ =	4,969	lb
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	11,397	lb
Axial Segment Weight = $W_e\,L\sin\theta$ =	2,921	lb
Pulling Load on Entry Tangent =	**19,286**	**lb**
Total Pulling Load =	**83,086**	**lb**

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	1,012	ok	0	ok	0	ok	0.02	ok	0.00	ok
	777	ok	0	ok	269	ok	0.01	ok	0.00	ok
PC										
	777	ok	18,125	ok	269	ok	0.41	ok	0.12	ok
	524	ok	18,125	ok	437	ok	0.41	ok	0.12	ok
PT										
	524	ok	0	ok	437	ok	0.01	ok	0.00	ok
	524	ok	0	ok	437	ok	0.01	ok	0.00	ok
PC										
	524	ok	18,125	ok	437	ok	0.41	ok	0.12	ok
	315	ok	18,125	ok	330	ok	0.40	ok	0.12	ok
PT										
	315	ok	0	ok	330	ok	0.01	ok	0.00	ok
Exit Point	0	ok	0	ok	-67	ok	0.00	ok	0.00	ok

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	36" Cape Fear River Crossing	Date :	6/15/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 18' deeper than design with a 2,400' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	36.000	in	
Wall Thickness =	0.741	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	12755.22	in^4	
Pipe Face Surface Area =	82.08	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	279.04	lb/ft	
Pipe Interior Volume =	6.50	ft^3/ft	
Pipe Exterior Volume =	7.07	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	405.51	lb/ft	
Displaced Mud Weight =	634.48	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,517	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,639	psi	Yes
Allowable Bending Stress, F_b =	45,639	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,812	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,446	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	12,027	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,812	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,208	psi	

Cape Fear River R0 Installation Stress Analysis (worst-case).xlsm

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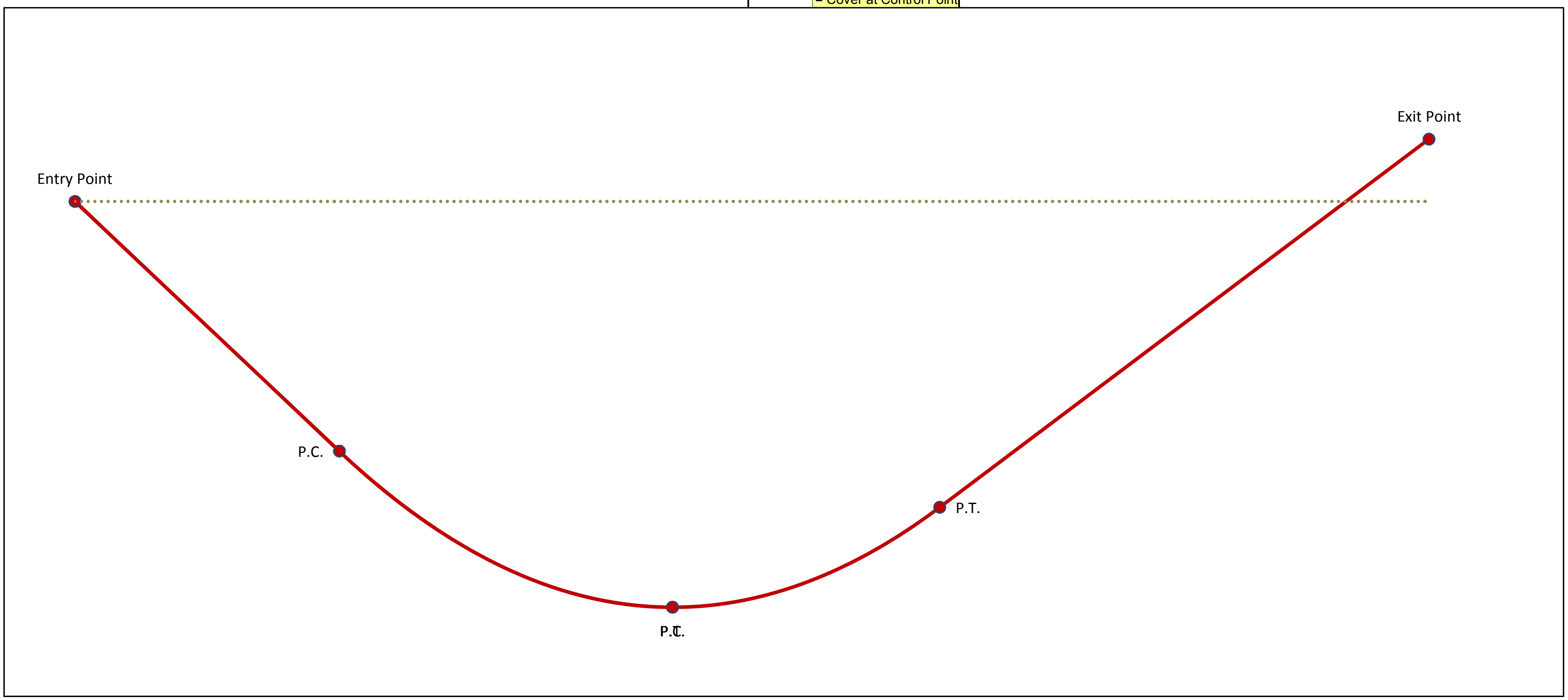
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	49.22	10.00				305,472
Entry Tangent						335.90		
Entry Sag Bend	PC	320.80	-9.11					279,534
	PI	527.58	-45.57	10.00	2400	418.88	239,746	
	PT	737.55	-45.57				0	199,957
Bottom Tangent				0.00		0.03		
Exit Sag Bend	PC	737.59	-45.57					199,953
	PI	905.41	-45.57	8.00	2400	335.10	158,378	
	PT	1071.60	-22.21				0	116,803
Exit Tangent						618.03		
Exit Point		1683.62	63.80	8.00	Above Ground Load			0
Drilling Mud			49.22	(Graph = ...)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Step 2, Drilled Path Input

Cape Fear River R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	36.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	279.0	lb/ft	Ballast Weight / ft Pipe, W_b =	405.5	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	634.5	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	618.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	65,261	lb
Fluidic Drag = 12 π D L C_d =	20,969	lb
Axial Segment Weight = W_e L sinθ =	30,573	lb
Pulling Load on Exit Tangent =	**116,803**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	335.1	ft	Average Tension, T =	158,378	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	2,400	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

h = R [1 - cos(α/2)] =	5.85	ft	$j = [(E\ I) / T]^{1/2}$ =	1,528	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	8.5E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	343.81	
U = (12 L) / j =	2.63		N = [(T h) - W_e cosθ (Y/144)] / (X / 12)	105,786	lb
Bending Frictional Drag = 2 μ N =	63,472	lb			
Fluidic Drag = 12 π D L C_d =	11,370	lb			
Axial Segment Weight = W_e L sinθ =	8,309	lb			
Pulling Load on Exit Sag Bend =	**83,150**	**lb**			
Total Pulling Load =	**199,953**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-355.4	lb/ft

Frictional Drag = W_e L μ =	4	lb
Fluidic Drag = 12 π D L C_d =	1	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**5**	**lb**
Total Pulling Load =	**199,957**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 418.9 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 239,746 lb
Radius of Curvature, R = 2,400 ft
Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

$h = R [1 - \cos(\alpha/2)]$ = 9.13 ft

$j = [(E I) / T]^{1/2}$ = 1,242

$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ = 2.0E+06

$X = (3 L) - [(j / 2) \tanh(U/2)]$ = 656.91

$U = (12 L) / j$ = 4.05

$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ = 130,568 lb

Bending Frictional Drag = $2 \mu N$ = 78,341 lb

Fluidic Drag = $12 \pi D L C_d$ = 14,212 lb

Axial Segment Weight = $W_e L \sin\theta$ = -12,976 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 79,577 lb
Total Pulling Load = 279,534 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 335.9 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -355.4 lb/ft

Frictional Drag = $W_e L \mu \cos\theta$ = 35,274 lb

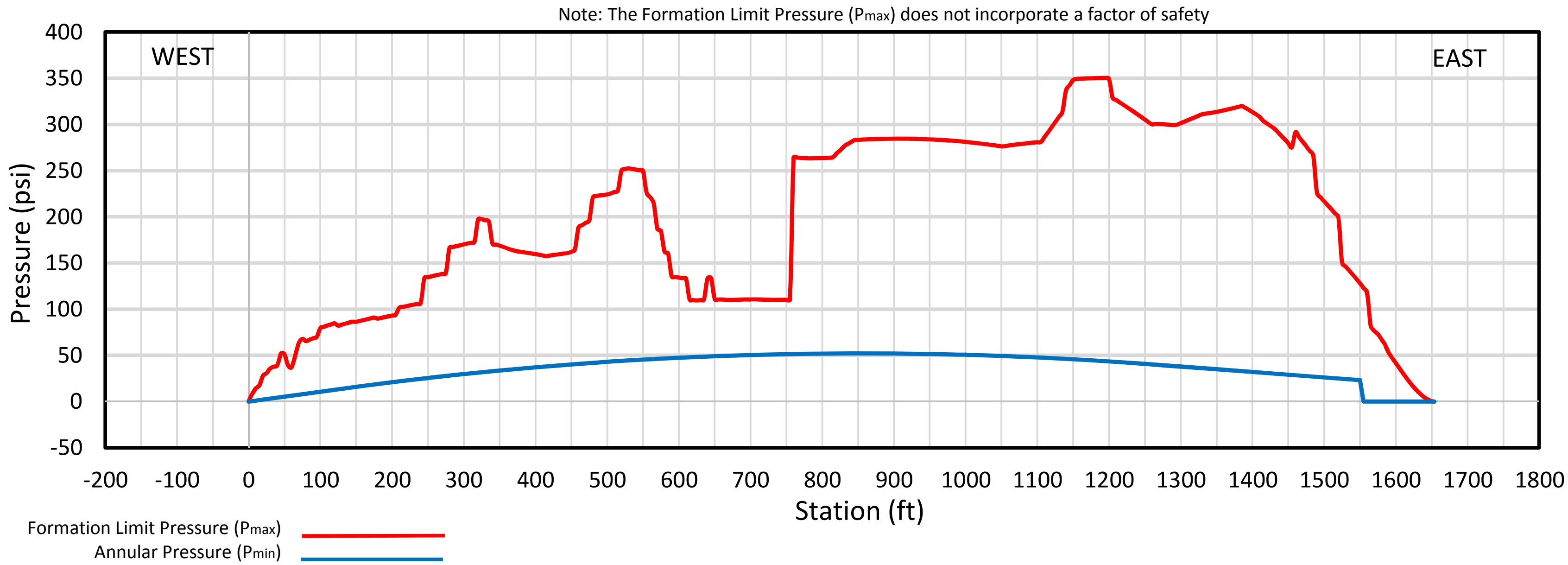
Fluidic Drag = $12 \pi D L C_d$ = 11,397 lb

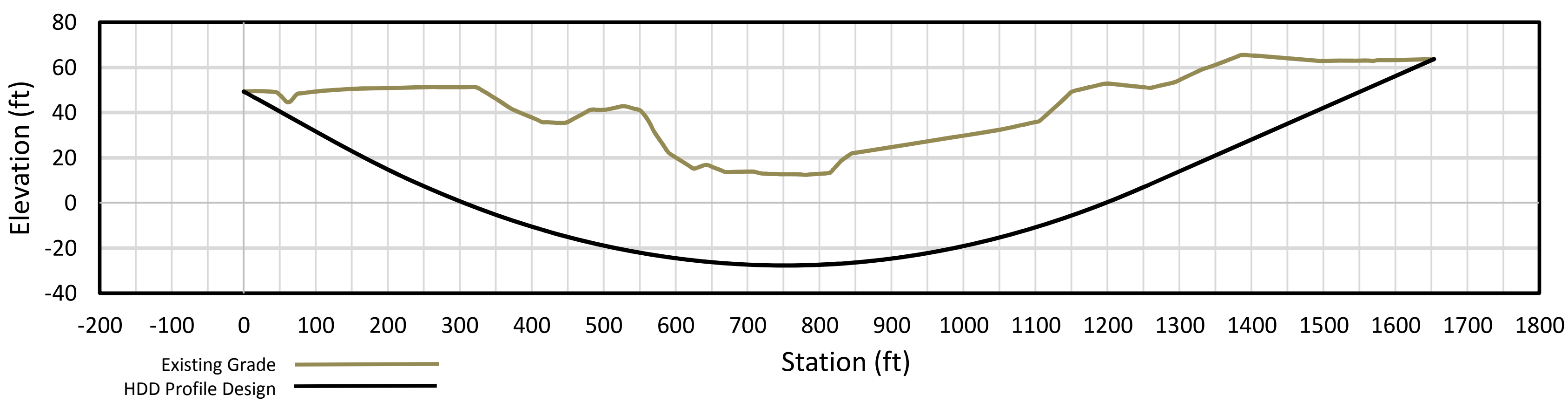
Axial Segment Weight = $W_e L \sin\theta$ = -20,732 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 25,938 lb
Total Pulling Load = 305,472 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,722	ok	0	ok	0	ok	0.06	ok	0.00	ok
	3,406	ok	0	ok	883	ok	0.05	ok	0.02	ok
PC										
	3,406	ok	18,125	ok	883	ok	0.45	ok	0.18	ok
	2,436	ok	18,125	ok	1435	ok	0.44	ok	0.21	ok
PT										
	2,436	ok	0	ok	1435	ok	0.04	ok	0.04	ok
	2,436	ok	0	ok	1435	ok	0.04	ok	0.04	ok
PC										
	2,436	ok	18,125	ok	1435	ok	0.44	ok	0.21	ok
	1,423	ok	18,125	ok	1082	ok	0.42	ok	0.17	ok
PT										
	1,423	ok	0	ok	1082	ok	0.02	ok	0.02	ok
Exit Point	0	ok	0	ok	-221	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

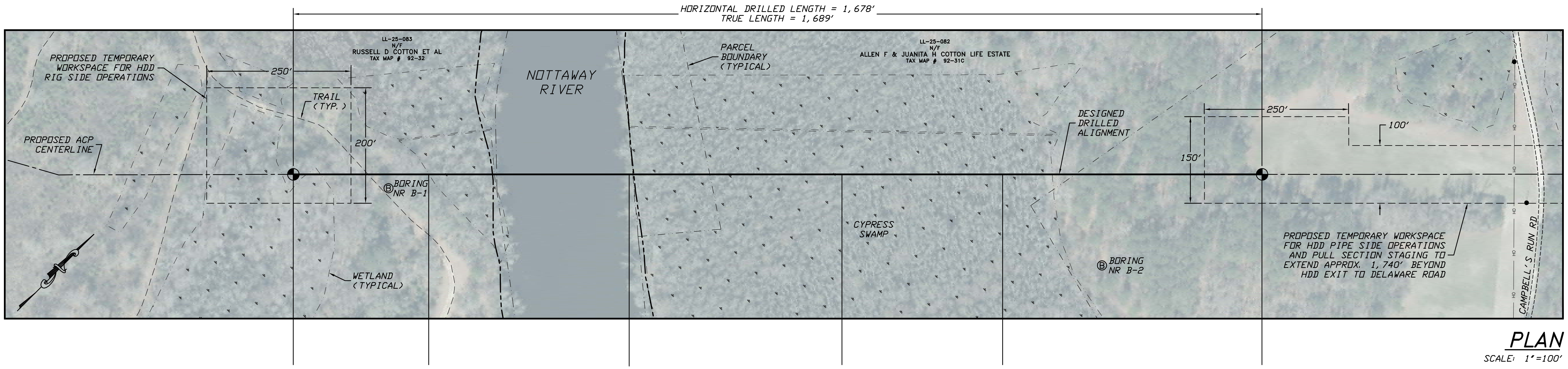
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
36-INCH CAPE FEAR REROUTE CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

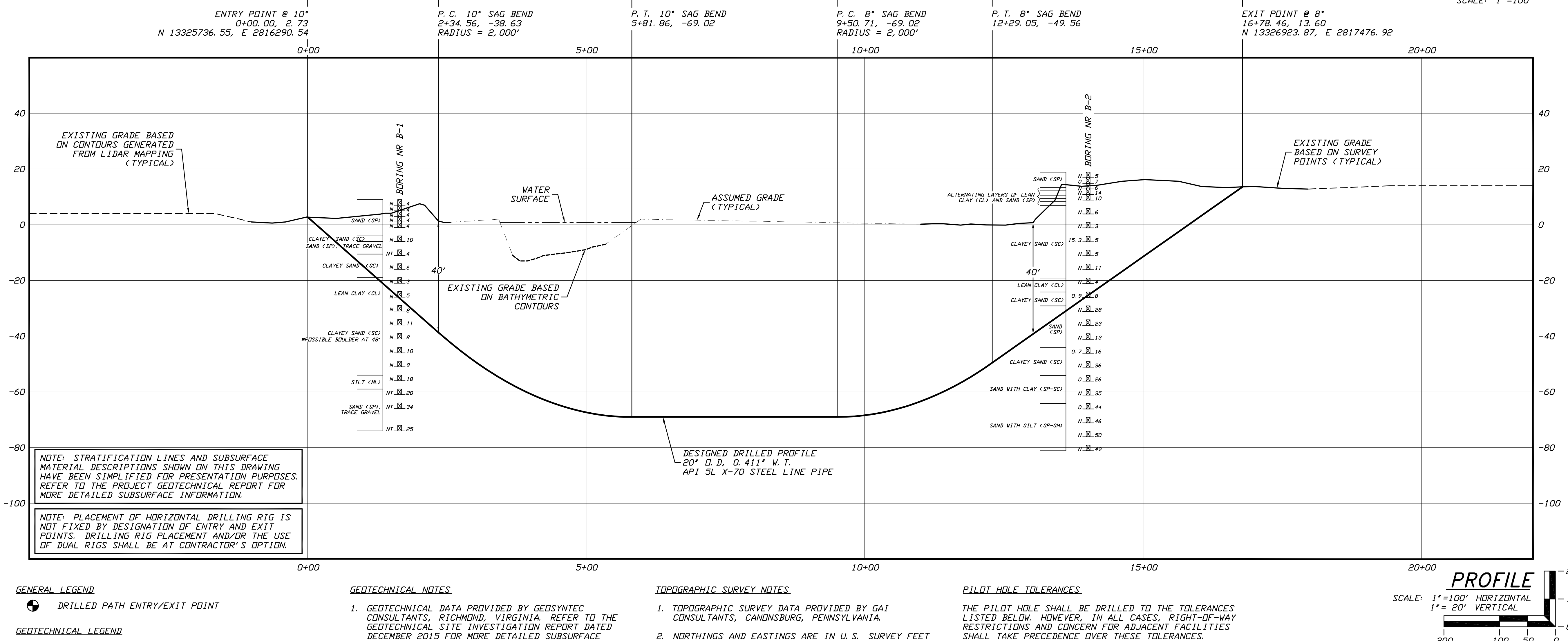
Date: 7/11/2016 Revision: 0

Nottaway River

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)





GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES; PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT DATED DECEMBER 2015 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
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3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF THE NOTTAWAY RIVER
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: SOUTHAMPTON COUNTY, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	02/04/16	JSP	JSP	SHOWN FOR D-SIZED PLOT	NOTTAWAY	1

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.
1	07/13/16	UPDATE HDD ALIGNMENT & BORING LOCATIONS	ACM	DMP	JSP

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-033

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	JSP
Crossing :	20" Nottaway River Crossing	Date :	2/4/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

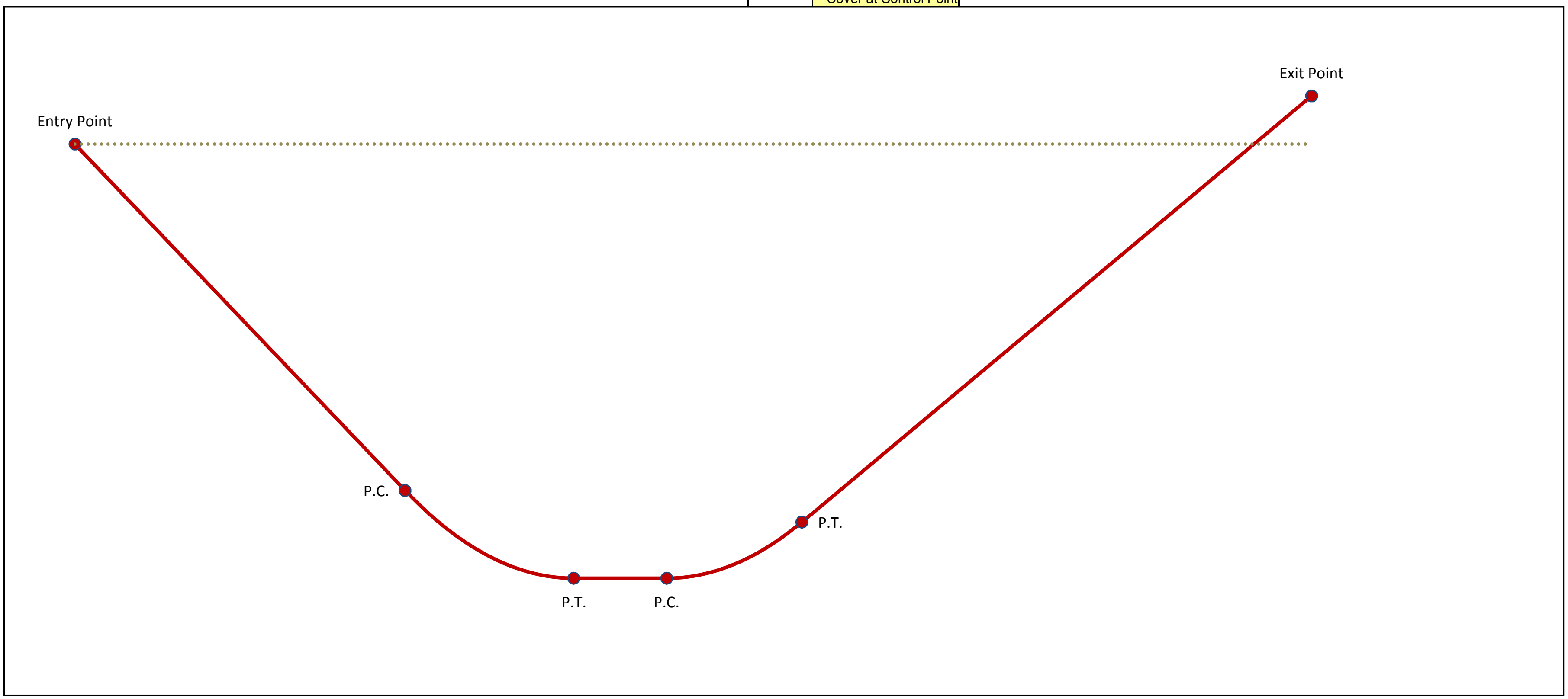
Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

Nottaway River R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	2.40	10.00				107,890
Entry Tangent						465.94		
Entry Sag Bend	PC	448.86	-78.51					92,874
	PI	565.17	-99.01	10.00	1350	235.62	83,129	
	PT	683.28	-99.01				0	73,384
Bottom Tangent				0.00		129.18		
Exit Sag Bend	PC	812.46	-99.01					66,693
	PI	906.86	-99.01	8.00	1350	188.50	57,218	
	PT	1000.35	-85.88				0	47,744
Exit Tangent						715.08		
Exit Point		1708.46	13.64	8.00	Above Ground Load			0
Drilling Mud			2.40	(Graph =)				
Ballast				(Graph =)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
		= Cover at Control Point	



Step 2, Drilled Path Input

Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	715.1	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	23,334	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	13,479	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	10,931	lb
Pulling Load on Exit Tangent =	**47,744**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	57,218	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\ [1 - \cos(\alpha/2)]$ =	3.29	ft	$j = [(E\ I) / T]^{1/2}$ =	784	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	3.0E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	214.91	
$U = (12\ L) / j$ =	2.88		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	23,252	lb
Bending Frictional Drag = $2\ \mu\ N$ =	13,951	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	3,553	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**18,949**	**lb**			
Total Pulling Load =	**66,693**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	129.2	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	4,257	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	2,435	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**6,692**	**lb**
Total Pulling Load =	**73,384**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	83,129	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E I) / T]^{1/2}$ =	651	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	6.7E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	389.90	
$U = (12 L) / j$ =	4.35		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	28,840	lb
Bending Frictional Drag = $2 \mu N$ =	17,304	lb			
Fluidic Drag = $12 \pi D L C_d$ =	4,441	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**19,490**	**lb**			
Total Pulling Load =	**92,874**	**lb**			

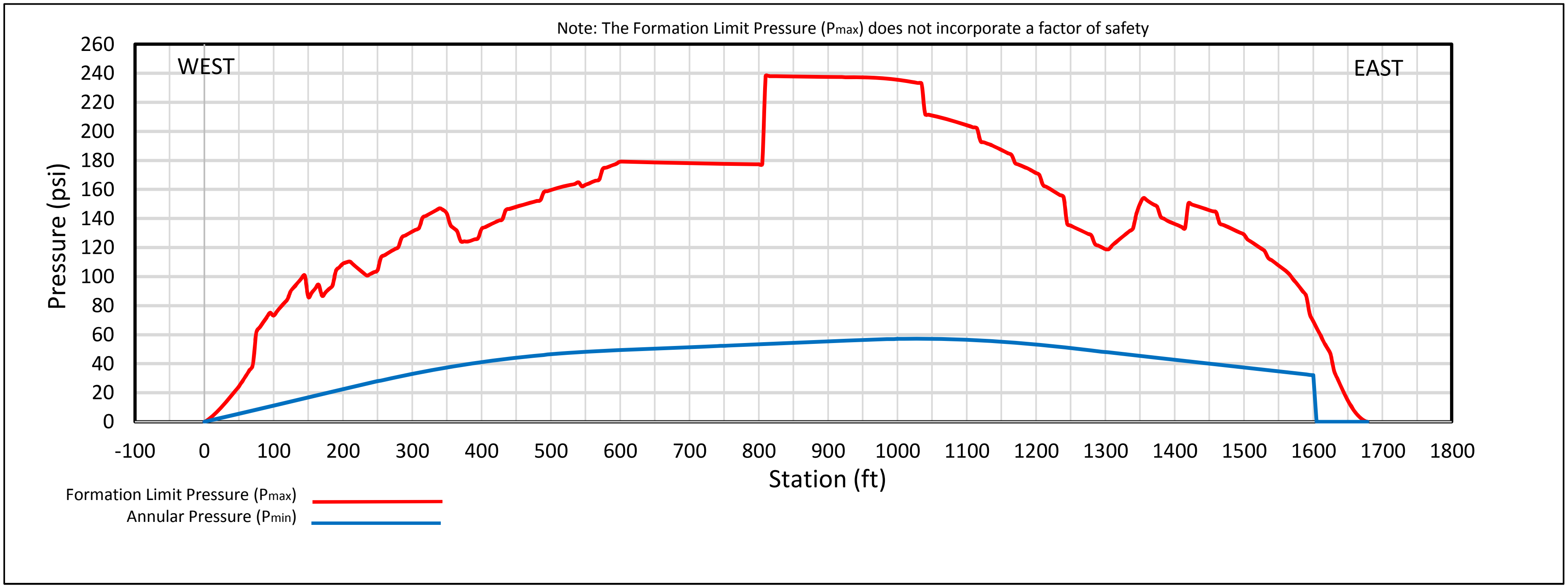
Entry Tangent - Summary of Pulling Load Calculations

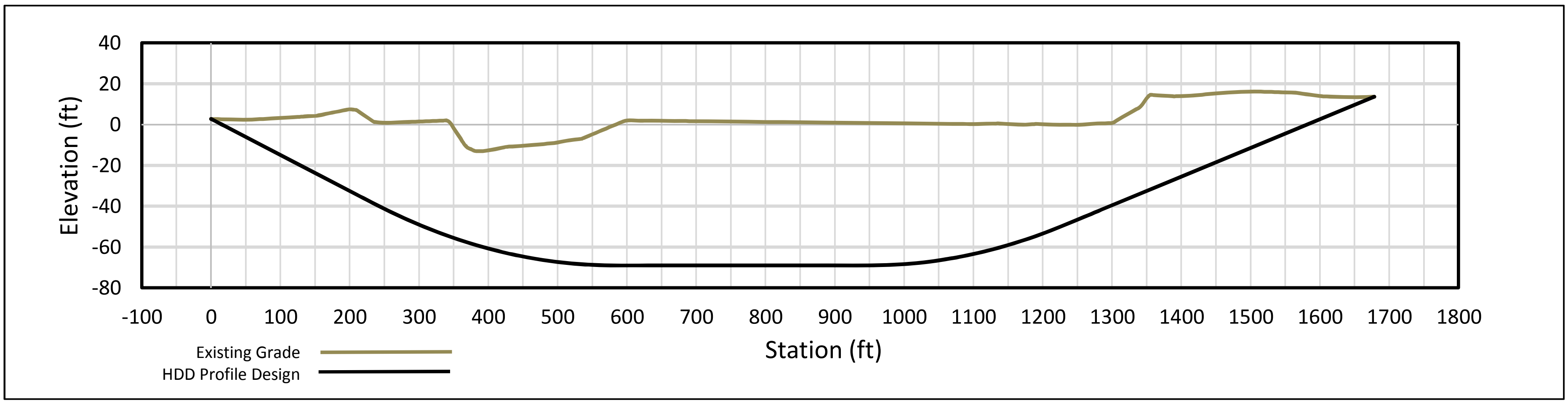
Segment Length, L =	465.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	15,120	lb	
Fluidic Drag = $12 \pi D L C_d$ =	8,783	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-8,887	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**15,016**	**lb**	
Total Pulling Load =	**107,890**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	4,266	ok	0	ok	0	ok	0.07	ok	0.01	ok
	3,672	ok	0	ok	1227	ok	0.06	ok	0.04	ok
PC										
	3,672	ok	17,901	ok	1227	ok	0.45	ok	0.21	ok
	2,901	ok	17,901	ok	1538	ok	0.44	ok	0.22	ok
PT										
	2,901	ok	0	ok	1538	ok	0.05	ok	0.05	ok
	2,637	ok	0	ok	1538	ok	0.04	ok	0.05	ok
PC										
	2,637	ok	17,901	ok	1538	ok	0.43	ok	0.22	ok
	1,888	ok	17,901	ok	1339	ok	0.42	ok	0.19	ok
PT										
	1,888	ok	0	ok	1339	ok	0.03	ok	0.04	ok
Exit Point	0	ok	0	ok	-170	ok	0.00	ok	0.00	ok





HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH NOTTAWAY RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

J.D.Hair&Associates, Inc.

Date: 7/12/2016

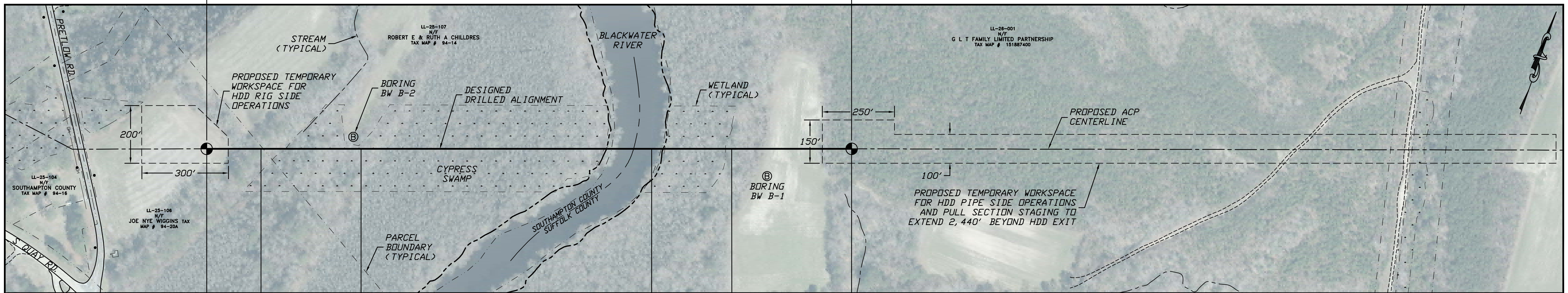
Revision: 1

Blackwater River

Supporting Information

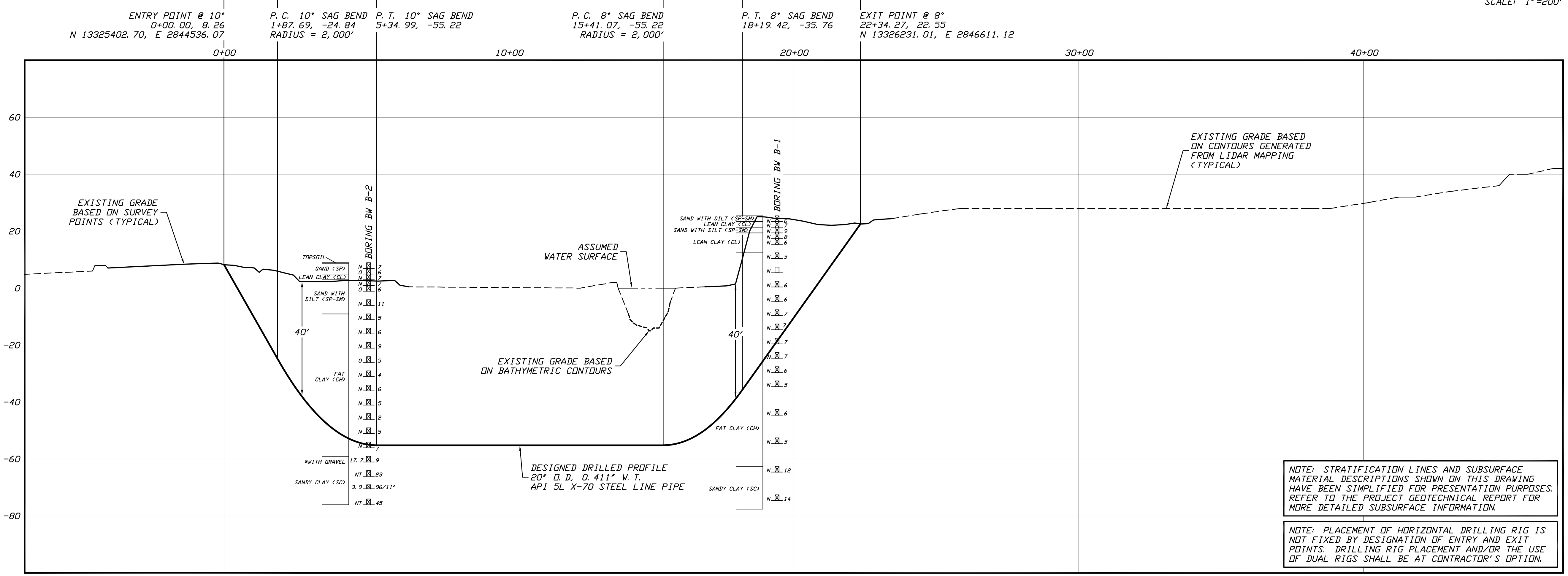
- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)

HORIZONTAL DRILLED LENGTH = 2,234'
TRUE LENGTH = 2,244'



PLAN

SCALE: 1"=200'



NOTE: STRATIFICATION LINES AND SUBSURFACE MATERIAL DESCRIPTIONS SHOWN ON THIS DRAWING HAVE BEEN SIMPLIFIED FOR PRESENTATION PURPOSES. REFER TO THE PROJECT GEOTECHNICAL REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.

NOTE: PLACEMENT OF HORIZONTAL DRILLING RIG IS NOT FIXED BY DESIGNATION OF ENTRY AND EXIT POINTS. DRILLING RIG PLACEMENT AND/OR THE USE OF DUAL RIGS SHALL BE AT CONTRACTOR'S OPTION.

PROFILE

SCALE: 1"=200' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

SHELBY TUBE SAMPLE

53 — PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

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1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF THE BLACKWATER RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: SOUTHAMPTON & SUFFOLK COUNTIES, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	02/09/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	BLACKWATER	1

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.
1	04/28/16	UPDATE HDD ALIGNMENT BASED ON SURVEYED CL	ACM	DMP	JSP

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-039

Blackwater River R1 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	20" Blackwater River Crossing	Date :	6/15/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

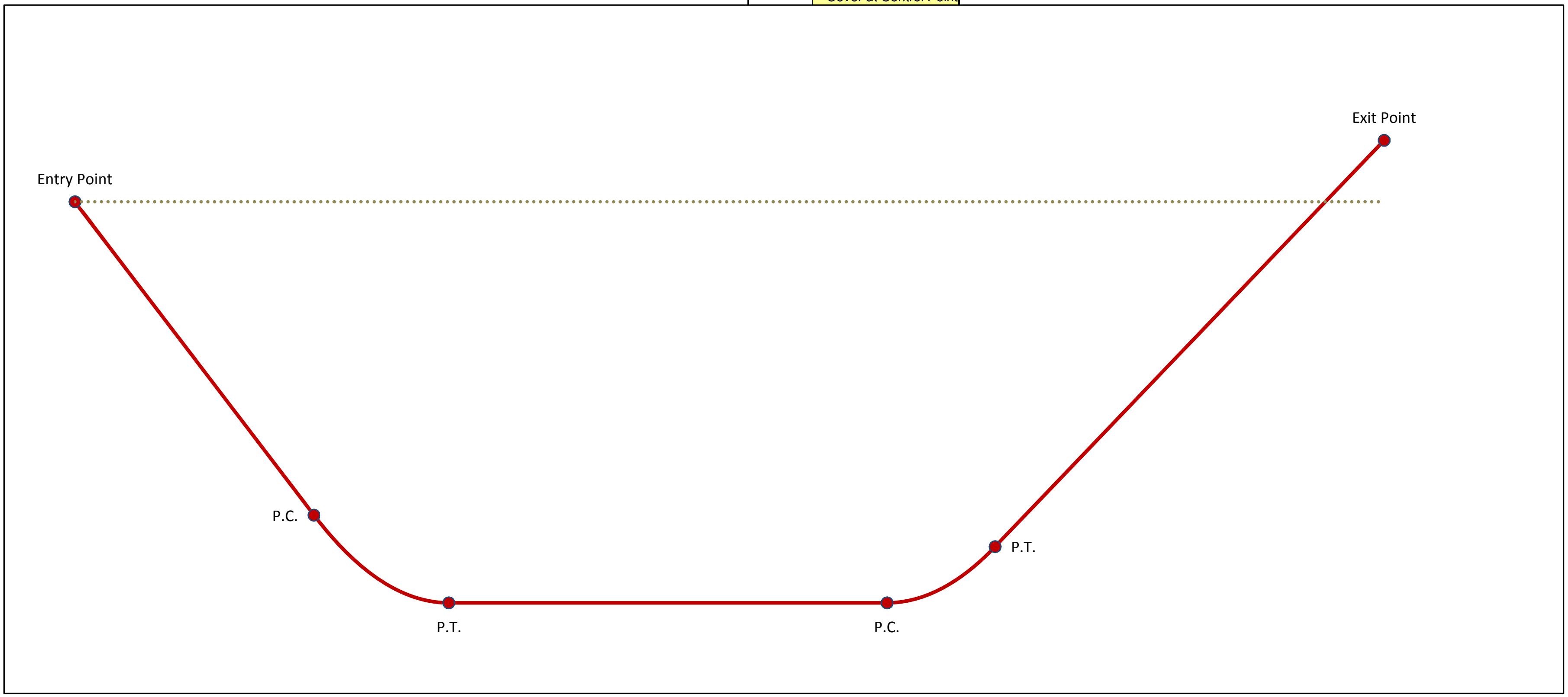
Blackwater River R1 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	8.51	10.00				138,721
Entry Tangent						421.66		
Entry Sag Bend	PC	405.25	-64.71					125,132
	PI	521.57	-85.22	10.00	1350	235.62	114,477	
	PT	639.68	-85.22				0	103,822
Bottom Tangent				0.00		760.95		
Exit Sag Bend	PC	1400.63	-85.22					64,404
	PI	1495.03	-85.22	8.00	1350	188.50	54,983	
	PT	1588.51	-72.08				0	45,562
Exit Tangent						682.40		
Exit Point		2264.27	22.89	8.00	Above Ground Load			0
Drilling Mud			8.51	(Graph =)				
Ballast				(Graph =)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Step 2, Drilled Path Input

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Blackwater River R1 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	682.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\, L\, \mu \cos\theta$ =	22,268	lb
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	12,863	lb
Axial Segment Weight = $W_e\, L \sin\theta$ =	10,432	lb
Pulling Load on Exit Tangent =	**45,562**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	54,983	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	3.29	ft	$j = [(E\,I) / T]^{1/2}$ =	800	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	2.9E+05		$X = (3\,L) - [\,(j / 2) \tanh(U/2)\,]$ =	210.19	
$U = (12\,L) / j$ =	2.83		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$	23,074	lb
Bending Frictional Drag = $2\,\mu\,N$ =	13,844	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	3,553	lb			
Axial Segment Weight = $W_e\,L \sin\theta$ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**18,842**	**lb**			
Total Pulling Load =	**64,404**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	760.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = $W_e\, L\, \mu$ =	25,075	lb
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	14,344	lb
Axial Segment Weight = $W_e\, L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**39,418**	**lb**
Total Pulling Load =	**103,822**	**lb**

Blackwater River R1 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	114,477	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E\ I) / T]^{1/2}$ =	554	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	7.4E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	433.03	
$U = (12 L) / j$ =	5.10		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	31,873	lb
Bending Frictional Drag = $2 \mu N$ =	19,124	lb			
Fluidic Drag = $12 \pi D L C_d$ =	4,441	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**21,309**	**lb**			
Total Pulling Load =	**125,132**	**lb**			

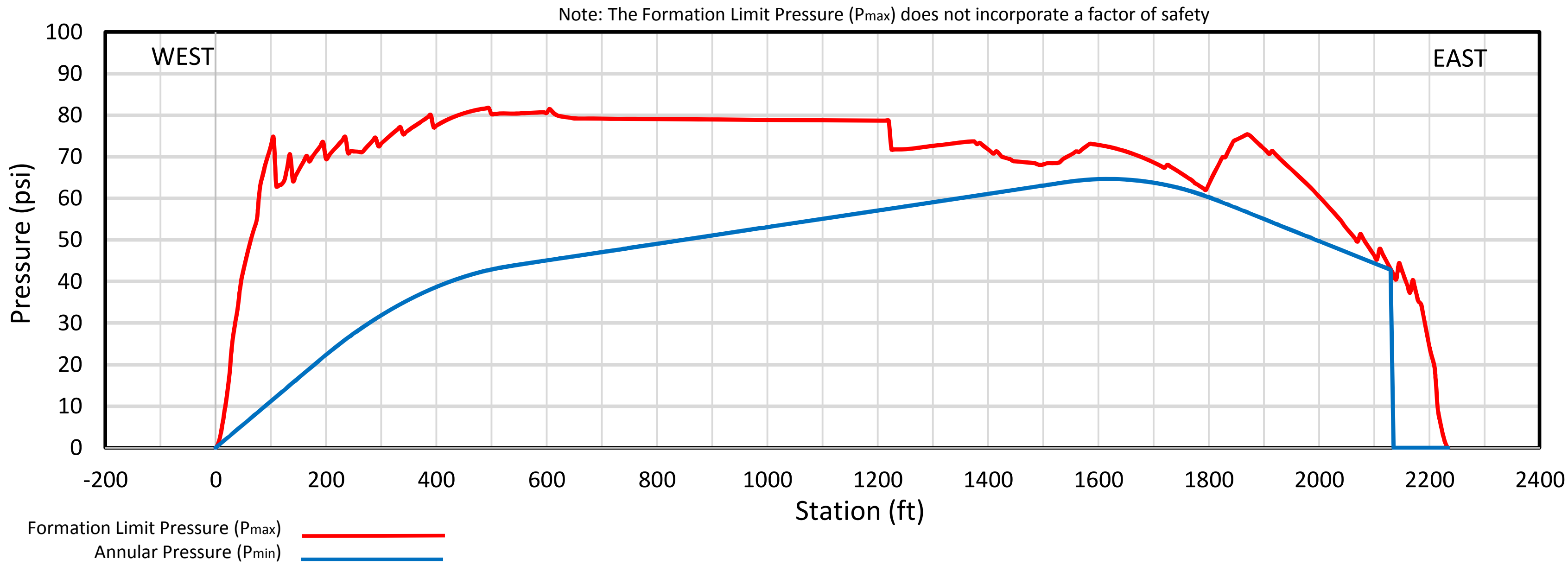
Entry Tangent - Summary of Pulling Load Calculations

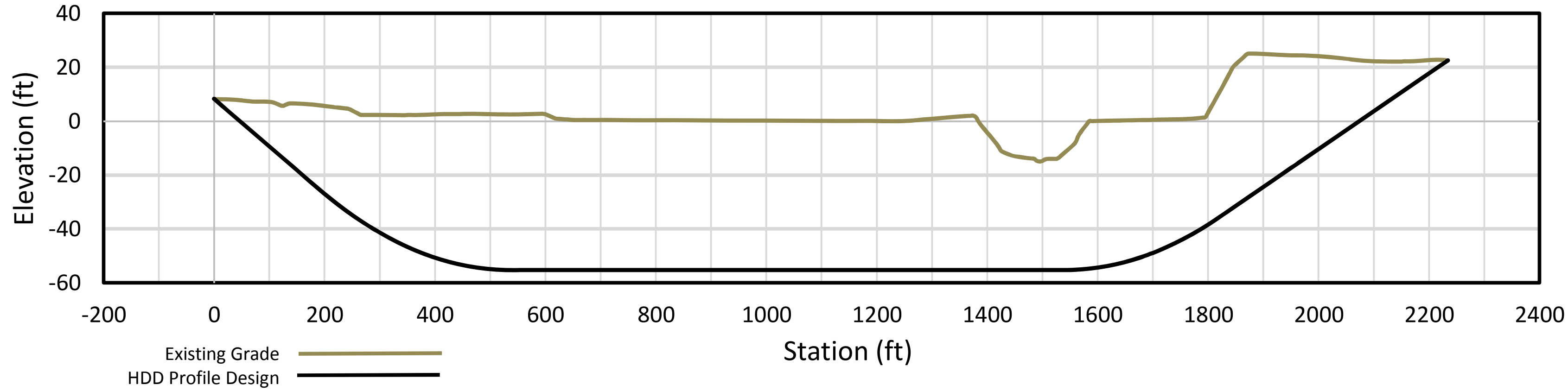
Segment Length, L =	421.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	13,683	lb	
Fluidic Drag = $12 \pi D L C_d$ =	7,948	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-8,043	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**13,589**	**lb**	
Total Pulling Load =	**138,721**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	5,485	ok	0	ok	0	ok	0.09	ok	0.01	ok
	4,947	ok	0	ok	1110	ok	0.08	ok	0.04	ok
PC										
	4,947	ok	17,901	ok	1110	ok	0.47	ok	0.22	ok
	4,105	ok	17,901	ok	1422	ok	0.46	ok	0.23	ok
PT										
	4,105	ok	0	ok	1422	ok	0.07	ok	0.05	ok
	2,546	ok	0	ok	1422	ok	0.04	ok	0.04	ok
PC										
	2,546	ok	17,901	ok	1422	ok	0.43	ok	0.21	ok
	1,801	ok	17,901	ok	1222	ok	0.42	ok	0.18	ok
PT										
	1,801	ok	0	ok	1222	ok	0.03	ok	0.03	ok
Exit Point	0	ok	0	ok	-218	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH BLACKWATER RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

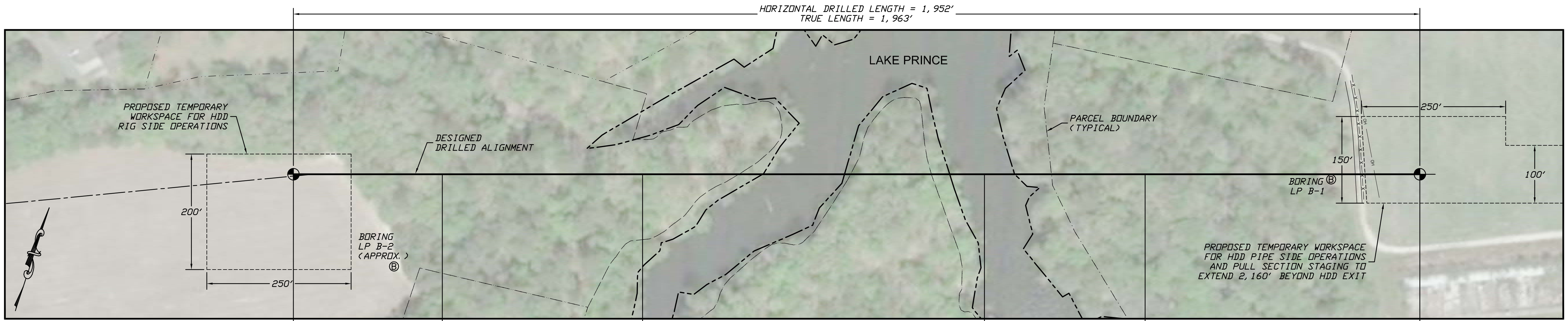
Date: 1/12/2016

Revision: 1

Lake Prince

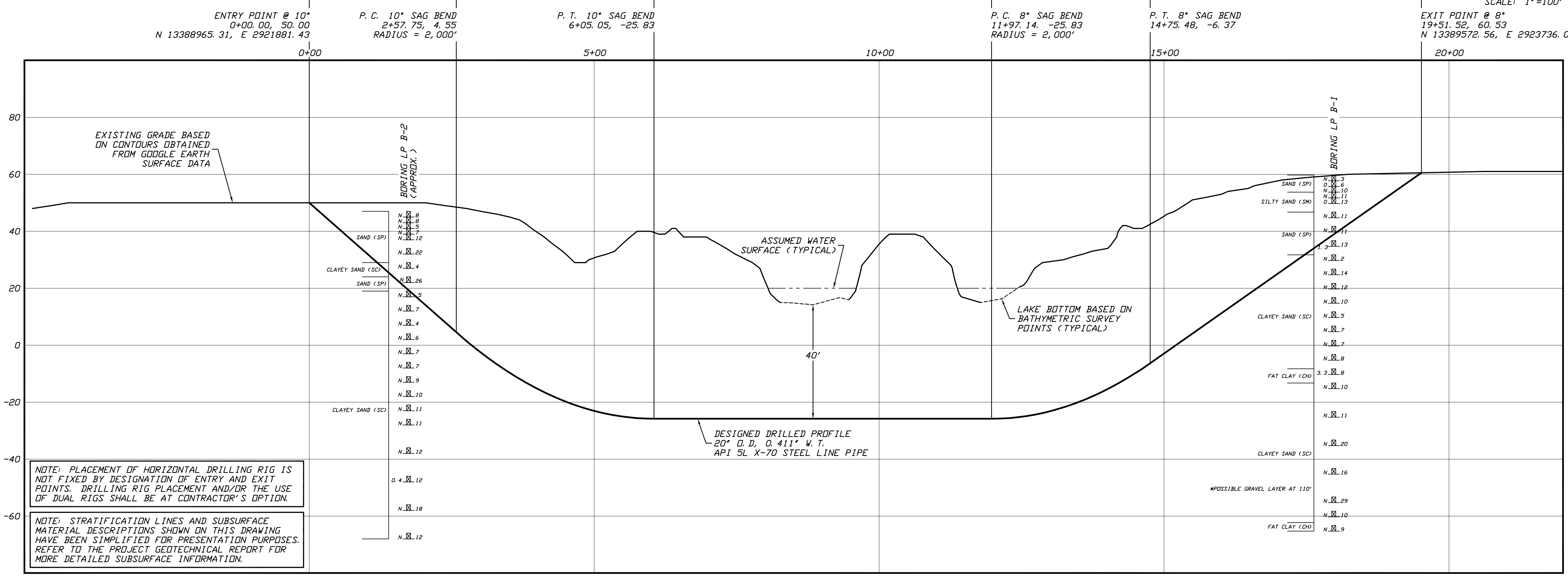
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=100'



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 ⊠ 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE DRAFT PROJECT GEOTECHNICAL REPORT DATED DECEMBER 2015 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF LAKE PRINCE
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: SUFFOLK, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	02/12/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	LAKE PRINCE	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

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Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-061

Lake Prince R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	20" Lake Prince Crossing	Date :	2/9/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

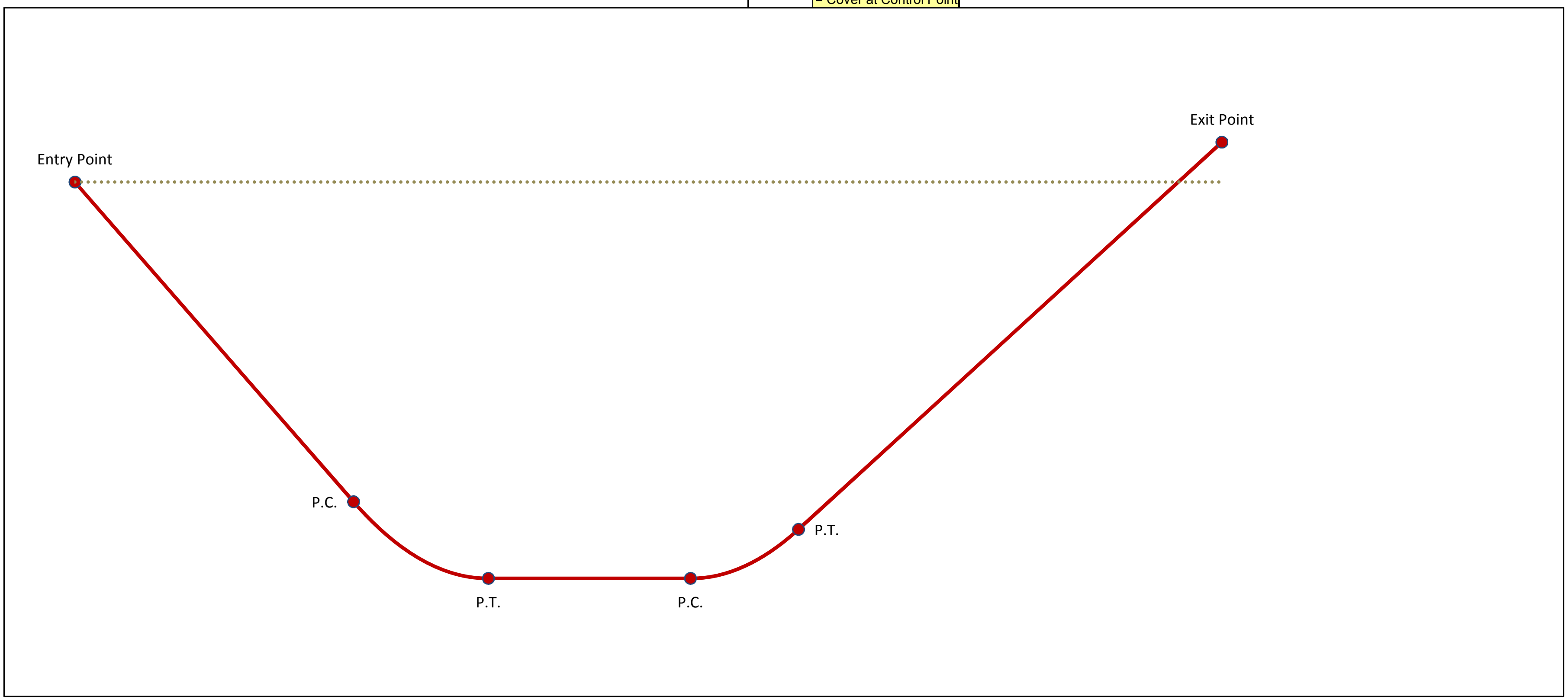
Lake Prince R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	50.00	10.00				122,924
Entry Tangent						491.34		
Entry Sag Bend	PC	473.88	-35.32					107,090
	PI	590.19	-55.83	10.00	1350	235.62	96,943	
	PT	708.30	-55.83				0	86,797
Bottom Tangent				0.00		350.87		
Exit Sag Bend	PC	1059.17	-55.83					68,621
	PI	1153.57	-55.83	8.00	1350	188.50	59,102	
	PT	1247.05	-42.69				0	49,583
Exit Tangent						742.61		
Exit Point		1982.44	60.66	8.00	Above Ground Load			0
Drilling Mud			50.00	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Step 2, Drilled Path Input

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Lake Prince R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	742.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\, L\, \mu \cos\theta$ =	24,233	lb
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	13,998	lb
Axial Segment Weight = $W_e\, L \sin\theta$ =	11,352	lb
Pulling Load on Exit Tangent =	**49,583**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	59,102	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	3.29	ft	$j = [(E\, I) / T]^{1/2}$ =	772	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	3.1E+05		$X = (3\,L) - [\,(j / 2) \tanh(U/2)\,]$ =	218.76	
$U = (12\,L) / j$ =	2.93		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	23,402	lb
Bending Frictional Drag = $2\,\mu\,N$ =	14,041	lb			
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	3,553	lb			
Axial Segment Weight = $W_e\, L \sin\theta$ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**19,039**	**lb**			
Total Pulling Load =	**68,621**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	350.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = $W_e\, L\, \mu$ =	11,562	lb
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	6,614	lb
Axial Segment Weight = $W_e\, L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**18,176**	**lb**
Total Pulling Load =	**86,797**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 235.6 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 96,943 lb
Radius of Curvature, R = 1,350 ft
Effective Weight, $W_e = W + W_b - W_m$ = -109.8 lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ = 5.14 ft

$j = [(E\,I) / T]^{1/2}$ = 602

$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ = 7.1E+05

$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ = 411.11

$U = (12\,L) / j$ = 4.69

$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ = 30,178 lb

Bending Frictional Drag = $2\,\mu\,N$ = 18,107 lb

Fluidic Drag = $12\,\pi\,D\,L\,C_d$ = 4,441 lb

Axial Segment Weight = $W_e\,L\sin\theta$ = -2,256 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 20,293 lb
Total Pulling Load = 107,090 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 491.3 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -109.8 lb/ft

Frictional Drag = $W_e\,L\,\mu\cos\theta$ = 15,945 lb

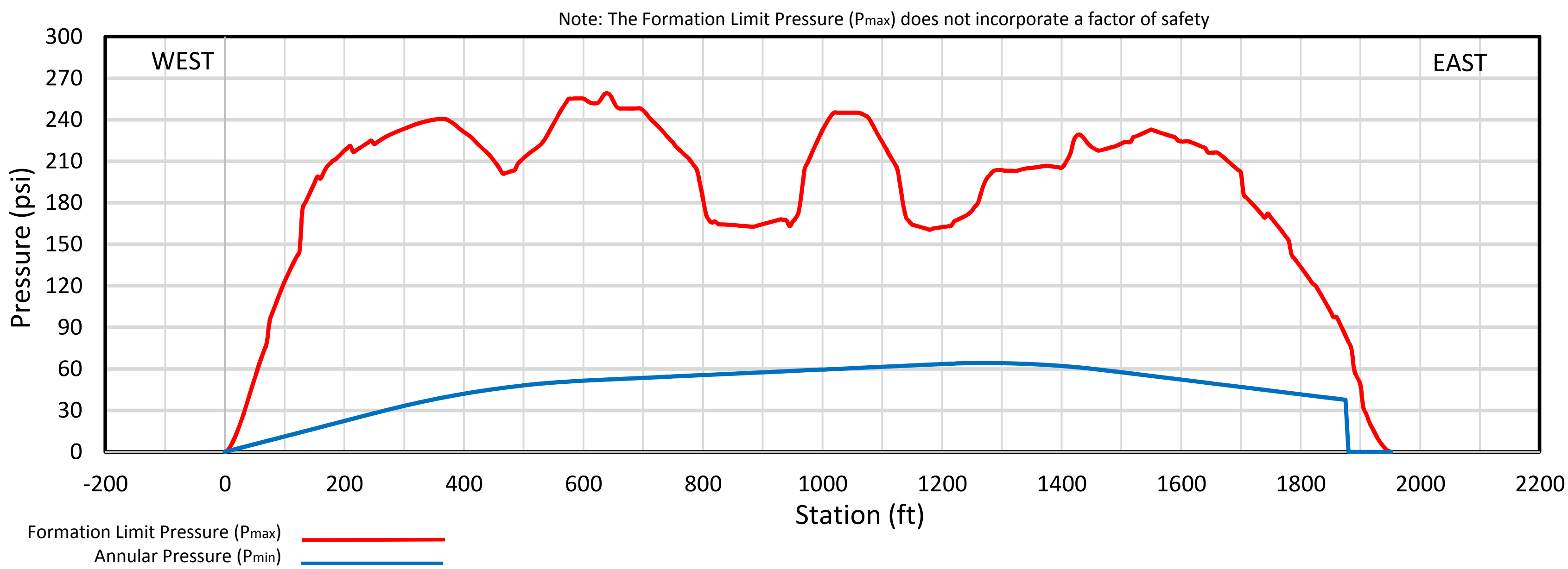
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ = 9,262 lb

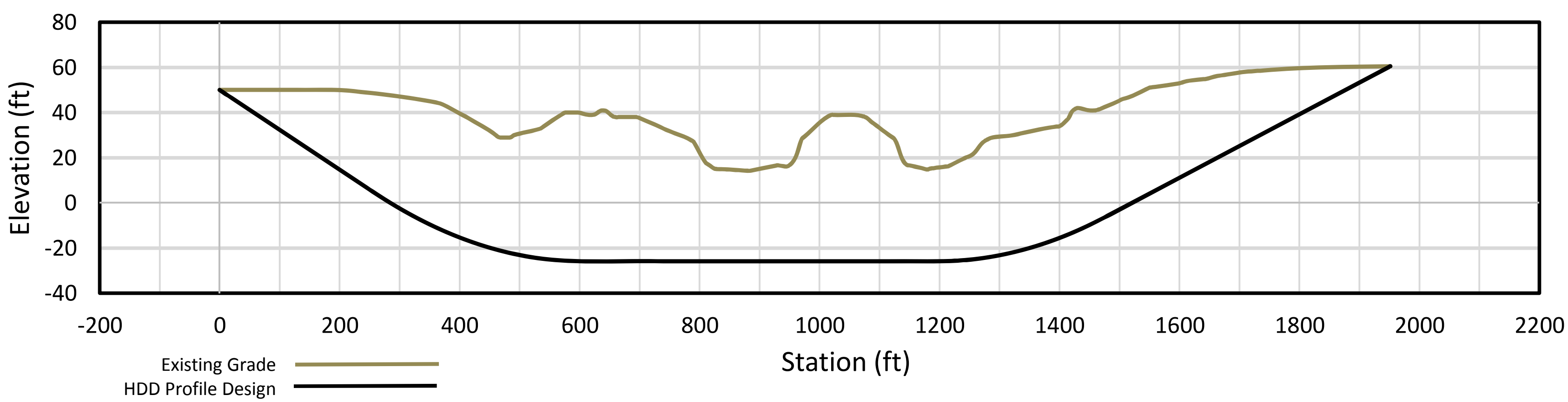
Axial Segment Weight = $W_e\,L\sin\theta$ = -9,372 lb — Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 15,835 lb
Total Pulling Load = 122,924 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	4,860	ok	0	ok	0	ok	0.08	ok	0.01	ok
	4,234	ok	0	ok	1294	ok	0.07	ok	0.04	ok
PC										
	4,234	ok	17,901	ok	1294	ok	0.46	ok	0.22	ok
	3,432	ok	17,901	ok	1605	ok	0.45	ok	0.23	ok
PT										
	3,432	ok	0	ok	1605	ok	0.05	ok	0.06	ok
	2,713	ok	0	ok	1605	ok	0.04	ok	0.06	ok
PC										
	2,713	ok	17,901	ok	1605	ok	0.44	ok	0.22	ok
	1,960	ok	17,901	ok	1406	ok	0.42	ok	0.20	ok
PT										
	1,960	ok	0	ok	1406	ok	0.03	ok	0.04	ok
Exit Point	0	ok	0	ok	-162	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

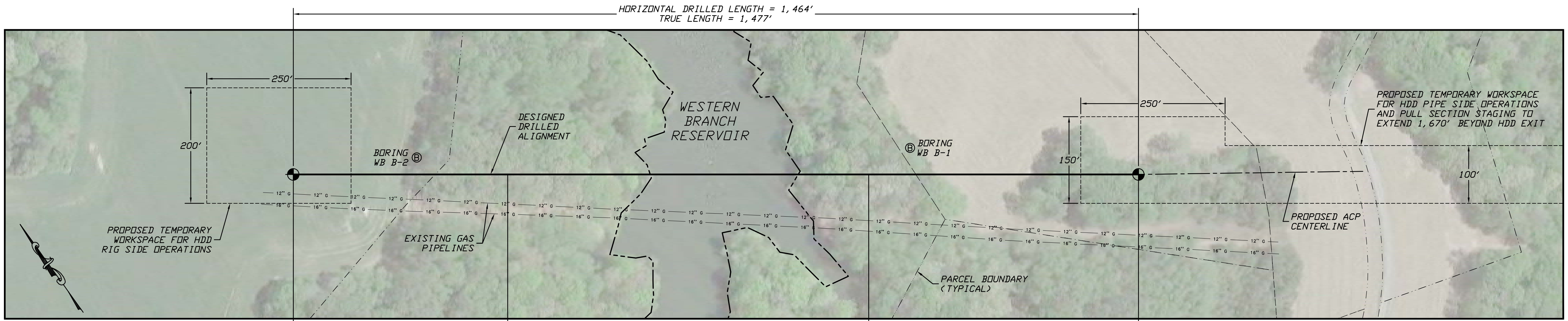
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH LAKE PRINCE CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 7/12/2016 Revision: 0

Western Branch Reservoir

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

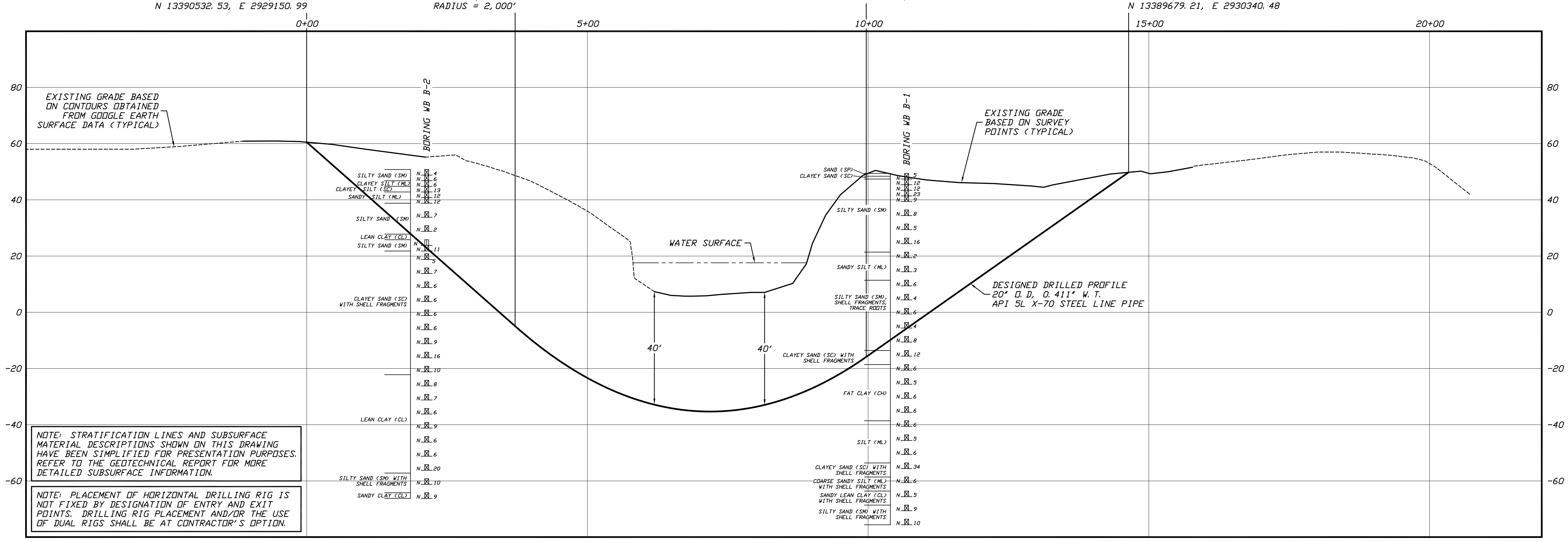
SCALE: 1"=100'

ENTRY POINT @ 10°
0+00.00, 60.51
N 13390532.53, E 2929150.99

P.C. 18° SAG BEND
3+71.17, -4.93
RADIUS = 2,000'

P.T. 18° SAG BEND
9+96.82, -15.85

EXIT POINT @ 8°
14+63.91, 49.79
N 13389679.21, E 2930340.48



PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

Ⓑ BORING LOCATION

SPLIT SPOON SAMPLE

53 ⊠ 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
└ PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

SHELBY TUBE SAMPLE

53 ▯
└ PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 15 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF WESTERN BRANCH RESERVOIR BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: SUFFOLK, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	05/20/16	ACM	JSP	SHOWN FOR D-SIZED PLOT	WB RESERVOIR	1

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.
1	06/10/16	REVISE GEOTECHNICAL LEGEND	JSP	JSP	JSP

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-063

Western Branch Reservoir R1 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	ACM
Crossing :	20" Western Branch Reservoir Crossing	Date :	6/15/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer, up to 11' deeper than design with 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

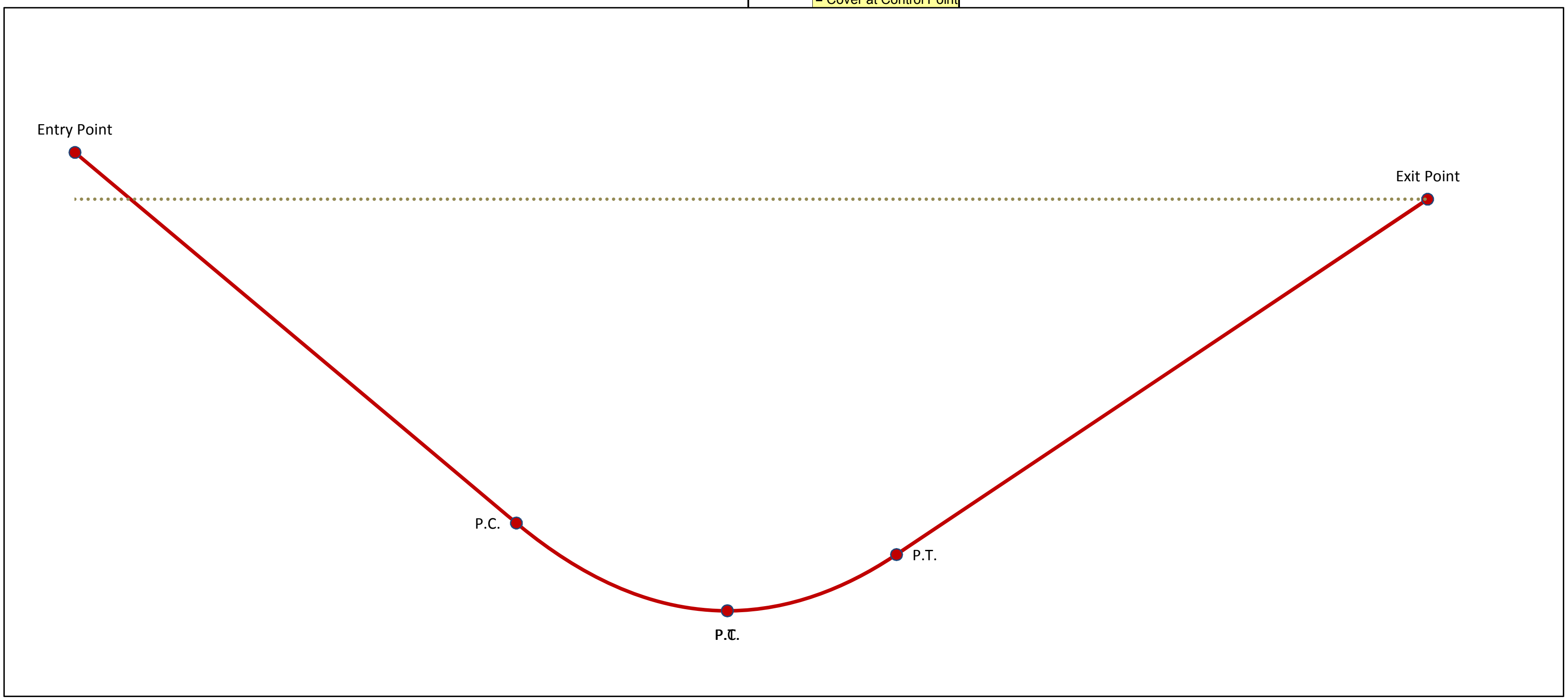
Western Branch Reservoir R1 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	60.67	10.00				93,043
Entry Tangent						498.42		
Entry Sag Bend	PC	480.85	-25.88					76,980
	PI	597.17	-46.39	10.00	1350	235.62	67,685	
	PT	715.28	-46.39				0	58,390
Bottom Tangent				0.00		0.09		
Exit Sag Bend	PC	715.37	-46.39					58,385
	PI	809.77	-46.39	8.00	1350	188.50	49,105	
	PT	903.25	-33.25				0	39,825
Exit Tangent						596.47		
Exit Point		1493.91	49.76	8.00	Above Ground Load			0
Drilling Mud			49.76	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Step 2, Drilled Path Input

Western Branch Reservoir R1 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	596.5	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	19,464	lb
Fluidic Drag = 12 π D L C_d =	11,243	lb
Axial Segment Weight = W_e L sinθ =	9,118	lb
Pulling Load on Exit Tangent =	**39,825**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	49,105	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

h = R [1 - cos(α/2)] =	3.29	ft	$j = [(E\ I) / T]^{1/2}$ =	846	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	2.8E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	196.96	
U = (12 L) / j =	2.67		N = [(T h) - W_e cosθ (Y/144)] / (X / 12)	22,605	lb
Bending Frictional Drag = 2 μ N =	13,563	lb			
Fluidic Drag = 12 π D L C_d =	3,553	lb			
Axial Segment Weight = W_e L sinθ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**18,560**	**lb**			
Total Pulling Load =	**58,385**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.1	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = W_e L μ =	3	lb
Fluidic Drag = 12 π D L C_d =	2	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**5**	**lb**
Total Pulling Load =	**58,390**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	67,685	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E\,I) / T]^{1/2}$ =	721	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	6.2E+05		$X = (3\,L) - [\,(j/2)\tanh(U/2)\,]$ =	360.37	
$U = (12\,L) / j$ =	3.92		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X/12)$ =	27,341	lb
Bending Frictional Drag = $2\,\mu\,N$ =	16,405	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	4,441	lb			
Axial Segment Weight = $W_e\,L \sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**18,590**	**lb**			
Total Pulling Load =	**76,980**	**lb**			

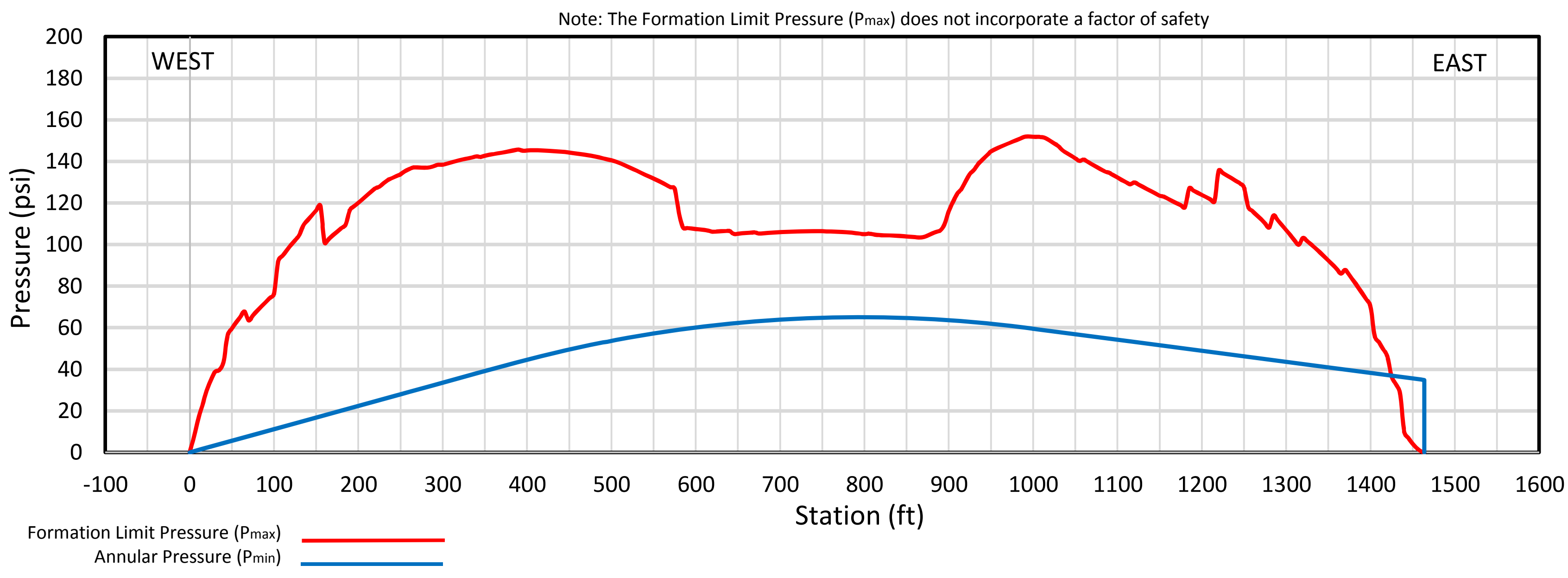
Entry Tangent - Summary of Pulling Load Calculations

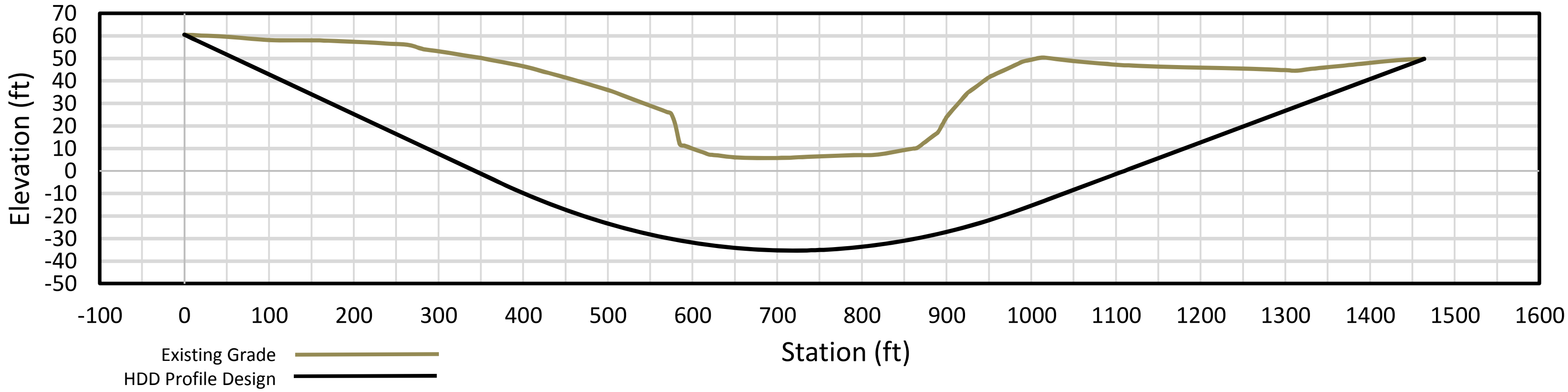
Segment Length, L =	498.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu \cos\theta$ =	16,175	lb	
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	9,395	lb	
Axial Segment Weight = $W_e\,L \sin\theta$ =	-9,507	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**16,063**	**lb**	
Total Pulling Load =	**93,043**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	3,679	ok	0	ok	0	ok	0.06	ok	0.00	ok
	3,044	ok	0	ok	1147	ok	0.05	ok	0.03	ok
PC										
	3,044	ok	17,901	ok	1147	ok	0.44	ok	0.19	ok
	2,309	ok	17,901	ok	1458	ok	0.43	ok	0.20	ok
PT										
	2,309	ok	0	ok	1458	ok	0.04	ok	0.05	ok
	2,308	ok	0	ok	1458	ok	0.04	ok	0.05	ok
PC										
	2,308	ok	17,901	ok	1458	ok	0.43	ok	0.20	ok
	1,575	ok	17,901	ok	1259	ok	0.42	ok	0.18	ok
PT										
	1,575	ok	0	ok	1259	ok	0.02	ok	0.03	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH WESTERN BRANCH RESERVOIR CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 6/16/2015 Revision: 1

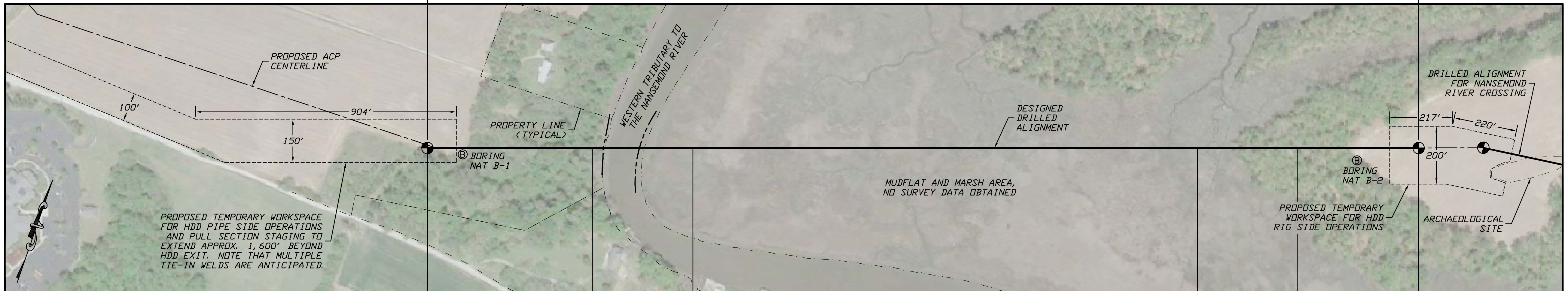
J.D.Hair&Associates, Inc.

Nansemond River Tributary

<u>Supporting Information</u>

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)

HORIZONTAL DRILLED LENGTH = 3,435'
TRUE LENGTH = 3,454'



PLAN

SCALE: 1"=200'

EXIT POINT @ 10° 34+35.33, 48.41 N 13388704.69, E 2934780.08

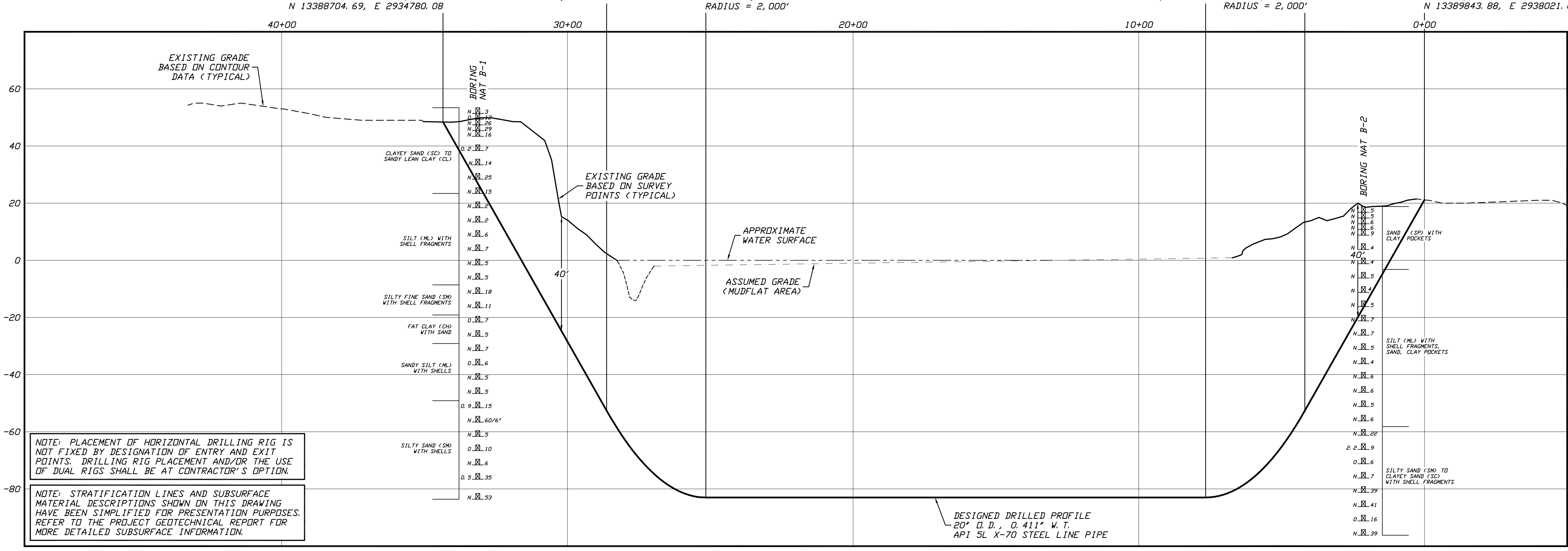
P.T. 10° SAG BEND 28+62.40, -52.62

P.C. 10° SAG BEND 25+15.11, -83.00 RADIUS = 2,000'

P.T. 10° SAG BEND 7+65.73, -83.00

P.C. 10° SAG BEND 4+18.43, -52.62 RADIUS = 2,000'

ENTRY POINT @ 10° 0+00.00, 21.16 N 13389843.88, E 2938021.03



PROFILE

SCALE: 1"=200' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 ⊠ 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

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1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

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3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF THE NANSEMOND RIVER TRIB. BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: SUFFOLK, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	04/08/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	NANSEMOND TRIB	2

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.
2	06/10/16	UPDATED RIG SIDE WORKSPACE	ACM	JSP	JSP
1	04/29/16	LOWER DESIGN TO REDUCE RISK OF INAD. RETURNS	KMN	ACM	JSP

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2424 East 21st Street
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Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-064

Nansemond Tributary R1 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	JSP
Crossing :	20" Nansemond Tributary Crossing	Date :	4/29/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

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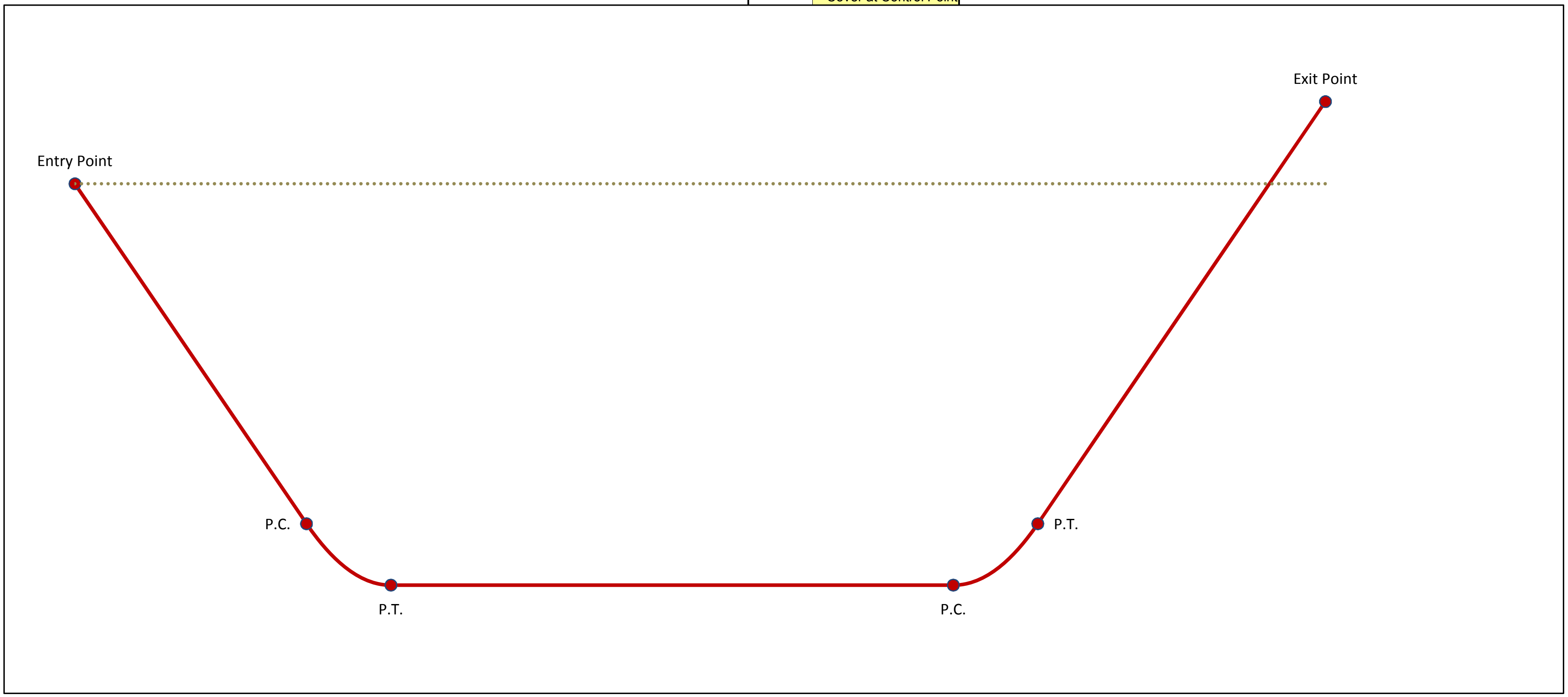
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	21.06	10.00				207,053
Entry Tangent						653.93		
Entry Sag Bend	PC	633.99	-92.49					185,978
	PI	750.31	-113.00	10.00	1350	235.62	173,618	
	PT	868.42	-113.00				0	161,257
Bottom Tangent				0.00		1563.09		
Exit Sag Bend	PC	2431.51	-113.00					80,286
	PI	2549.62	-113.00	10.00	1350	235.62	68,706	
	PT	2665.94	-92.49				0	57,125
Exit Tangent						811.73		
Exit Point		3465.33	48.47	10.00	Above Ground Load			0
Drilling Mud			21.06	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Nansemond Tributary R1 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	811.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	10.0	°			

Frictional Drag = W_e L μ cosθ =	26,342	lb
Fluidic Drag = 12 π D L C_d =	15,301	lb
Axial Segment Weight = W_e L sinθ =	15,483	lb
Pulling Load on Exit Tangent =	**57,125**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	68,706	lb
Segment Angle with Horizontal, θ =	-10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

h = R [1 - cos(α/2)] =	5.14	ft	$j = [(E\ I) / T]^{1/2}$ =	716	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	6.3E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	362.56	
U = (12 L) / j =	3.95		N = [(T h) - W_e cosθ (Y/144)] / (X / 12) =	27,440	lb
Bending Frictional Drag = 2 μ N =	16,464	lb			
Fluidic Drag = 12 π D L C_d =	4,441	lb			
Axial Segment Weight = W_e L sinθ =	2,256	lb			
Pulling Load on Exit Sag Bend =	**23,161**	**lb**			
Total Pulling Load =	**80,286**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	1563.1	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = W_e L μ =	51,507	lb
Fluidic Drag = 12 π D L C_d =	29,464	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**80,971**	**lb**
Total Pulling Load =	**161,257**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	173,618	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E I) / T]^{1/2}$ =	450	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	8.1E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	482.62	
$U = (12 L) / j$ =	6.28		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	37,559	lb
Bending Frictional Drag = $2 \mu N$ =	22,535	lb			
Fluidic Drag = $12 \pi D L C_d$ =	4,441	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**24,721**	**lb**			
Total Pulling Load =	**185,978**	**lb**			

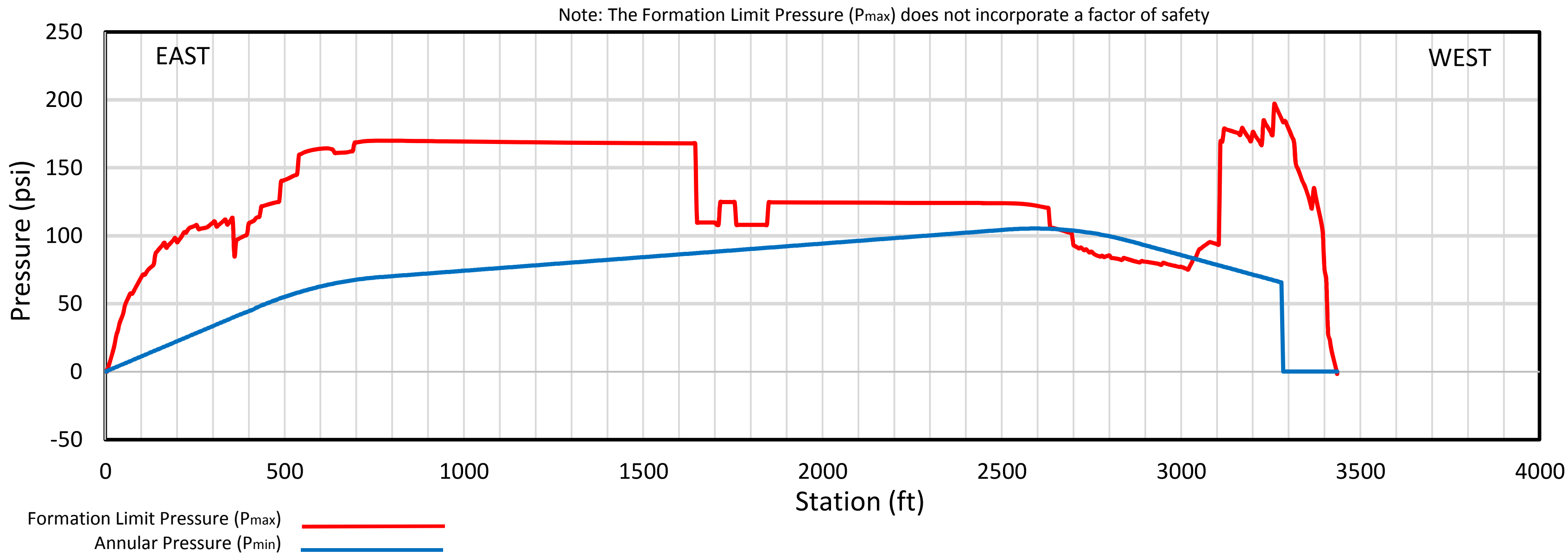
Entry Tangent - Summary of Pulling Load Calculations

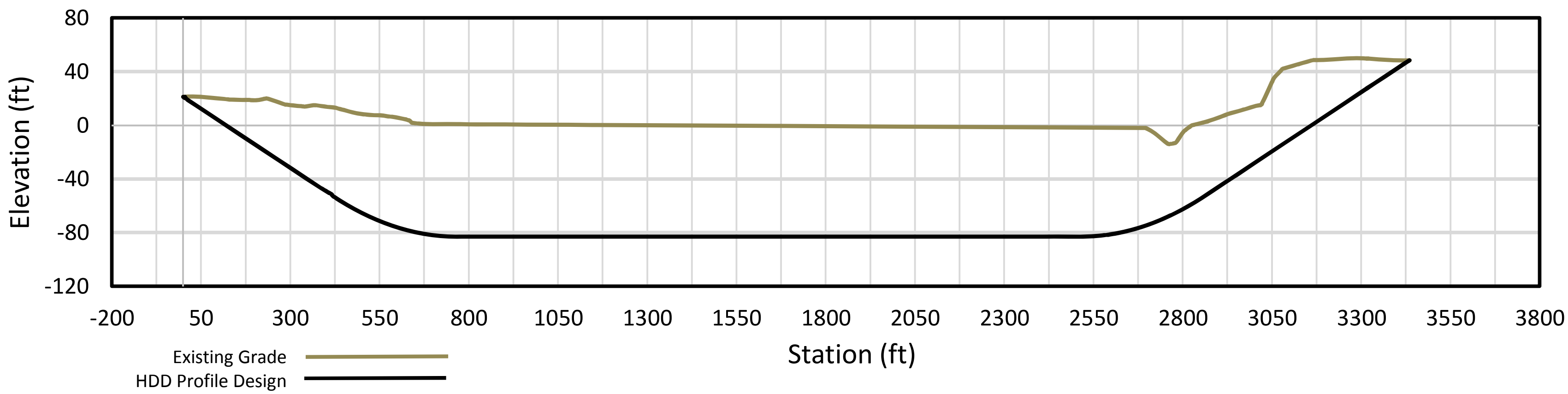
Segment Length, L =	653.9	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	21,221	lb	
Fluidic Drag = $12 \pi D L C_d$ =	12,326	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-12,473	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**21,074**	**lb**	
Total Pulling Load =	**207,053**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	8,186	ok	0	ok	0	ok	0.13	ok	0.02	ok
	7,353	ok	0	ok	1722	ok	0.12	ok	0.09	ok
PC										
	7,353	ok	17,901	ok	1722	ok	0.51	ok	0.31	ok
	6,376	ok	17,901	ok	2033	ok	0.49	ok	0.32	ok
PT										
	6,376	ok	0	ok	2033	ok	0.10	ok	0.11	ok
	3,174	ok	0	ok	2033	ok	0.05	ok	0.09	ok
PC										
	3,174	ok	17,901	ok	2033	ok	0.44	ok	0.27	ok
	2,259	ok	17,901	ok	1722	ok	0.43	ok	0.23	ok
PT										
	2,259	ok	0	ok	1722	ok	0.04	ok	0.06	ok
Exit Point	0	ok	0	ok	-416	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
NANSEMOND TRIB. CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

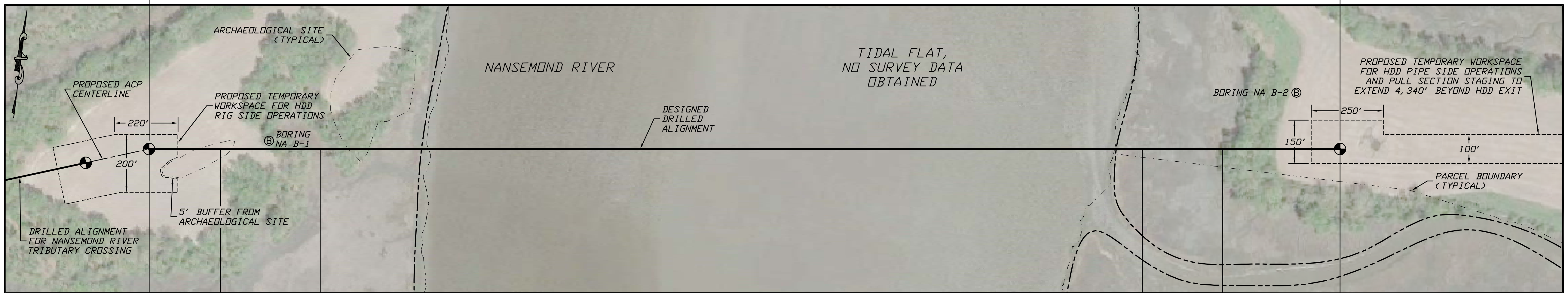
Date: 4/19/2016 Revision: 1

Nansemond River

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)

HORIZONTAL DRILLED LENGTH = 4,127'
TRUE LENGTH = 4,138'



PLAN

SCALE: 1"=200'

ENTRY POINT @ 10°
0+00.00, 20.00
N 13389919.29, E 2938232.57

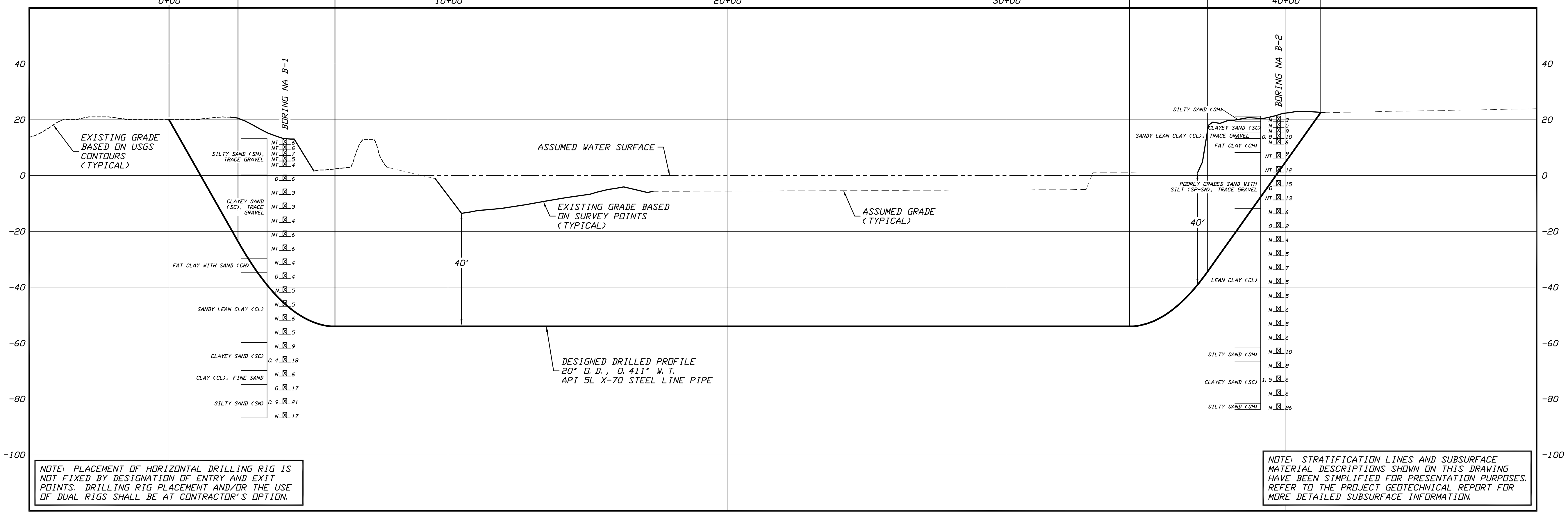
P.C. 10° SAG BEND
2+47.36, -23.62
RADIUS = 2,000'

P.T. 10° SAG BEND
5+94.65, -54.00

P.C. 8° SAG BEND
34+41.88, -54.00
RADIUS = 2,000'

P.T. 8° SAG BEND
37+20.23, -34.54

EXIT POINT @ 8°
41+27.10, 22.65
N 13390444.72, E 2942326.09



PROFILE

SCALE: 1"=200' HORIZONTAL
1"= 20' VERTICAL

400 200 100 0
20 10 0

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE GEOTECHNICAL SITE INVESTIGATION REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF THE NANSEMOND RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: SUFFOLK, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	06/03/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	NANSEMOND	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-065

Nansemond River R0 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	20" Nansemond River Crossing	Date :	7/22/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

Nansemond River R0 Installation Stress Analysis (worst-case).xlsm
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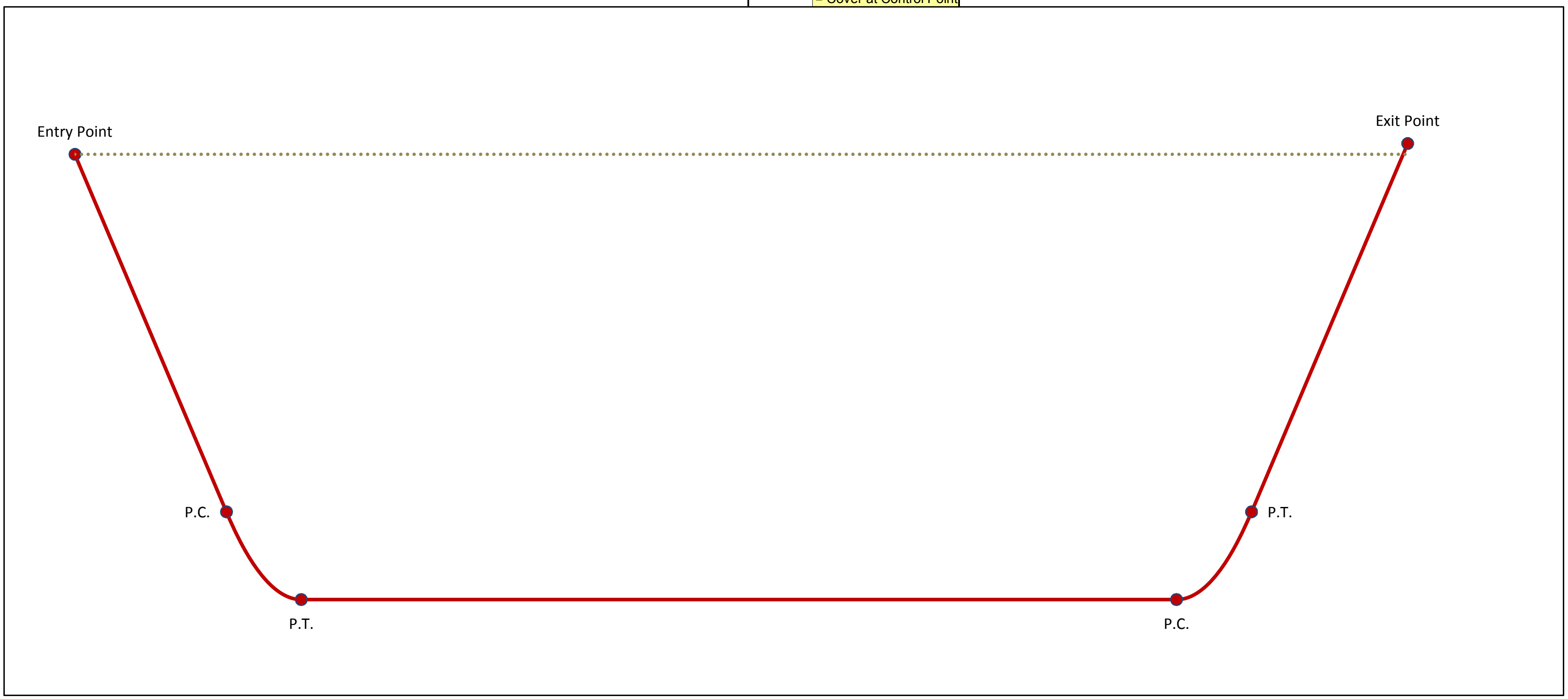
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	20.00	10.00				240,879
Entry Tangent						480.80		
Entry Sag Bend	PC	463.50	-63.49					225,384
	PI	579.81	-84.00	10.00	1350	235.62	211,924	
	PT	697.92	-84.00				0	198,465
Bottom Tangent				0.00		2736.68		
Exit Sag Bend	PC	3434.60	-84.00					56,700
	PI	3552.71	-84.00	10.00	1350	235.62	45,789	
	PT	3669.03	-63.49				0	34,878
Exit Tangent						495.60		
Exit Point		4157.10	22.57	10.00	Above Ground Load			0
Drilling Mud			20.00	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

	= Cover at Control Point



Step 2, Drilled Path Input

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	495.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	10.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	16,083	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	9,342	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	9,453	lb
Pulling Load on Exit Tangent =	**34,878**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	45,789	lb
Segment Angle with Horizontal, θ =	-10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E\ I) / T]^{1/2}$ =	877	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	5.3E+05		$X = (3\ L) - [\,(j / 2) \tanh(U/2)\,]$ =	302.07	
$U = (12\ L) / j$ =	3.23		$N = [(T\ h) - W_e \cos\theta\,(Y/144)] / (X / 12)$	25,209	lb
Bending Frictional Drag = $2\ \mu\ N$ =	15,125	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	4,441	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	2,256	lb			
Pulling Load on Exit Sag Bend =	**21,822**	**lb**			
Total Pulling Load =	**56,700**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	2736.7	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = $W_e\ L\ \mu$ =	90,179	lb
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	51,585	lb
Axial Segment Weight = $W_e\ L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**141,765**	**lb**
Total Pulling Load =	**198,465**	**lb**

Nansemond River R0 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	211,924	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R [1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E\ I) / T]^{1/2}$ =	407	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	8.4E+05		$X = (3 L) - [(j / 2) \tanh(U/2)]$ =	503.53	
$U = (12 L) / j$ =	6.94		$N = [(T h) - W_e \cos\theta (Y/144)] / (X / 12)$ =	41,223	lb
Bending Frictional Drag = $2 \mu N$ =	24,734	lb			
Fluidic Drag = $12 \pi D L C_d$ =	4,441	lb			
Axial Segment Weight = $W_e L \sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**26,919**	**lb**			
Total Pulling Load =	**225,384**	**lb**			

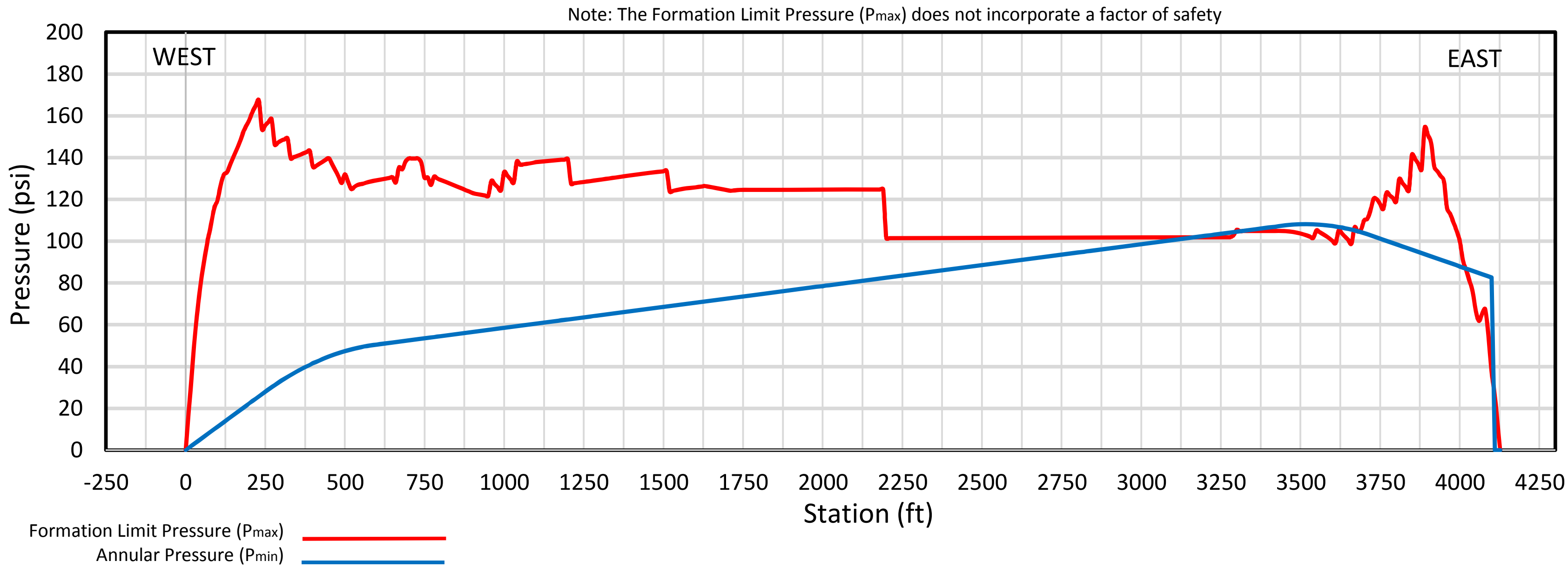
Entry Tangent - Summary of Pulling Load Calculations

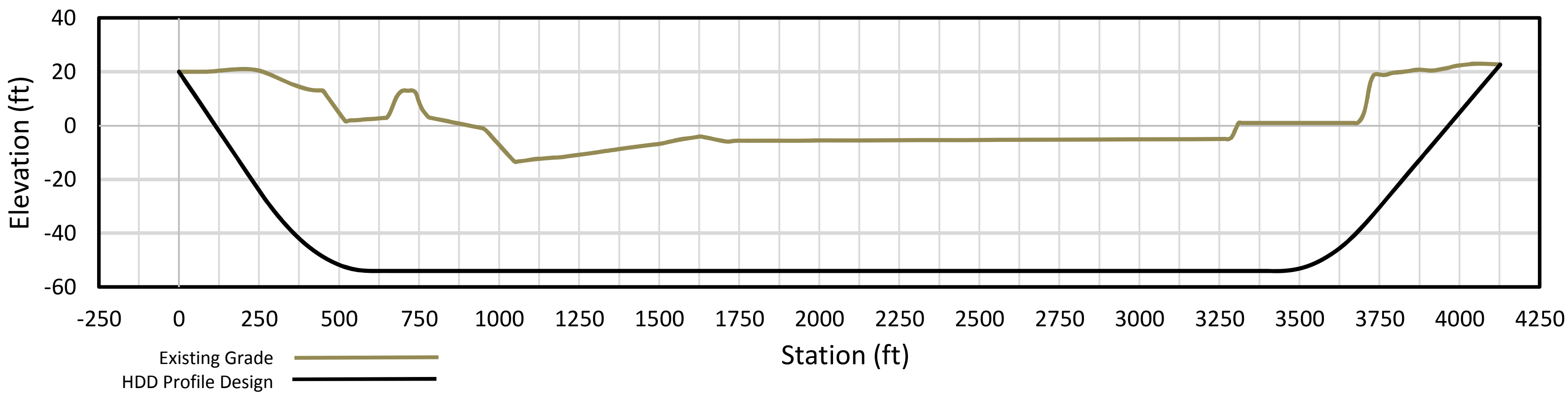
Segment Length, L =	480.8	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e L \mu \cos\theta$ =	15,603	lb	
Fluidic Drag = $12 \pi D L C_d$ =	9,063	lb	
Axial Segment Weight = $W_e L \sin\theta$ =	-9,171	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**15,495**	**lb**	
Total Pulling Load =	**240,879**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	9,523	ok	0	ok	0	ok	0.15	ok	0.03	ok
	8,911	ok	0	ok	1266	ok	0.14	ok	0.07	ok
PC										
	8,911	ok	17,901	ok	1266	ok	0.53	ok	0.30	ok
	7,847	ok	17,901	ok	1577	ok	0.52	ok	0.31	ok
PT										
	7,847	ok	0	ok	1577	ok	0.12	ok	0.08	ok
	2,242	ok	0	ok	1577	ok	0.04	ok	0.05	ok
PC										
	2,242	ok	17,901	ok	1577	ok	0.43	ok	0.21	ok
	1,379	ok	17,901	ok	1266	ok	0.41	ok	0.18	ok
PT										
	1,379	ok	0	ok	1266	ok	0.02	ok	0.03	ok
Exit Point	0	ok	0	ok	-39	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

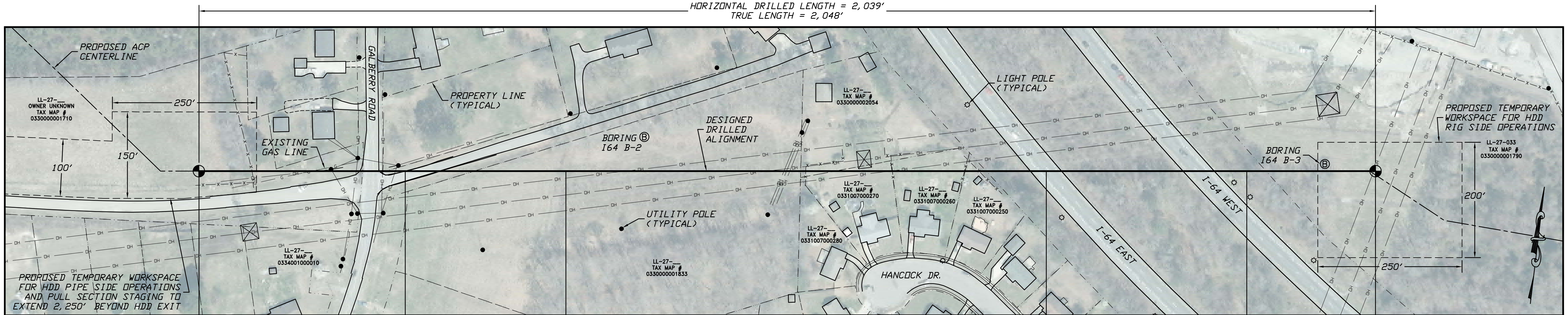
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH NANSEMOND RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 5/31/2016 Revision: 0

Interstate 64

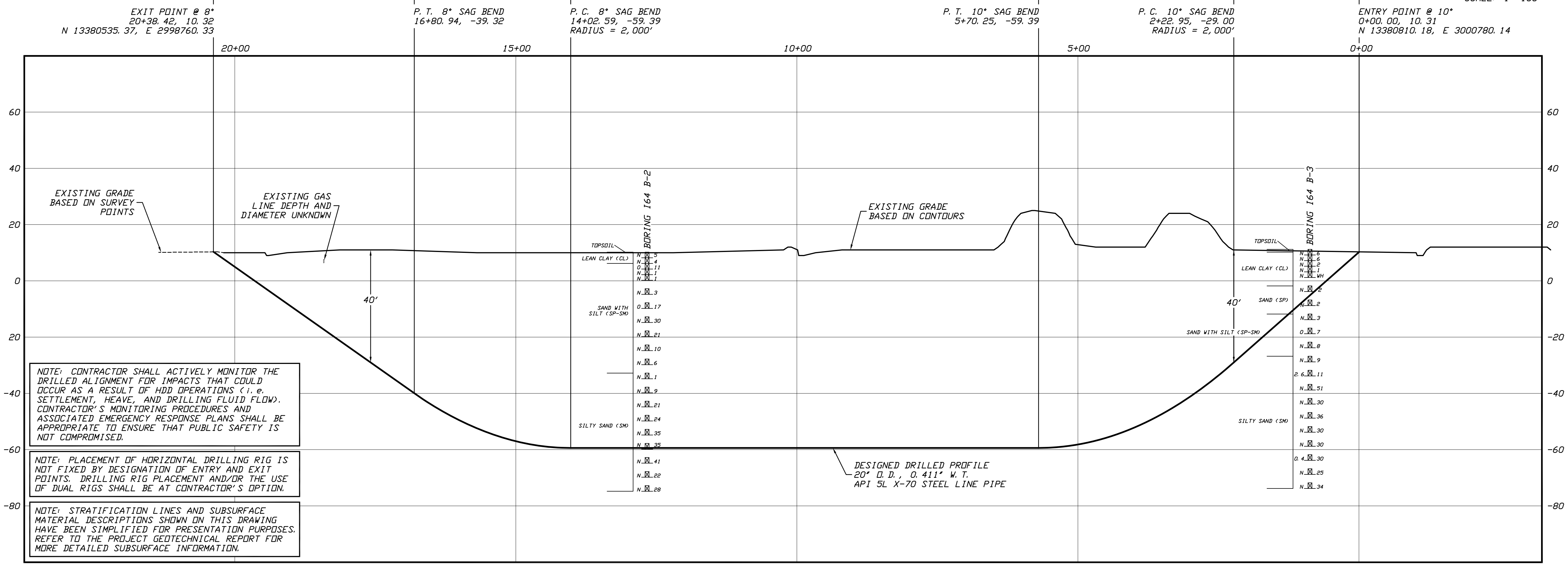
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=100'



NOTE: CONTRACTOR SHALL ACTIVELY MONITOR THE DRILLED ALIGNMENT FOR IMPACTS THAT COULD OCCUR AS A RESULT OF HDD OPERATIONS (i.e. SETTLEMENT, HEAVE, AND DRILLING FLUID FLOW). CONTRACTOR'S MONITORING PROCEDURES AND ASSOCIATED EMERGENCY RESPONSE PLANS SHALL BE APPROPRIATE TO ENSURE THAT PUBLIC SAFETY IS NOT COMPROMISED.

NOTE: PLACEMENT OF HORIZONTAL DRILLING RIG IS NOT FIXED BY DESIGNATION OF ENTRY AND EXIT POINTS. DRILLING RIG PLACEMENT AND/OR THE USE OF DUAL RIGS SHALL BE AT CONTRACTOR'S OPTION.

NOTE: STRATIFICATION LINES AND SUBSURFACE MATERIAL DESCRIPTIONS SHOWN ON THIS DRAWING HAVE BEEN SIMPLIFIED FOR PRESENTATION PURPOSES. REFER TO THE PROJECT GEOTECHNICAL REPORT FOR MORE DETAILED SUBSURFACE INFORMATION.

PROFILE

SCALE: 1"=100' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

Ⓑ BORING LOCATION

SPLIT SPOON SAMPLE

53.⊠.23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES; PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE PROJECT GEOTECHNICAL REPORT DATED DECEMBER 2015 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS:

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF INTERSTATE 64
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: CHESAPEAKE, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	03/31/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	INTERSTATE 64	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-078

Interstate 64 R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	20" Interstate 64 Crossing	Date :	7/22/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

Interstate 64 R0 Installation Stress Analysis (worst-case).xlsm

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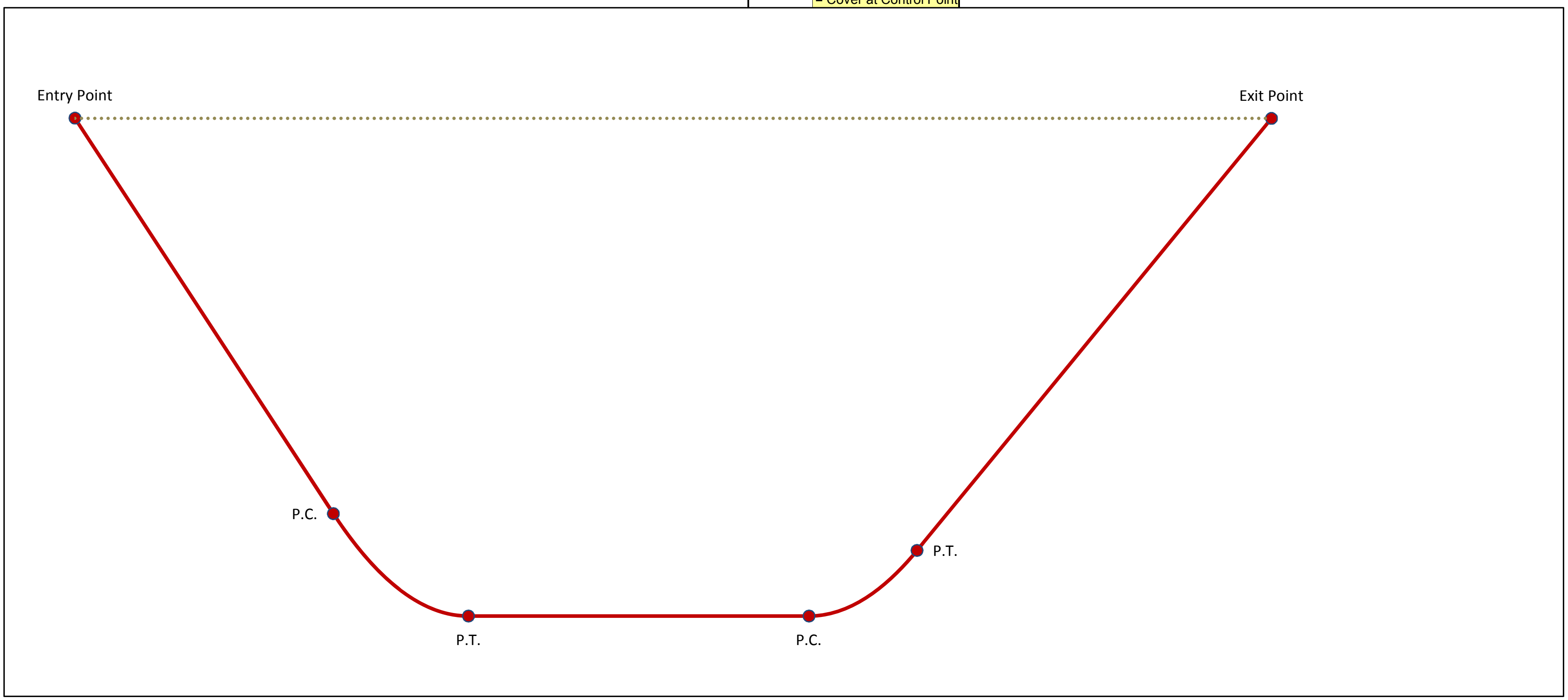
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	10.31	10.00				126,012
Entry Tangent						456.04		
Entry Sag Bend	PC	439.11	-68.88					111,315
	PI	555.43	-89.39	10.00	1350	235.62	101,049	
	PT	673.54	-89.39				0	90,784
Bottom Tangent				0.00		591.44		
Exit Sag Bend	PC	1264.97	-89.39					60,147
	PI	1359.37	-89.39	8.00	1350	188.50	50,825	
	PT	1452.86	-76.25				0	41,504
Exit Tangent						621.61		
Exit Point		2068.42	10.26	8.00	Above Ground Load			0
Drilling Mud			10.26	(Graph = ...)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

= Cover at Control Point



Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	621.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	20,284	lb
Fluidic Drag = 12 π D L C_d =	11,717	lb
Axial Segment Weight = W_e L sinθ =	9,503	lb
Pulling Load on Exit Tangent =	**41,504**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	50,825	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

h = R [1 - cos(α/2)] =	3.29	ft	$j = [(E\ I) / T]^{1/2}$ =	832	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	2.8E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	200.97	
U = (12 L) / j =	2.72		N = [(T h) - W_e cosθ (Y/144)] / (X / 12)	22,742	lb
Bending Frictional Drag = 2 μ N =	13,645	lb			
Fluidic Drag = 12 π D L C_d =	3,553	lb			
Axial Segment Weight = W_e L sinθ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**18,643**	**lb**			
Total Pulling Load =	**60,147**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	591.4	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = W_e L μ =	19,489	lb
Fluidic Drag = 12 π D L C_d =	11,148	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**30,637**	**lb**
Total Pulling Load =	**90,784**	**lb**

Interstate 64 R0 Installation Stress Analysis (worst-case).xlsm

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Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	101,049	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E\,I) / T]^{1/2}$ =	590	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	7.1E+05		$X = (3\,L) - [\,(j/2)\tanh(U/2)\,]$ =	416.68	
$U = (12\,L) / j$ =	4.79		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X/12)$ =	30,575	lb
Bending Frictional Drag = $2\,\mu\,N$ =	18,345	lb			
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	4,441	lb			
Axial Segment Weight = $W_e\,L\sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**20,531**	**lb**			
Total Pulling Load =	**111,315**	**lb**			

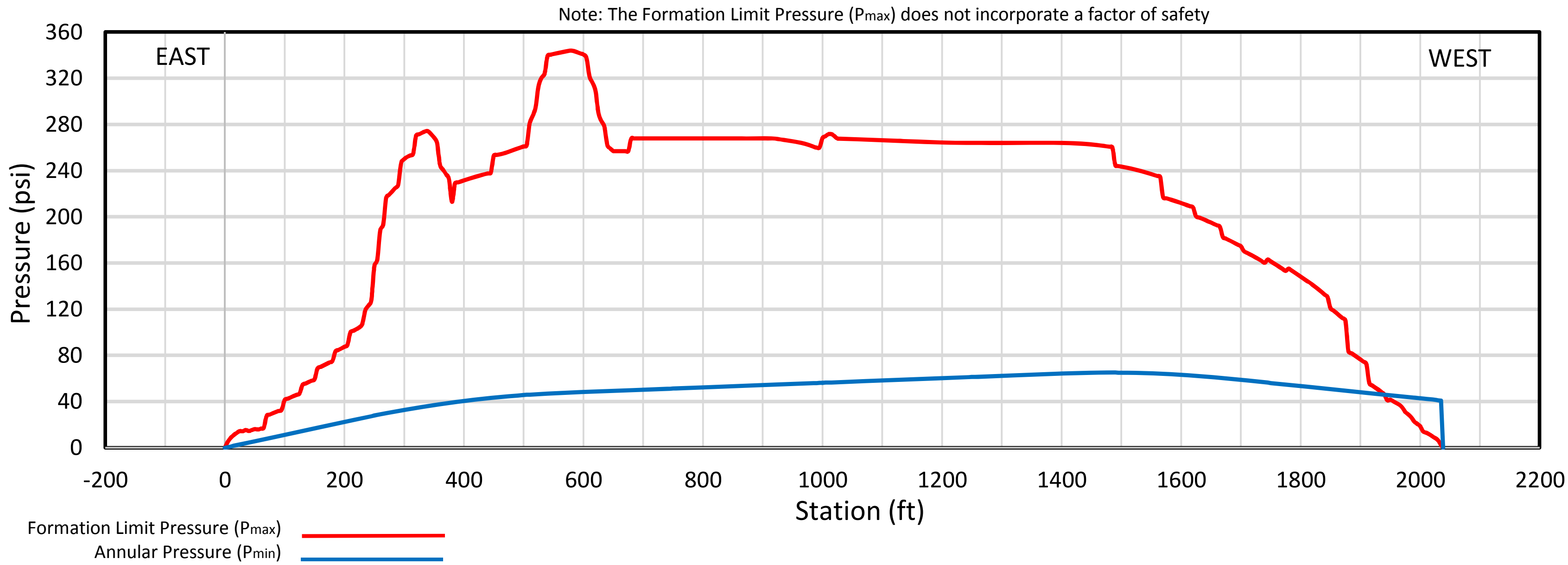
Entry Tangent - Summary of Pulling Load Calculations

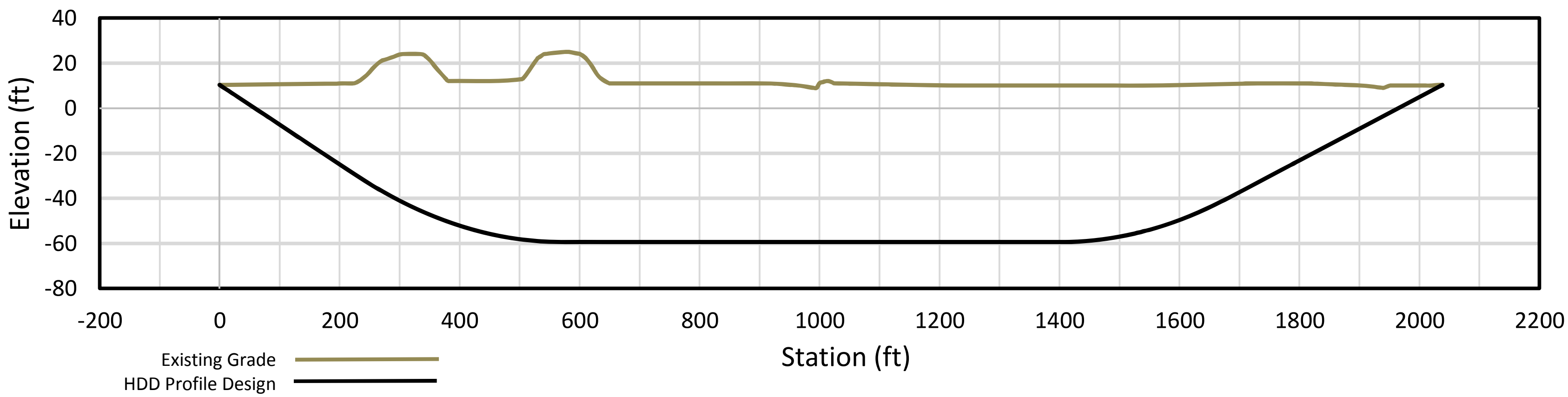
Segment Length, L =	456.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\,L\,\mu\cos\theta$ =	14,799	lb	
Fluidic Drag = $12\,\pi\,D\,L\,C_d$ =	8,596	lb	
Axial Segment Weight = $W_e\,L\sin\theta$ =	-8,698	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**14,697**	**lb**	
Total Pulling Load =	**126,012**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	4,982	ok	0	ok	0	ok	0.08	ok	0.01	ok
	4,401	ok	0	ok	1200	ok	0.07	ok	0.04	ok
PC										
	4,401	ok	17,901	ok	1200	ok	0.46	ok	0.22	ok
	3,589	ok	17,901	ok	1511	ok	0.45	ok	0.23	ok
PT										
	3,589	ok	0	ok	1511	ok	0.06	ok	0.05	ok
	2,378	ok	0	ok	1511	ok	0.04	ok	0.05	ok
PC										
	2,378	ok	17,901	ok	1511	ok	0.43	ok	0.21	ok
	1,641	ok	17,901	ok	1312	ok	0.42	ok	0.18	ok
PT										
	1,641	ok	0	ok	1312	ok	0.03	ok	0.04	ok
Exit Point	0	ok	0	ok	0	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH INTERSTATE 64 CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 6/16/2015

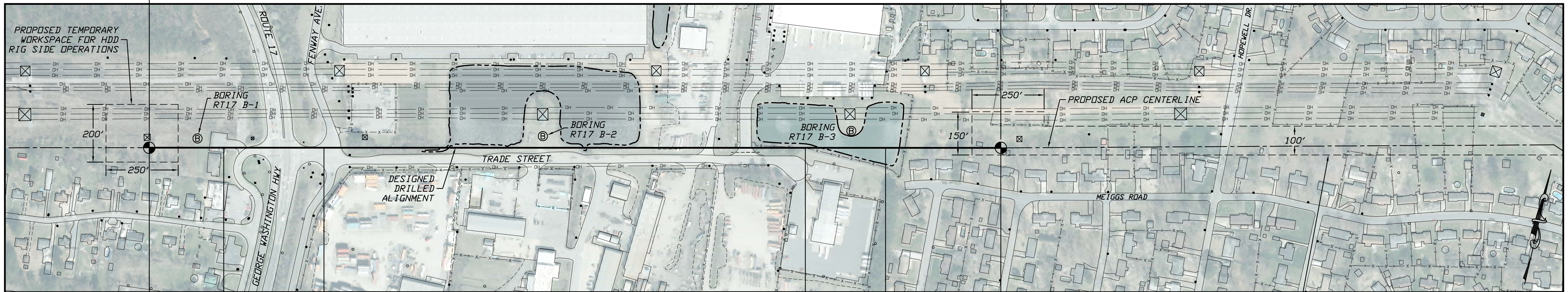
Revision: 0

Route 17

Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)

HORIZONTAL DRILLED LENGTH = 2,951'
TRUE LENGTH = 2,961'



PROPOSED TEMPORARY WORKSPACE FOR HDD PIPE SIDE OPERATIONS AND PULL SECTION STAGING TO EXTEND 3,150' BEYOND HDD EXIT

PLAN

SCALE: 1"=200'

ENTRY POINT @ 10° 0+00.00, 10.37 N 13381684.57, E 3003630.63

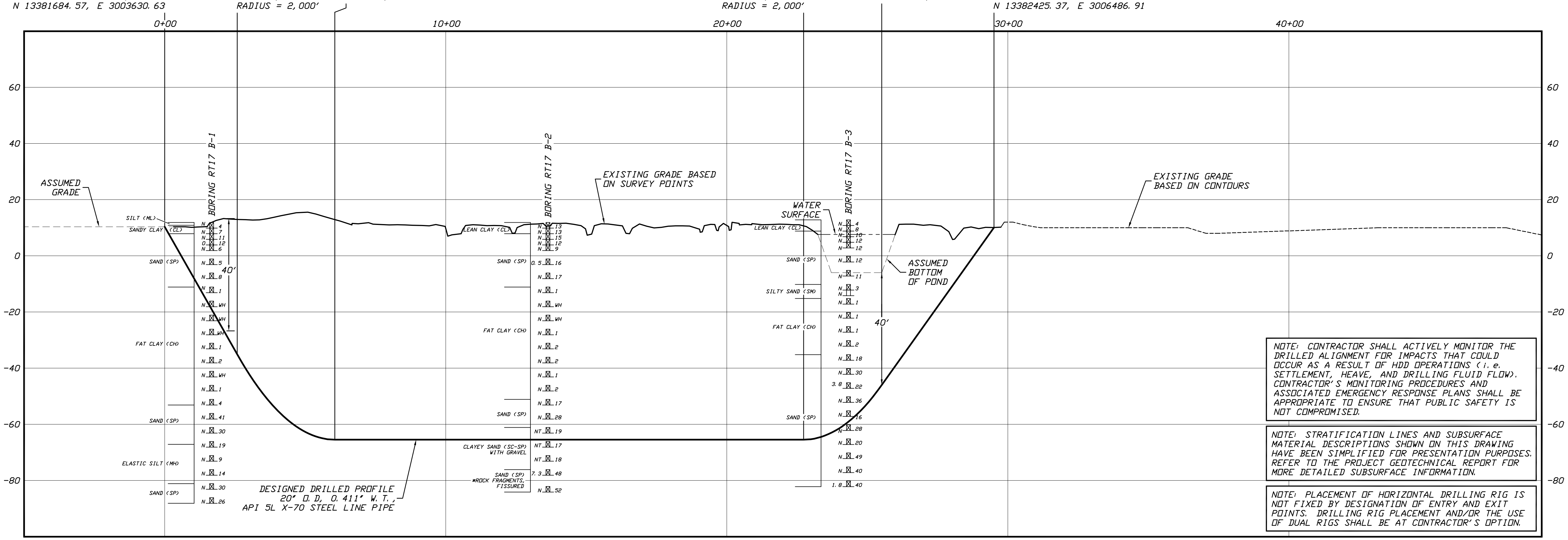
P.C. 10° SAG BEND 2+57.75, -35.08 RADIUS = 2,000'

P.T. 10° SAG BEND 6+05.05, -65.46

P.C. 8° SAG BEND 22+73.19, -65.46 RADIUS = 2,000'

P.T. 8° SAG BEND 25+51.54, -46.00

EXIT POINT @ 8° 29+50.78 10.11 N 13382425.37, E 3006486.91



PROFILE

SCALE: 1"=200' HORIZONTAL
1"= 20' VERTICAL

400 200 100 0

20 10 0

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

Ⓑ BORING LOCATION

SPLIT SPOON SAMPLE

53 ⊠ 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
— PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

SHELBY TUBE SAMPLE

53 — PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE PROJECT GEOTECHNICAL REPORT DATED DECEMBER 2015 FOR MORE DETAILED SUBSURFACE INFORMATION.
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1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS:

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE
20-INCH PIPELINE CROSSING OF ROUTE 17
BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: CHESAPEAKE, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	04/01/16	ACM	JSP	SHOWN FOR D-SIZED PLOT	ROUTE 17	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-079

Route 17 R0 Installation Stress Analysis (worst-case).xlsm

J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	20" Route 17 Crossing	Date :	7/22/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 30' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

Route 17 R0 Installation Stress Analysis (worst-case).xlsm

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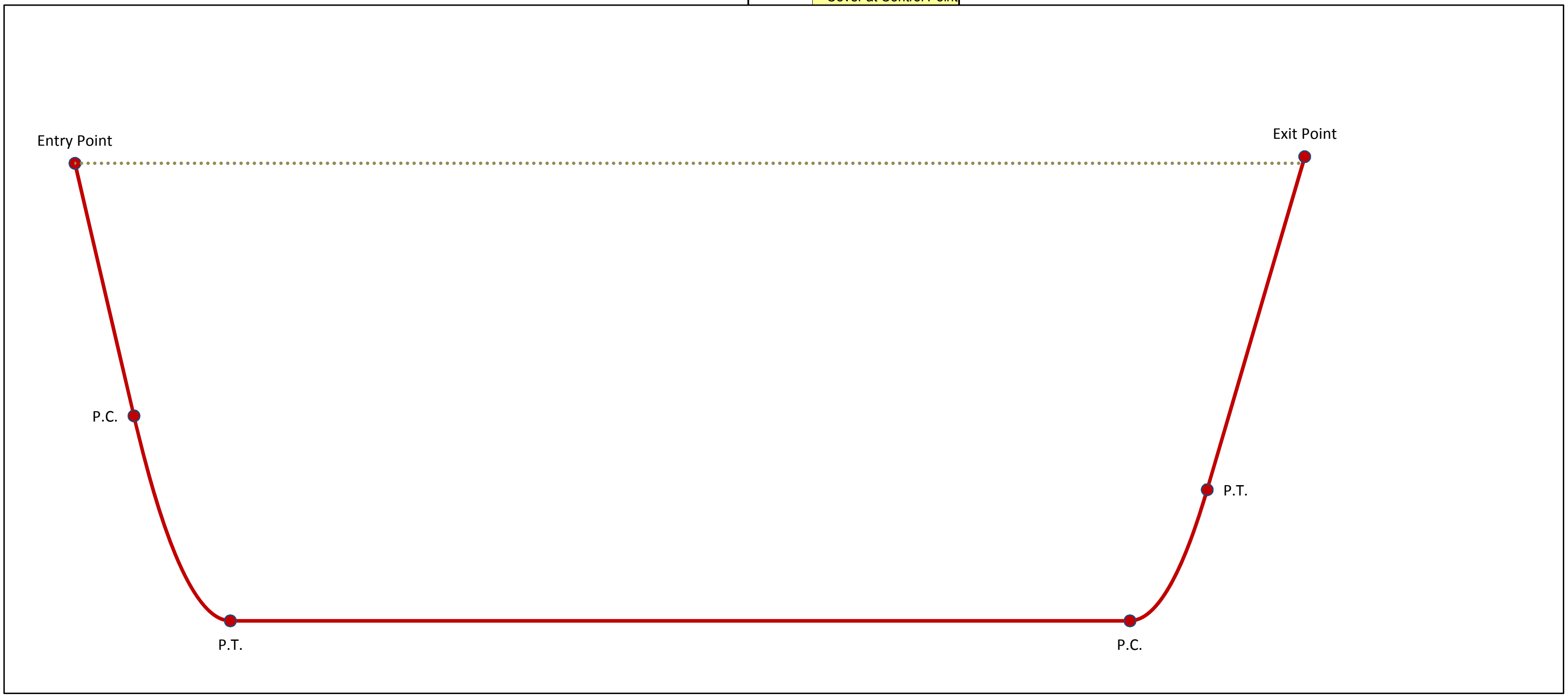
		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	10.37	10.00				175,267
Entry Tangent						145.81		
Entry Sag Bend	PC	133.60	-14.95					170,568
	PI	249.91	-35.46	10.00	1350	235.62	158,638	
	PT	368.02	-35.46				0	146,709
Bottom Tangent				0.00		2187.56		
Exit Sag Bend	PC	2555.59	-35.46					33,389
	PI	2649.99	-35.46	8.00	1350	188.50	24,695	
	PT	2743.47	-22.32				0	16,000
Exit Tangent						239.64		
Exit Point		2980.78	11.03	8.00	Above Ground Load			0
Drilling Mud			10.37	(Graph = ········)				
Ballast				(Graph = – – – –)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point
			= Cover at Control Point



Step 2, Drilled Path Input

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Route 17 R0 Installation Stress Analysis (worst-case).xlsm

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	239.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = W_e L μ cosθ =	7,820	lb
Fluidic Drag = 12 π D L C_d =	4,517	lb
Axial Segment Weight = W_e L sinθ =	3,663	lb
Pulling Load on Exit Tangent =	**16,000**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	24,695	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

h = R [1 - cos(α/2)] =	3.29	ft	$j = [(E\ I) / T]^{1/2}$ =	1,194	
$Y = [18 (L)^2] - [(j)^2 (1 - \cosh(U/2)^{-1}]$ =	1.8E+05		X = (3 L) - [(j / 2) tanh(U/2)] =	124.65	
U = (12 L) / j =	1.90		N = [(T h) - W_e cosθ (Y/144)] / (X / 12)	20,653	lb
Bending Frictional Drag = 2 μ N =	12,392	lb			
Fluidic Drag = 12 π D L C_d =	3,553	lb			
Axial Segment Weight = W_e L sinθ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**17,389**	**lb**			
Total Pulling Load =	**33,389**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	2187.6	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = W_e L μ =	72,085	lb
Fluidic Drag = 12 π D L C_d =	41,235	lb
Axial Segment Weight = W_e L sinθ =	0	lb
Pulling Load on Bottom Tangent =	**113,319**	**lb**
Total Pulling Load =	**146,709**	**lb**

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L = 235.6 ft
Segment Angle with Horizontal, θ = 10.0 °
Deflection Angle, α = 5.0 °

Average Tension, T = 158,638 lb
Radius of Curvature, R = 1,350 ft
Effective Weight, $W_e = W + W_b - W_m$ = -109.8 lb/ft

h = R [1 - cos(α/2)] = 5.14 ft

$j = [(E\ I) / T]^{1/2}$ = 471

$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ = 8.0E+05

$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ = 472.55

U = (12 L) / j = 6.00

$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ = 36,123 lb

Bending Frictional Drag = 2 μ N = 21,674 lb

Fluidic Drag = 12 π D L C_d = 4,441 lb

Axial Segment Weight = W_e L sinθ = -2,256 lb

Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Sag Bend = 23,859 lb
Total Pulling Load = 170,568 lb

Entry Tangent - Summary of Pulling Load Calculations

Segment Length, L = 145.8 ft
Entry Angle, θ = 10.0 °

Effective Weight, $W_e = W + W_b - W_m$ = -109.8 lb/ft

Frictional Drag = W_e L μ cosθ = 4,732 lb

Fluidic Drag = 12 π D L C_d = 2,749 lb

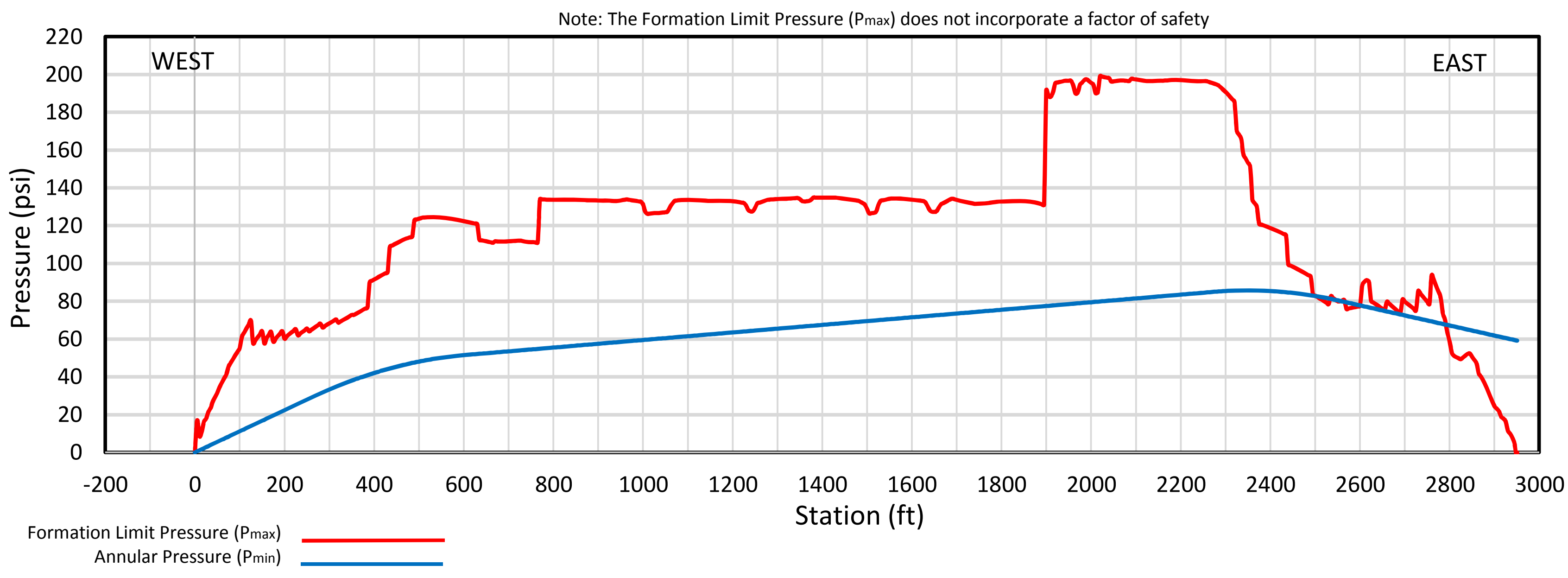
Axial Segment Weight = W_e L sinθ = -2,781 lb

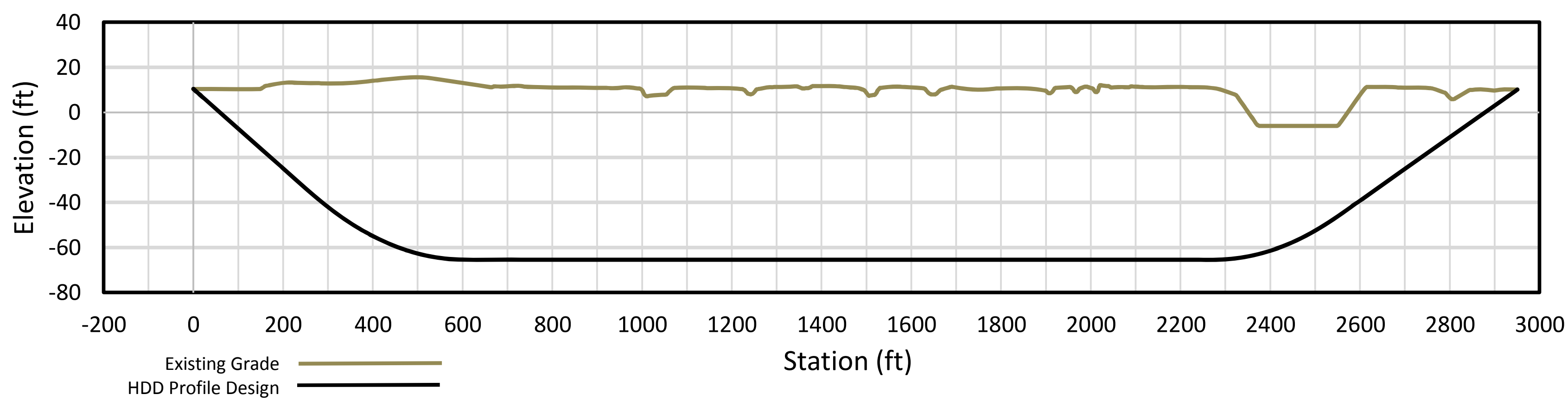
Negative value indicates axial weight applied in direction of installation

Pulling Load on Entry Tangent = 4,699 lb
Total Pulling Load = 175,267 lb

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	6,929	ok	0	ok	0	ok	0.11	ok	0.02	ok
	6,744	ok	0	ok	384	ok	0.11	ok	0.02	ok
PC										
	6,744	ok	17,901	ok	384	ok	0.50	ok	0.21	ok
	5,800	ok	17,901	ok	695	ok	0.48	ok	0.21	ok
PT										
	5,800	ok	0	ok	695	ok	0.09	ok	0.02	ok
	1,320	ok	0	ok	695	ok	0.02	ok	0.01	ok
PC										
	1,320	ok	17,901	ok	695	ok	0.41	ok	0.14	ok
	633	ok	17,901	ok	496	ok	0.40	ok	0.12	ok
PT										
	633	ok	0	ok	496	ok	0.01	ok	0.01	ok
Exit Point	0	ok	0	ok	-10	ok	0.00	ok	0.00	ok





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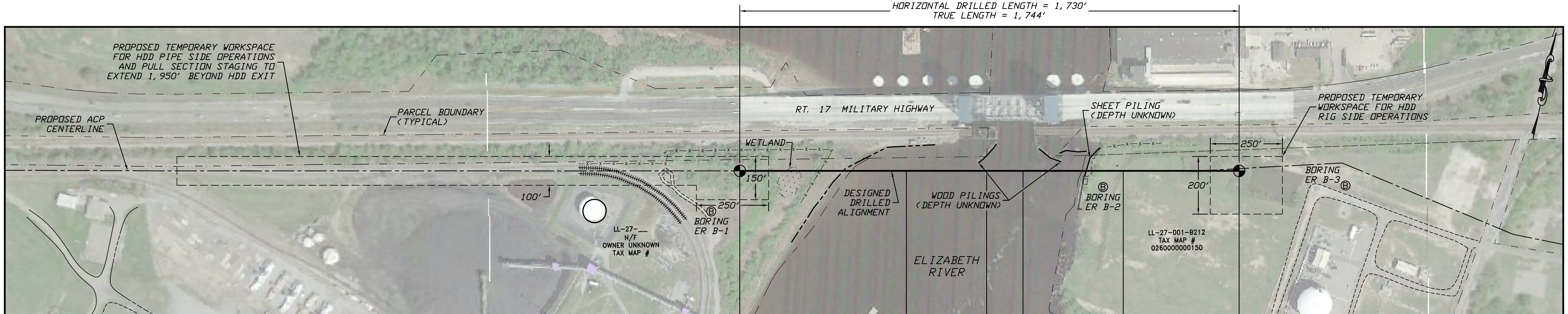
HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH ROUTE 17 CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 6/16/2015 Revision: 0

Elizabeth River

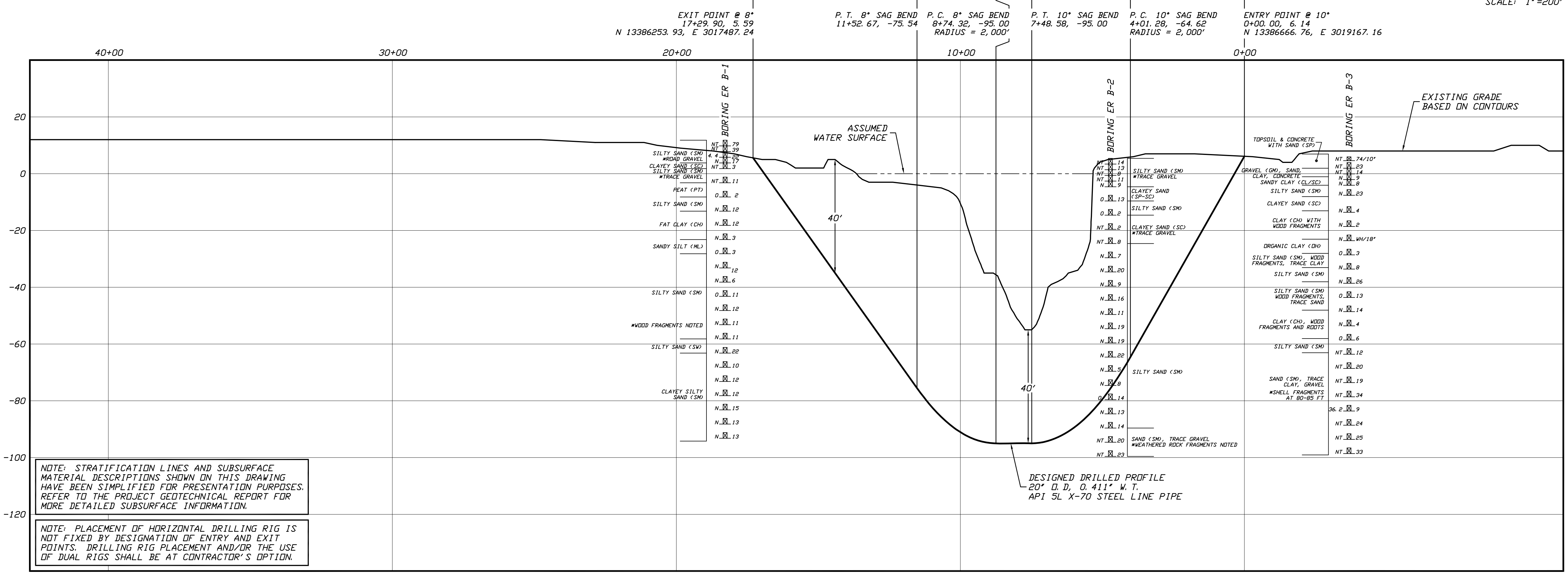
Supporting Information

- Plan & profile drawing presenting HDD crossing design (1 page, 11x17)
- Installation stress analysis, without buoyancy control (4 pages)
- Hydrofracture evaluation (1 page)



PLAN

SCALE: 1"=200'



PROFILE

SCALE: 1"=200' HORIZONTAL
1"= 20' VERTICAL

GENERAL LEGEND

DRILLED PATH ENTRY/EXIT POINT

GEOTECHNICAL LEGEND

BORING LOCATION

SPLIT SPOON SAMPLE

53 23 — PENETRATION RESISTANCE IN BLOWS PER FOOT FOR A 140 POUND HAMMER FALLING 30 INCHES
PERCENTAGE OF GRAVEL BY WEIGHT FOR SAMPLES CONTAINING GRAVEL

GEOTECHNICAL NOTES

1. GEOTECHNICAL DATA PROVIDED BY GEOSYNTEC CONSULTANTS, RICHMOND, VIRGINIA. REFER TO THE DRAFT PROJECT GEOTECHNICAL REPORT DATED DECEMBER 2015 FOR MORE DETAILED SUBSURFACE INFORMATION.
2. THE LETTER "N" TO THE LEFT OF A SPLIT SPOON SAMPLE INDICATES THAT NO GRAVEL WAS OBSERVED IN THE SAMPLE. THE LETTERS "NT" INDICATE THAT GRAVEL WAS OBSERVED BUT NO GRADATION TEST WAS PERFORMED.
3. THE GEOTECHNICAL DATA IS ONLY DESCRIPTIVE OF THE LOCATIONS ACTUALLY SAMPLED. EXTENSION OF THIS DATA OUTSIDE OF THE ORIGINAL BORINGS MAY BE DONE TO CHARACTERIZE THE SOIL CONDITIONS, HOWEVER, COMPANY DOES NOT GUARANTEE THESE CHARACTERIZATIONS TO BE ACCURATE. CONTRACTOR MUST USE HIS OWN EXPERIENCE AND JUDGMENT IN INTERPRETING THIS DATA.

TOPOGRAPHIC SURVEY NOTES

1. TOPOGRAPHIC SURVEY DATA PROVIDED BY GAI CONSULTANTS, CANONSBURG, PENNSYLVANIA.
2. NORTHINGS AND EASTINGS ARE IN U.S. SURVEY FEET REFERENCED TO UTM COORDINATES, ZONE 17, NAD 83.
3. ELEVATIONS ARE IN FEET REFERENCED TO NAVD 88.

DRILLED PATH NOTES

1. DRILLED PATH STATIONING IS IN FEET BY HORIZONTAL MEASUREMENT AND IS REFERENCED TO CONTROL ESTABLISHED FOR THE DRILLED SEGMENT.
2. DRILLED PATH COORDINATES REFER TO CENTERLINE OF PILOT HOLE AS OPPOSED TO TOP OF INSTALLED PIPE.

PILOT HOLE TOLERANCES

THE PILOT HOLE SHALL BE DRILLED TO THE TOLERANCES LISTED BELOW. HOWEVER, IN ALL CASES, RIGHT-OF-WAY RESTRICTIONS AND CONCERN FOR ADJACENT FACILITIES SHALL TAKE PRECEDENCE OVER THESE TOLERANCES.

1. ENTRY POINT: UP TO 10 FEET FORWARD OR BACK FROM THE DESIGNED ENTRY POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
2. EXIT POINT: UP TO 10 FEET SHORT OR 30 FEET LONG RELATIVE TO THE DESIGNED EXIT POINT; UP TO 5 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
3. ELEVATION: UP TO 5 FEET ABOVE AND 30 FEET BELOW THE DESIGNED PROFILE
4. ALIGNMENT: UP TO 10 FEET RIGHT OR LEFT OF THE DESIGNED ALIGNMENT
5. CURVE RADIUS: NO LESS THAN 1,350 FEET BASED ON A 3-JOINT AVERAGE (RANGE 2 DRILL PIPE)

PROTECTION OF EXISTING FACILITIES

CONTRACTOR SHALL UNDERTAKE THE FOLLOWING STEPS PRIOR TO COMMENCING DRILLING OPERATIONS.

1. CONTACT THE UTILITY LOCATION/NOTIFICATION SERVICE FOR THE CONSTRUCTION AREA.
2. POSITIVELY LOCATE AND STAKE ALL EXISTING UNDERGROUND FACILITIES. ANY FACILITIES LOCATED WITHIN 10 FEET OF THE DESIGNED DRILLED PATH SHALL BE EXPOSED.
3. MODIFY DRILLING PRACTICES AND DOWNHOLE ASSEMBLIES AS NECESSARY TO PREVENT DAMAGE TO EXISTING FACILITIES.

ATLANTIC COAST PIPELINE PROJECT

PLAN AND PROFILE 20-INCH PIPELINE CROSSING OF THE ELIZABETH RIVER BY HORIZONTAL DIRECTIONAL DRILLING

LOCATION: PORTSMOUTH COUNTY, VIRGINIA

DRAWN	DATE	CHECKED	APPROVED	SCALE	DRAWING LABEL	REVISION
KMN	03/30/16	DMP	JSP	SHOWN FOR D-SIZED PLOT	ELIZABETH RIVER	0

NO.	DATE	REVISION DESCRIPTION	BY	CHK'D	APP.

Jeffrey S. Puckett, P.E.
Consulting Engineer
2424 East 21st Street
Suite 510
Tulsa, Oklahoma 74114

PROJECT NO.
Dominion\1508

MILE POST
AP3-082

Elizabeth River R0 Installation Stress Analysis (worst-case).xlsm

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Project Information			
Project :	Dominion Atlantic Coast Pipeline	User :	KMN
Crossing :	20" Elizabeth River Crossing	Date :	7/22/2016
Comments :	Installation stress analysis based on worst-case drilled path per tolerances (40' longer and 20' deeper than design with a 1,350' radius) with 12 ppg mud and no BC		

Line Pipe Properties			
Pipe Outside Diameter =	20.000	in	
Wall Thickness =	0.411	in	
Specified Minimum Yield Strength =	70,000	psi	
Young's Modulus =	2.9E+07	psi	
Moment of Inertia =	1213.22	in^4	
Pipe Face Surface Area =	25.29	in^2	
Diameter to Wall Thickness Ratio, D/t =	49		
Poisson's Ratio =	0.3		
Coefficient of Thermal Expansion =	6.5E-06	in/in/°F	
Pipe Weight in Air =	85.99	lb/ft	
Pipe Interior Volume =	2.01	ft^3/ft	
Pipe Exterior Volume =	2.18	ft^3/ft	

HDD Installation Properties			
Drilling Mud Density =	12.0	ppg	
=	89.8	lb/ft^3	
Ballast Density =	62.4	lb/ft^3	
Coefficient of Soil Friction =	0.30		
Fluid Drag Coefficient =	0.025	psi	
Ballast Weight =	125.18	lb/ft	
Displaced Mud Weight =	195.83	lb/ft	

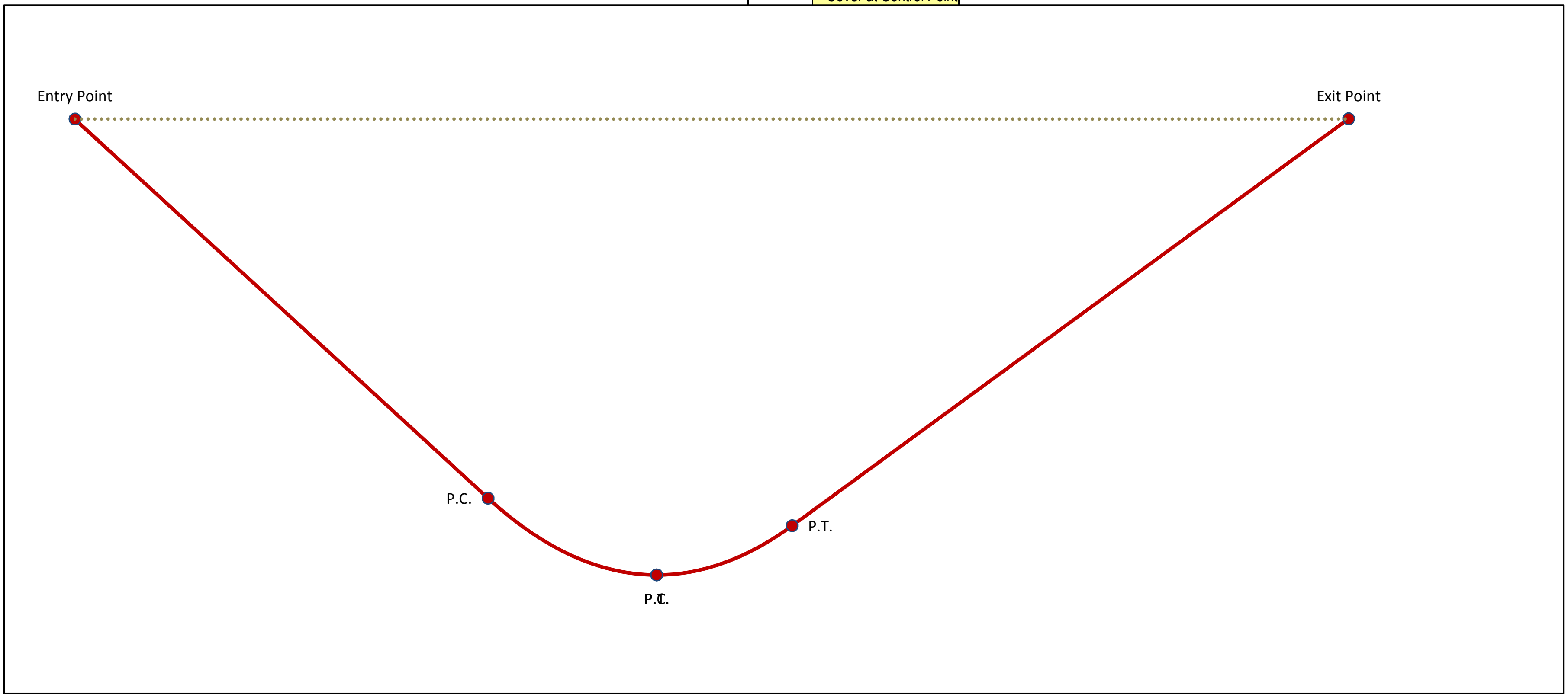
Installation Stress Limits			
Tensile Stress Limit, 90% of SMYS, F_t =	63,000	psi	
For D/t <= 1,500,000/SMYS, F_b =	52,500	psi	No
For D/t > 1,500,000/SMYS and <= 3,000,000/SMYS, F_b =	44,493	psi	No
For D/t > 3,000,000/SMYS and <= 300, F_b =	45,631	psi	Yes
Allowable Bending Stress, F_b =	45,631	psi	
Elastic Hoop Buckling Stress, F_{he} =	10,777	psi	
For F_{he} <= 0.55*SMYS, Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	Yes
For F_{he} > 0.55*SMYS and <= 1.6*SMYS, F_{hc} =	33,440	psi	No
For F_{he} > 1.6*SMYS and <= 6.2*SMYS, F_{hc} =	11,994	psi	No
For F_{he} > 6.2*SMYS, F_{hc} =	70,000	psi	No
Critical Hoop Buckling Stress, F_{hc} =	10,777	psi	
Allowable Hoop Buckling Stress, $F_{hc}/1.5$ =	7,185	psi	

Elizabeth River R0 Installation Stress Analysis (worst-case).xlsm
J:\Dominion\1508 - Atlantic Coast\Working\Stress Analysis\

		Station	Elevation	Angle	Radius	Length	Average Tension	Total Pull
Entry Point		-10.00	6.09	10.00				109,466
Entry Tangent						583.02		
Entry Sag Bend	PC	564.16	-95.15					90,677
	PI	680.48	-115.66	10.00	1350	235.62	80,994	
	PT	798.59	-115.66				0	71,311
Bottom Tangent				0.00		0.05		
Exit Sag Bend	PC	798.63	-115.66					71,309
	PI	893.03	-115.66	8.00	1350	188.50	61,727	
	PT	986.52	-102.52				0	52,145
Exit Tangent						780.98		
Exit Point		1759.90	6.17	8.00	Above Ground Load			0
Drilling Mud			6.09	(Graph = ········)				
Ballast				(Graph = - - - - -)				

No.	Station	Elevation	
1			Grade Elevation Points
2			
3			
4			
5			
6			
7			
8			
9			
10			
1			Control Point

= Cover at Control Point



Step 2, Drilled Path Input

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Pipe and Installation Properties

Based on profile design entered in 'Step 2, Drilled Path Input'.

Pipe Diameter, D =	20.000	in	Fluid Drag Coefficient, C_d =	0.025	psi	
PIpe Weight, W =	86.0	lb/ft	Ballast Weight / ft Pipe, W_b =	125.2	lb	(If Ballasted)
Coefficient of Soil Friction, μ =	0.30		Drilling Mud Displaced / ft Pipe, W_m =	195.8	lb	(If Submerged)
			Above Ground Load =	0	lb	

Exit Tangent - Summary of Pulling Load Calculations

Segment Length, L =	781.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Exit Angle, θ =	8.0	°			

Frictional Drag = $W_e\, L\, \mu \cos\theta$ =	25,485	lb
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	14,721	lb
Axial Segment Weight = $W_e\, L \sin\theta$ =	11,939	lb
Pulling Load on Exit Tangent =	**52,145**	**lb**

Exit Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	188.5	ft	Average Tension, T =	61,727	lb
Segment Angle with Horizontal, θ =	-8.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	-4.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	3.29	ft	$j = [(E\, I) / T]^{1/2}$ =	755	
$Y = [18\,(L)^2] - [(j)^2\,(1 - \cosh(U/2)^{-1}]$ =	3.1E+05		$X = (3\,L) - [\,(j / 2)\tanh(U/2)\,]$ =	223.94	
$U = (12\,L) / j$ =	3.00		$N = [(T\,h) - W_e \cos\theta\,(Y/144)] / (X / 12)$ =	23,611	lb
Bending Frictional Drag = $2\,\mu\,N$ =	14,167	lb			
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	3,553	lb			
Axial Segment Weight = $W_e\, L \sin\theta$ =	1,444	lb			
Pulling Load on Exit Sag Bend =	**19,164**	**lb**			
Total Pulling Load =	**71,309**	**lb**			

Bottom Tangent - Summary of Pulling Load Calculations

Segment Length, L =	0.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

Frictional Drag = $W_e\, L\, \mu$ =	1	lb
Fluidic Drag = $12\, \pi\, D\, L\, C_d$ =	1	lb
Axial Segment Weight = $W_e\, L \sin\theta$ =	0	lb
Pulling Load on Bottom Tangent =	**2**	**lb**
Total Pulling Load =	**71,311**	**lb**

Fluidic drag is calculated as zero unless entire segment is submerged in drilling fluid.
Please reference Step 2, Drilled Path Input

Entry Sag Bend - Summary of Pulling Load Calculations

Segment Length, L =	235.6	ft	Average Tension, T =	80,994	lb
Segment Angle with Horizontal, θ =	10.0	°	Radius of Curvature, R =	1,350	ft
Deflection Angle, α =	5.0	°	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft

$h = R\,[1 - \cos(\alpha/2)]$ =	5.14	ft	$j = [(E\ I) / T]^{1/2}$ =	659	
$Y = [18\ (L)^2] - [(j)^2\ (1 - \cosh(U/2)^{-1}]$ =	6.7E+05		$X = (3\ L) - [\ (j / 2) \tanh(U/2)\ ]$ =	386.23	
$U = (12\ L) / j$ =	4.29		$N = [(T\ h) - W_e \cos\theta\ (Y/144)] / (X / 12)$ =	28,633	lb
Bending Frictional Drag = $2\ \mu\ N$ =	17,180	lb			
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	4,441	lb			
Axial Segment Weight = $W_e\ L \sin\theta$ =	-2,256	lb	Negative value indicates axial weight applied in direction of installation		
Pulling Load on Entry Sag Bend =	**19,366**	**lb**			
Total Pulling Load =	**90,677**	**lb**			

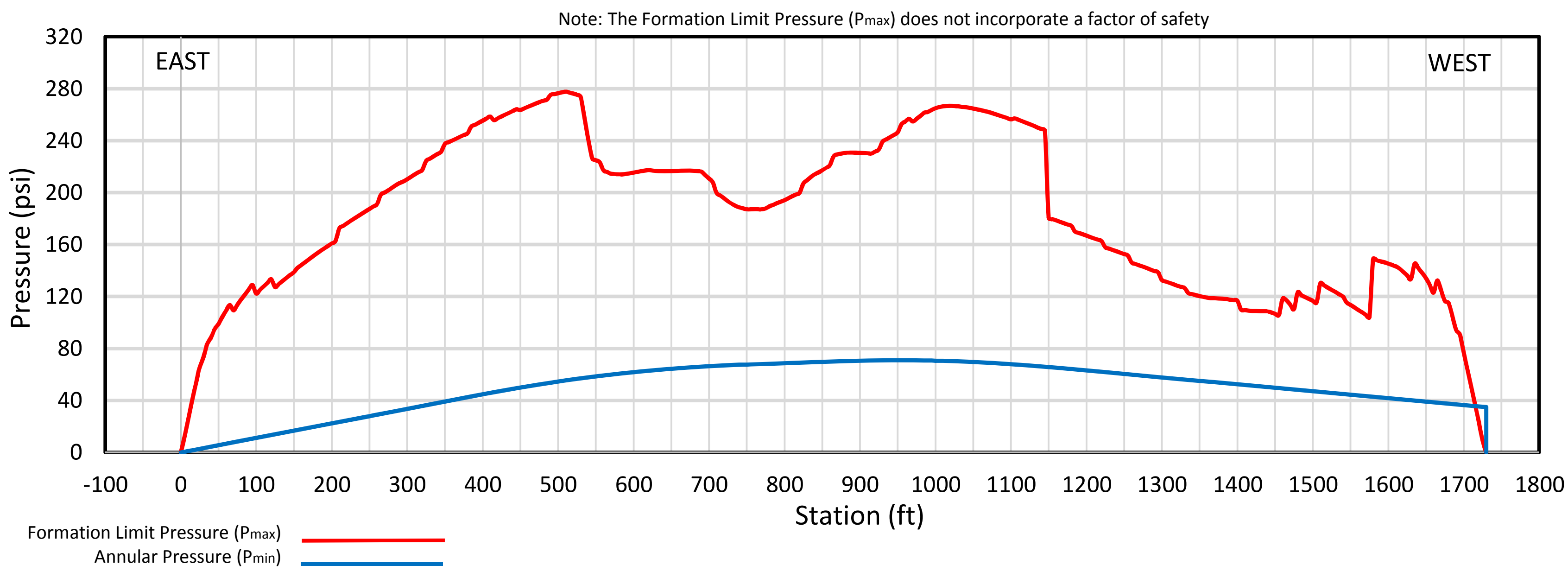
Entry Tangent - Summary of Pulling Load Calculations

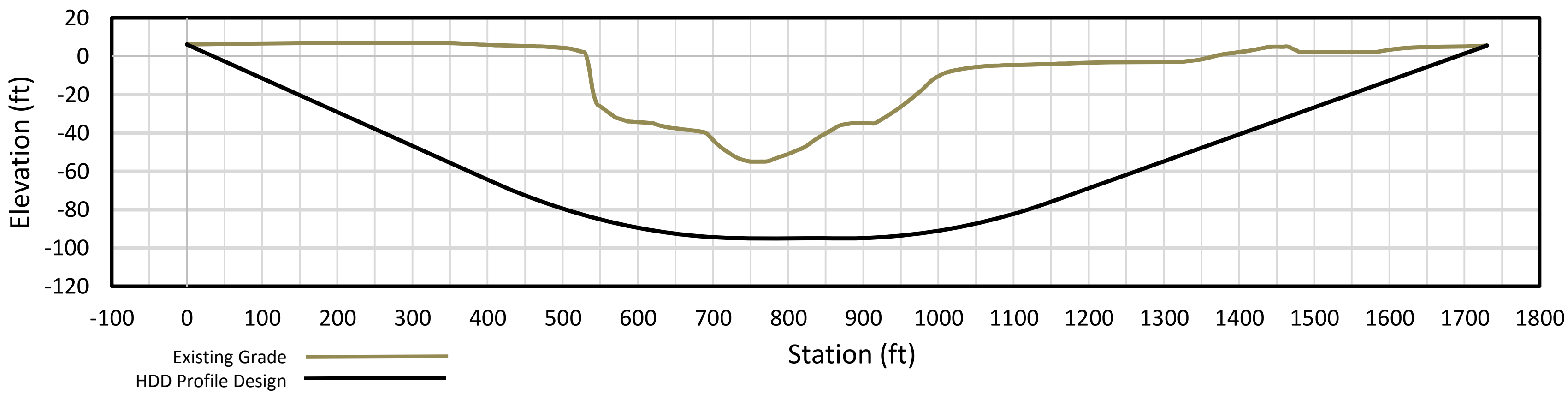
Segment Length, L =	583.0	ft	Effective Weight, $W_e = W + W_b - W_m$ =	-109.8	lb/ft
Entry Angle, θ =	10.0	°			

Frictional Drag = $W_e\ L\ \mu \cos\theta$ =	18,920	lb	
Fluidic Drag = $12\ \pi\ D\ L\ C_d$ =	10,990	lb	
Axial Segment Weight = $W_e\ L \sin\theta$ =	-11,120	lb	Negative value indicates axial weight applied in direction of installation
Pulling Load on Entry Tangent =	**18,789**	**lb**	
Total Pulling Load =	**109,466**	**lb**	

Summary of Calculated Stress vs. Allowable Stress

	Tensile Stress		Bending Stress		External Hoop Stress		Combined Tensile & Bending		Combined Tensile, Bending & Ext. Hoop	
Entry Point	4,328	ok	0	ok	0	ok	0.07	ok	0.01	ok
	3,585	ok	0	ok	1535	ok	0.06	ok	0.05	ok
PC										
	3,585	ok	17,901	ok	1535	ok	0.45	ok	0.23	ok
	2,819	ok	17,901	ok	1846	ok	0.44	ok	0.25	ok
PT										
	2,819	ok	0	ok	1846	ok	0.04	ok	0.07	ok
	2,819	ok	0	ok	1846	ok	0.04	ok	0.07	ok
PC										
	2,819	ok	17,901	ok	1846	ok	0.44	ok	0.25	ok
	2,062	ok	17,901	ok	1647	ok	0.43	ok	0.22	ok
PT										
	2,062	ok	0	ok	1647	ok	0.03	ok	0.06	ok
Exit Point	0	ok	0	ok	-1	ok	0.00	ok	0.00	ok





J.D.Hair&Associates, Inc.

HYDROFRACTURE EVALUATION
FORMATION LIMIT PRESSURE VS. ANNULAR PRESSURE
20-INCH ELIZABETH RIVER CROSSING
BY HORIZONTAL DIRECTIONAL DRILLING

Date: 6/16/2015 Revision: 0

APPENDIX U

Road Crossing Methods Table

CROSSING NUMBER	ROAD CROSSING ID	SPREAD NUMBER	MP	AP	ROAD NAME	ROAD NUMBER	WIDTH	STATE	COUNTY	METHOD
1	WV-HAR-0001	SPREAD 1-1	1.07	1	Kincheloe Road	CO 35/3	60	WV	HARRISON	OPEN CUT
2	WV-LEW-0001	SPREAD 1-1	1.42	1	Sand Fork Road	CO 2	60	WV	LEWIS	OPEN CUT
3	WV-LEW-0002	SPREAD 1-1	3.93	1	Elk Lick Road	CO 4/3	60	WV	LEWIS	OPEN CUT
4	WV-LEW-0003	SPREAD 1-1		1	Oil Road			WV	LEWIS	OPEN CUT
5	WV-LEW-0004	SPREAD 1-1	4.10	1	Hog Camp Run Road	CO 10/10	60	WV	LEWIS	OPEN CUT
6	WV-LEW-0005	SPREAD 1-1	5.00	1	Millstone Run Road	CO 10/11	60	WV	LEWIS	OPEN CUT
7	WV-LEW-0006	SPREAD 1-1	5.74	1	Turkeypen Creek Road	CO 10/12	60	WV	LEWIS	OPEN CUT
8	WV-LEW-0007	SPREAD 1-1	7.71	1	Hollick Run Road	CO 1/1	60	WV	LEWIS	OPEN CUT
9	WV-LEW-0008	SPREAD 1-1	8.15	1	Kincheloe Road	CO 1	60+river=100	WV	LEWIS	OPEN CUT
10	WV-LEW-0009	SPREAD 1-1	8.39	1	Elk City Road	CO 8/1	60	WV	LEWIS	BORE
11	WV-LEW-0010	SPREAD 1-1	9.37	1	Broad Run Road	CO 8	60	WV	LEWIS	BORE
12	WV-LEW-0011	SPREAD 1-1	9.68	1	Wymer Run Road	CO 8/3	60	WV	LEWIS	BORE
13	WV-LEW-0012	SPREAD 1-1	10.45	1	Landmark Estate	CO 8/11	60	WV	LEWIS	OPEN CUT
14	WV-LEW-0013	SPREAD 1-1	11.73	1	Sycamore Lick Road	CO 10	60	WV	LEWIS	BORE
15	WV-LEW-0014	SPREAD 1-1	12.65	1	Hidden Cove/ HARP 915	US-19	100	WV	LEWIS	BORE
16	WV-LEW-0015	SPREAD 1-1	14.00	1	Interstate 79	I-79	650	WV	LEWIS	BORE
17	WV-LEW-0016	SPREAD 1-1	14.30	1	Life's Run Road	CO 14	40	WV	LEWIS	BORE
18	WV-LEW-0017	SPREAD 1-1	15.47	1	Cottrill Run Road	CO 7/4	60	WV	LEWIS	OPEN CUT
19	WV-LEW-0018	SPREAD 1-1	17.15	1	Berlin Road	CO 13	60	WV	LEWIS	BORE
20	WV-LEW-0019	SPREAD 1-2	18.10	1	Laurel Lick Road	CO 26	60	WV	LEWIS	OPEN CUT
21	WV-LEW-0020	SPREAD 1-2	20.83	1	Buffalo Road	CO 32/2	60	WV	LEWIS	OPEN CUT
22	WV-LEW-0021	SPREAD 1-2	20.54	1	Buckhannon Run Road	CO 32	60	WV	LEWIS	OPEN CUT
23	WV-UPS-0001	SPREAD 1-2	23.16	1	Brushy Fork Road	CO 12	60	WV	UPSHUR	OPEN CUT
24	WV-UPS-0002	SPREAD 1-2	23.19	1	Corridor H, US Route 33/119	US 33/119	400	WV	UPSHUR	BORE
25	WV-UPS-0003	SPREAD 1-2	23.98	1	Fink Run Road	CO 5/5	60	WV	UPSHUR	OPEN CUT
26	WV-UPS-0004	SPREAD 1-2	24.64	1	Right Branch of Brushy Fork	CO 7/4	60	WV	UPSHUR	OPEN CUT
27	WV-UPS-0005	SPREAD 1-2	25.00	1	Golden Pond Lane		60	WV	UPSHUR	OPEN CUT
28	WV-UPS-0006	SPREAD 1-2	25.78	1	Brushy Fork Road	CO 7	60	WV	UPSHUR	BORE
29	WV-UPS-0007	SPREAD 1-2	27.06	1	Stoney Run-Atlas Spruce Fork	CO 14	60	WV	UPSHUR	OPEN CUT
30	WV-UPS-0008	SPREAD 1-2	29.10	1	Kanawha Road	WV-20	80	WV	UPSHUR	BORE
31	WV-UPS-0009	SPREAD 1-2	29.28	1	Mt. Carmel Road/Sago-Tallmansville	CO 22	80	WV	UPSHUR	BORE
32	WV-UPS-0010	SPREAD 1-2	30.45	1	Left Fork French Creek	CO 20/9	60	WV	UPSHUR	OPEN CUT
33	WV-UPS-0011	SPREAD 1-2	31.10	1	CSX RR	RR	80	WV	UPSHUR	BORE
34	WV-UPS-0012	SPREAD 1-2	32.51	1	Sago-Tallmansville	CO 22	60	WV	UPSHUR	BORE
35	WV-UPS-0013	SPREAD 1-2	31.55	1	CSX RR	RR	80	WV	UPSHUR	BORE
36	WV-UPS-0014	SPREAD 1-2	31.63	1	Mount Caramel Road	CO 9/2	60	WV	UPSHUR	OPEN CUT
37	WV-UPS-0015	SPREAD 2-1	33.73	1	Mount Caramel Road	CO 22	60	WV	UPSHUR	BORE
38	WV-UPS-0016	SPREAD 2-1	34.32	1	Our Mills	CO 22/3	60	WV	UPSHUR	BORE

CROSSING NUMBER	ROAD CROSSING ID	SPREAD NUMBER	MP	AP	ROAD NAME	ROAD NUMBER	WIDTH	STATE	COUNTY	METHOD
39	WV-UPS-0017	SPREAD 2-1	36.69	1	Laurel Run Road	CO 24	40	WV	UPSHUR	OPEN CUT
40	WV-UPS-0018	SPREAD 2-1	37.55	1	CSX RR	RR	80	WV	UPSHUR	OPEN CUT
41	WV-UPS-0019	SPREAD 2-1	37.60	1	Ten Mile Road	CO 9/8	60	WV	UPSHUR	BORE
42	WV-UPS-0020	SPREAD 2-1	40.54	1	Democrate Ridge	CO 30/18	40	WV	UPSHUR	OPEN CUT
43	WV-UPS-0021	SPREAD 2-1	41.18	1	ADRIAN ABBOTT ROAD	CO 30	60	WV	UPSHUR	BORE
44	WV-UPS-0022	SPREAD 2-1	41.27	1	Tallmansville Road	CO 9	60	WV	UPSHUR	OPEN CUT
45	WV-UPS-0023	SPREAD 2-1	43.78	1	CUBANA ROAD	CO 9/23	60	WV	UPSHUR	OPEN CUT
46	WV-RAN-0001	SPREAD 2-1	45.27	1	Adolph Cassity	CO 34	40	WV	RANDOLPH	OPEN CUT
47	WV-RAN-0002	SPREAD 2-2		1	Old Adoplph Road	CO 42		WV	RANDOLPH	OPEN CUT
48	WV-RAN-0003	SPREAD 2-2		1	Palace Valley	CO 44		WV	RANDOLPH	OPEN CUT
49	WV-RAN-0004	SPREAD 2-2		1	High Germany Road	CO 46/2		WV	RANDOLPH	OPEN CUT
50	WV-RAN-0005	SPREAD 2-2		1	High Germany Road	CO 46/2		WV	RANDOLPH	OPEN CUT
51	WV-RAN-0006	SPREAD 2-2		1	High Germany Road	CO 46/2		WV	RANDOLPH	OPEN CUT
52	WV-RAN-0007	SPREAD 2-2		1	Adolph Road	CO 46		WV	RANDOLPH	BORE
53	WV-RAN-0008	SPREAD 2-2		1	Turkey Bone Road	CO 45		WV	RANDOLPH	OPEN CUT
63	WV-POCA-0002	SPREAD 3		1	West Virginia Central RR	RR		WV	POCAHONTAS	BORE
64	WV-POCA-0003	SPREAD 3		1	Seneca Trail	US 219		WV	POCAHONTAS	BORE
67	WV-POCA-0006	SPREAD 3		1	Gardner Road	CO 1/5		WV	POCAHONTAS	BORE
73	WV-POCA-0012	SPREAD 3A		1	Public Road 55	PR 55		WV	POCAHONTAS	BORE
534	WV-RAN-0017	SPREAD 2A		1	WV 15	SR 15		WV	RANDOLPH	BORE
535	WV-RAN-0018	SPREAD 2A		1	Valley Fork	CO 49		WV	RANDOLPH	BORE
536	WV-RAN-0019	SPREAD 2A		1	Mingo Run	CO 219/14		WV	RANDOLPH	BORE
537	WV-RAN-0020	SPREAD 3		1	Old Dry Branch Road	CO 51/1		WV	RANDOLPH	BORE
538	WV-POCA-0013	SPREAD 3		1	Dry Branch Road	CO 219/2		WV	POCAHONTAS	BORE
539	WV-POCA-0014	SPREAD 3		1	Beverage Road	CO 9/2		WV	POCAHONTAS	BORE
540	WV-POCA-0015	SPREAD 3		1	Back Mountain Road	CO 1		WV	POCAHONTAS	BORE
541	WV-POCA-0016	SPREAD 3		1	Greenbrier River Trail	RR		WV	POCAHONTAS	BORE
542	WV-POCA-0017	SPREAD 3		1	Laurel Run Road	CO 1/4		WV	POCAHONTAS	BORE
543	WV-POCA-0018	SPREAD 3		1	Public Road 1/10	PR 1/10		WV	POCAHONTAS	BORE
544	WV-POCA-0019	SPREAD 3		1	Public Road 1/10	PR 1/10		WV	POCAHONTAS	BORE
545	WV-POCA-0020	SPREAD 3		1	WV 28 Browns Creek Road	SR 28		WV	POCAHONTAS	BORE
546	WV-POCA-0021	SPREAD 3A		1	WV 92 Frost Road	SR 92		WV	POCAHONTAS	BORE

APPENDIX V

Site-Specific Construction Plans for Residences

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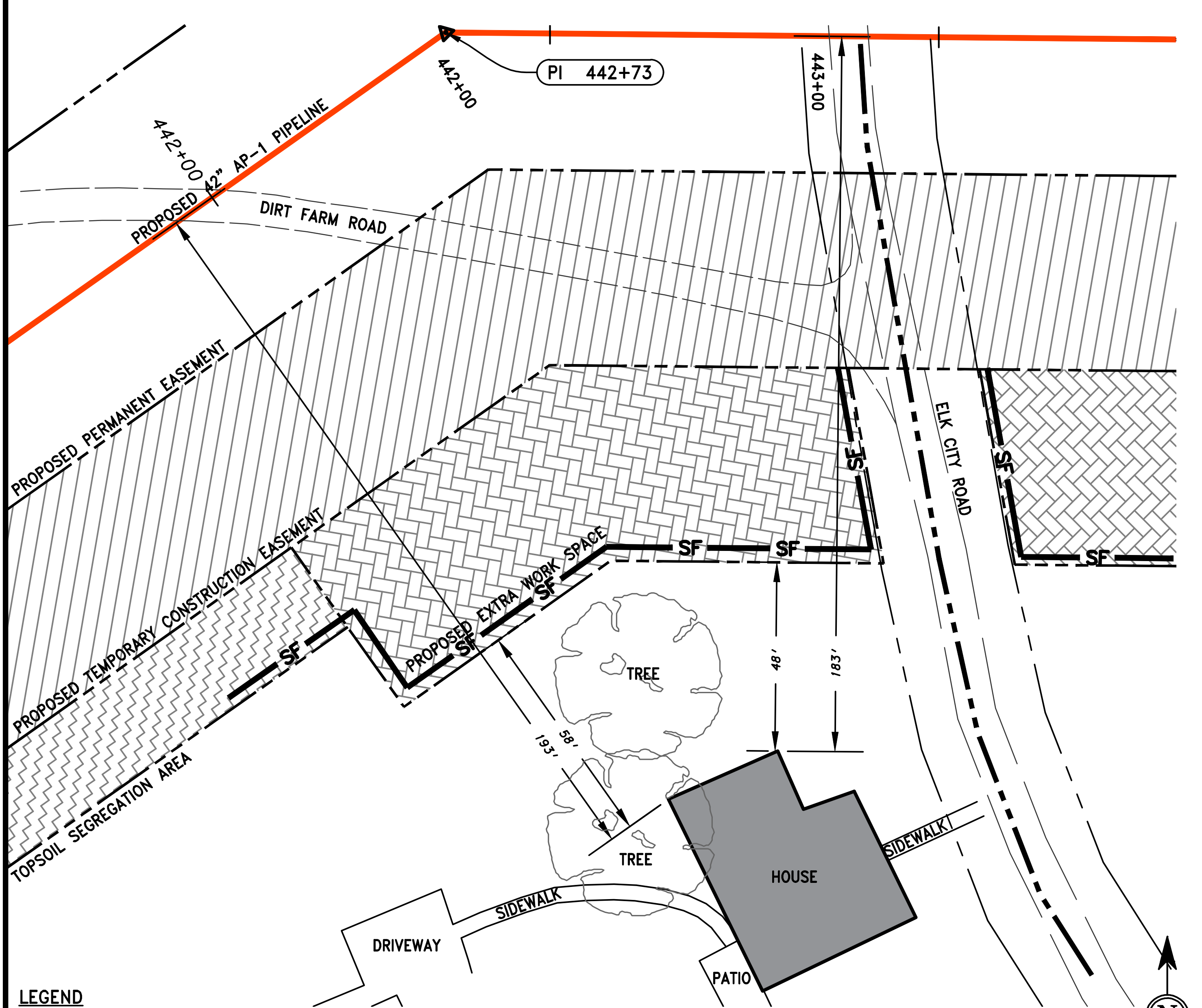
1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE

PROPOSED PERMANENT EASEMENT

PROPOSED GAS PIPELINE

SF ORANGE SAFETY FENCE

EXTRA WORK SPACE

PROPOSED TEMPORARY R.O.W.

TOPSOIL SEGREGATION AREA

LL-02-039
789 ELK CITY ROAD
JANE LEW, WEST VIRGINIA 26378
TAX MAP # 04-7B000200000000
AP-1 PIPELINE
MILE POST 8.37

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
LEWIS COUNTY, WEST VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 6/28/2016

SCALE: AS SHOWN | TASK NO. 01

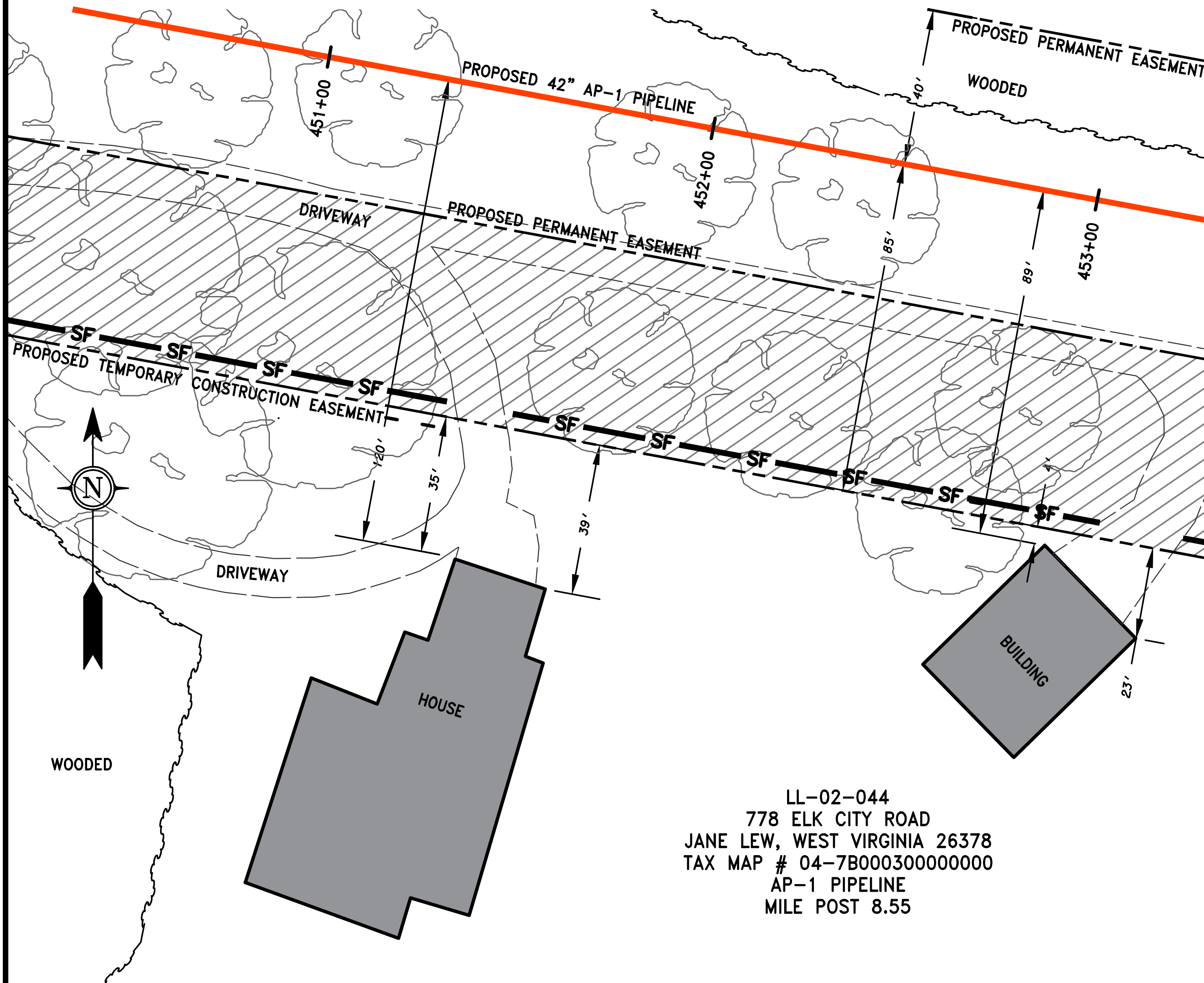
PROJECT NO./DASH NO. 140468

DRAWING NO. LL-02-039 REV

GAI CAD FILE: J:\2665 -GA\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\BUILDING CONFLICT EXHIBITS\2665-01 SPREAD-1 - BUILDING CONFLICT EXHIBITS LL-02-039.DWG

6/28/2016 3:34 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-02-044
778 ELK CITY ROAD
JANE LEW, WEST VIRGINIA 26378
TAX MAP # 04-7B000300000000
AP-1 PIPELINE
MILE POST 8.55

LEGEND

PROPERTY LINE
PROPOSED LIMITS OF CONSTR□CTION
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
LEWIS COUNTY, WEST VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

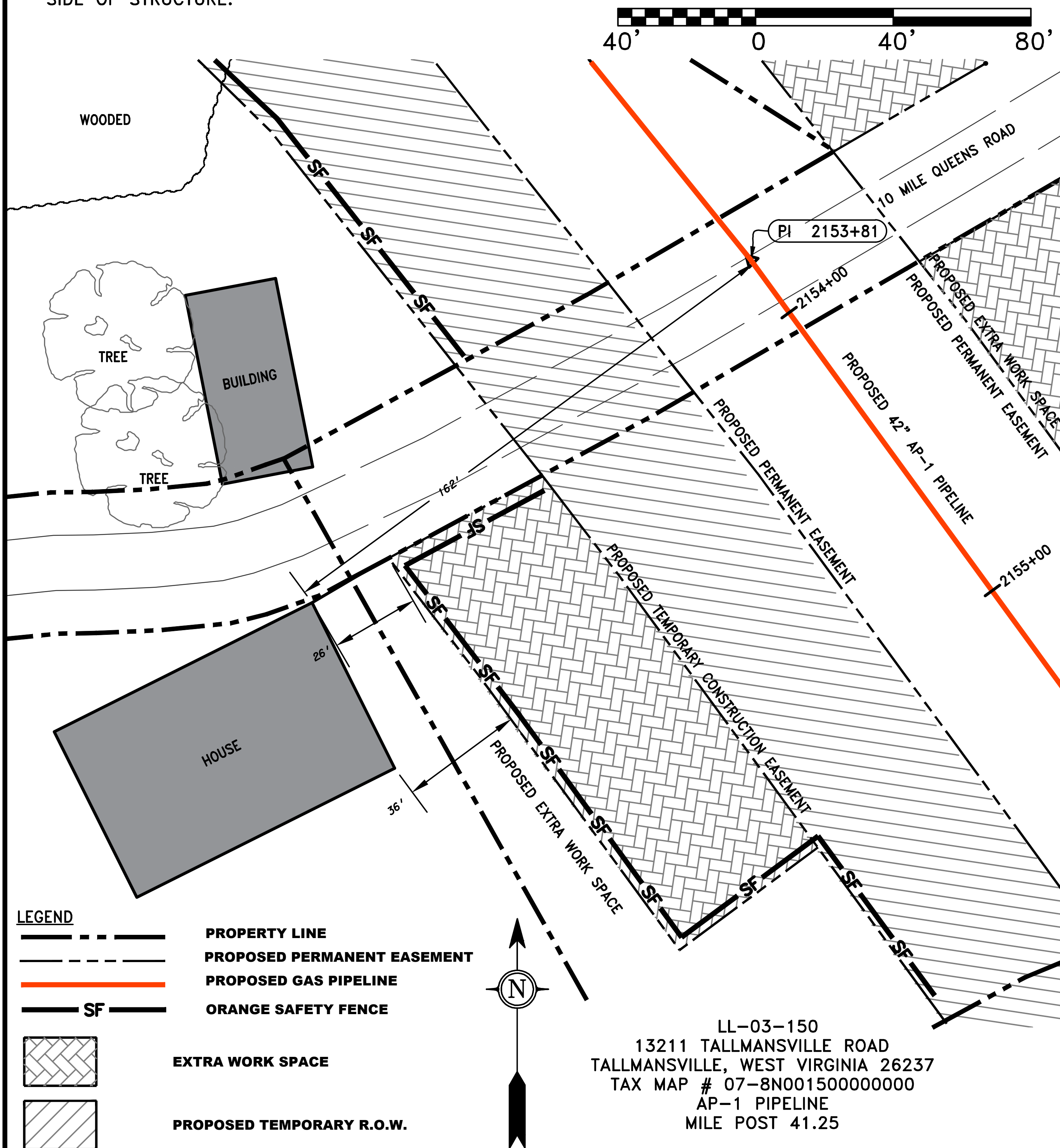
DWN. RDC | CHKD. DLH | APPD. NET | DATE 6/28/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-02-044
REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\BUILDING CONFLICT EXHIBITS\2665-01 SPREAD-1 - BUILDING CONFLICT EXHIBITS LL-02-044.DWG

6/28/2016 3:29 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

SCALE: 1" = 40'



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

LL-03-150
13211 TALLMANSVILLE ROAD
TALLMANSVILLE, WEST VIRGINIA 26237
TAX MAP # 07-8N001500000000
AP-1 PIPELINE
MILE POST 41.25

gai consultants
SOUTHPOINTE OFFICE
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CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
UPSHUR COUNTY, WEST VIRGINIA

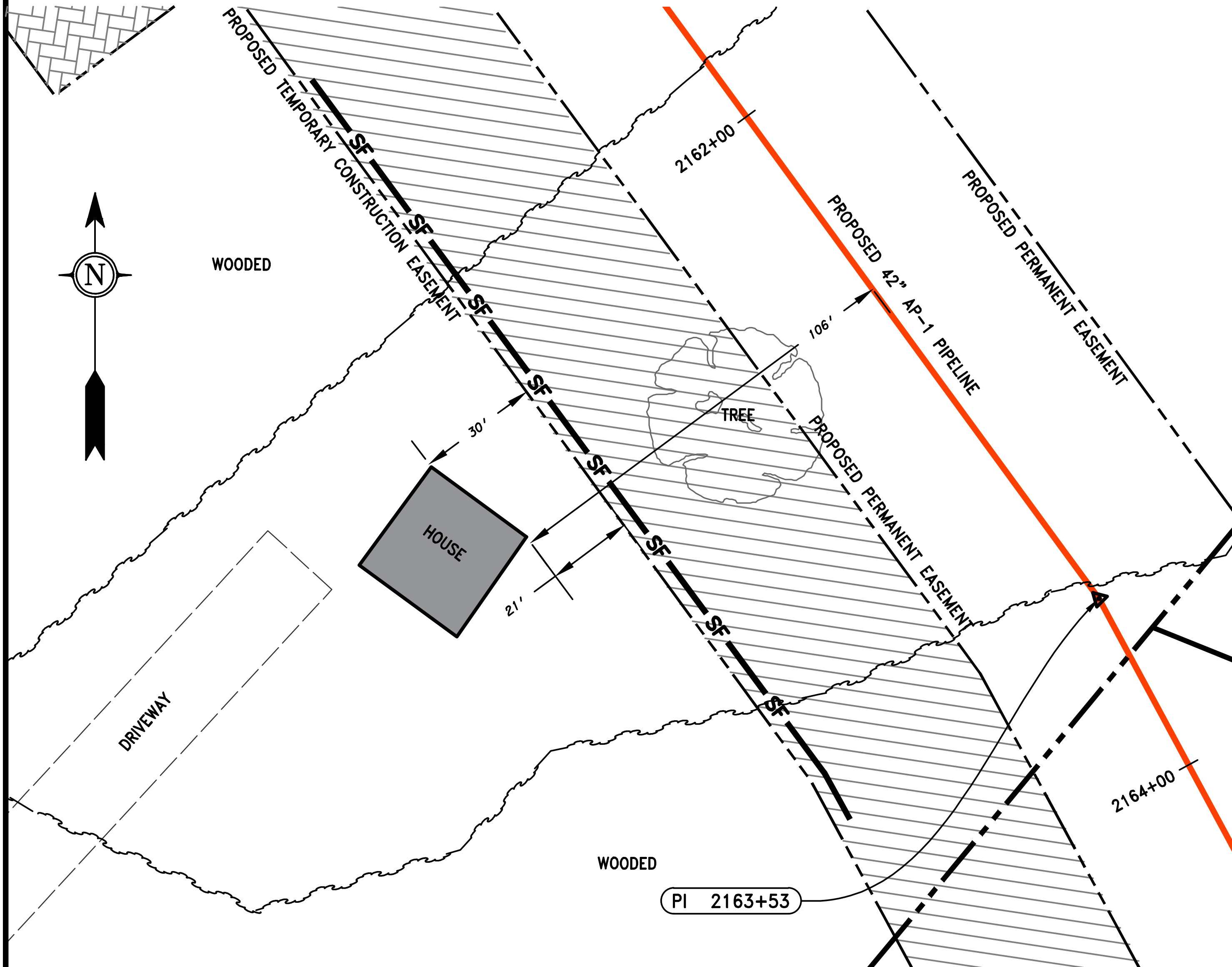
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC CHKD. DLH APPD. NET DATE 6/28/2016
SCALE: AS SHOWN TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-03-150 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\BUILDING CONFLICT EXHIBITS\2665-01 SPREAD-1 - BUILDING CONFLICT EXHIBITS LL-03-150.DWG

6/28/2016 3:24 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

LL-03-154
1950 GUM ROAD
ELKINS, WEST VIRGINIA 26241
TAX MAP # 07-8N002800000000
AP-1 PIPELINE
MILE POST 41.41

SCALE: 1" = 40'

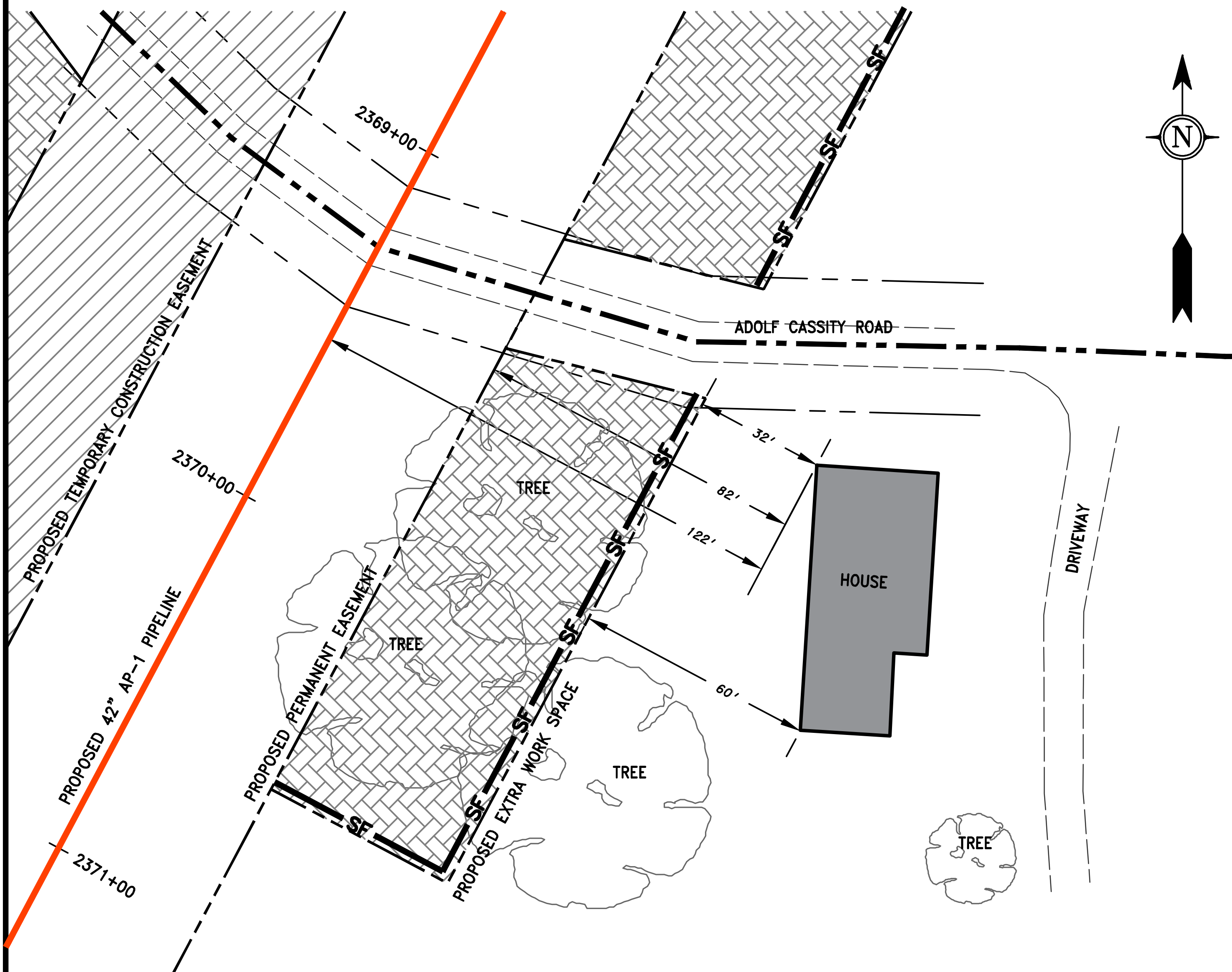
40' 0 40' 80'

gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES UPSHUR COUNTY, WEST VIRGINIA	DWN. RDC CHKD. DLH APPD. NET DATE 6/24/2016 SCALE: AS SHOWN TASK NO. 01
		ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. 140468 DRAWING NO. LL-03-154 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\BUILDING CONFLICT EXHIBITS\2665-01 SPREAD-1 - BUILDING CONFLICT EXHIBITS LL-03-154.DWG

6/24/2016 3:03 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

LL-04-002-A002
2332 CASSITY ROAD
MABIE, WEST VIRGINIA 26278
TAX MAP # 11-111001000000000
AP-1 PIPELINE
MILE POST 45.35

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
RANDOLPH COUNTY, WEST VIRGINIA

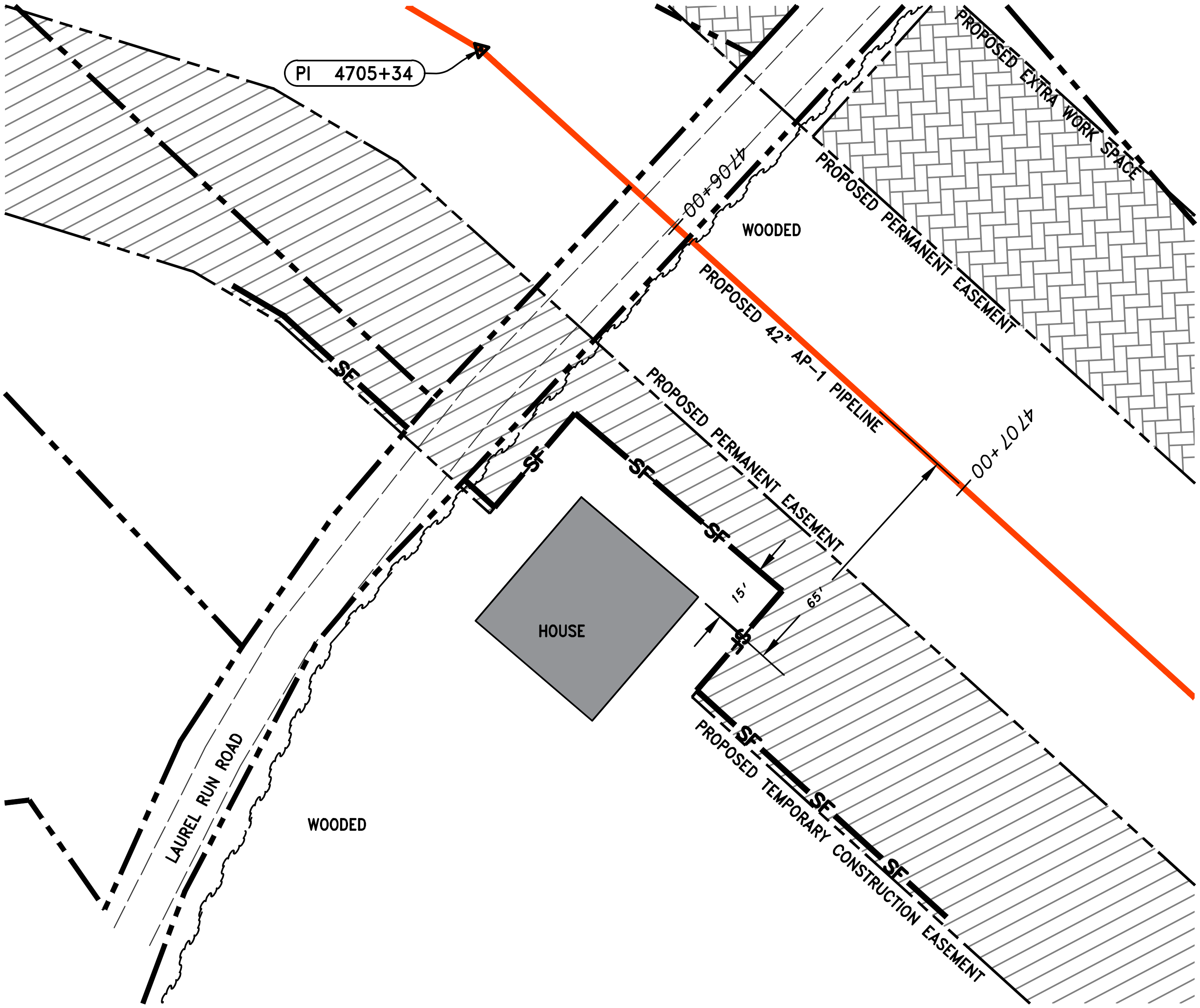
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 6/24/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-04-002-A002 | REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\BUILDING CONFLICT EXHIBITS\2665-01 SPREAD-1 - BUILDING CONFLICT EXHIBITS LL-04-002-A002.DWG

6/24/2016 2:41 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.
TOPSOIL SEGREGATION AREA

LL-05-001-E102
P.O. BOX 4938
EASTMAN, GEORGIA
TAX MAP # 04 83A001300000000
AP-1 PIPELINE
MILE POST 76.5

SCALE: 1" = 40'

40' 0 40' 80'

N

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
POCAHONTAS, WEST VIRGINIA

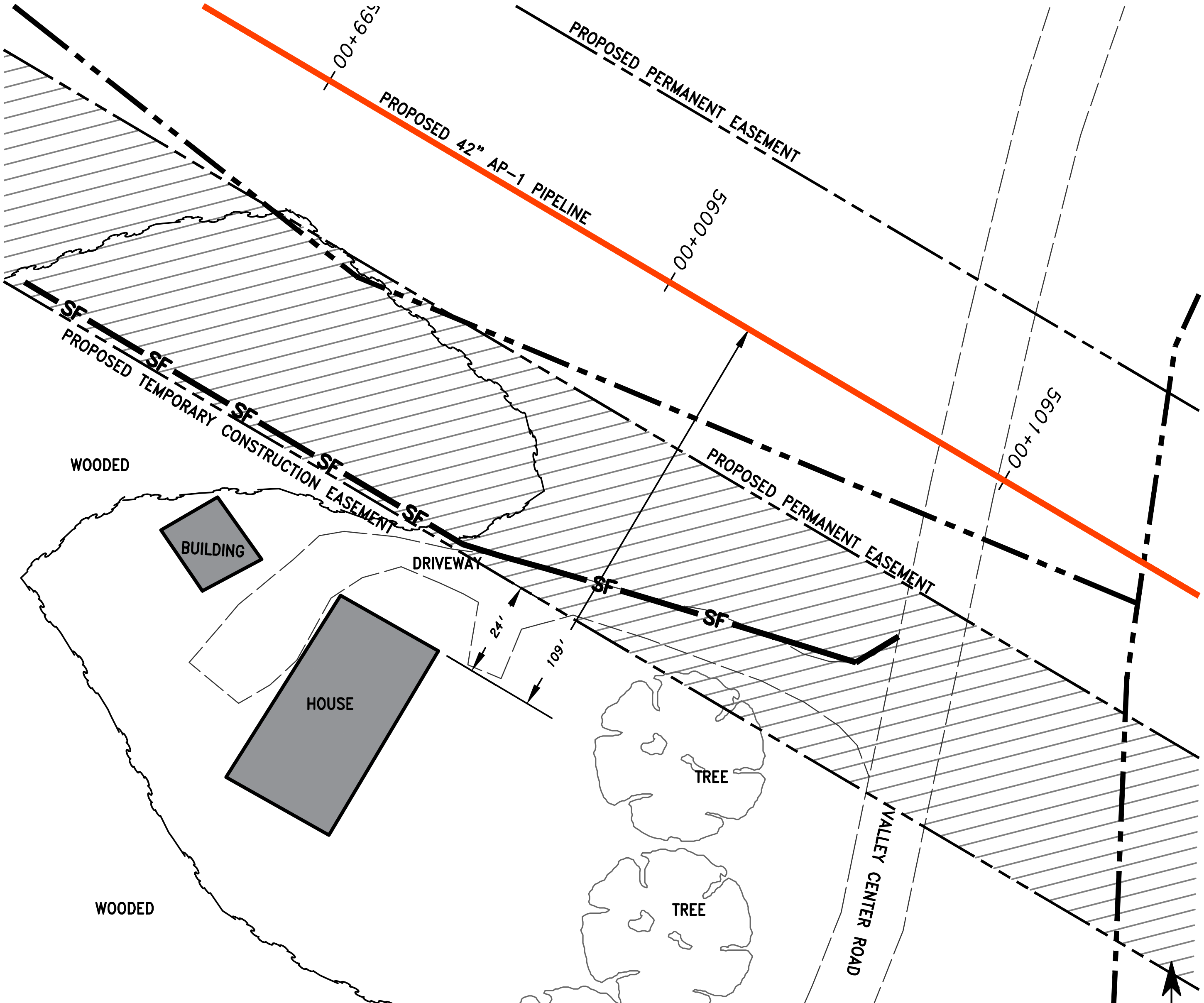
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC CHKD. DLH APPD. NET DATE 7/18/2016
SCALE: AS SHOWN TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-05-001-E102 1 REV

GAI CAD FILE: J:\2665 -GA\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\1 - REROUTE 1A\BUILDING EXHIBITS\2665-01 SPREAD-1A - LL-05-001-E102.DWG

7/18/2016 2:34 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.
- TOPSOIL SEGREGATION AREA

LL-06-001-C008
457 FORESTRY ROAD
HOT SPRINGS, VIRGINIA 24445
TAX MAP # 64-4-1
AP-1 PIPELINE
MILE POST 88.45

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

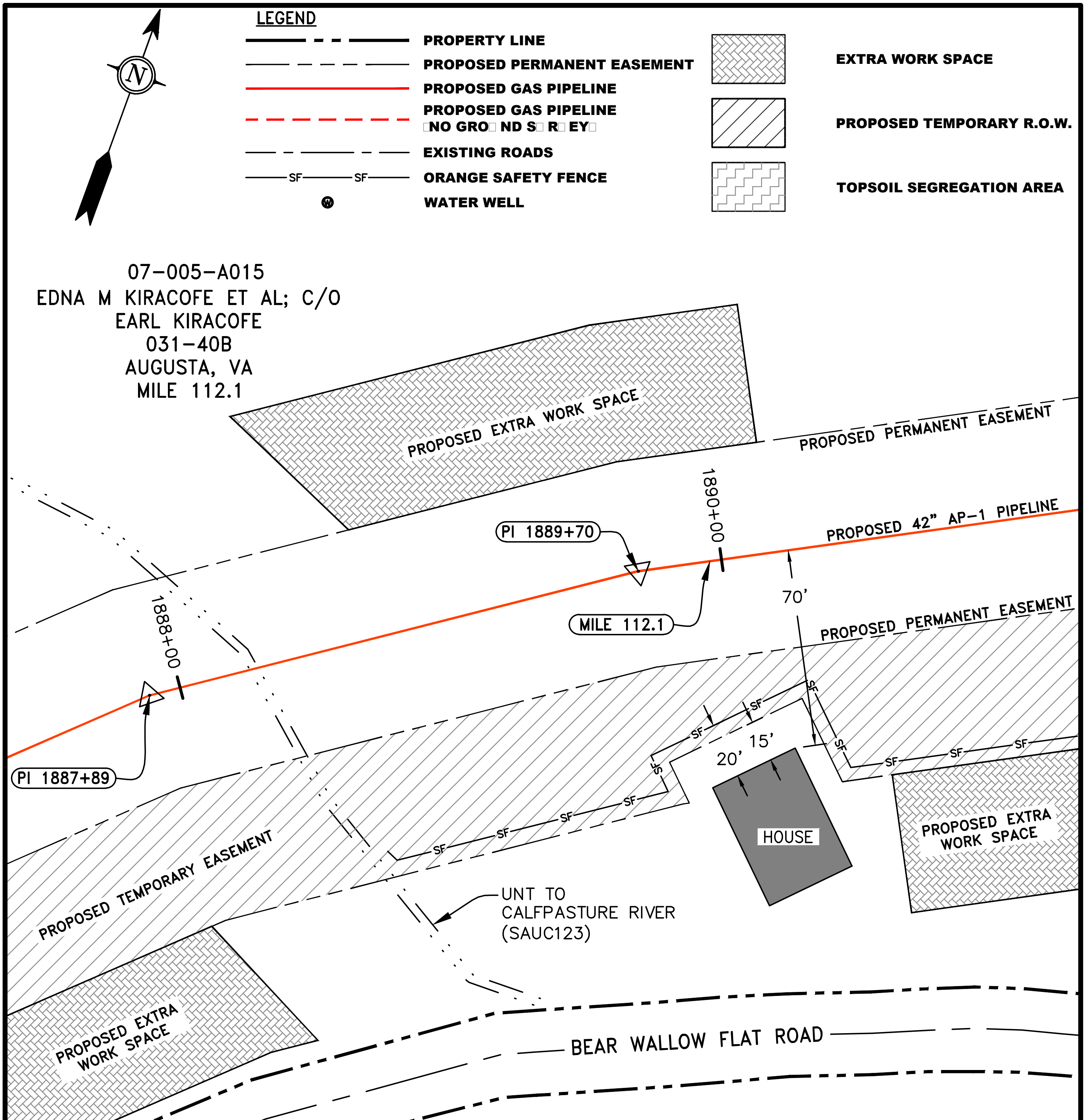
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
HIGHLAND COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 6/24/2016
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-06-001-C008			REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 02 - SOUTHEAST PIPELINE (SECTION 1)\1 - REROUTE 1A\BUILDING EXHIBITS\2665-01 SPREAD-1A - LL-06-001-C008.DWG

6/24/2016 12:55 PM



NOTES:

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE. ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

SCALE: 1" = 50'

50' 0 50' 100'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
SUITE 300 EAST
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
AGUSTA COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. ACE | CHKD. DLH | APPD. NET | DATE 7/18/16

SCALE: AS SHOWN | TASK NO. 001

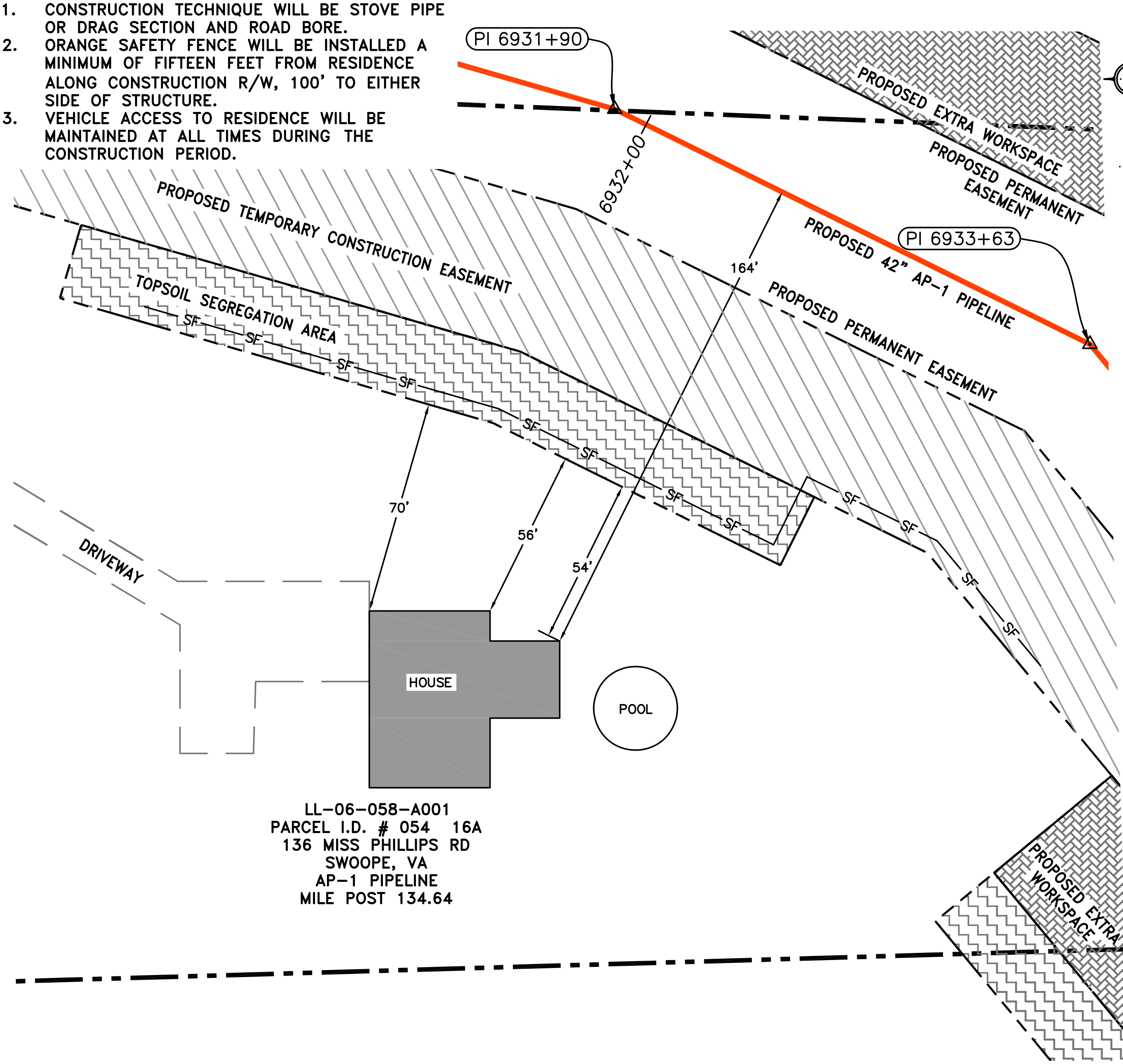
PROJECT NO./DASH NO. C140468

DRAWING NO. LL-07-005-A015 REV –

GAI CAD FILE: \\GAICONSULTANTS.LOCAL\BUPROJ\ENERGY\2014\C140468.00 - DOMINION - SOUTHEAST PIPE\CAD\MON FOREST REROUTE\DWG\HOUSE EXHIBITS\SITE SPECIFIC-LL-07-005-A015.DWG

7/18/2016 1:43 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE

PROPOSED PERMANENT EASEMENT

PROPOSED GAS PIPELINE

SF — SF — ORANGE SAFETY FENCE

PROPOSED TEMPORARY R.O.W.

EXTRA WORK SPACE

TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
AUGUSTA COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. SIB | CHKD. DLH | APPD. NET | DATE 6/27/16

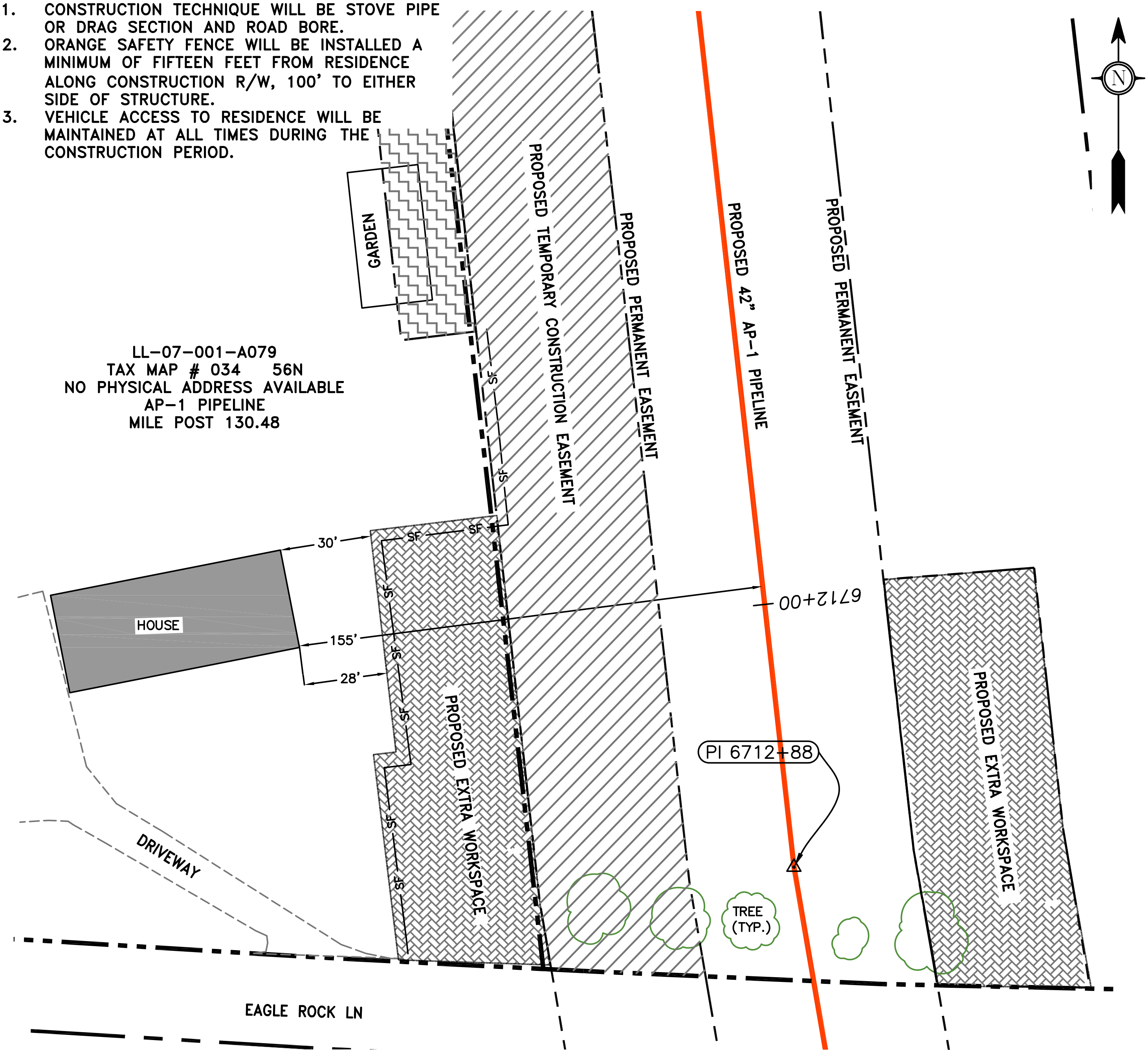
SCALE: AS SHOWN | TASK NO. 01

PROJECT NO./DASH NO. 140468

DRAWING NO. LL-06-058-A001 REV 2

GAI CAD FILE: R:\050-5159 – GIA, INC. – GAI – THRASHER – SERP – MAPPING\SURVEY\DRAWING\SEC 3\SECTION 3 HOUSE EXHIBITS – REROUTE.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants

SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
AUGUSTA COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

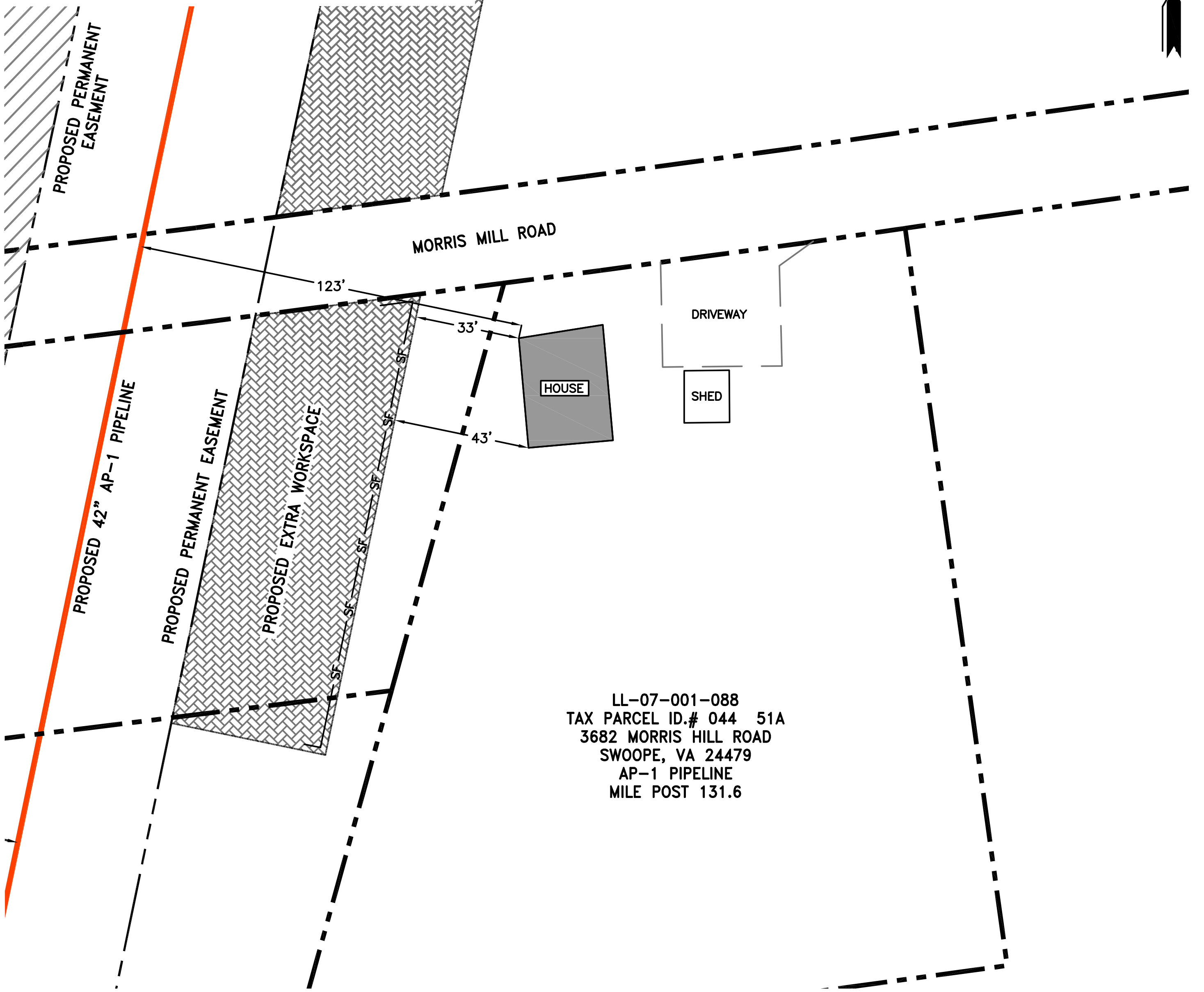
DWN. SIB	CHKD. DLH	APPD. NET	DATE 6/30/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468

DRAWING NO. LL-07-001-A079 REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 3\SECTION 3 HOUSE EXHIBITS - REROUTE.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE. ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants

SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
AUGUSTA COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

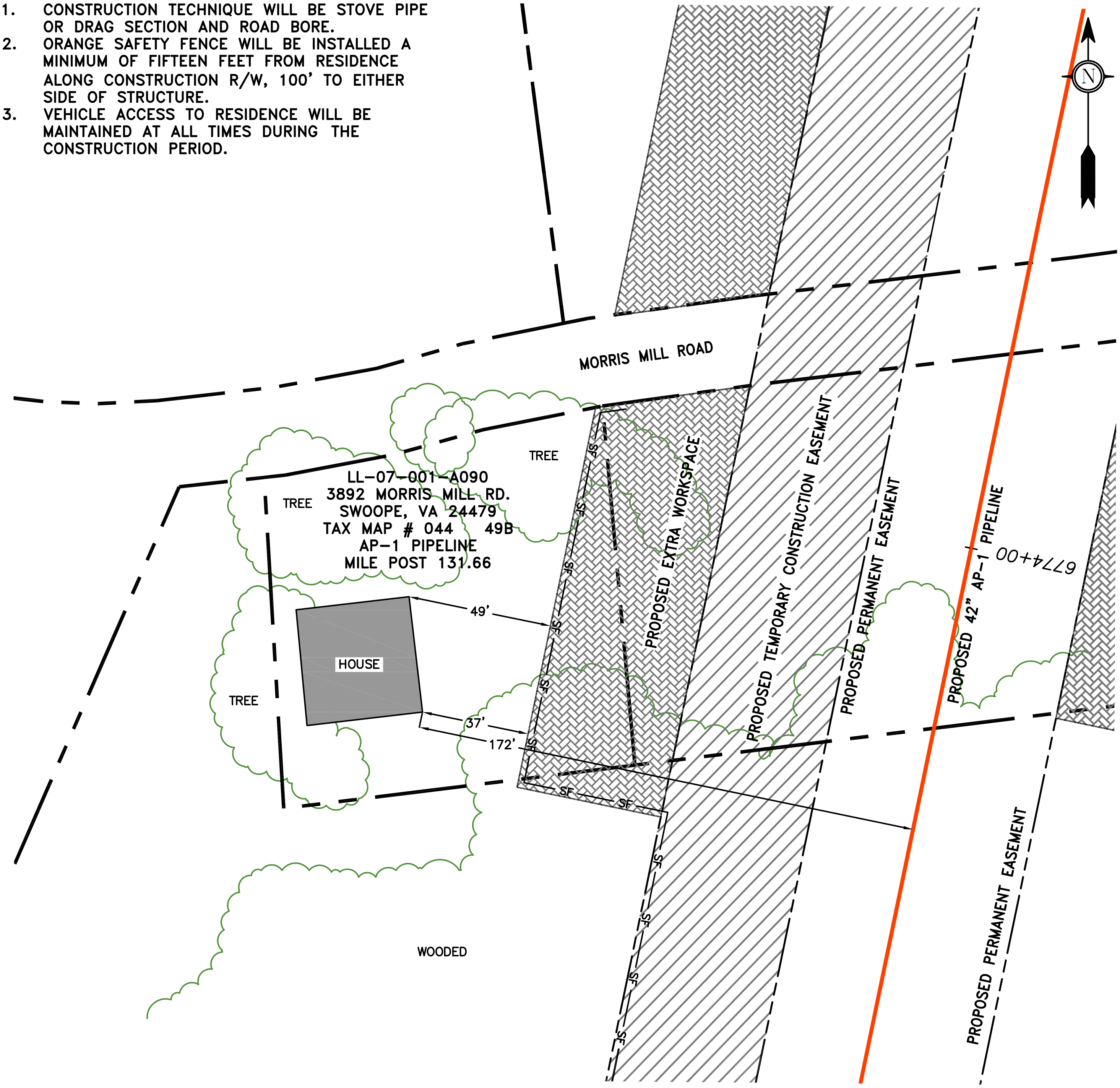
DWN. GPT	CHKD. DLH	APPD. NET	DATE 7/11/2016
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468

DRAWING NO. LL-07-001-A088 — REV

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 3\SECTION 3 HOUSE EXHIBITS - REROUTE.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE

PROPOSED PERMANENT EASEMENT

PROPOSED GAS PIPELINE

SF — SF ORANGE SAFETY FENCE

PROPOSED TEMPORARY R.O.W.

EXTRA WORK SPACE

SCALE: 1" = 50'

50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

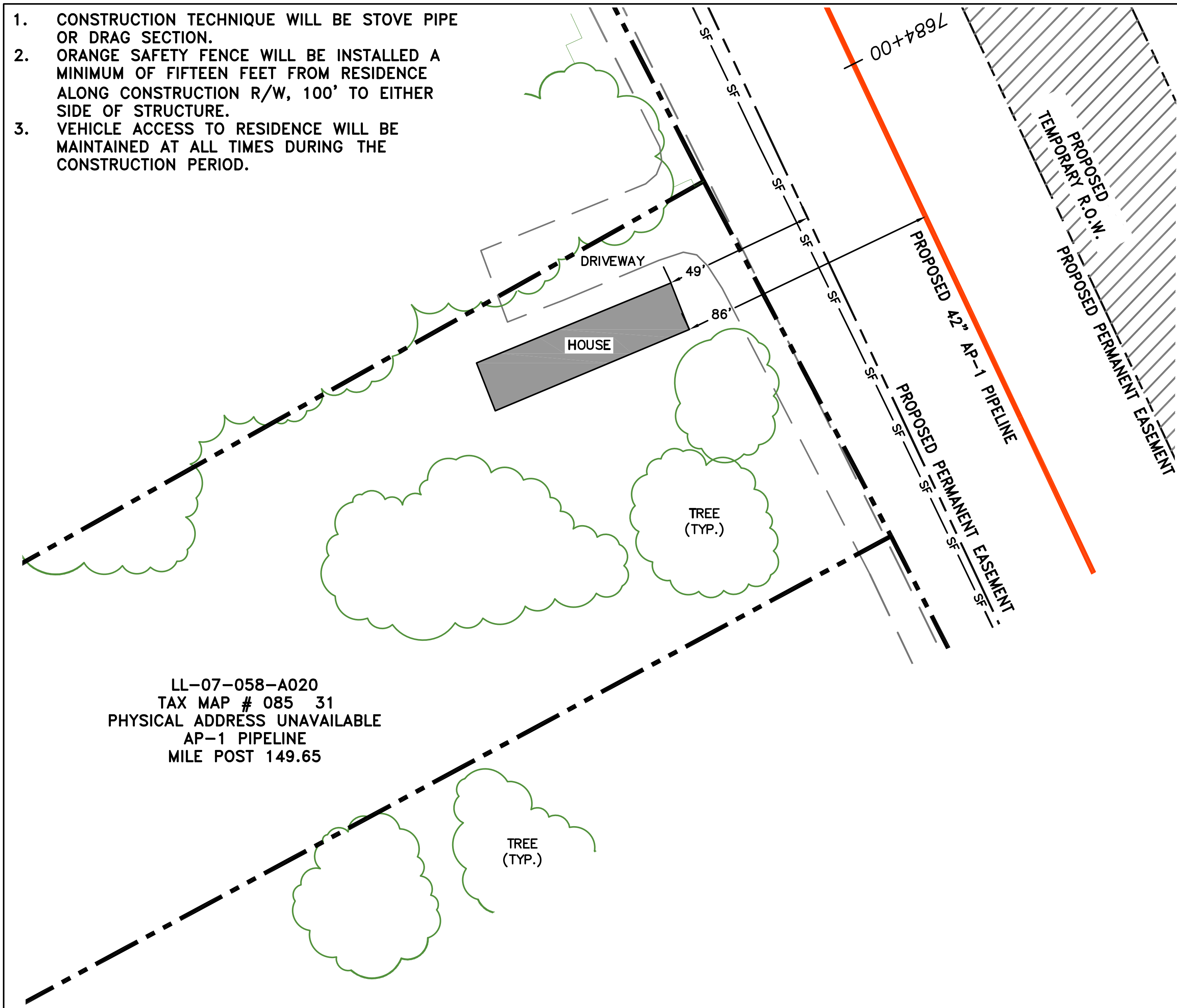
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
AUGUSTA COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/11/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-07-001-A090			REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 3\SECTION 3 HOUSE EXHIBITS.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF——SF ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'
50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
AUGUSTA COUNTY, VIRGINIA

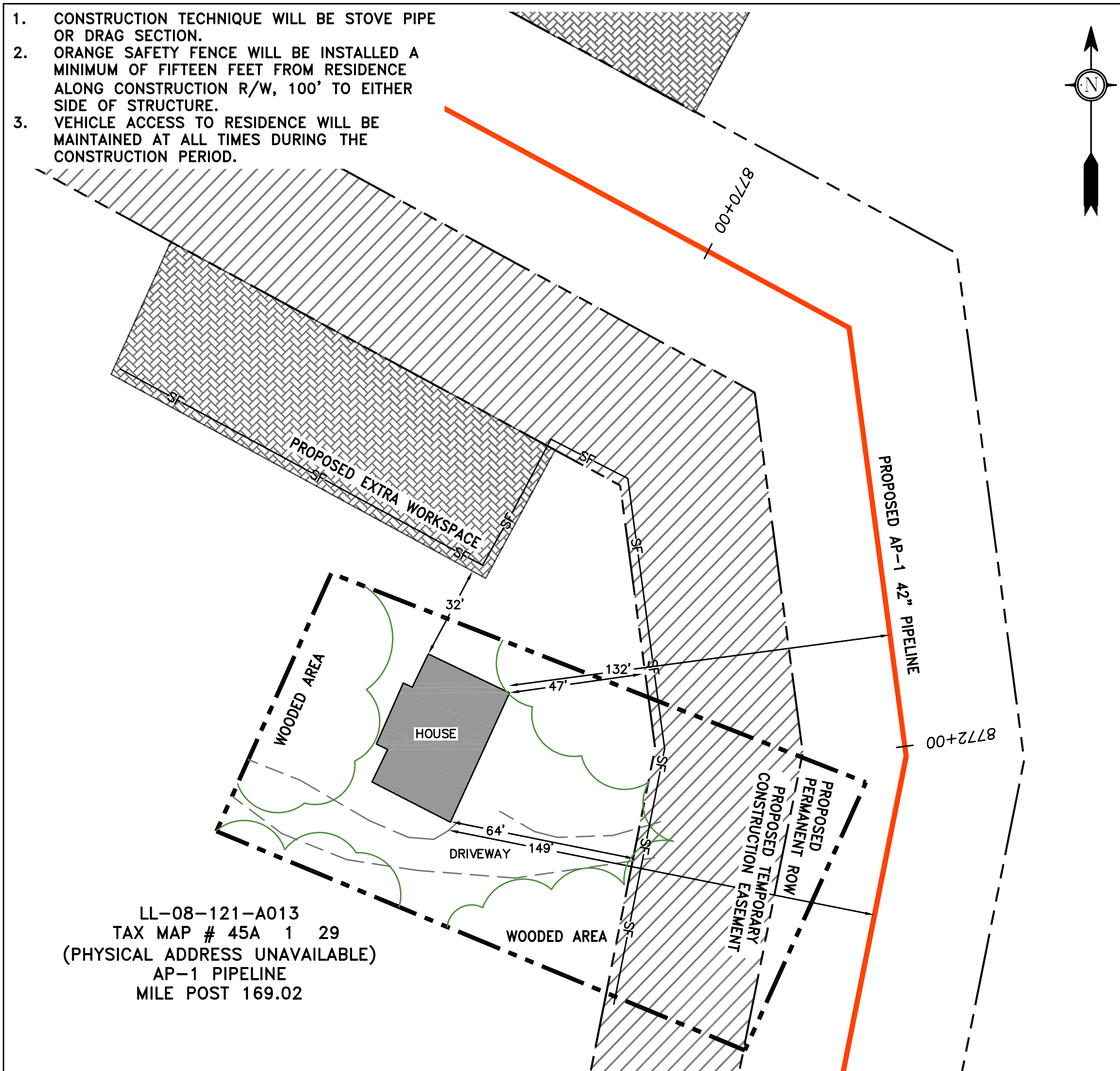
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/11/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-07-058-A020 REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 3\SECTION 3 HOUSE EXHIBITS - REROUTE.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-08-121-A013
TAX MAP # 45A 1 29
(PHYSICAL ADDRESS UNAVAILABLE)
AP-1 PIPELINE
MILE POST 169.02

LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF —— SF ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE

SCALE: 1" = 50'

50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

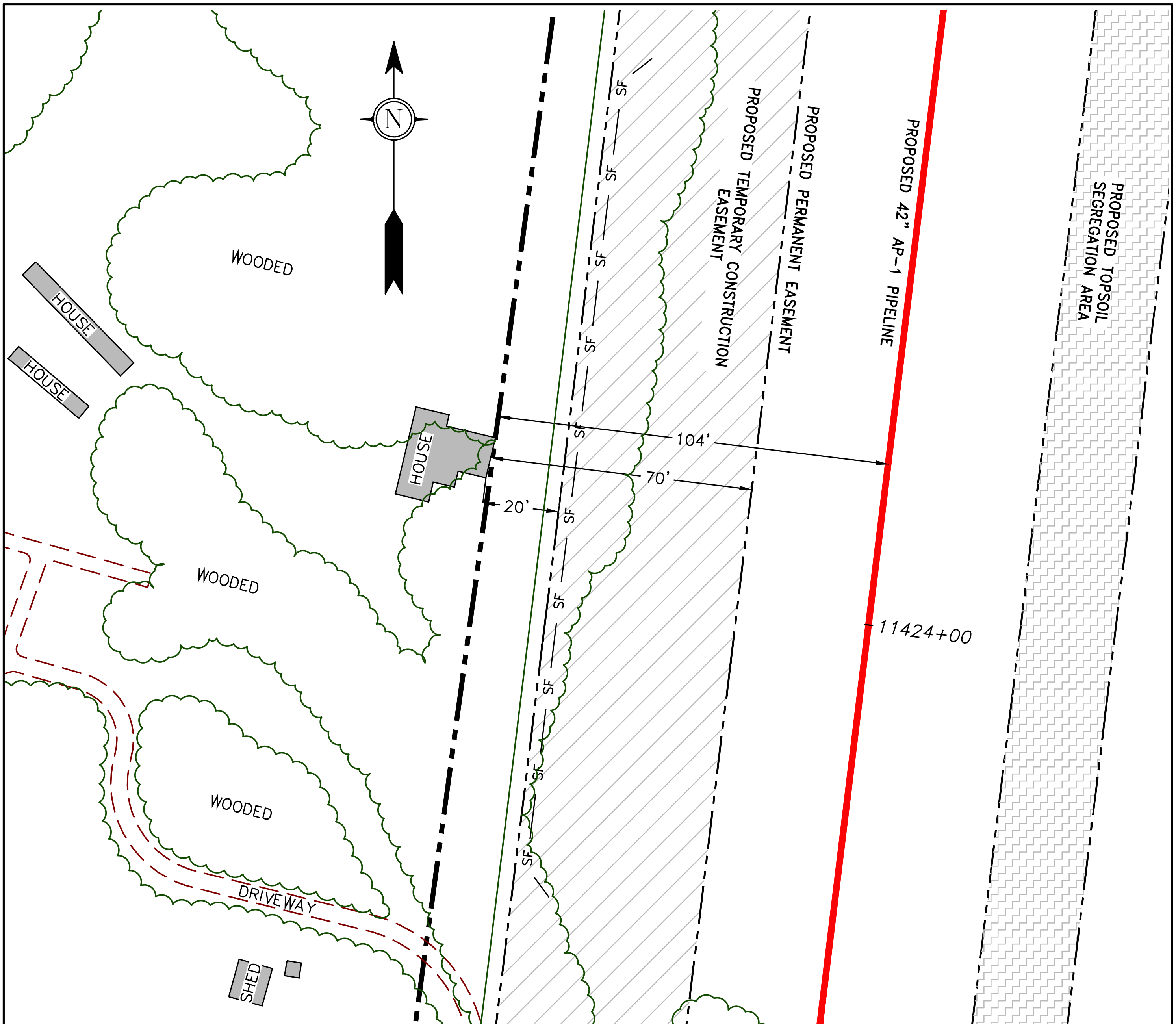
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
NELSON COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/11/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-08-121-A013 REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 4\HOUSE EXHIBITS\SECTION 4 HOUSE EXHIBITS_RVSD 6-30-16.DWG



1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-10-011
TAX MAP # 096-A-72B
376 RAINES TAVERN ROAD
FARMVILLE, VA 23901
AP-1 MILE POST 213.26

LEGEND

- PROPERTY LINE
- PERMANENT EASEMENT
- EDGE OF PA EMENT
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 40'

40' 0 40'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

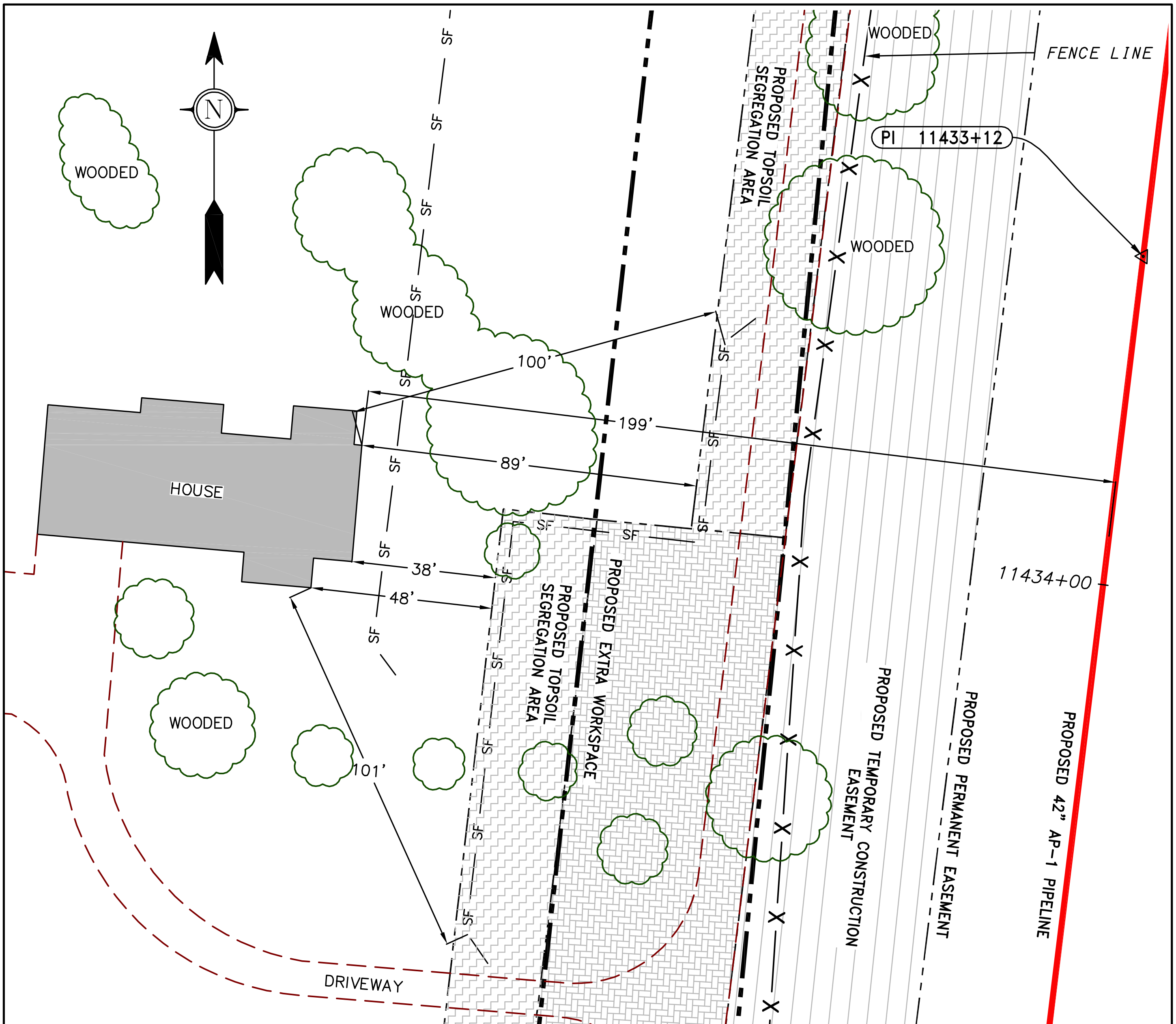
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. JFS	CHKD. DLH	APPD. NET	DATE 7/14/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. C140468			
DRAWING NO. LL-10-011			5 REV

GAI CAD FILE: T:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-10-011 HOUSE DETAIL.DWG

7/14/2016 8:53 a.m.



1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-10-011.5
N/F
RACHEL SHELTER
TAX MAP # 096-A-72A
378 RAINES TAVERN RD
CUMBERLAND, VA 23901
MILE POST 213.46

LEGEND

- TAX PARCEL LINE
- PERMANENT EASEMENT
- EDGE OF PAVEMENT
- SF — SF ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 40'

40' 0 40'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

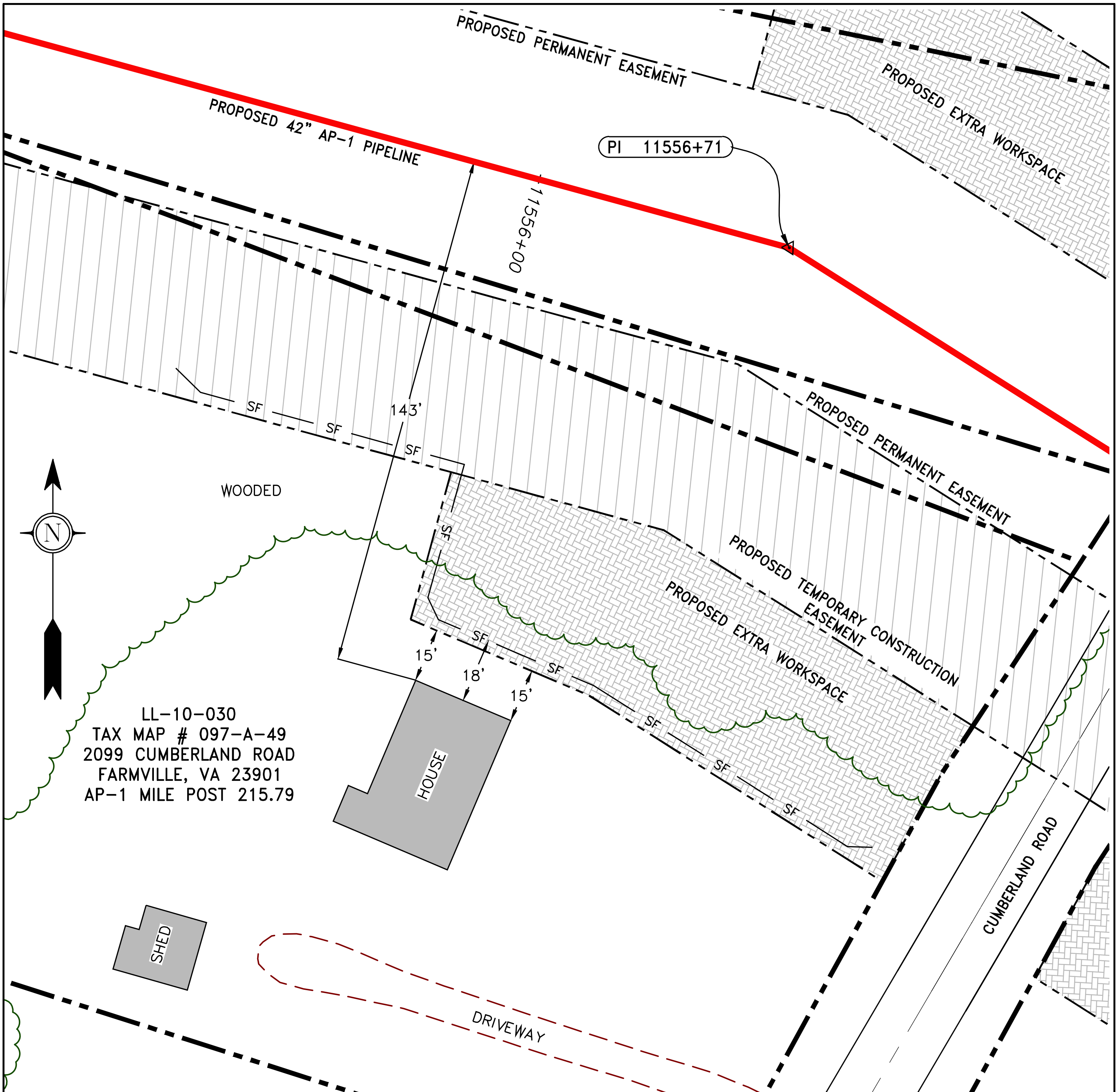
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. DOO	CHKD. DLH	APPD. NET	DATE 1/19/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. C140468			
DRAWING NO. LL-10-011.5			REV 1

GAI CAD FILE: F:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-10-011.5 HOUSE DETAIL.DWG

1/19/2016 1:33 p.m.



LEGEND

- PROPERTY LINE
- PERMANENT EASEMENT
- EDGE OF PA EMENT
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 40'

40' 0 40'

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

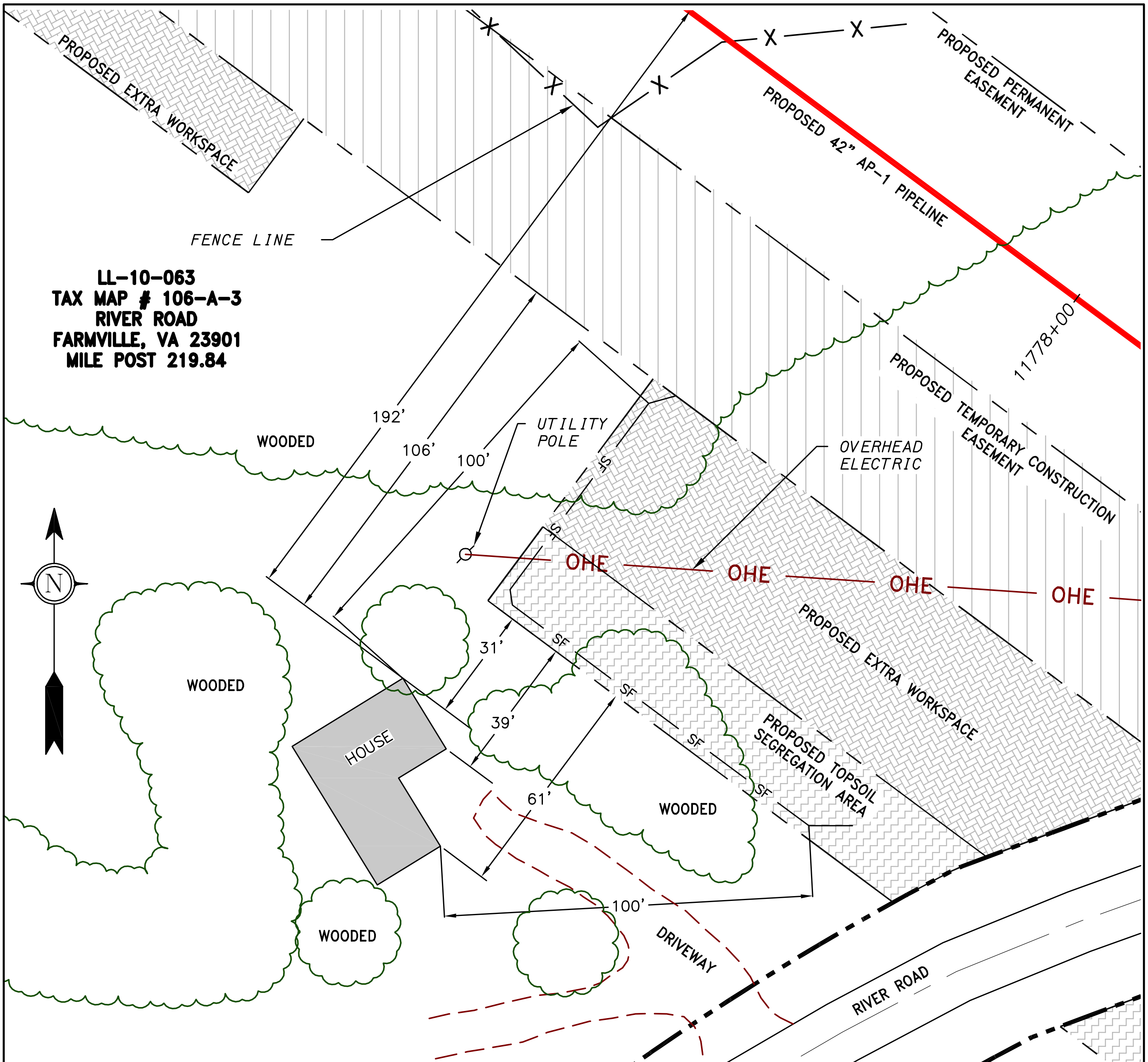
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. JFS	CHKD. DLH	APPD. NET	DATE 7/13/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. C140468			
DRAWING NO. LL-10-030			REV 3

GAI CAD FILE: T:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-10-030 HOUSE DETAIL.DWG

7/13/2016 4:30 p.m.



LEGEND

- TAX PARCEL LINE
- PERMANENT EASEMENT
- EDGE OF PAVEMENT
- ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE
- TOPSOIL SEGREGATION AREA

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

SCALE: 1" = 40'

40' 0 40'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, VIRGINIA

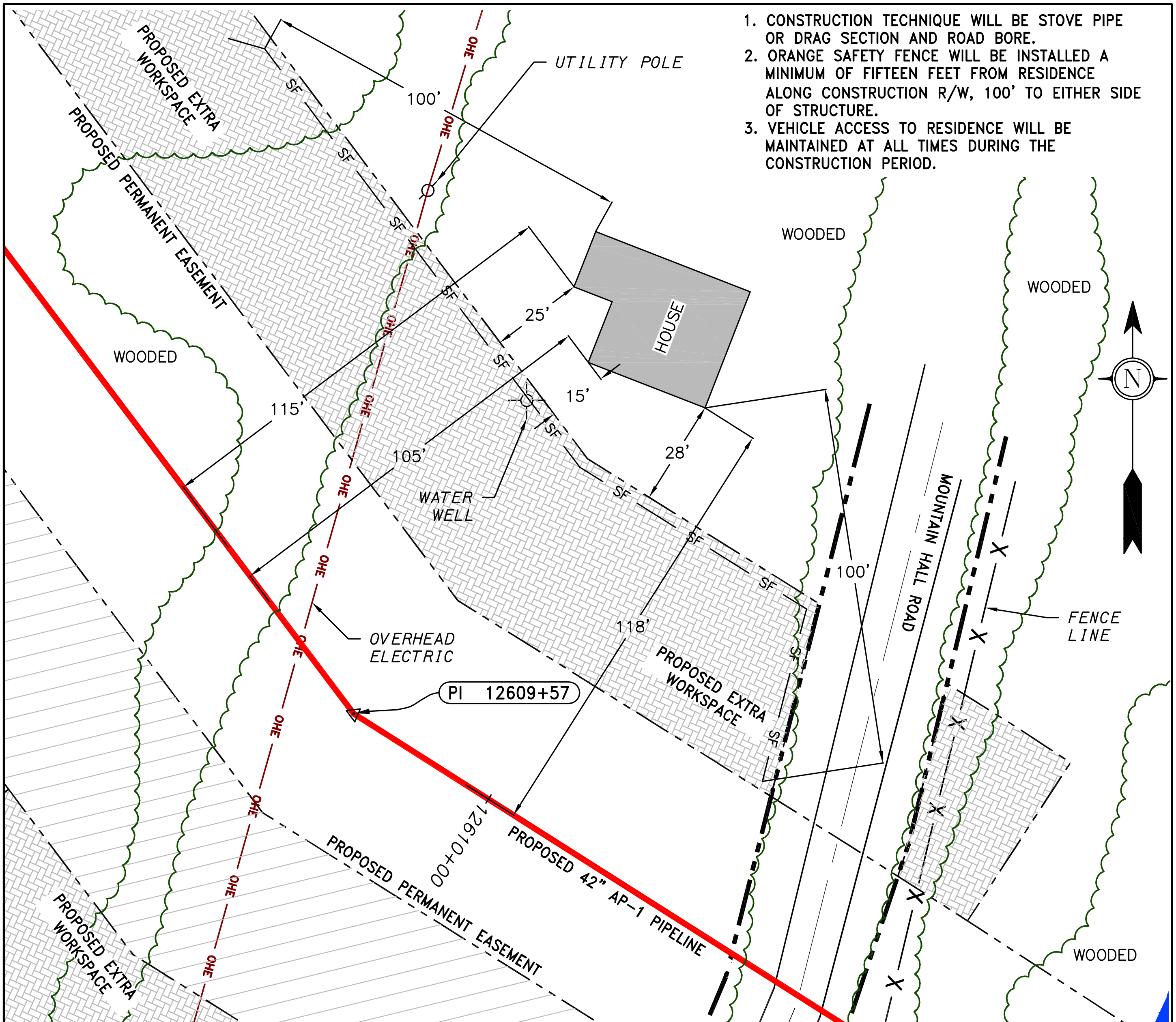
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. EEA	CHKD. DLH	APPD. NET	DATE 1/13/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. C140468			
DRAWING NO. LL-10-063			REV 1

GAI CAD FILE: F:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-10-063 HOUSE DETAIL.DWG

1/13/2016 1:08 p.m.

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-12-043
N/F
FRANK DYSON
TAX MAP # 6509-09-5118
MILE POST 235.62

(PHYSICAL ADDRESS UNAVAILABLE)

LEGEND

- TAX PARCEL LINE
- PERMANENT EASEMENT
- EDGE OF PAVEMENT
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 40'

40' 0 40'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

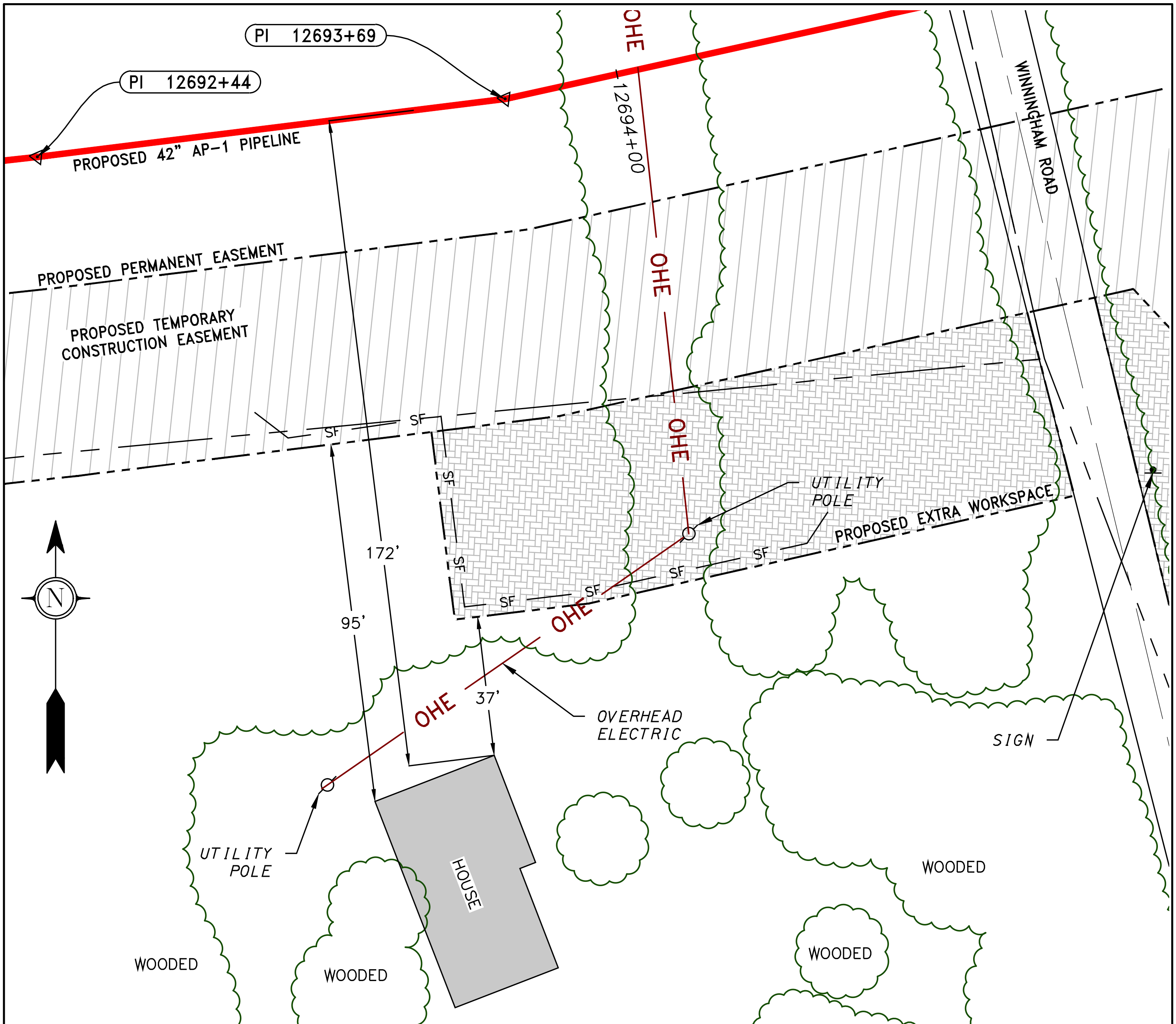
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
NOTTOWAY COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. EEA | CHKD. DLH | APPD. NET | DATE 1/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. C140468
DRAWING NO. LL-12-043 REV 2

GAI CAD FILE: F:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-12-043 HOUSE DETAIL.DWG

1/18/2016 1:54 p.m.



1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-12-049.5
TAX MAP # 20-11
AP-1 MILE POST 237.19

(PHYSICAL ADDRESS UNAVAILABLE)

LEGEND

- PROPERTY LINE
- PERMANENT EASEMENT
- EDGE OF PA□ EMENT
- SF —— SF ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 40'

40' 0 40'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
NOTTOWAY COUNTY, VIRGINIA

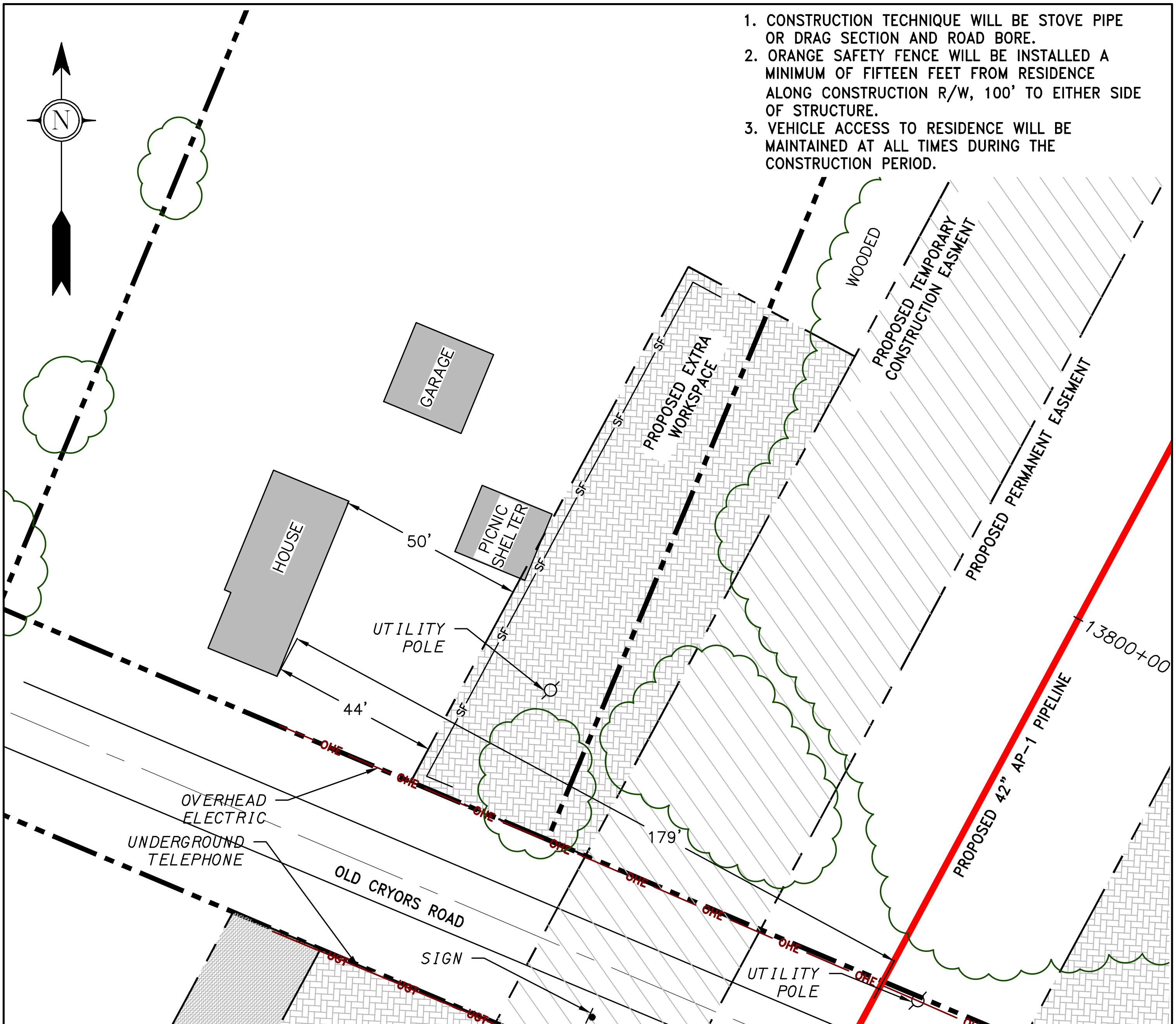
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. JFS | CHKD. DLH | APPD. NET | DATE 6/24/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. C140468
DRAWING NO. LL-12-049.5 REV 2

GAI CAD FILE: T:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-12-049.5 HOUSE DETAIL.DWG

6/24/2016 9:38 a.m.

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-13-019-A006
TAX MAP # 52-5A
AP-1 MILE POST 255.86
(PHYSICAL ADDRESS UNAVAILABLE)

LEGEND

- PROPERTY LINE
- PERMANENT EASEMENT
- EDGE OF PA□EMENT
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED GAS PIPELINE
- PROPOSED TEMPORARY WORKSPACE
- PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 40'

40' 0 40'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
DINWIDDIE COUNTY, VIRGINIA

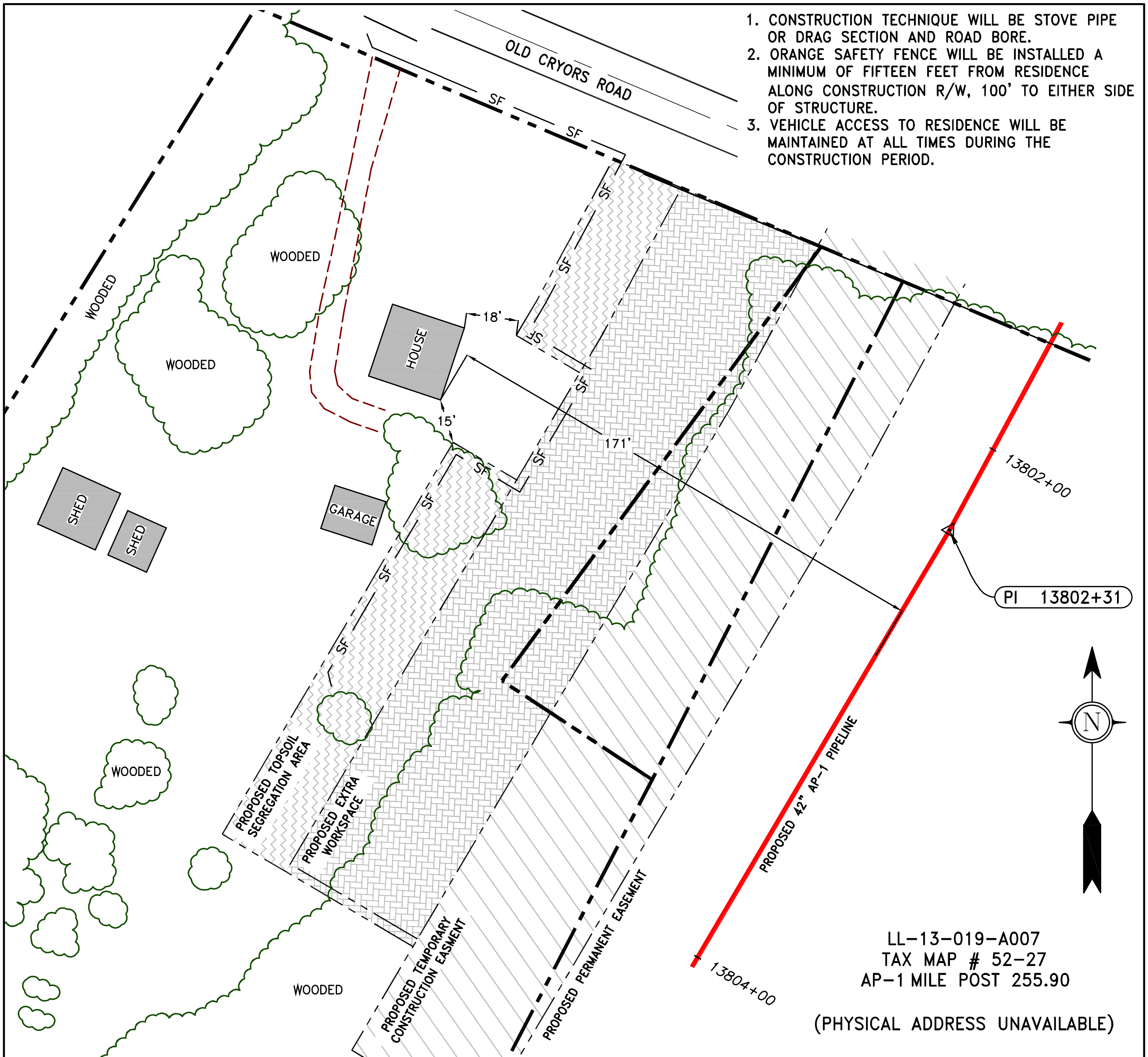
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. JFS | CHKD. DLH | APPD. NET | DATE 5/5/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. C140468
DRAWING NO. LL-13-019-A006 | REV 1

GAI CAD FILE: F:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-13-19-A006 HOUSE DETAIL.DWG

5/5/2016 1:21 p.m.

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-13-019-A007
TAX MAP # 52-27
AP-1 MILE POST 255.90

(PHYSICAL ADDRESS UNAVAILABLE)

LEGEND

PROPERTY LINE
PERMANENT EASEMENT
EDGE OF PAVEMENT
SF — SF — ORANGE SAFETY FENCE
PROPOSED GAS PIPELINE
PROPOSED TEMPORARY WORKSPACE
PROPOSED ADDITIONAL TEMPORARY WORKSPACE

SCALE: 1" = 50'
50' 0 50'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
DINWIDDIE COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. DGC | CHKD. DLH | APPD. NET | DATE 7/19/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. C140468
DRAWING NO. LL-13-019-A007 REV 2

GAI CAD FILE: T:\DOMINION\CADD-GIS DATA\HOUSE DETAILS\LL-13-19-A007 HOUSE DETAIL.DWG

7/19/2016 10:21 a.m.

[illegible]

1. [illegible]
2. [illegible]
3. [illegible]
4. [illegible]

[illegible]

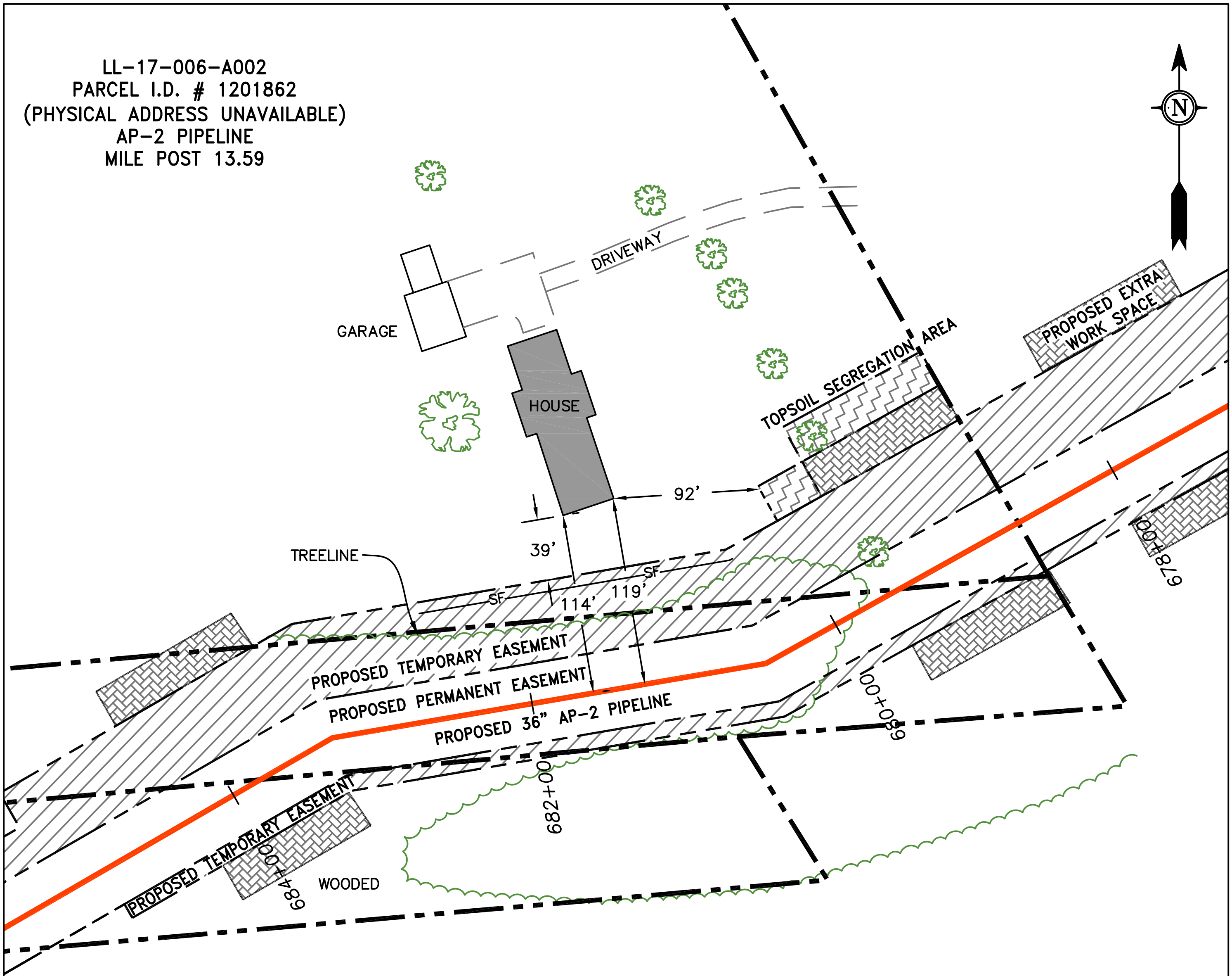
- [illegible]
- [illegible]
- [illegible]
- d. [illegible]
- [illegible]
- [illegible]
- [illegible]
  - [illegible]
  - [illegible]
  - [illegible]

gai consultants SOUTHPOINTE OFFICE 6000 TOWNE CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES GENERAL NOTES	DWN. JJP	CHKD. DLH	APPD. NET
		SCALE: NONE		DATE 07/28/2016
				TASK NO. 00
	ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. C140468		
		DRAWING NO. A001		REV –

GAI CAD FILE: Z:\ENERGY\2014\C140468.00 – DOMINION – SOUTHEAST PIPE\CAD\MASTER ROUTE\DRG\DRAWINGS\HOUSE_SITE_SPECIFIC_GENERAL_NOTES.DWG

7/19/2016 8:44 AM

LL-17-006-A002
PARCEL I.D. # 1201862
(PHYSICAL ADDRESS UNAVAILABLE)
AP-2 PIPELINE
MILE POST 13.59



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF SF — ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSRTUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

SCALE: 1" = 100'

100' 0 100'

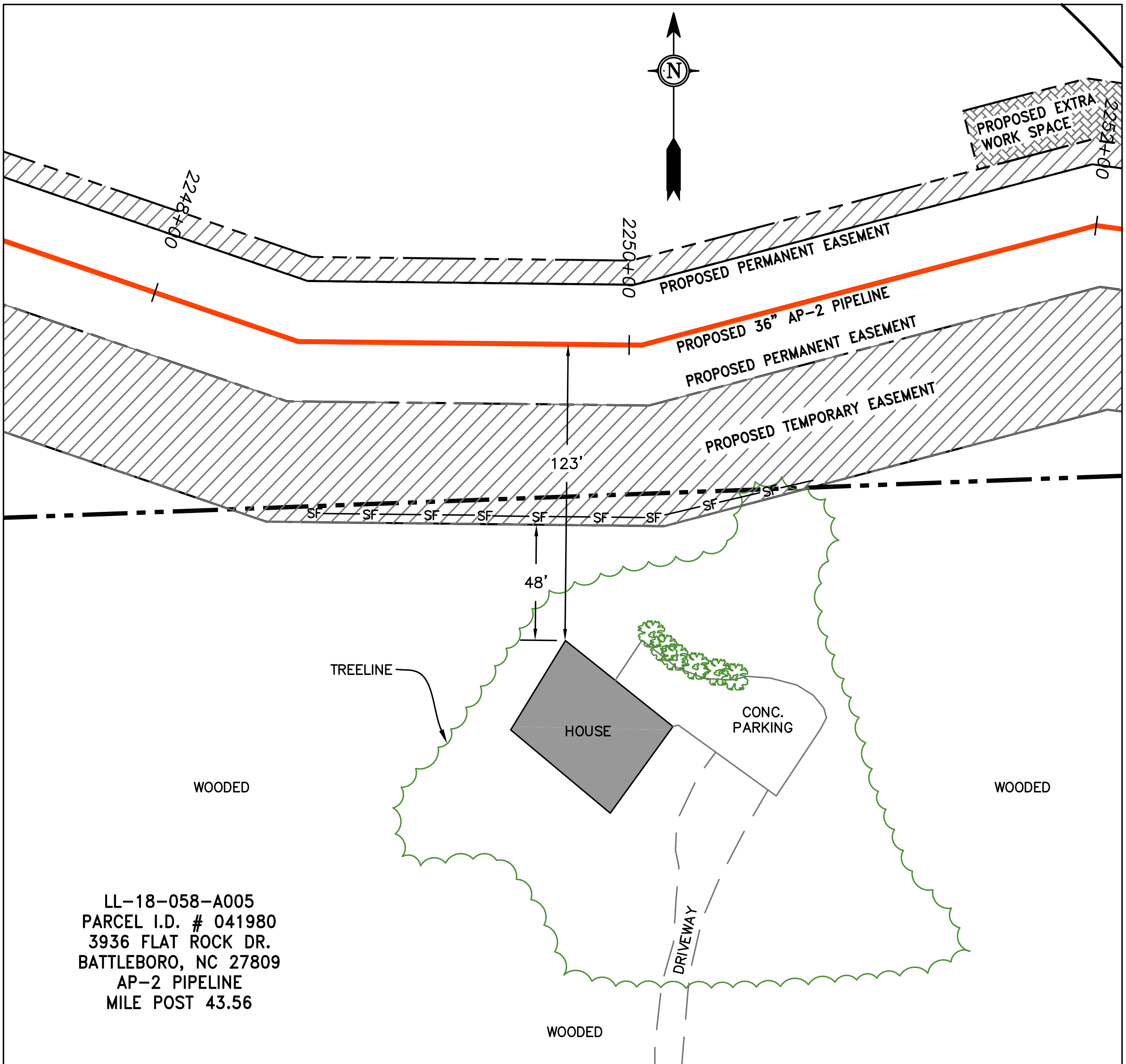
gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
HALIFAX COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. BJS | CHKD. DLH | APPD. NET | DATE 7/8/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-17-006-A002 REV —

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 9\SEC 9 HOUSE EXHIBITS.DWG



LL-18-058-A005
PARCEL I.D. # 041980
3936 FLAT ROCK DR.
BATTLEBORO, NC 27809
AP-2 PIPELINE
MILE POST 43.56

LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- —SF—SF— ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSRTUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

SCALE: 1" = 60'

60' 0 60'

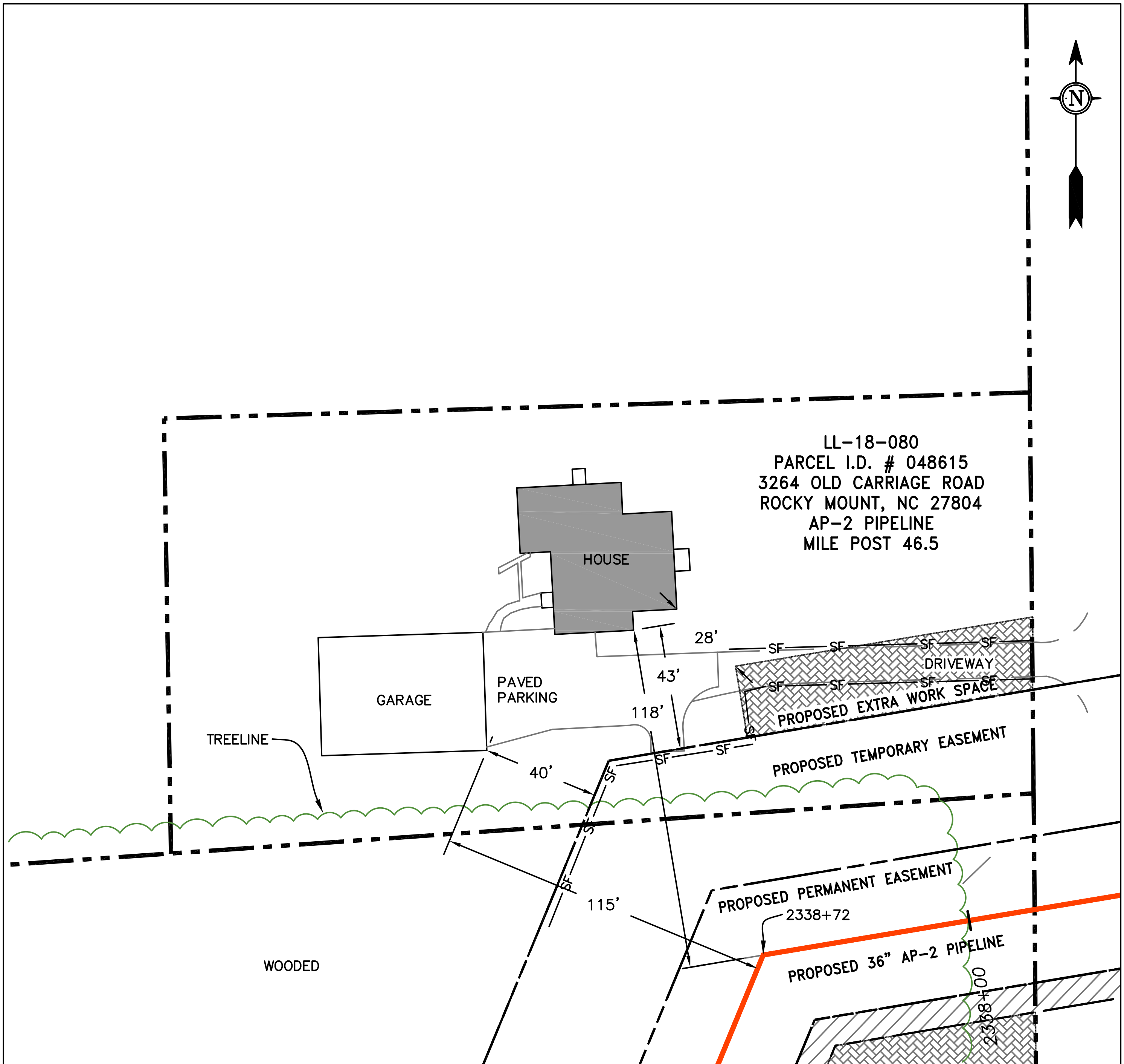
gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
NASH COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. BJS	CHKD. DLH	APPD. NET	DATE 7/8/2016
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-18-058-A005			REV 1

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 9\SEC 9 HOUSE EXHIBITS.DWG



LEGEND

PROPERTY LINE

PROPOSED PERMANENT EASEMENT

PROPOSED GAS PIPELINE

SF —— SF **ORANGE SAFETY FENCE**

PROPOSED TEMPORARY R.O.W.

EXTRA WORK SPACE

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSRTUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

SCALE: 1" = 50'

50' 0 50'

gai consultants
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

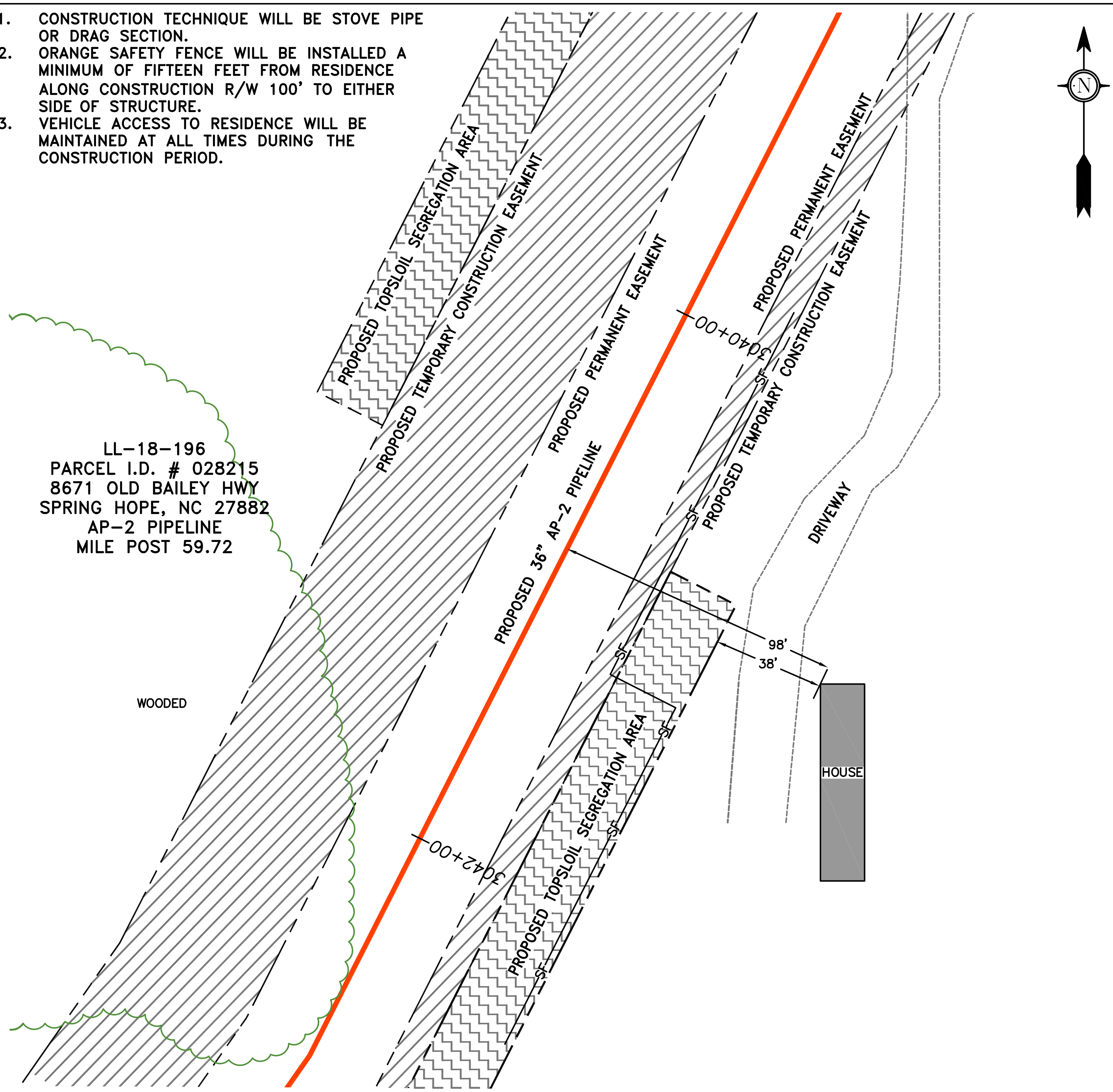
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
NASH COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. BJS | CHKD. DLH | APPD. NET | DATE 7/8/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-18-080 REV

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 9\SEC 9 HOUSE EXHIBITS.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — SF — ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
NASH COUNTY, NORTH CAROLINA

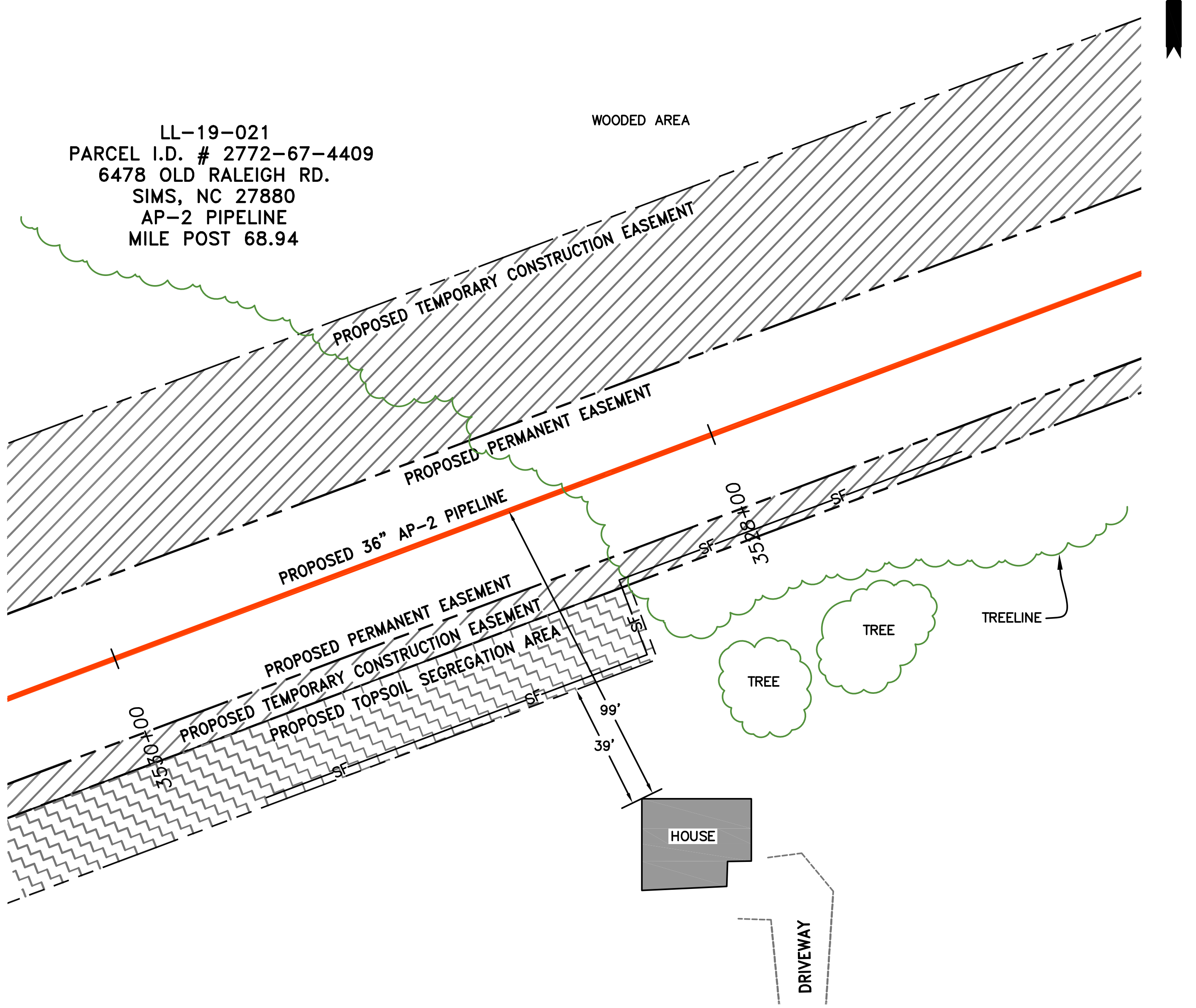
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/11/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-18-196
3 REV

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 10\HOUSE EXHIBITS\SECTION 10 HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE

PROPOSED PERMANENT EASEMENT

PROPOSED GAS PIPELINE

SF — SF ORANGE SAFETY FENCE

PROPOSED TEMPORARY R.O.W.

TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

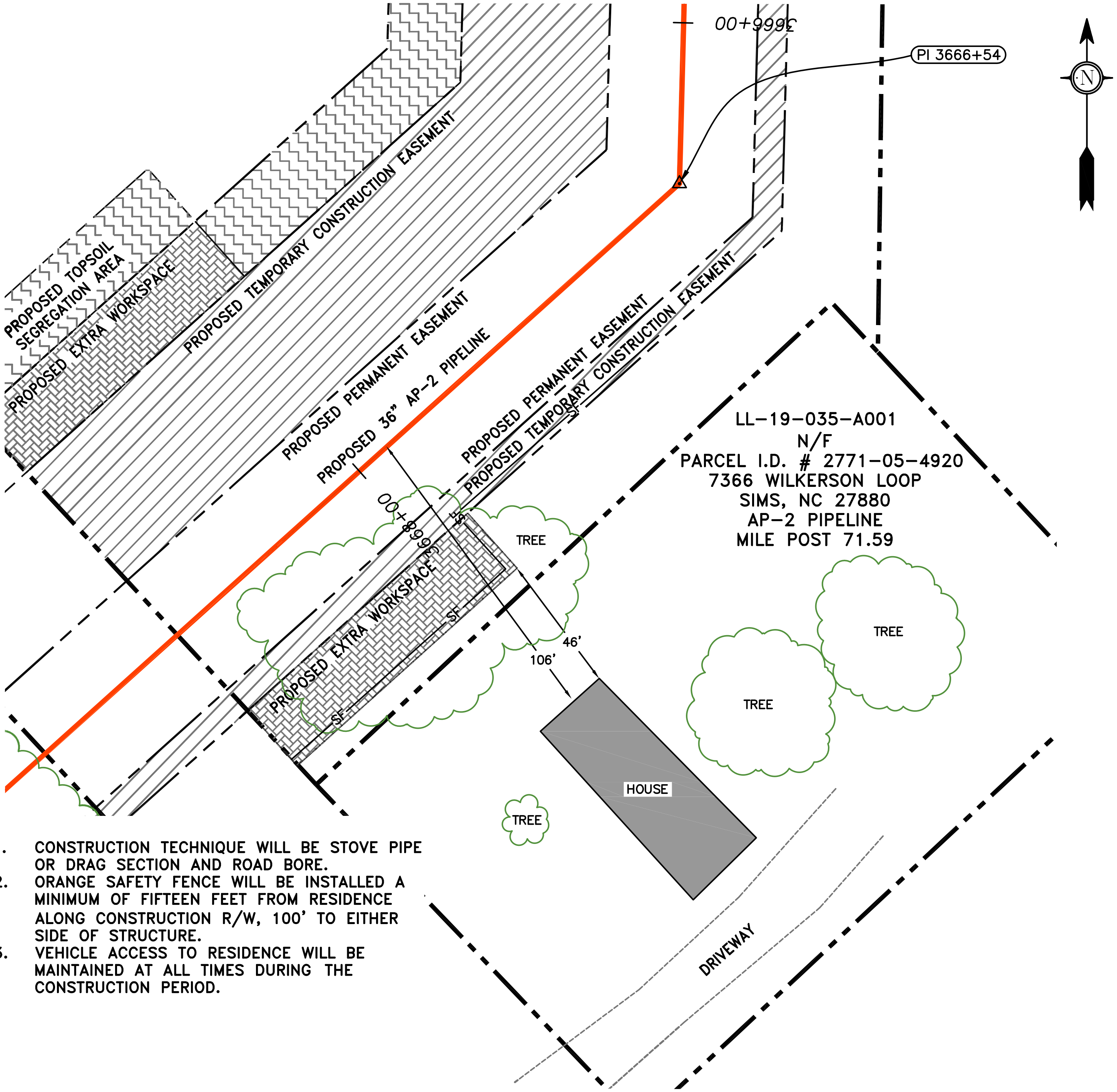
gai consultants

SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
WILSON COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/11/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-19-021			REV 2



1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF—SF ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

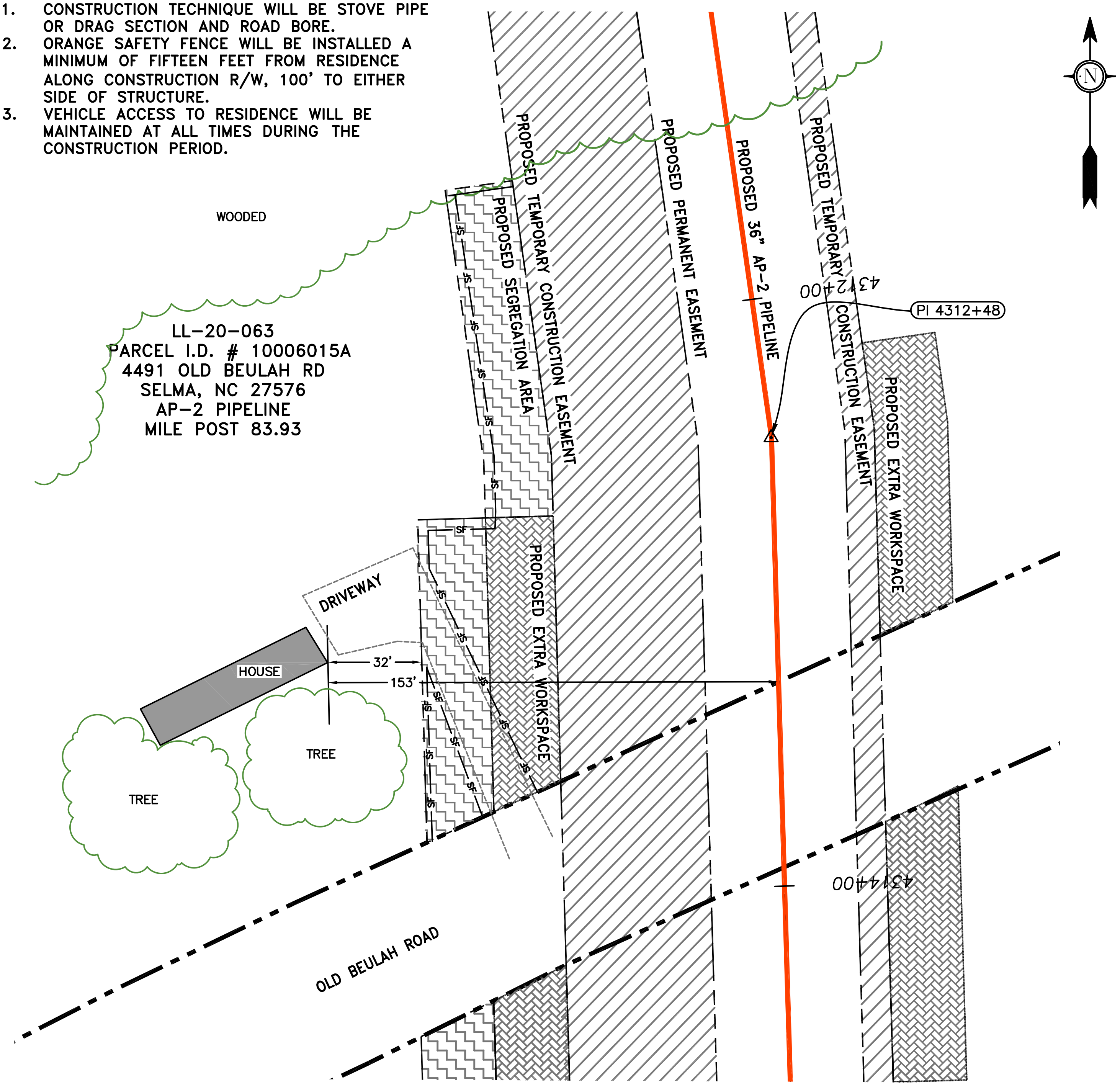
SCALE: 1" = 50'

50' 0 50'

gai consultants 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	**CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES** WILSON COUNTY, NORTH CAROLINA	DWN. CDM · CHKD. DLH · APPD. NET · DATE 7/11/16 SCALE: AS SHOWN · TASK NO. 01
	ATLANTIC COAST PIPELINE LLC **C/O DOMINION TRANSMISSION, INC.** 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. 140468 DRAWING NO. LL-19-035-A001 · REV 1

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 10\HOUSE EXHIBITS\SECTION 10 HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE

PROPOSED PERMANENT EASEMENT

PROPOSED GAS PIPELINE

—SF—SF— ORANGE SAFETY FENCE

PROPOSED TEMPORARY R.O.W.

EXTRA WORK SPACE

TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants

SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES

JOHNSTON COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC.

445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH | CHKD. DLH | APPD. NET | DATE 7/08/16

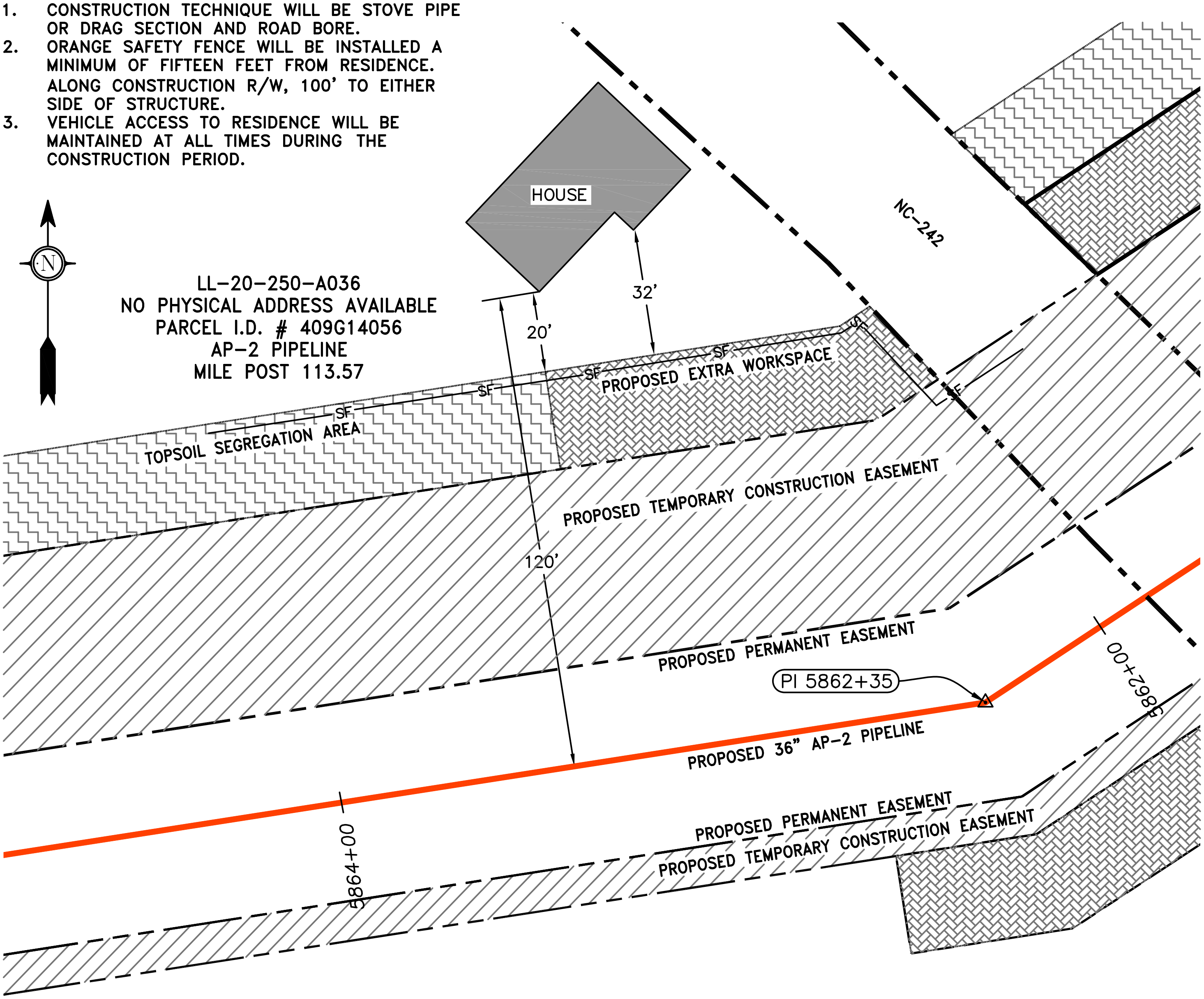
SCALE: AS SHOWN | TASK NO. 01

PROJECT NO./DASH NO. 140468

DRAWING NO. LL-20-063 | 2 REV

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 10\HOUSE EXHIBITS\SECTION 10 HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE. ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF — SF — ORANGE SAFETY FENCE
PROPOSED TEMPORARY R.O.W.
EXTRA WORK SPACE
TOPSOIL SEGREGATION AREA

SCALE: 1" = 40'
40' 0 40'

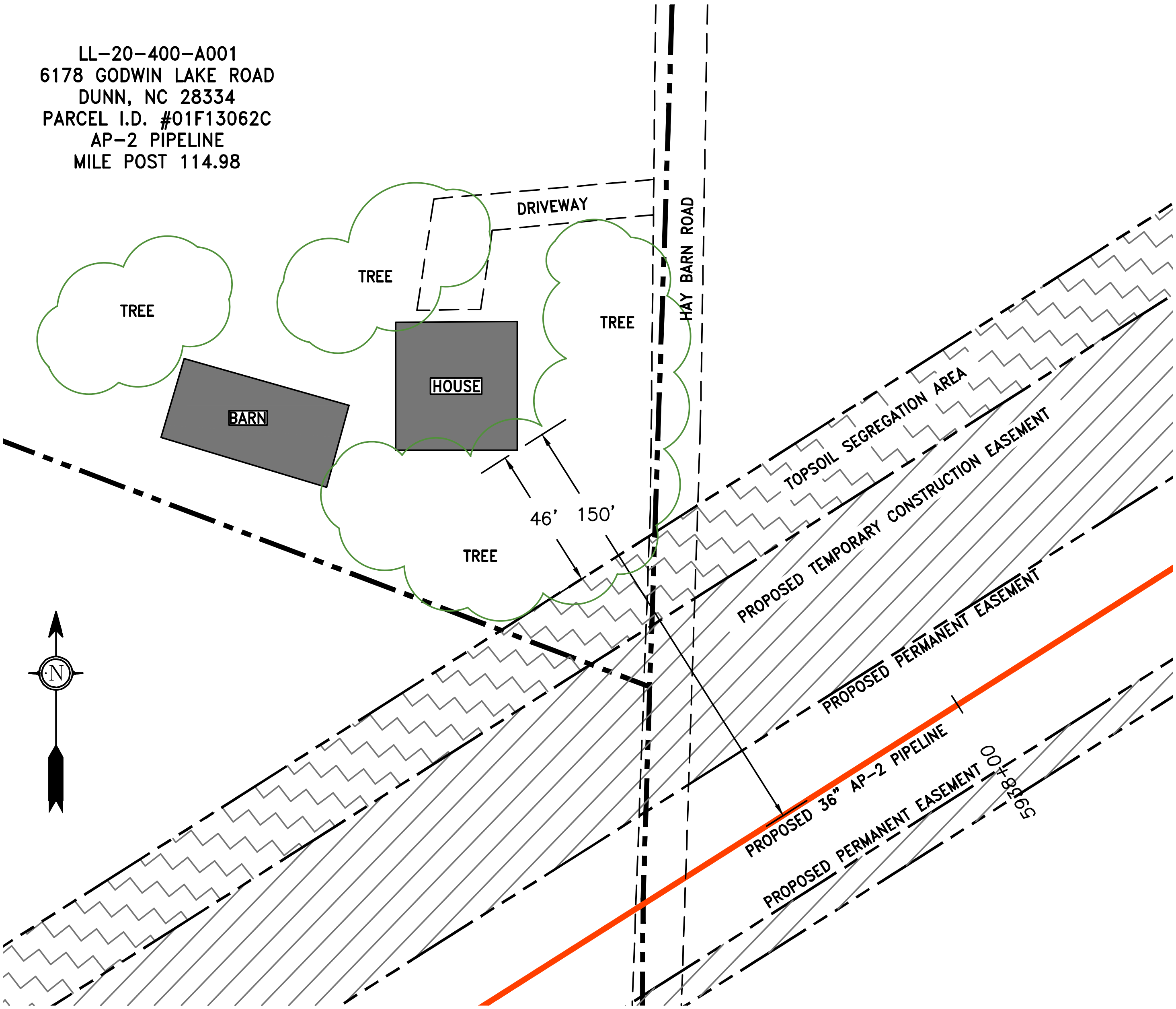
gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
JOHNSTON COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GPT | CHKD. DLH | APPD. NET | DATE 7/11/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-20-250-A036 REV -

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG



SCALE: 1" = 50'

50' 0 50'

LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — SF ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE. ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
JOHNSTON COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

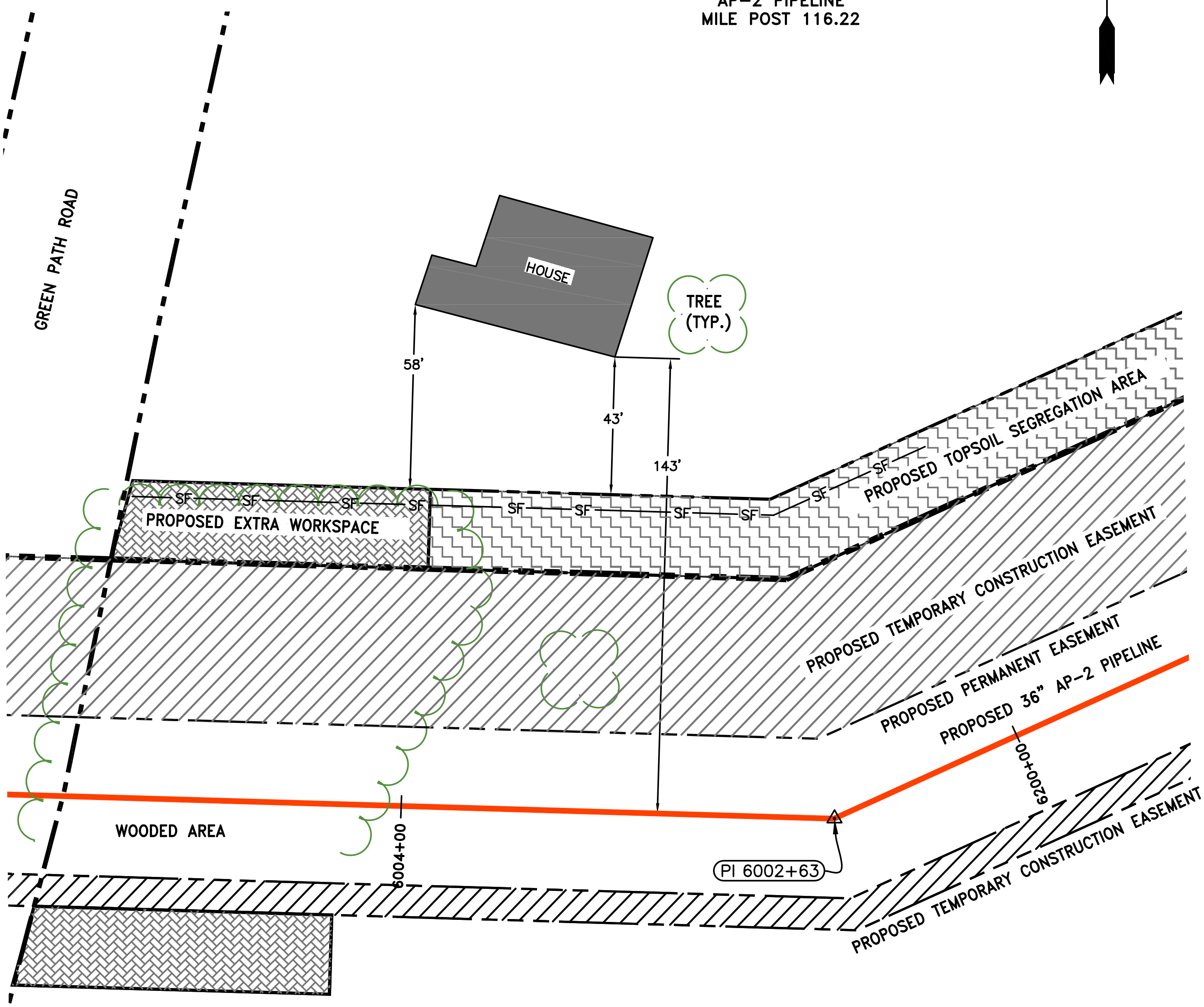
DWN. AKM | CHKD. DLH | APPD. NET | DATE 7/25/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-20-400-A001 REV –

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG

7/25/2016 4:26 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-21-015
PARCEL I.D. # 14060428001
(PHYSICAL ADDRESS UNAVAILABLE)
AP-2 PIPELINE
MILE POST 116.22



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- —SF—SF— ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

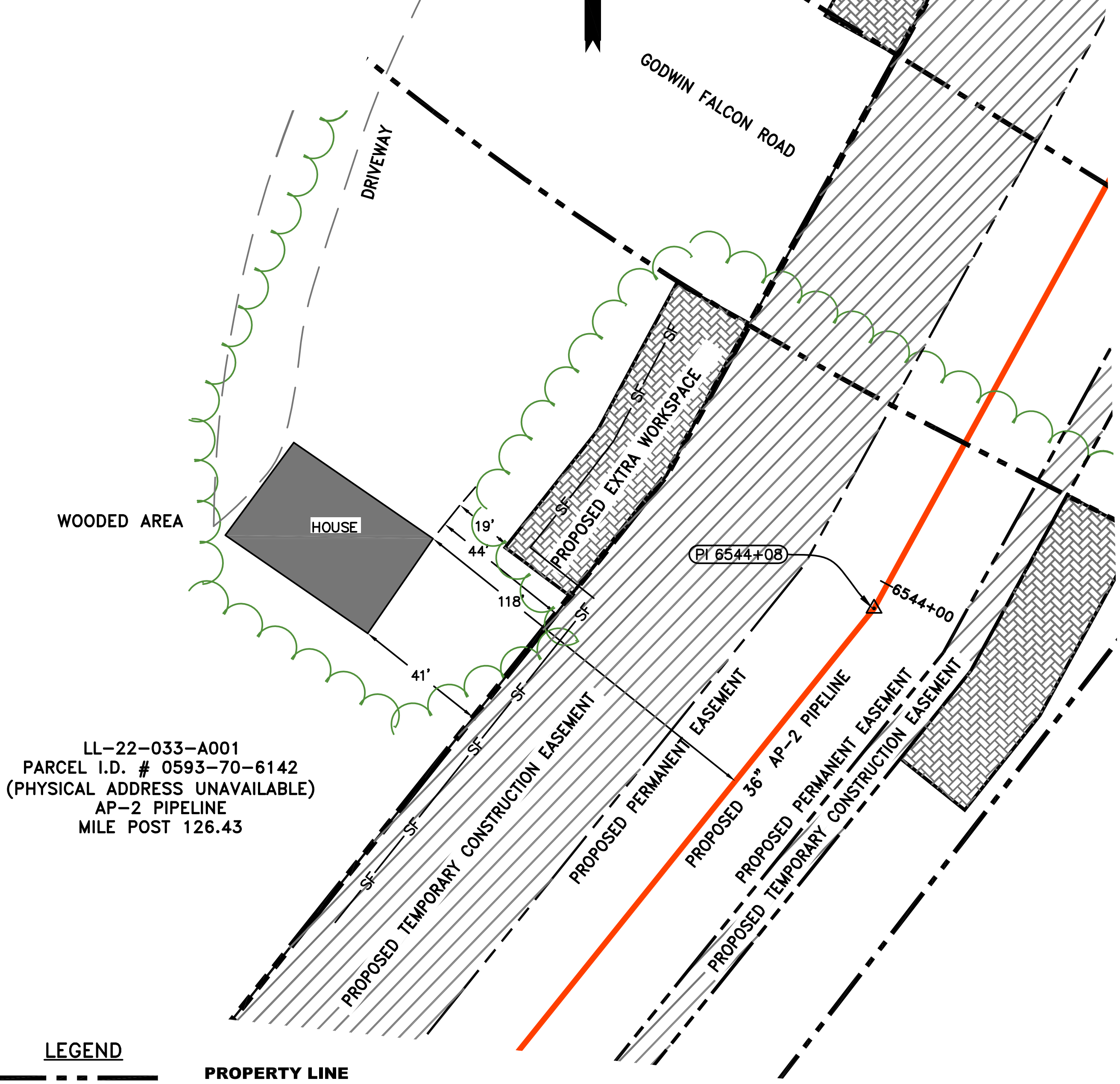
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
SAMPSON COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH | CHKD. DLH | APPD. NET | DATE 4/29/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-21-015 REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-22-033-A001
PARCEL I.D. # 0593-70-6142
(PHYSICAL ADDRESS UNAVAILABLE)
AP-2 PIPELINE
MILE POST 126.43

LEGEND

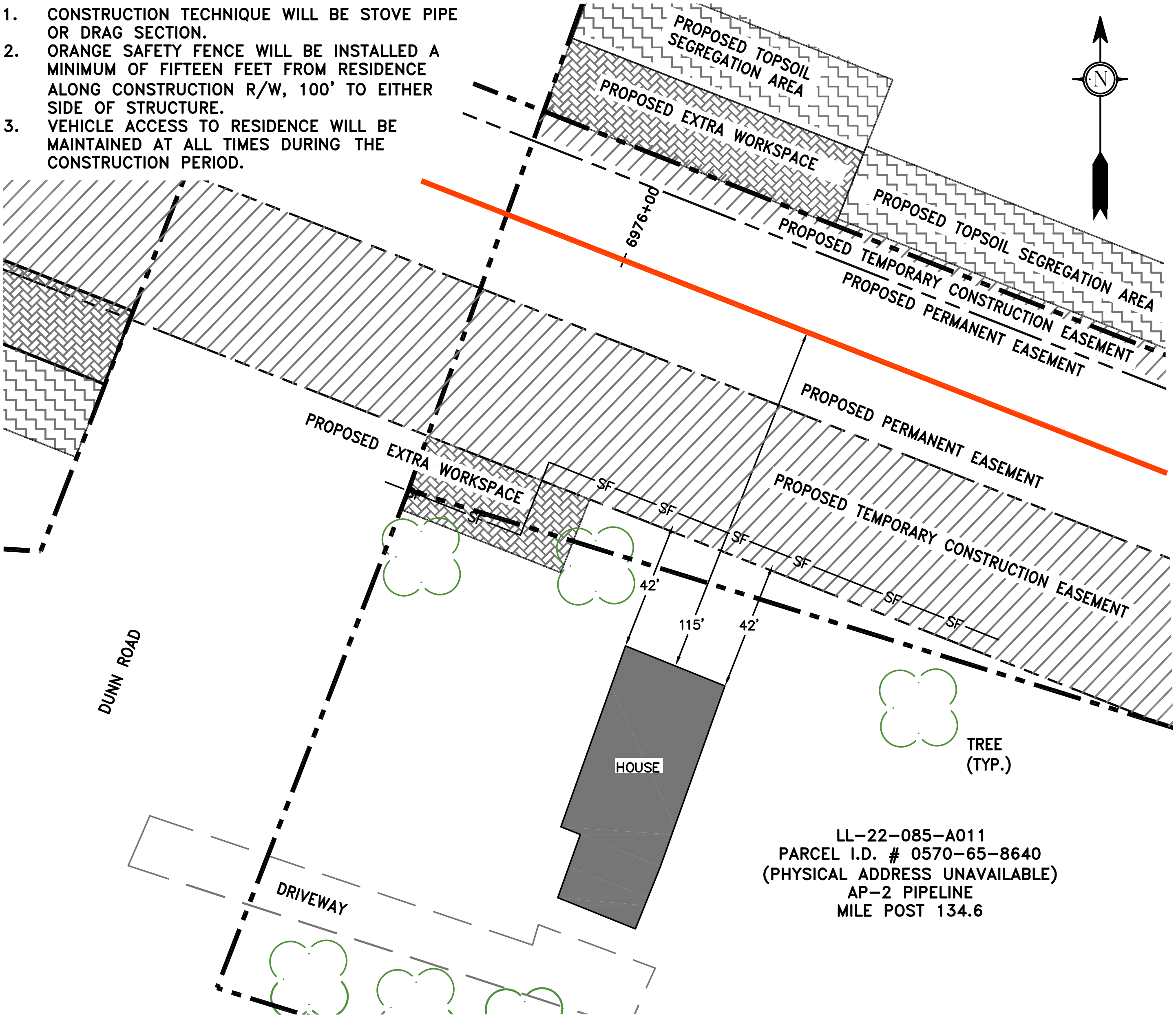
▬ ▪ ▪ ▬	PROPERTY LINE
— — —	PROPOSED PERMANENT EASEMENT
▬▬ (orange)	PROPOSED GAS PIPELINE
—SF—SF—	ORANGE SAFETY FENCE
(hatch)	PROPOSED TEMPORARY R.O.W.
(crosshatch)	EXTRA WORK SPACE

SCALE: 1" = 50'

50' 0 50'

gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	**CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES** CUMBERLAND COUNTY, NORTH CAROLINA	DWN. GAH	CHKD. DLH	APPD. NET
		DATE 4/29/16	SCALE: AS SHOWN	TASK NO. 01
	ATLANTIC COAST PIPELINE LLC **C/O DOMINION TRANSMISSION, INC.** 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. 140468	DRAWING NO. LL-22-033-A001	REV 2

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LL-22-085-A011
PARCEL I.D. # 0570-65-8640
(PHYSICAL ADDRESS UNAVAILABLE)
AP-2 PIPELINE
MILE POST 134.6

LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE (SF)
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'
50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

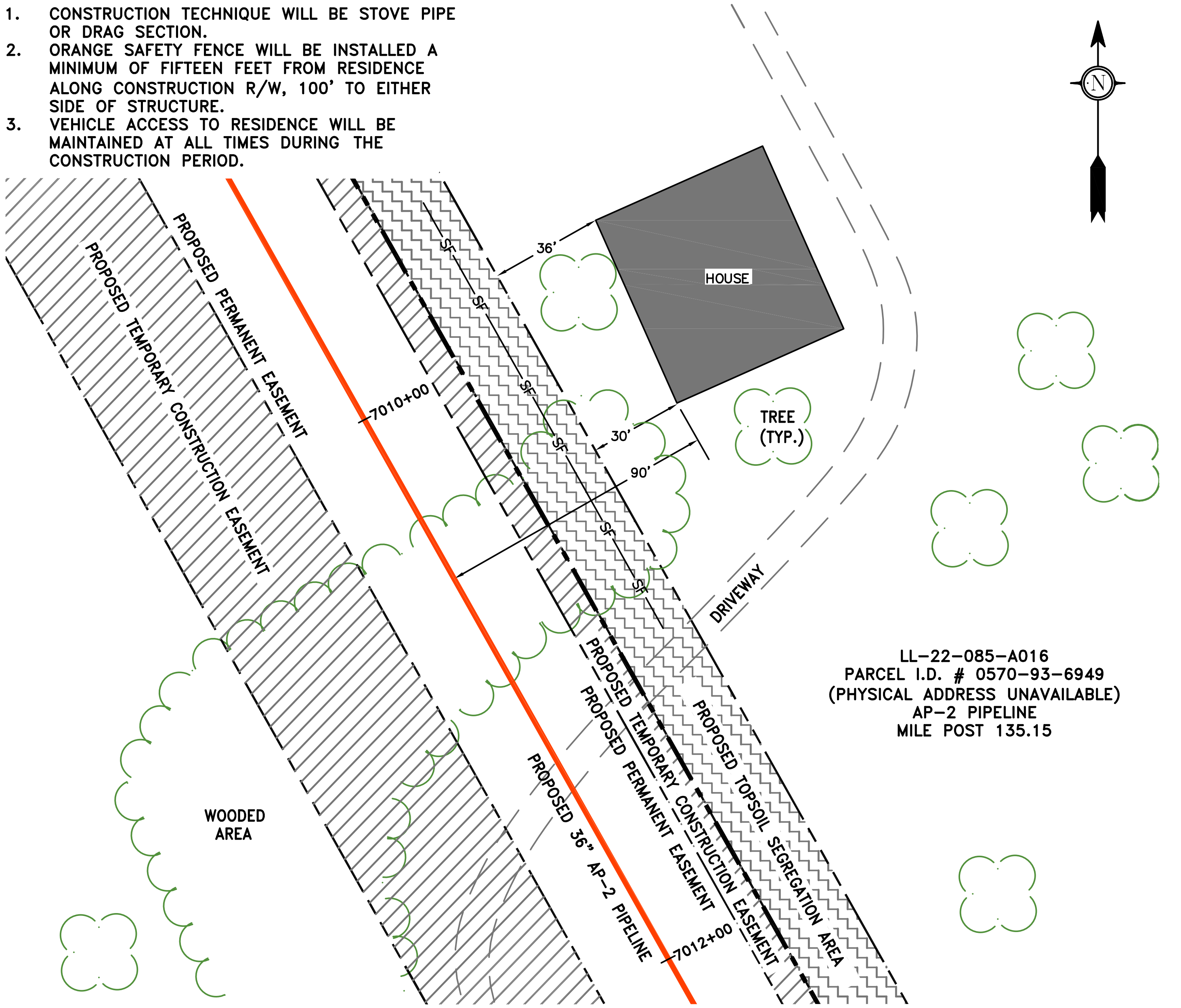
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 4/29/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-22-085-A011			REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF — SF ORANGE SAFETY FENCE

PROPOSED TEMPORARY R.O.W.

TOPSOIL SEGREGATION AREA

SCALE: 1" = 50'

50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, NORTH CAROLINA

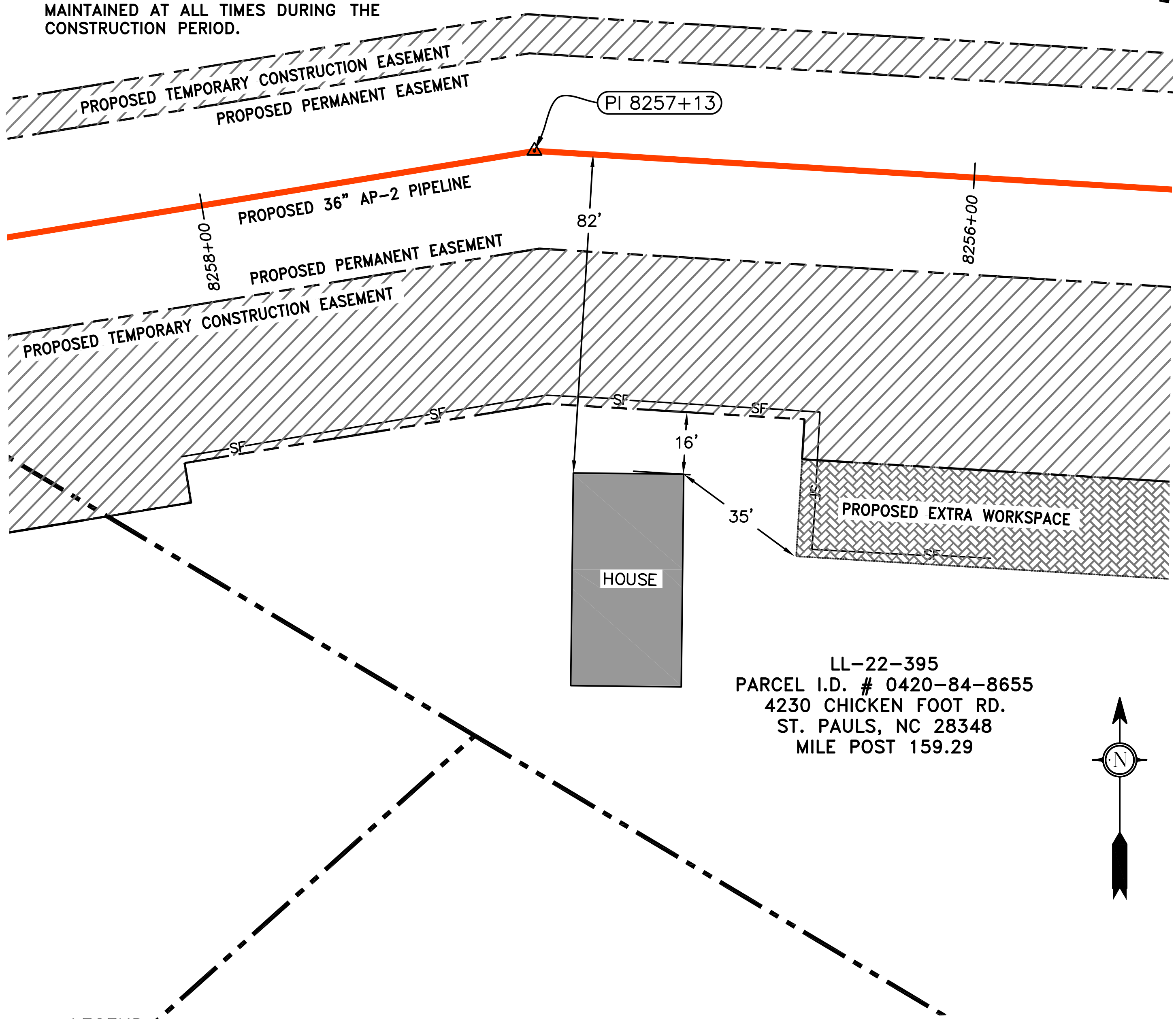
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 4/29/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-22-085-A016 REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF SF **ORANGE SAFETY FENCE**

PROPOSED TEMPORARY R.O.W.

EXTRA WORK SPACE

SCALE: 1" = 40'
40' 0 40'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, NORTH CAROLINA

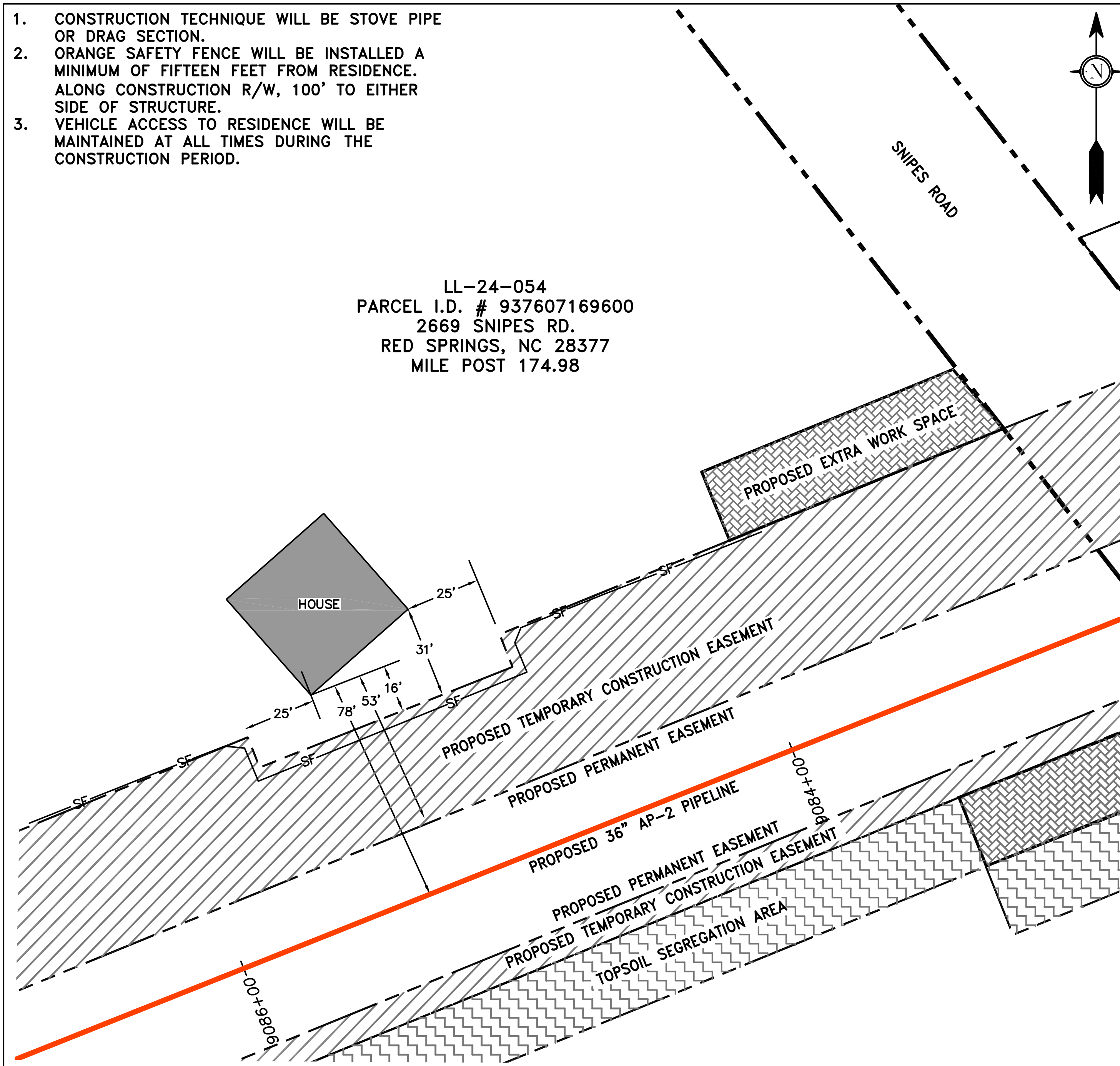
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 6/25/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-22-395 REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE. ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF SF ORANGE SAFETY FENCE
- PROPOSED TEMPORARY R.O.W.
- EXTRA WORK SPACE
- TOPSOIL SEGREGATION AREA

SCALE: 1" = 40'

40' 0 40'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CUMBERLAND COUNTY, NORTH CAROLINA

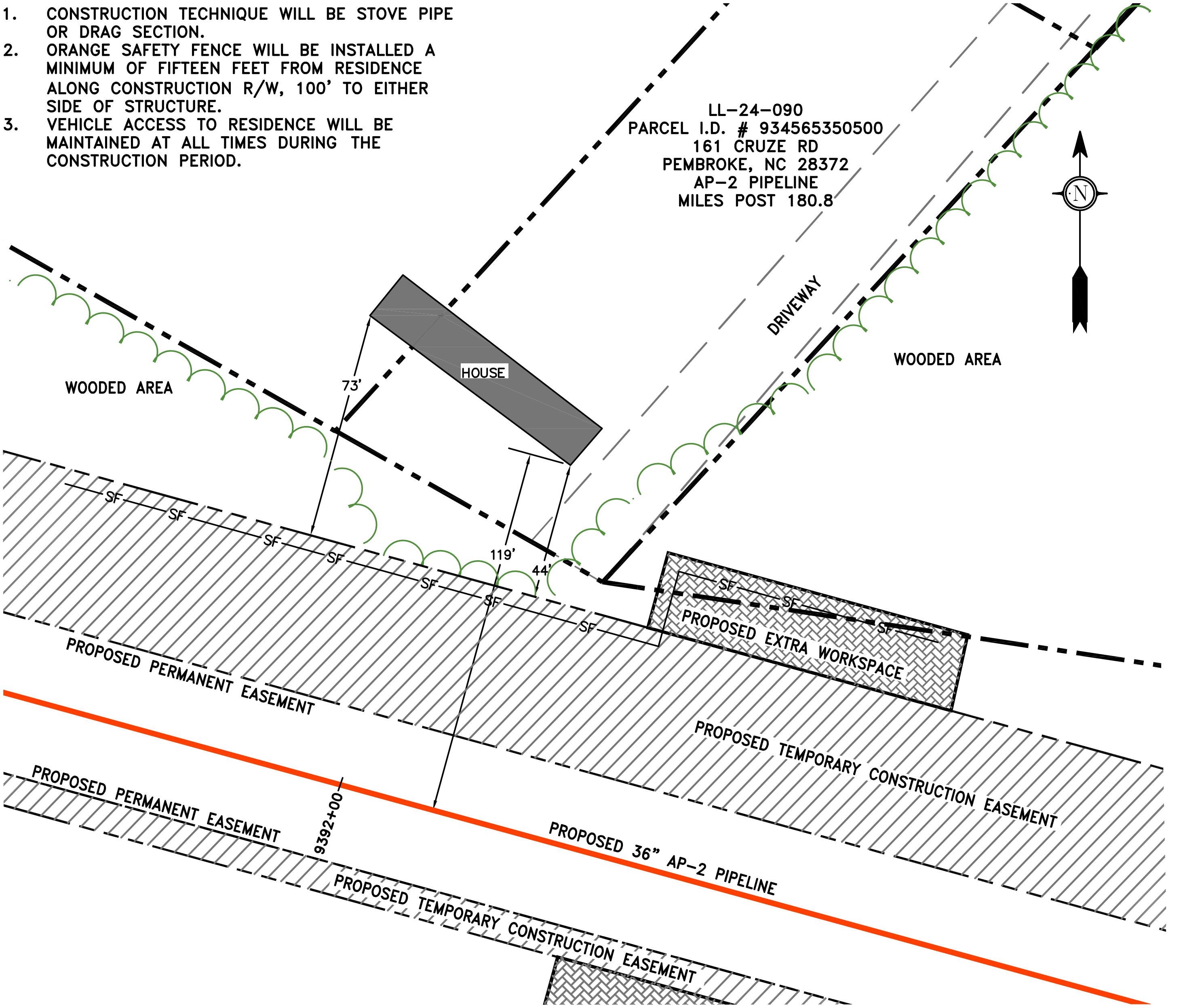
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/12/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-24-054
REV 2

GAI CAD FILE: R:\050-5159 – GIA, INC. – GAI – THRASHER – SERP – MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS – NO NAMES.DWG

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE (SF)
PROPOSED TEMPORARY R.O.W.
EXTRA WORK SPACE

SCALE: 1" = 50'
50' 0 50'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
ROBESON COUNTY, NORTH CAROLINA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. GAH	CHKD. DLH	APPD. NET	DATE 7/12/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-24-090			REV 2

GAI CAD FILE: R:\050-5159 - GIA, INC. - GAI - THRASHER - SERP - MAPPING\SURVEY\DRAWING\SEC 11\HOUSE EXHIBITS\SECT 11 REROUTE HOUSE EXHIBITS - NO NAMES.DWG

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

d. [illegible]

[illegible]

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]

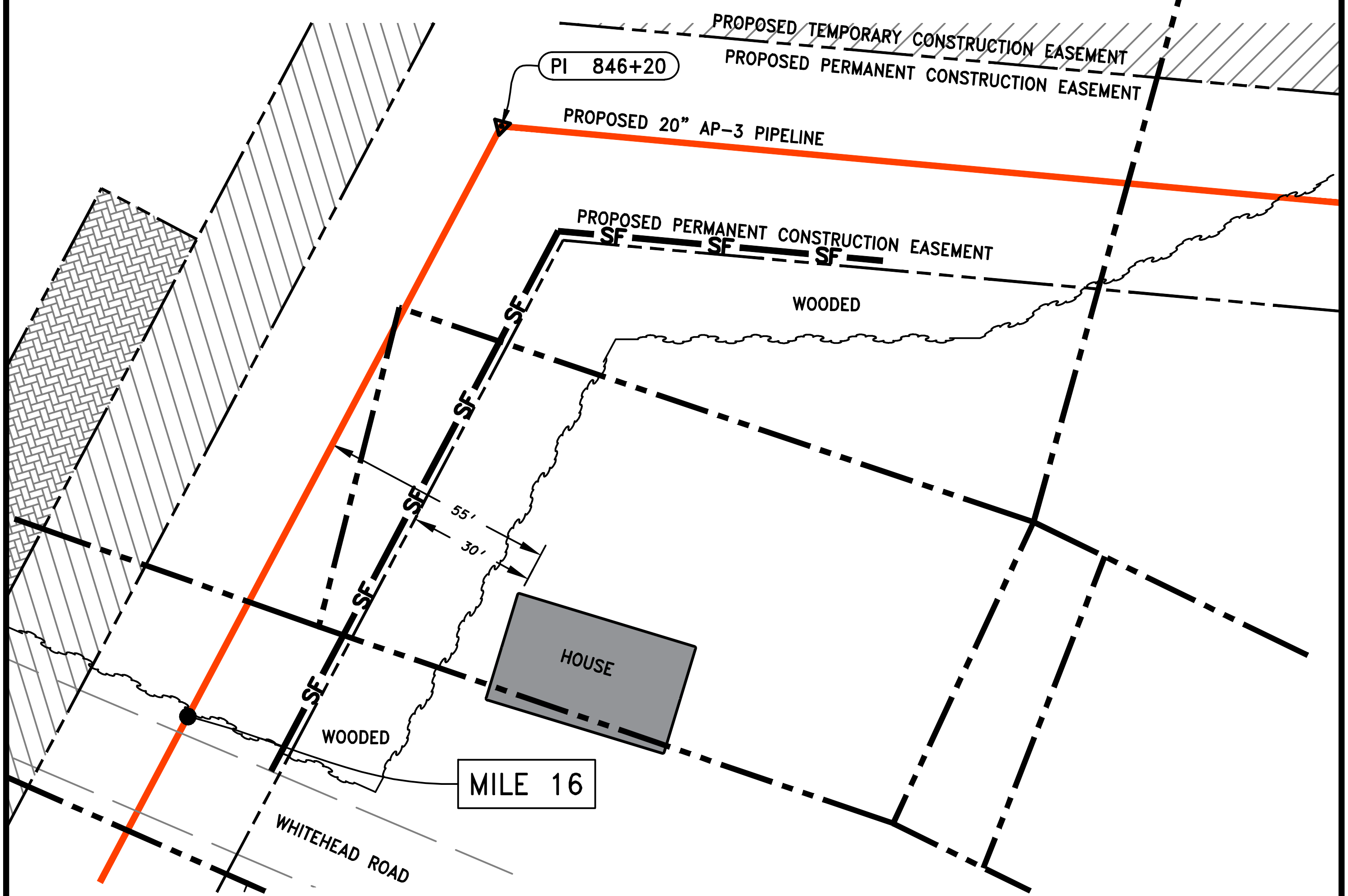
gai consultants SOUTHPOINTE OFFICE 6000 TOWNE CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES GENERAL NOTES	DWN. JJP / CHKD. DLH / APPD. NET / DATE 07/28/2016 SCALE: NONE / TASK NO. 00	
	ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. C140468 DRAWING NO. A001	REV –

GAI CAD FILE: Z:\ENERGY\2014\C140468.00 - DOMINION - SOUTHEAST PIPE\CAD\MASTER ROUTE\DRG\DRAWINGS\HOUSE_SITE_SPECIFIC_GENERAL_NOTES.DWG

7/19/2016 8:44 AM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-25-001-B022
PO BOX 122
BRANCHVILLE, VIRGINIA 23828
TAX MAP # 110-24
MILE POST 16.02



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES SOUTHAMPTON COUNTY, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301

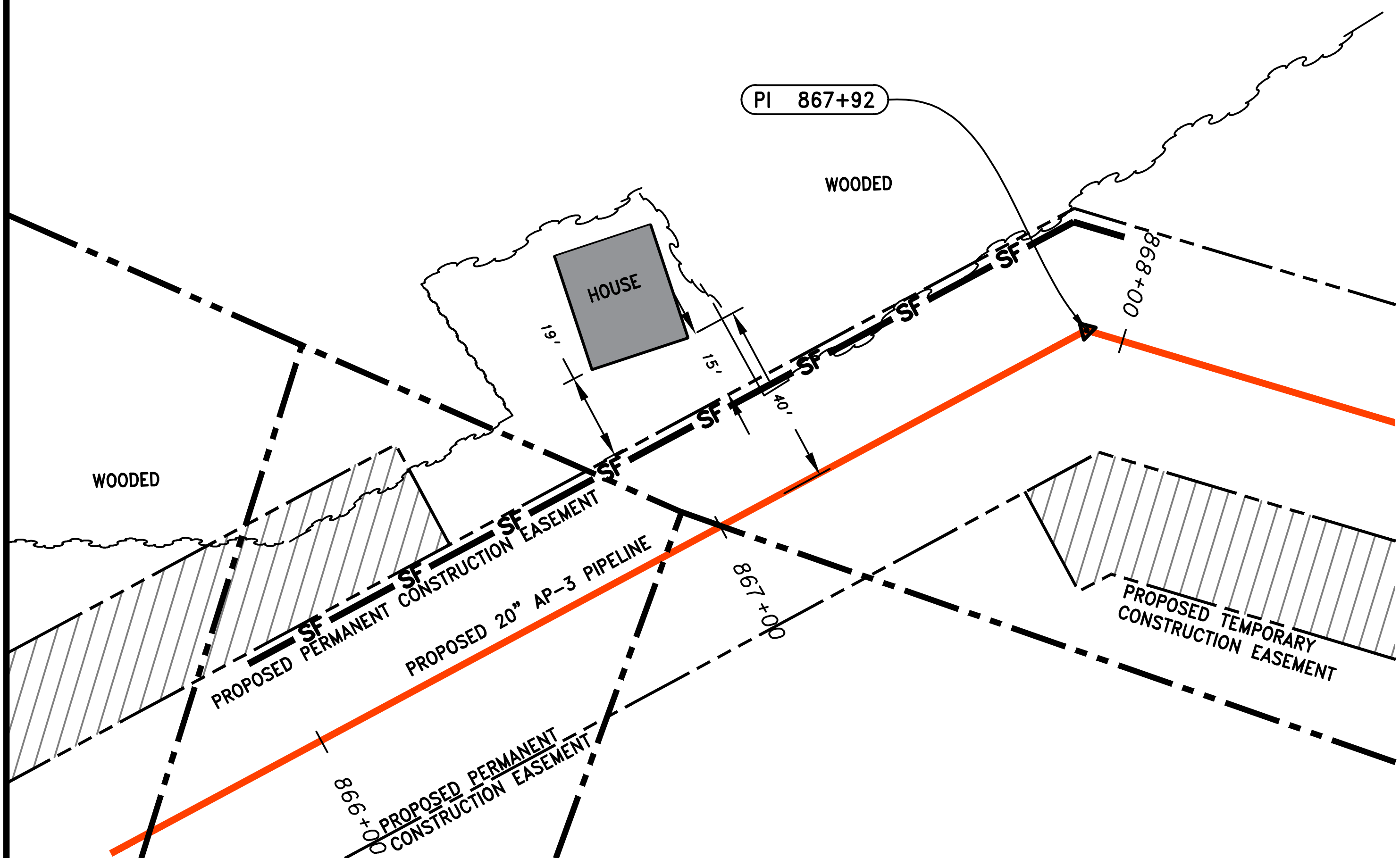
DWN. RDC CHKD. DLH APPD. NET DATE 6/24/16
SCALE: AS SHOWN TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-25-001-B022 1 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 06 - SOUTHEAST PIPELINE (SECTION 7)\3 - CAD DRAWINGS\BUILDING CONFLICTS EXHIBITS\2665-07 SPREAD-7 - BUILDING CONFLICT EXHIBITS.DWG

6/24/2016 12:16 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-25-001-B029
820 GLORIA PL
VIRGINIA BEACH, VIRGINIA 23454
TAX MAP # 111-1
MILE POST 16.37



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE (SF)
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
SOUTHAMPTON COUNTY, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

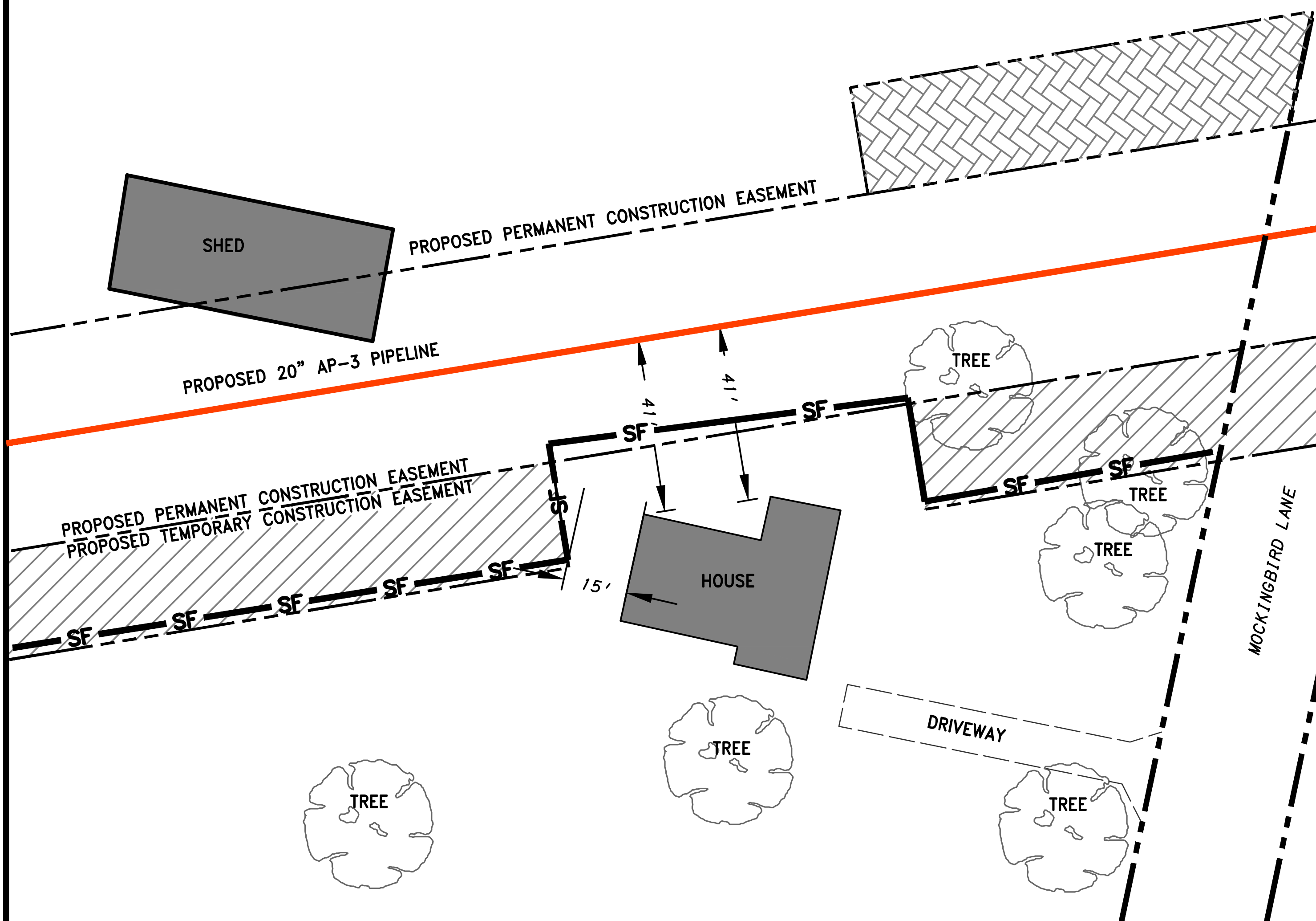
DWN. RDC | CHKD. DLH | APPD. NET | DATE 6/24/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-25-001-B029 | REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 06 - SOUTHEAST PIPELINE (SECTION 7)\3 - CAD DRAWINGS\BUILDING CONFLICTS EXHIBITS\2665-07 SPREAD-7 - BUILDING CONFLICT EXHIBITS.DWG

7/1/2016 2:48 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-26-060-A068
4124 MOCKINGBIRD LANE
SUFFOLK, VIRGINIA 23434
TAX MAP # 252953000
AP-3 PIPELINE
MILE POST 61.88



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

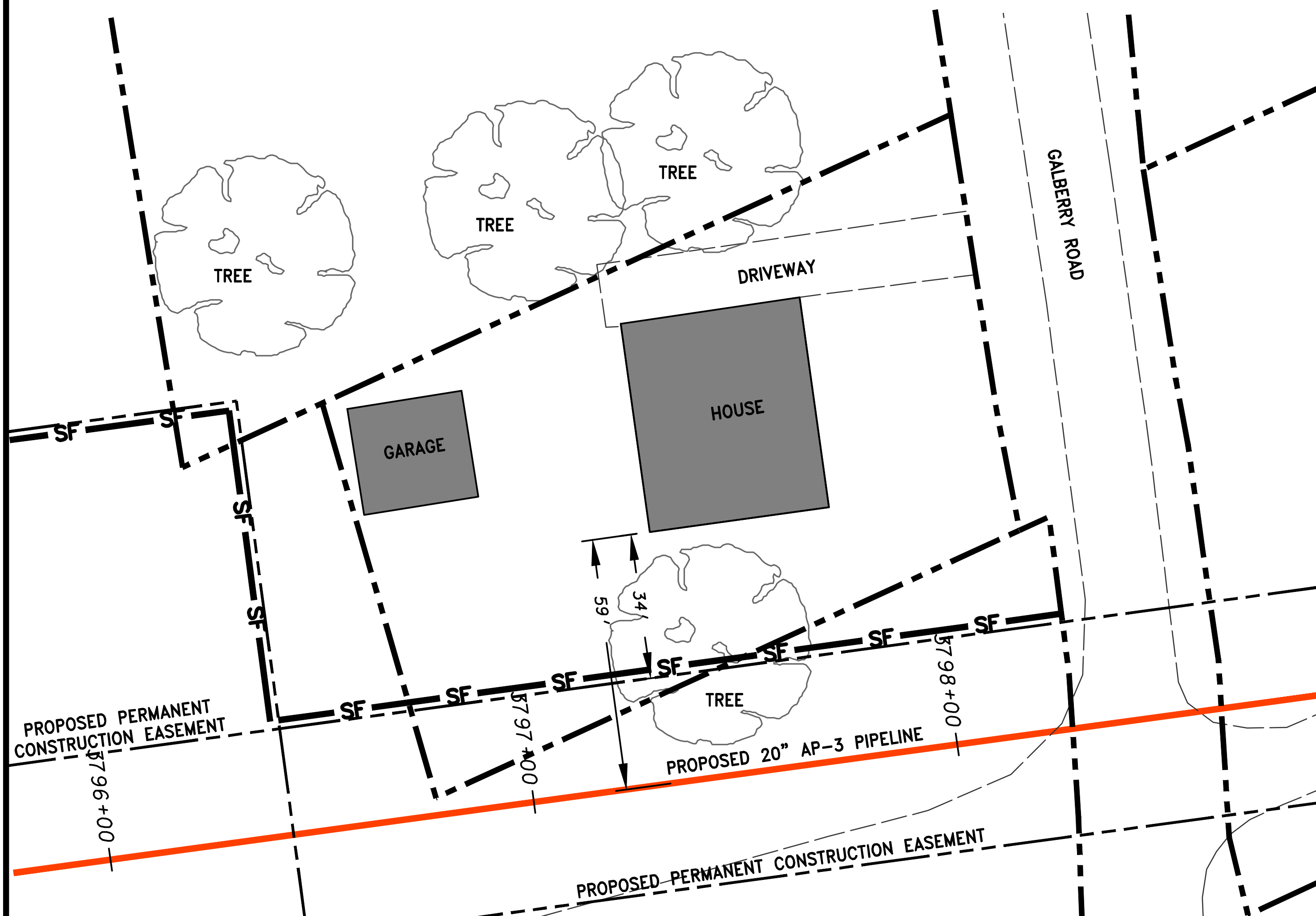
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-26-060-A068 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-26-060-A068.DWG

7/18/2016 12:20 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-026-A009
3321 GALBERRY ROAD
CHESAPEAKE, VIRGINIA 23323-1401
TAX MAP # 0330000001712
AP-3 PIPELINE
MILE POST 77.6



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

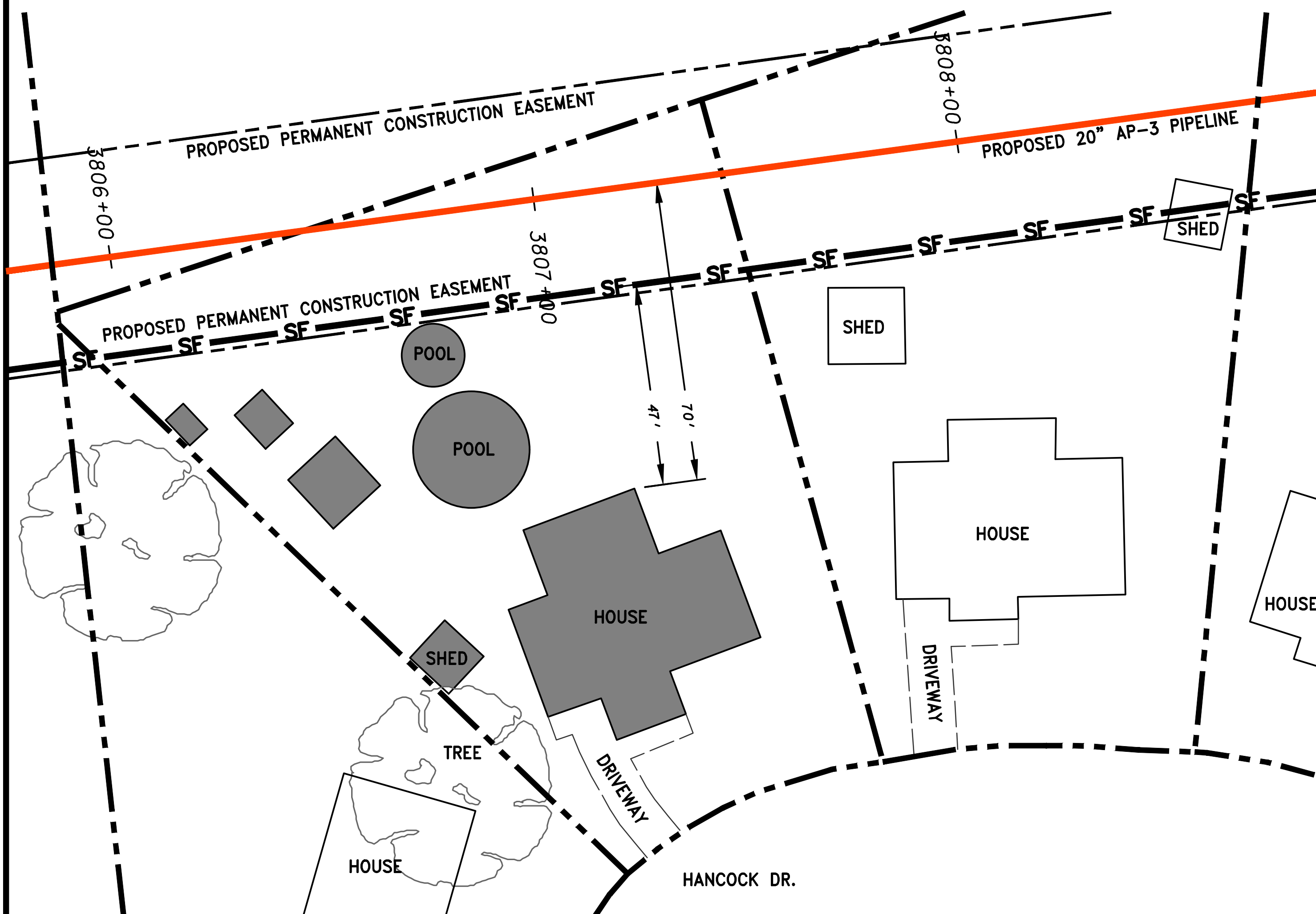
DWN. RDC CHKD. DLH APPD. NET DATE 7/19/16
SCALE: AS SHOWN TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-026-A009 REV —

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-026-A009.DWG

7/19/2016 12:28 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-026-A026
3261 HANCOCK DRIVE
CHESAPEAKE, VIRGINIA 23323-1937
TAX MAP # 0331007000270
AP-3 PIPELINE
MILE POST 77.8



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/19/16

SCALE: AS SHOWN | TASK NO. 01

PROJECT NO./DASH NO. 140468

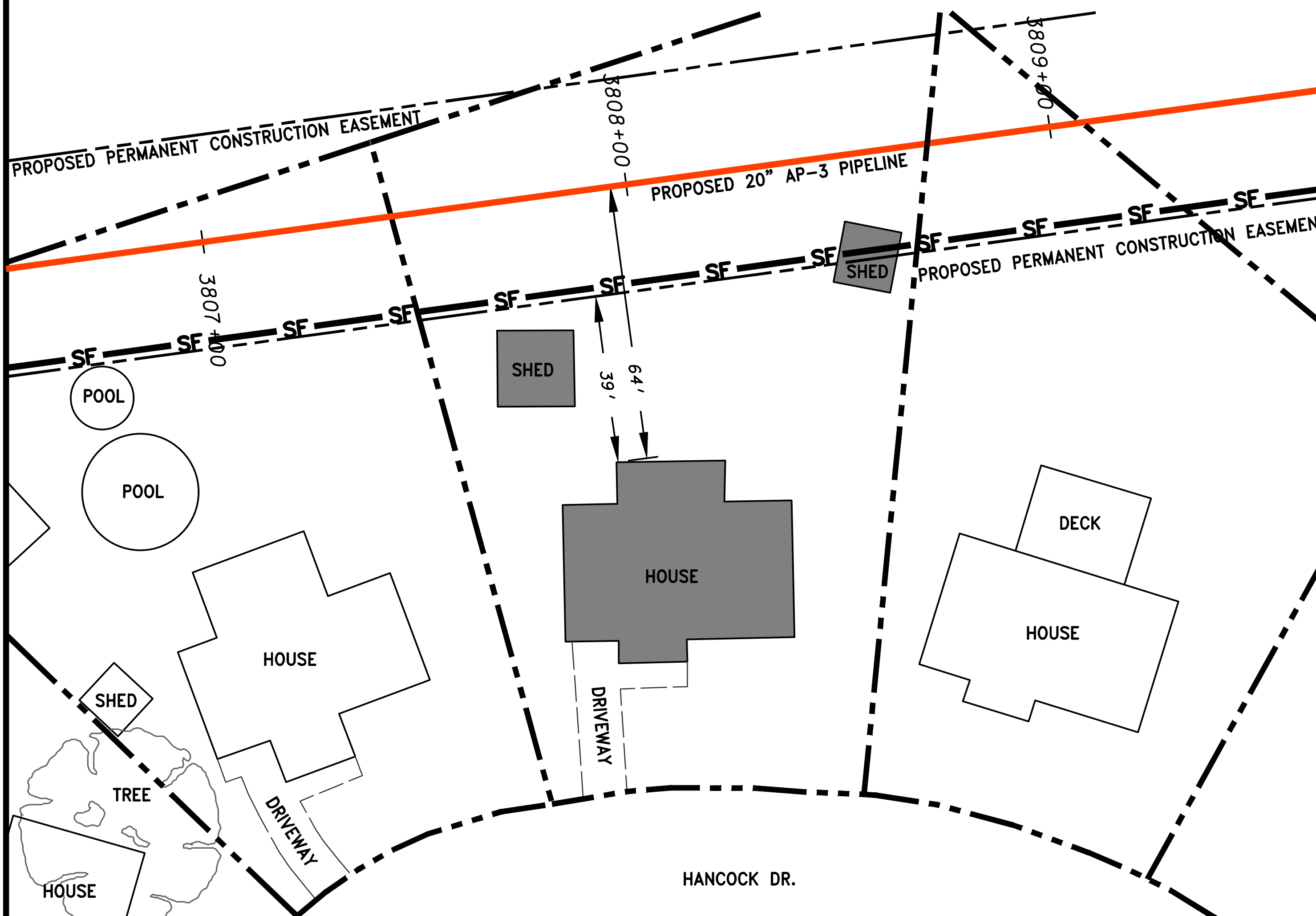
DRAWING NO. LL-27-026-A026 | REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-026-A026.DWG

7/19/2016 12:33 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-026-A027
3257 HANCOCK DRIVE
CHESAPEAKE, VIRGINIA 23323-1937
TAX MAP # 0331007000260
AP-3 PIPELINE
MILE POST 77.8



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/19/16

SCALE: AS SHOWN | TASK NO. 01

PROJECT NO./DASH NO. 140468

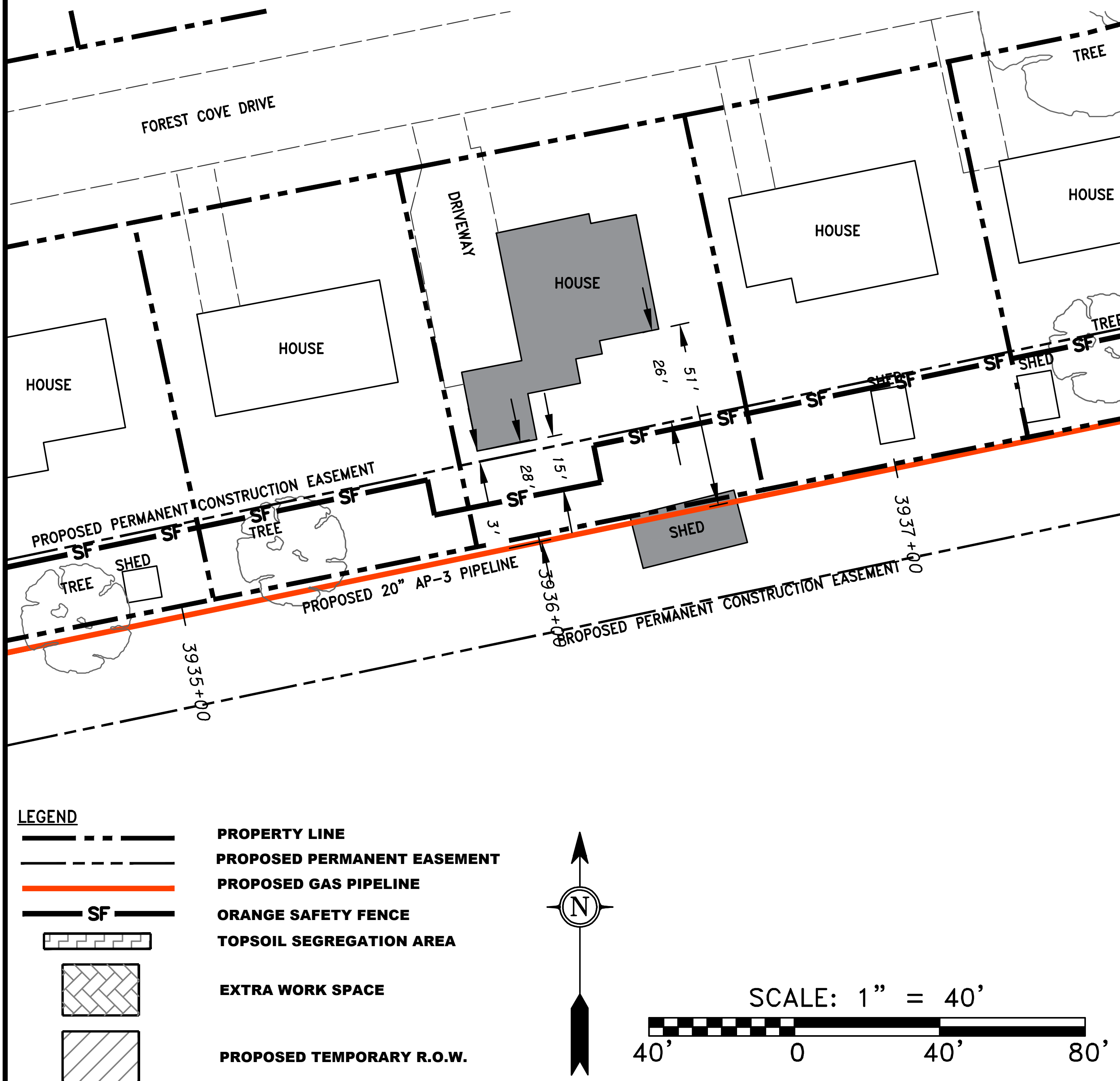
DRAWING NO. LL-27-026-A027 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-026-A027.DWG

7/19/2016 12:42 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A026
1515 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000060
AP-3 PIPELINE
MILE POST 80.27



GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A026.DWG

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

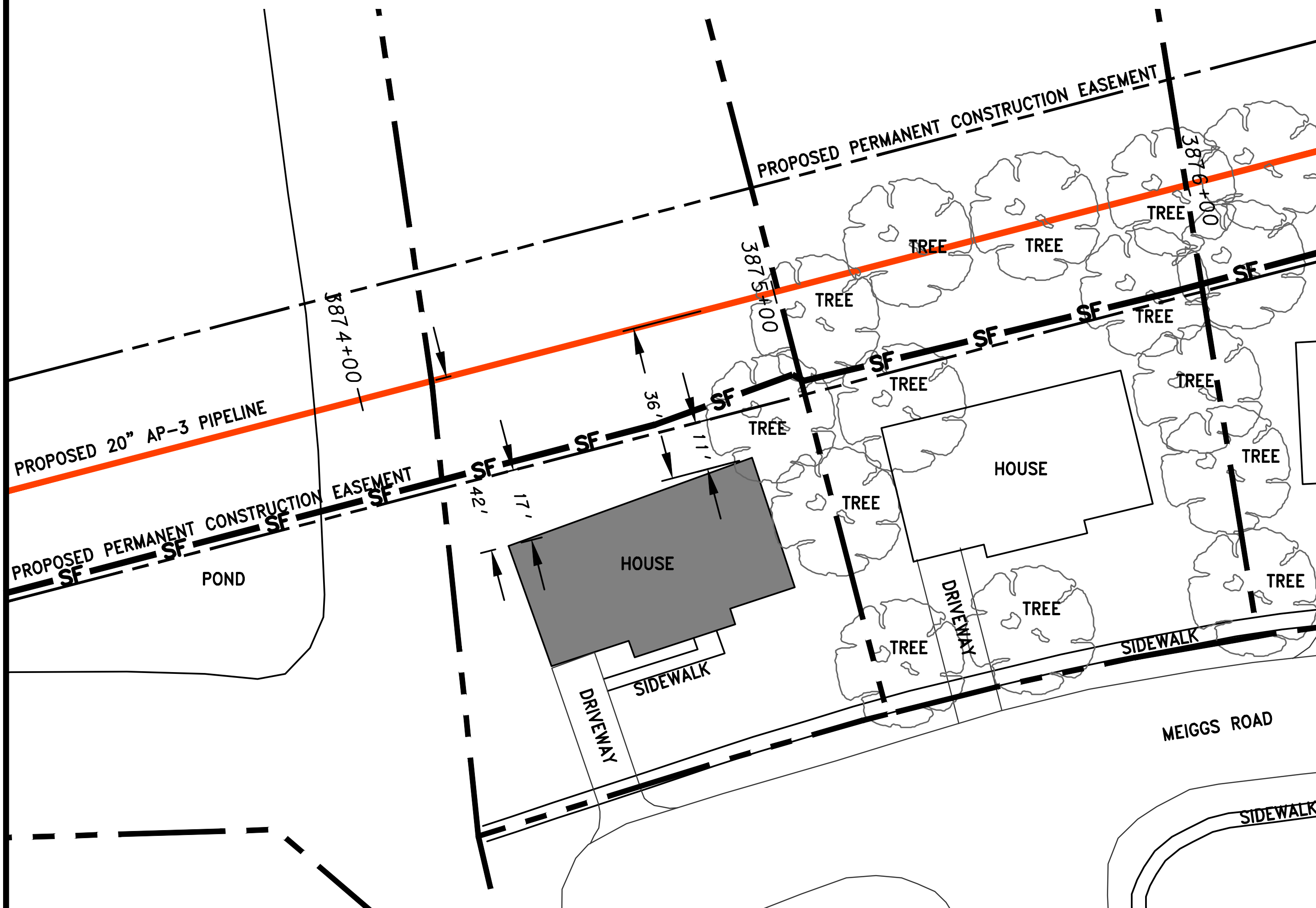
DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01

PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A026 REV 1

7/18/2016 2:15 PM

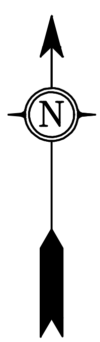
1. CONSTRUCTION TECHNIQUE WILL BE HORIZONTAL DIRECTIONAL DRILL.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100’ TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-058
5611 BRIAR OAKS LANE, APT 311
RALEIGH, NC 27612
TAX MAP # 0343011000010
AP-3 PIPELINE
MILE POST 79.10

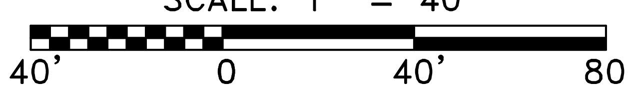


LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.



SCALE: 1” = 40’



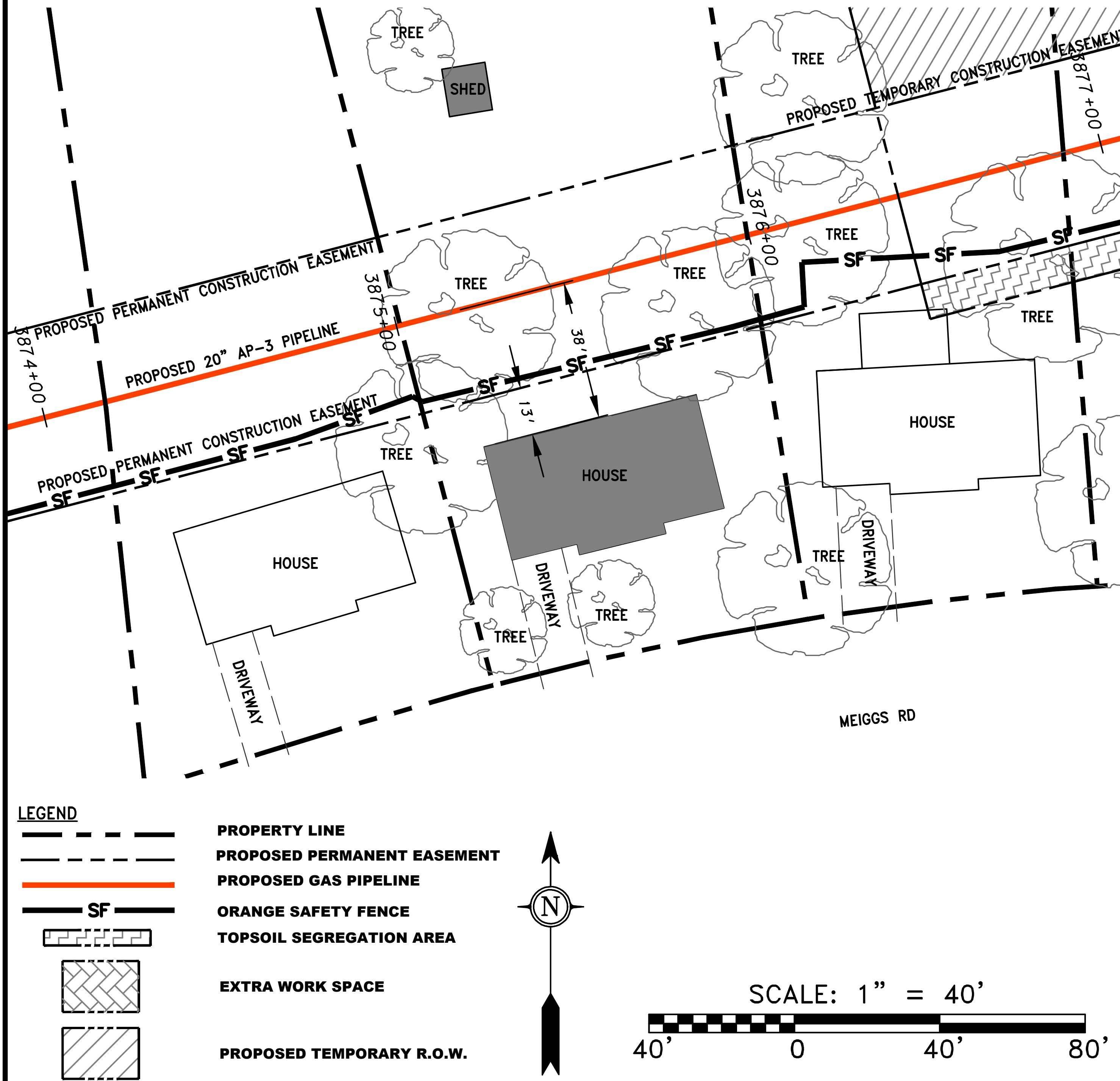
gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	DWN. RDC CHKD. DLH APPD. NET DATE 7/18/2016 SCALE: AS SHOWN TASK NO. 01 PROJECT NO./DASH NO. 140468 DRAWING NO. LL-27-058 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-058.DWG

7/18/2016 12:38 PM

1. CONSTRUCTION TECHNIQUE WILL BE HORIZONTAL DIRECTIONAL DRILL.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-060
2536 MEIGGS RD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343011000020
AP-3 PIPELINE
MILE POST 79.11



gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301

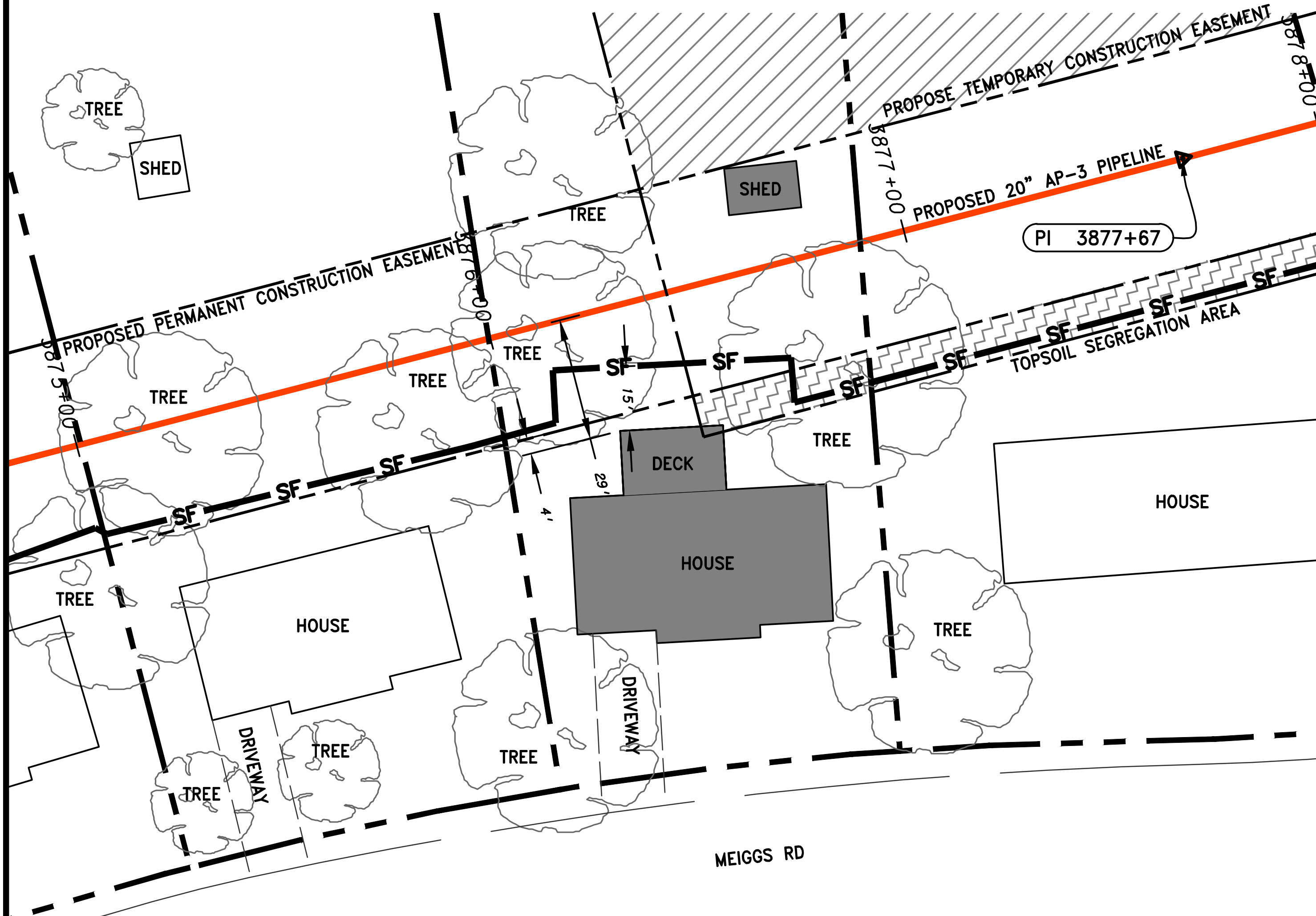
DWN. RDC CHKD. DLH APPD. NET DATE 7/18/16
SCALE: AS SHOWN TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-060 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-060.DWG

7/18/2016 12:35 PM

1. CONSTRUCTION TECHNIQUE WILL BE HORIZONTAL DIRECTIONAL DRILL.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-062
2532 MEIGGS RD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 034301100030
AP-3 PIPELINE
MILE POST 79.13



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

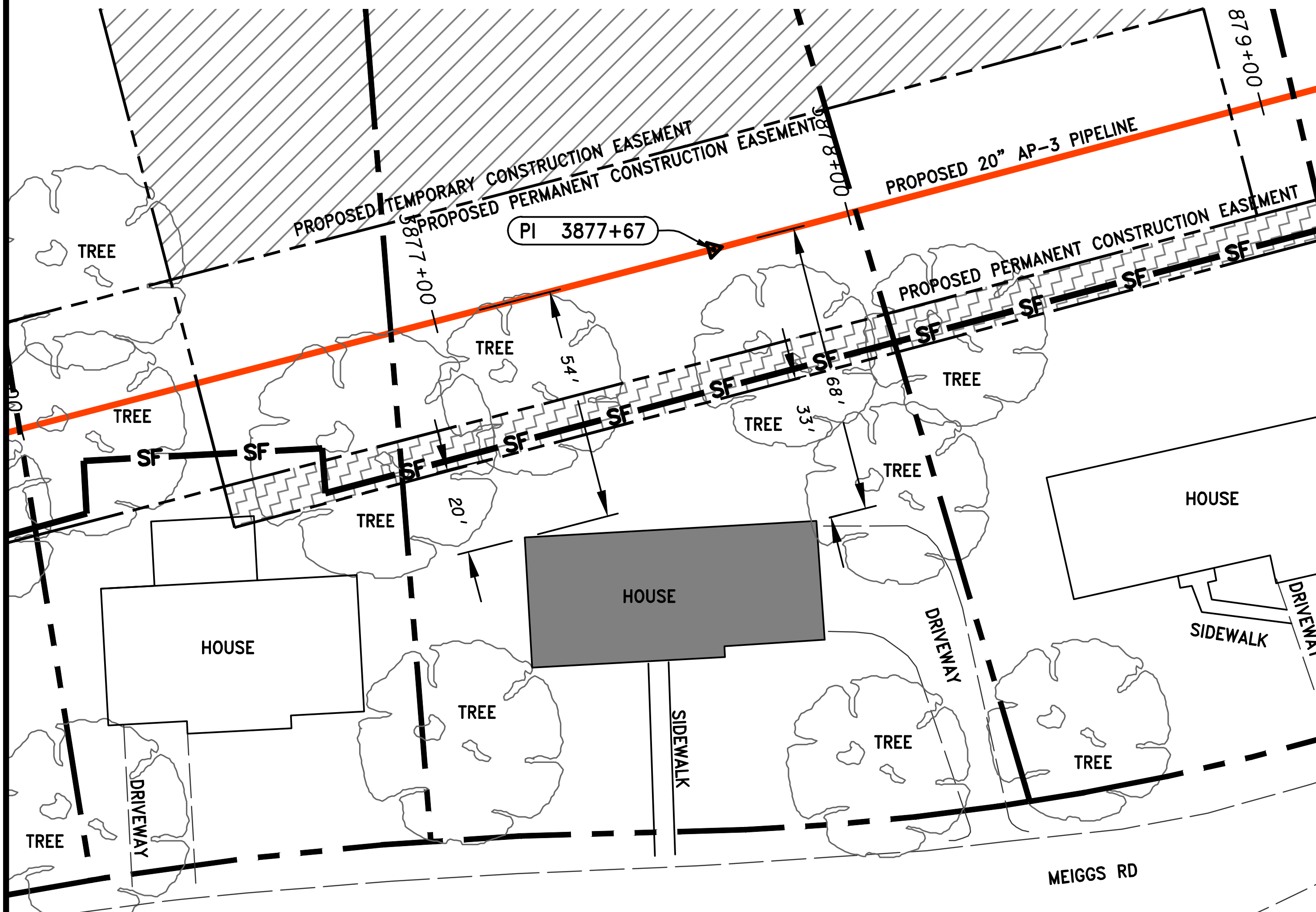
gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA	DWN. RDC CHKD. DLH APPD. NET DATE 7/18/16 SCALE: AS SHOWN TASK NO. 01
		ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. 140468 DRAWING NO. LL-27-062 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-062.DWG

7/18/2016 12:44 PM

1. CONSTRUCTION TECHNIQUE WILL BE HORIZONTAL DIRECTIONAL DRILL.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-064
121 CREEFS RIDGE ROAD
MANTEO, NORTH CAROLINA 27954
TAX MAP # 034300500200
AP-3 PIPELINE
MILE POST 79.14



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

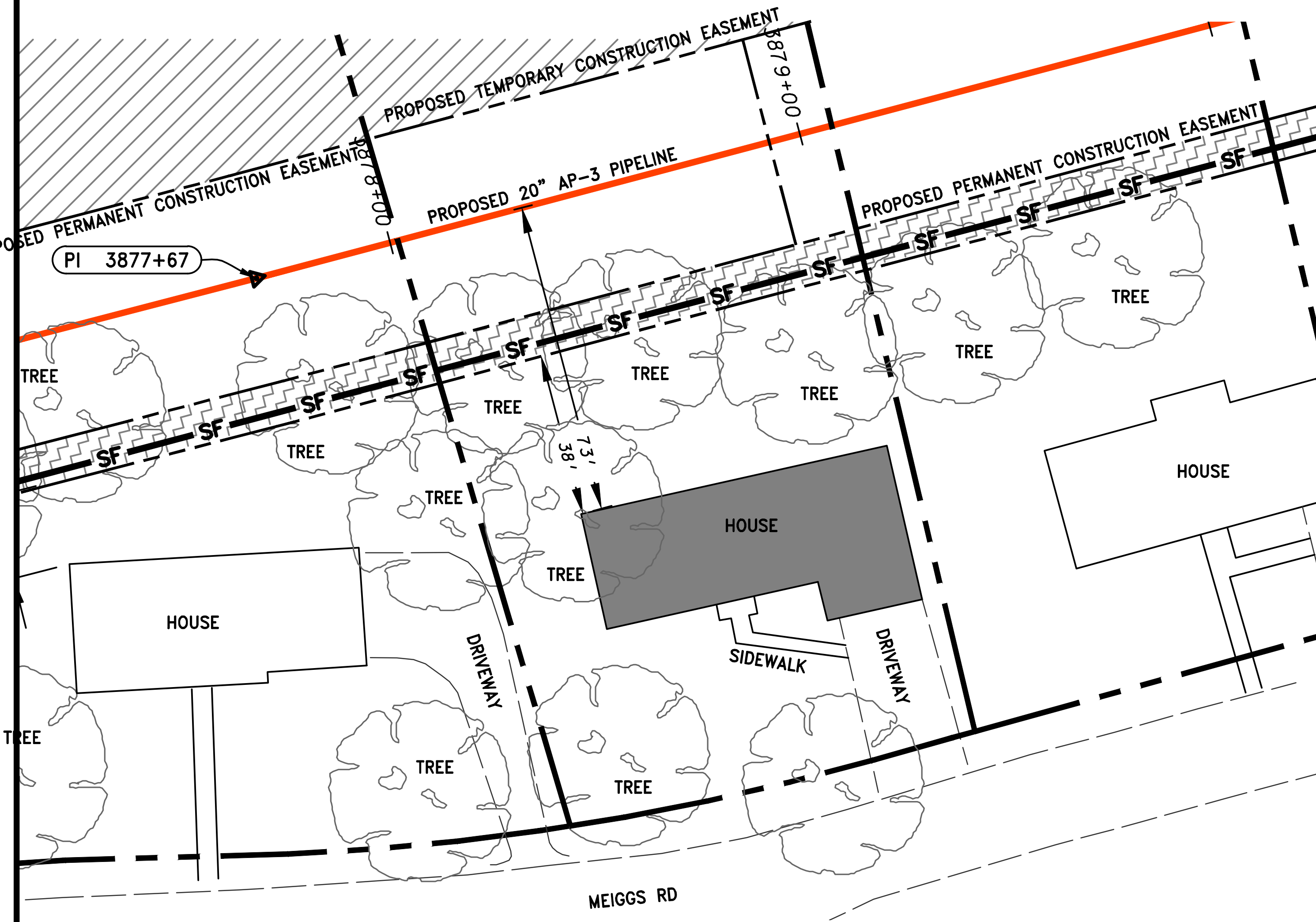
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-064
REV

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-064.DWG

7/18/2016 12:49 PM

1. CONSTRUCTION TECHNIQUE WILL BE HORIZONTAL DIRECTIONAL DRILL.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-066
2524 MEIGGS ROAD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 034300500021O
AP-3 PIPELINE
MILE POST 79.14



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

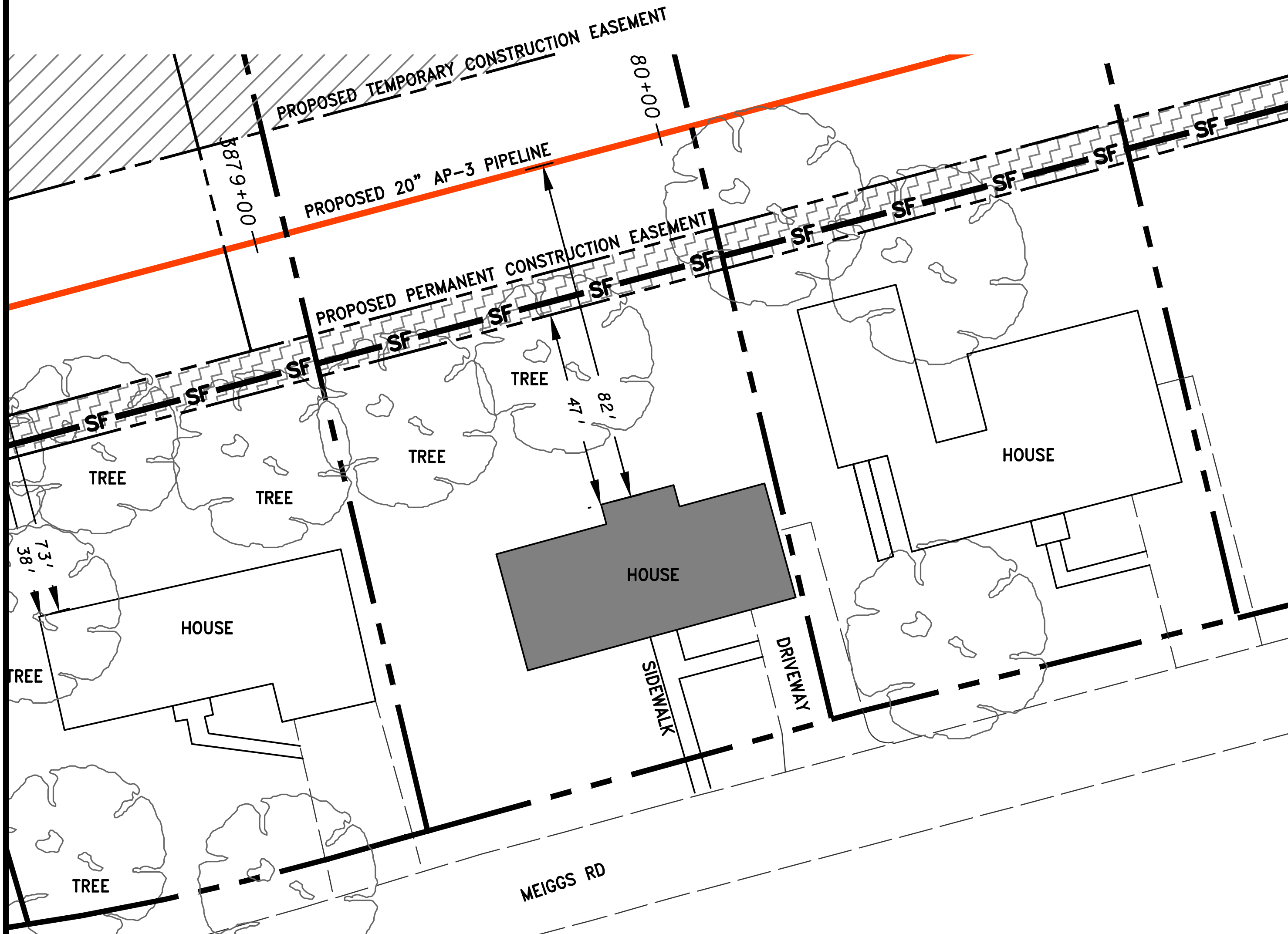
DWN. RDC CHKD. DLH APPD. NET DATE 7/22/16
SCALE: AS SHOWN TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-066 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-066.DWG

7/22/2016 2:01 PM

1. CONSTRUCTION TECHNIQUE WILL BE HORIZONTAL DIRECTIONAL DRILL.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-068
2520 MEIGGS ROAD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 034300500022O
AP-3 PIPELINE
MILE POST 79.15



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/22/16
SCALE: AS SHOWN			TASK NO. 01

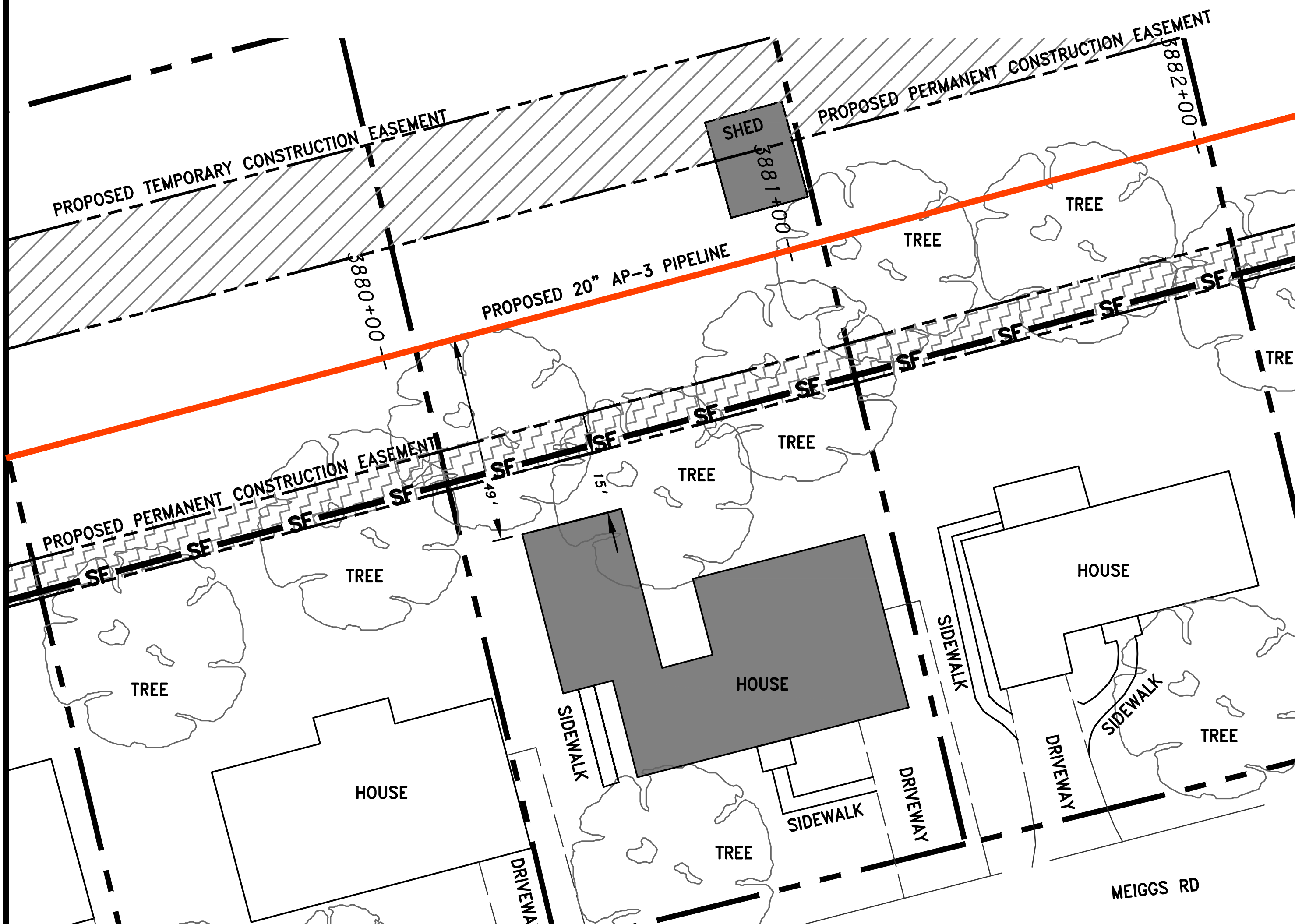
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-068
REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-068.DWG

7/22/2016 2:25 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.

LL-27-070
2516 MEIGGS RD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343005000230
AP-3 PIPELINE
MILE POST 79.20



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
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724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

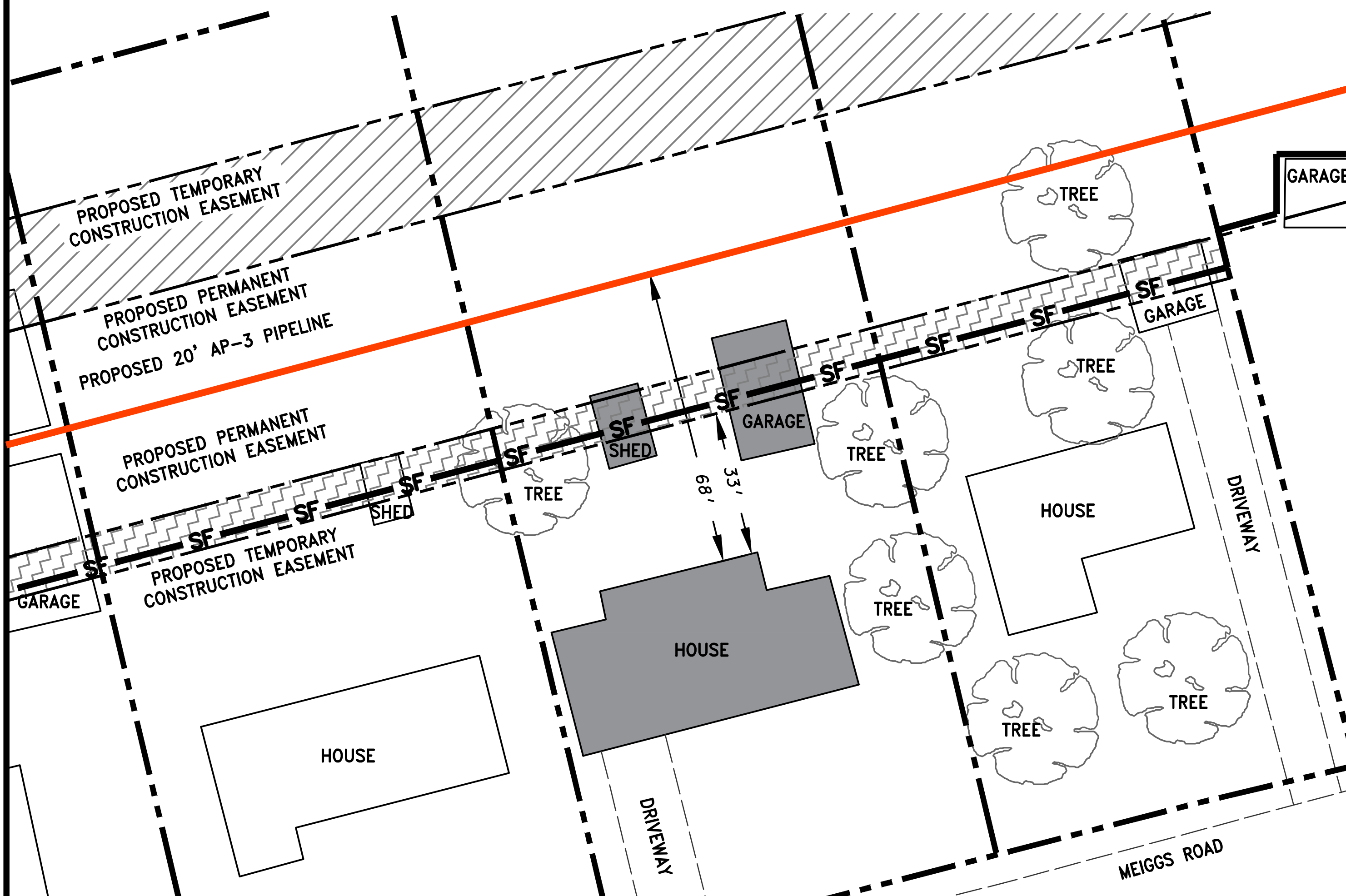
DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-27-070			REV

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-070.DWG

7/18/2016 12:53 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-075
2508 MEIGGS ROAD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343004000250
AP-3 PIPELINE
MILE POST 79.24



LEGEND

— · · —	PROPERTY LINE
— — —	PROPOSED PERMANENT EASEMENT
— (orange)	PROPOSED GAS PIPELINE
— SF —	ORANGE SAFETY FENCE
	TOPSOIL SEGREGATION AREA
	EXTRA WORK SPACE
	PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

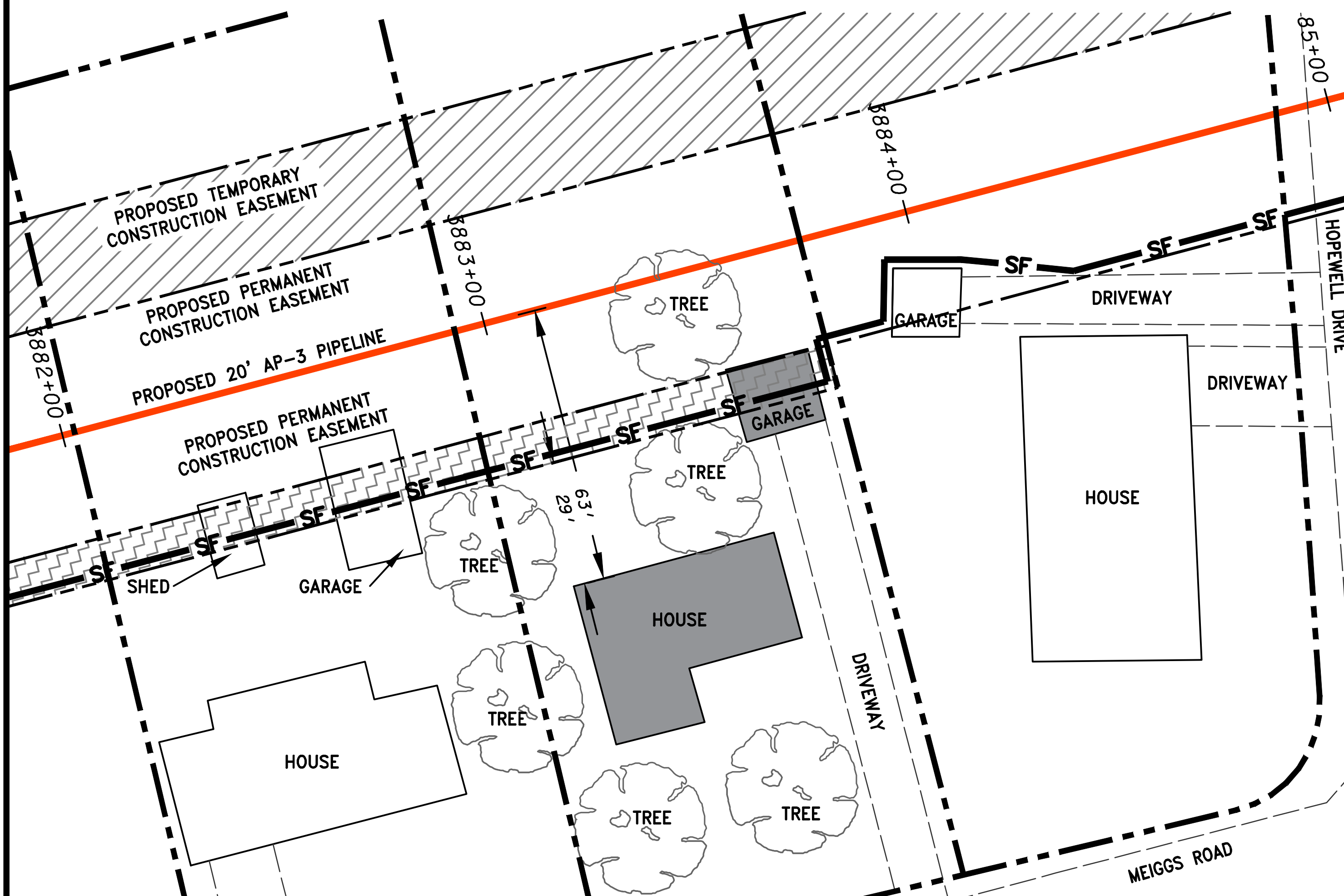
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-075 | 1 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-075.DWG

7/18/2016 4:33 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-076
2504 MEIGGS ROAD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343004000260
AP-3 PIPELINE
MILE POST 79.26



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

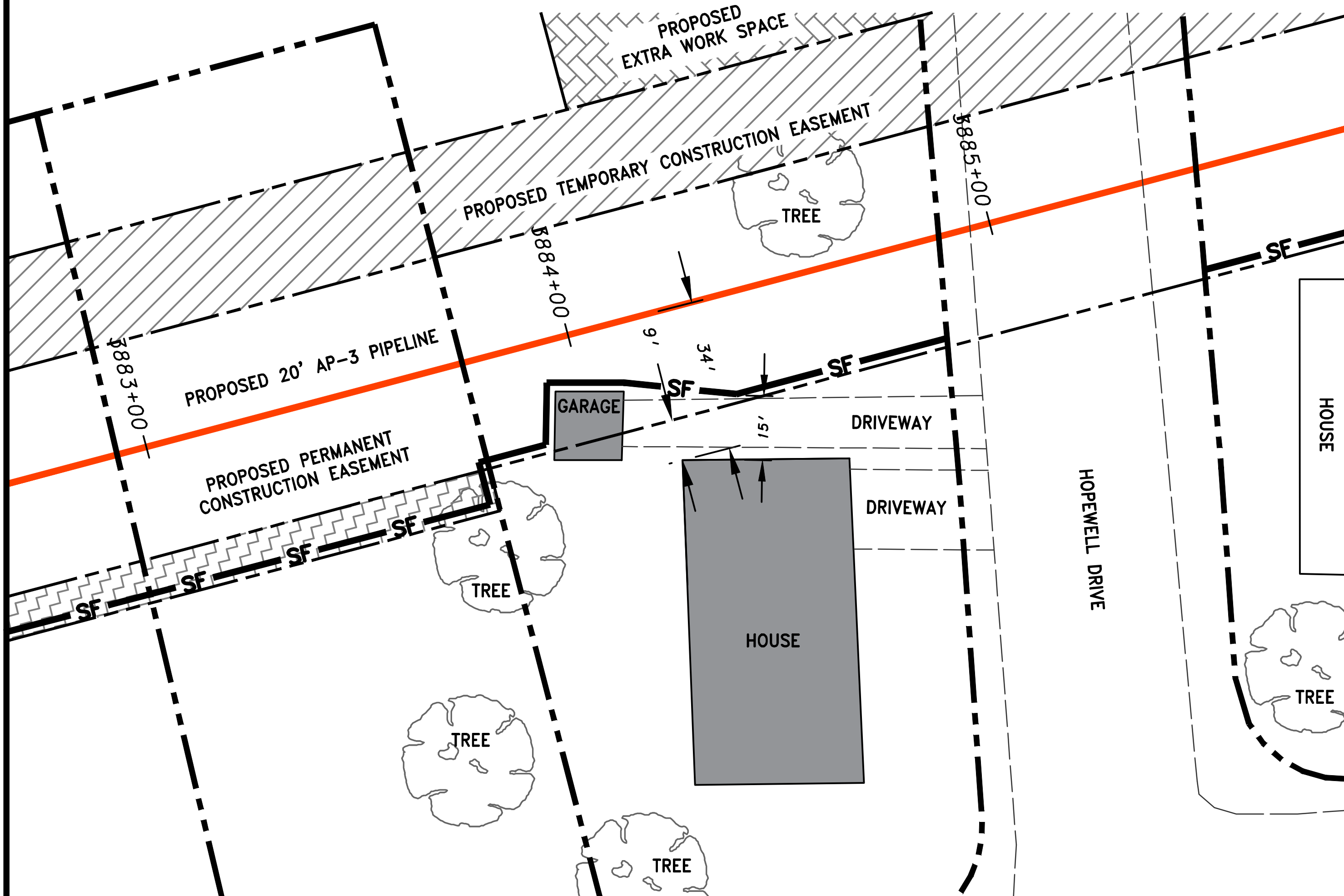
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-076 | REV 1

GAI CAD FILE: J:\2665 -GAI WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-076.DWG

7/18/2016 12:59 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-078
700 HOPEWELL DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 343004000270
AP-3 PIPELINE
MILE POST 79.27



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01

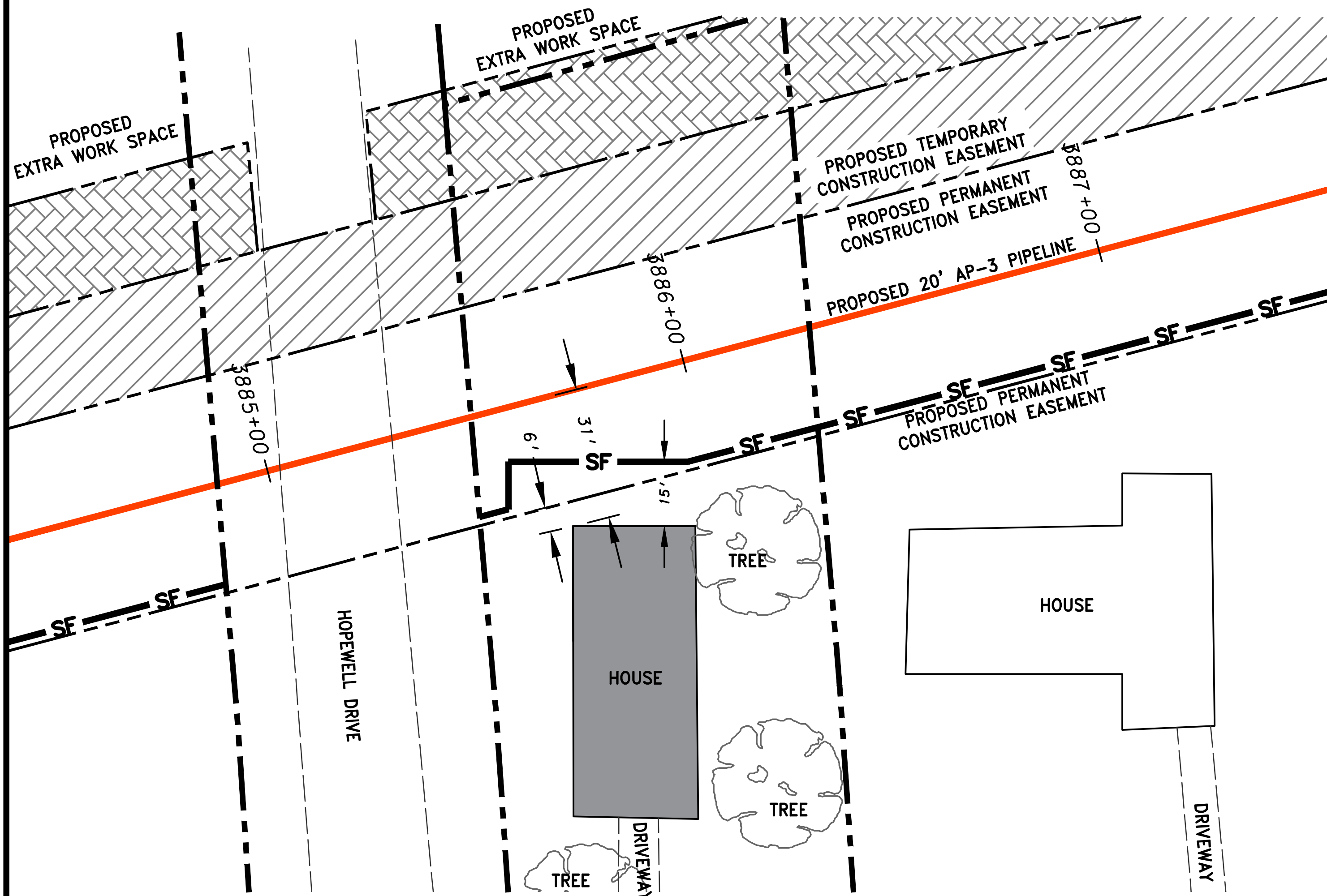
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-078 REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS\2665-07 SPREAD-8 - LL-27-078.DWG

7/18/2016 4:56 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION AND ROAD BORE.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-080
701 HOPEWELL DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343004000290
AP-3 PIPELINE
MILE POST 79.31



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01

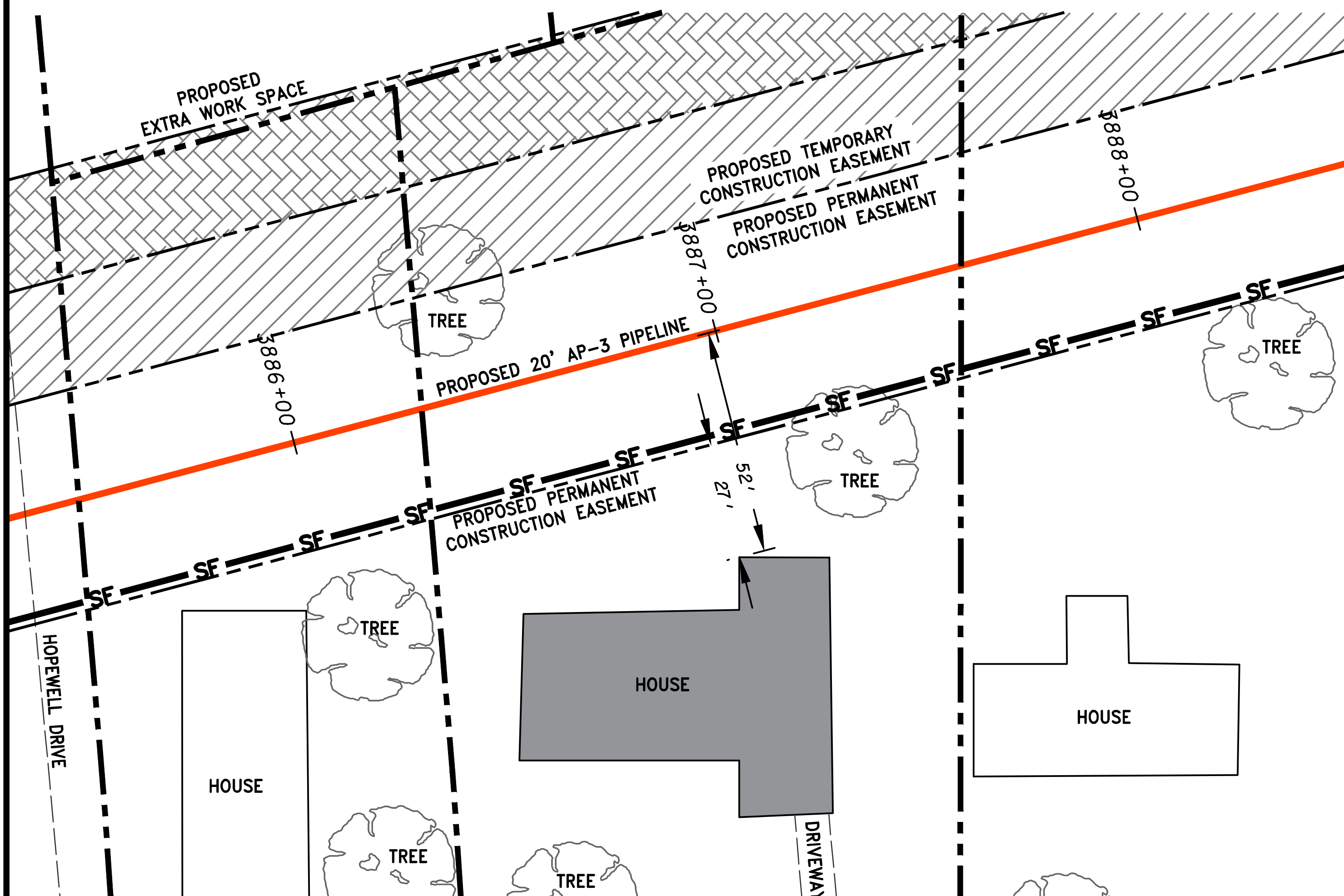
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-080 REV 1

GAI CAD FILE: J:\2665 -GAI WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-080.DWG

7/18/2016 1:09 PM

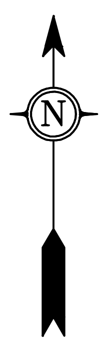
1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-082
2412 MEIGGS ROAD
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343005000300
AP-3 PIPELINE
MILE POST 79.33

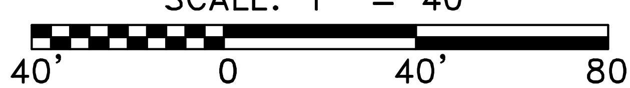


LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.



SCALE: 1" = 40'



gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

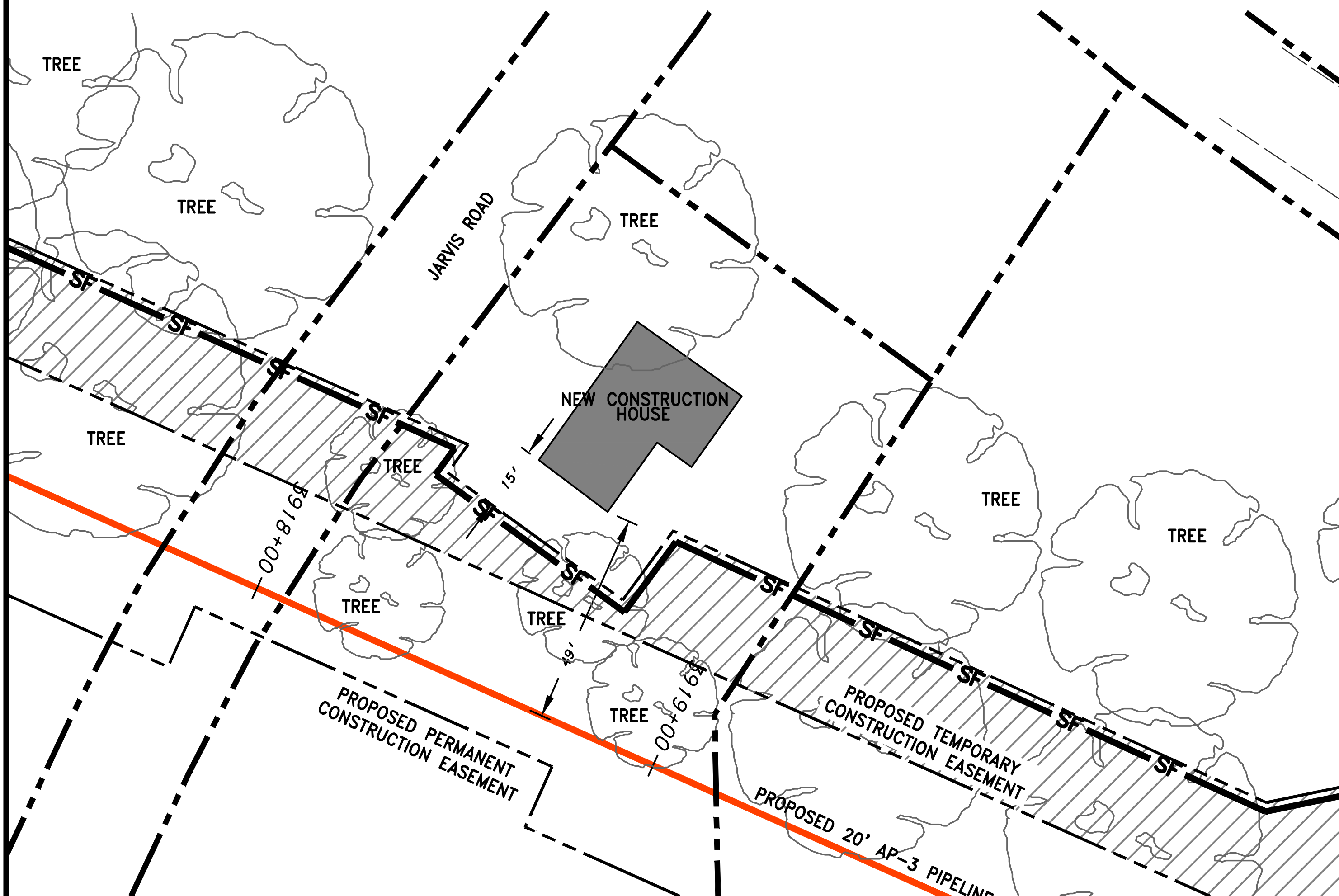
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-082 | REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-082.DWG

7/18/2016 1:13 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-134.1
2525 OCONEE AVE #101
VIRGINIA BEACH, VA 23454-3997
TAX MAP # 0340000001831
AP-3 PIPELINE
MILE POST 79.94



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16

SCALE: AS SHOWN | TASK NO. 01

PROJECT NO./DASH NO. 140468

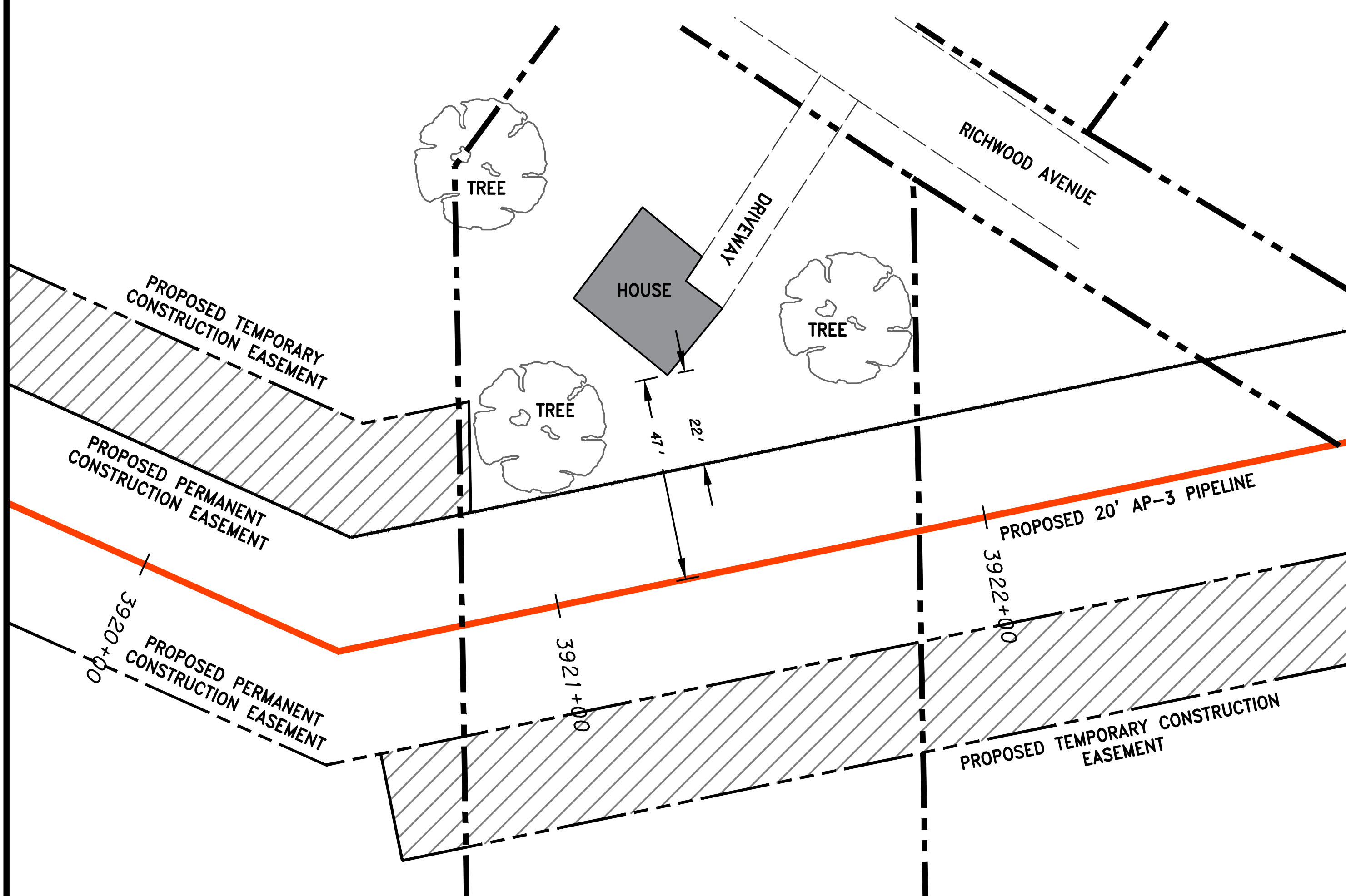
DRAWING NO. LL-27-134.1 | REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-134.1.DWG

7/18/2016 1:18 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-138
508 BAYLOR ST. STE. #B3
CHESAPEAKE, VIRGINIA 23320
TAX MAP # 0340000001820
AP-3 PIPELINE
MILE POST 79.99



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

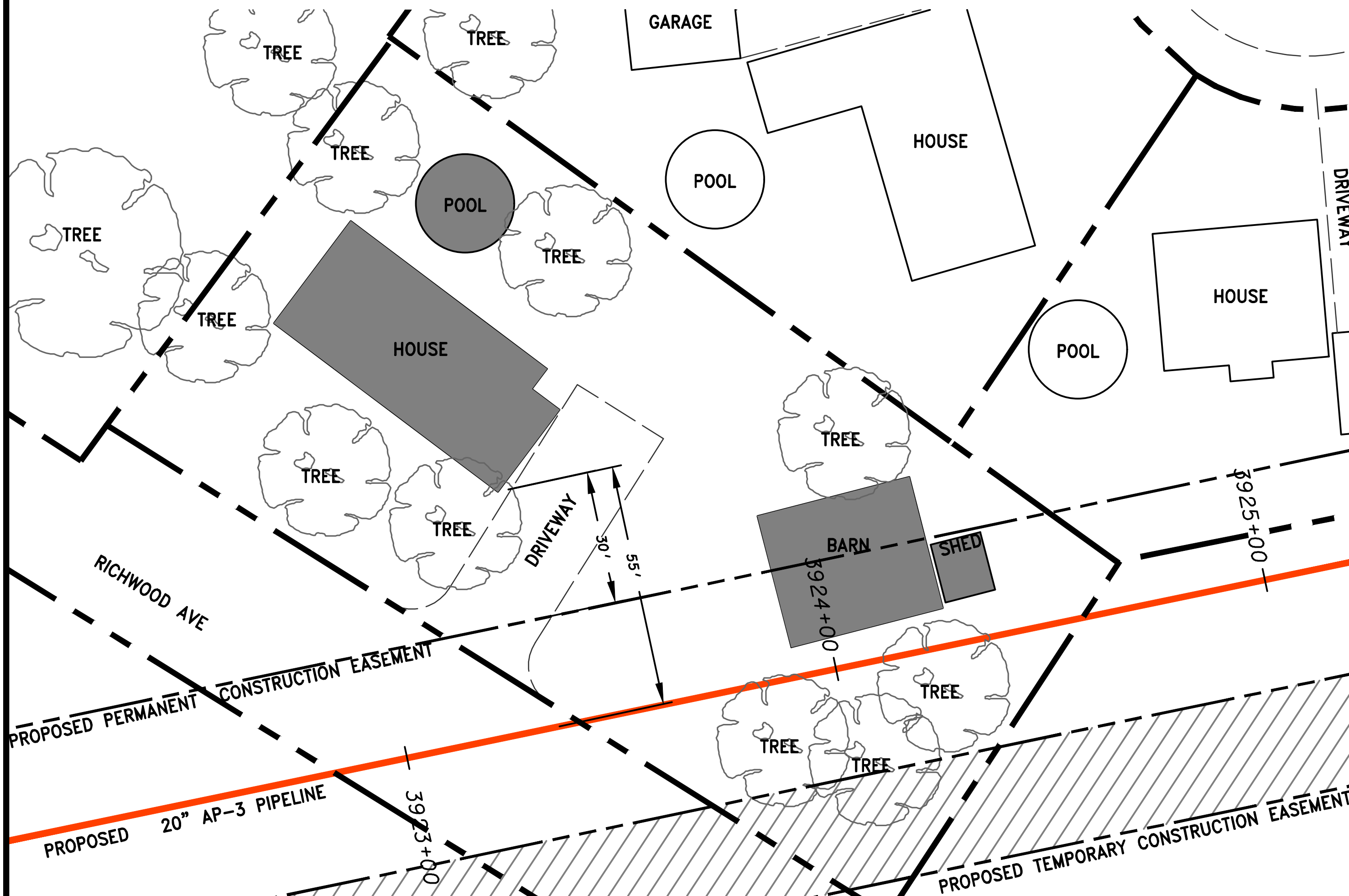
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-138
1 REV

GAI CAD FILE: J:\2665 -GAI WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-138.DWG

7/18/2016 1:32 PM

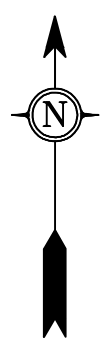
1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-137-A002
PSC 814 #524
FPO, AE 09865-9998
TAX MAP # 0343013000001
AP-3 PIPELINE
MILE POST 80.04



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.



SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

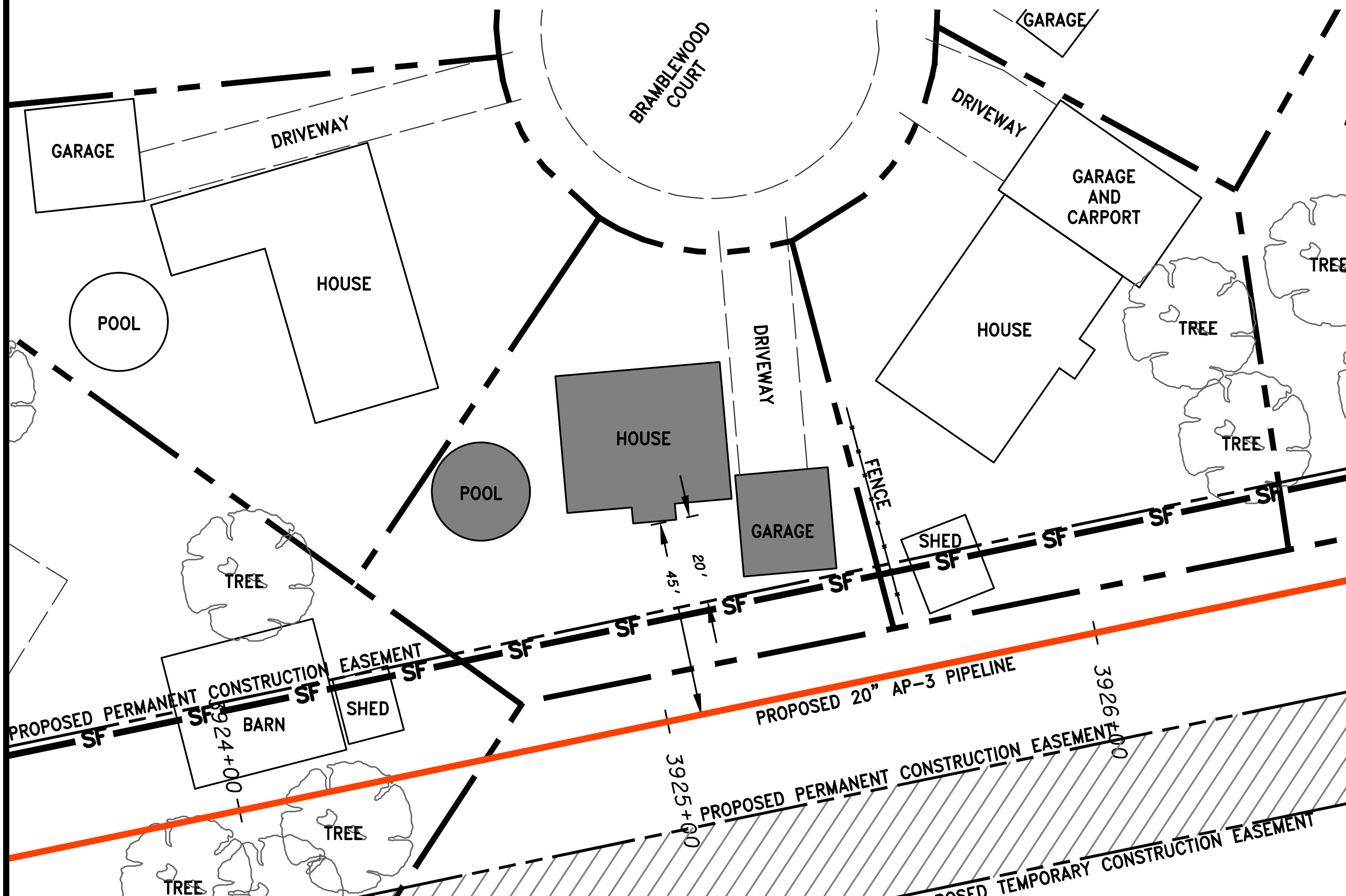
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-137-A002 REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-137-A002.DWG

7/18/2016 1:23 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A001
1201 BRAMBLEWOOD CT
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000090
AP-3 PIPELINE
MILE POST 80.06



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301

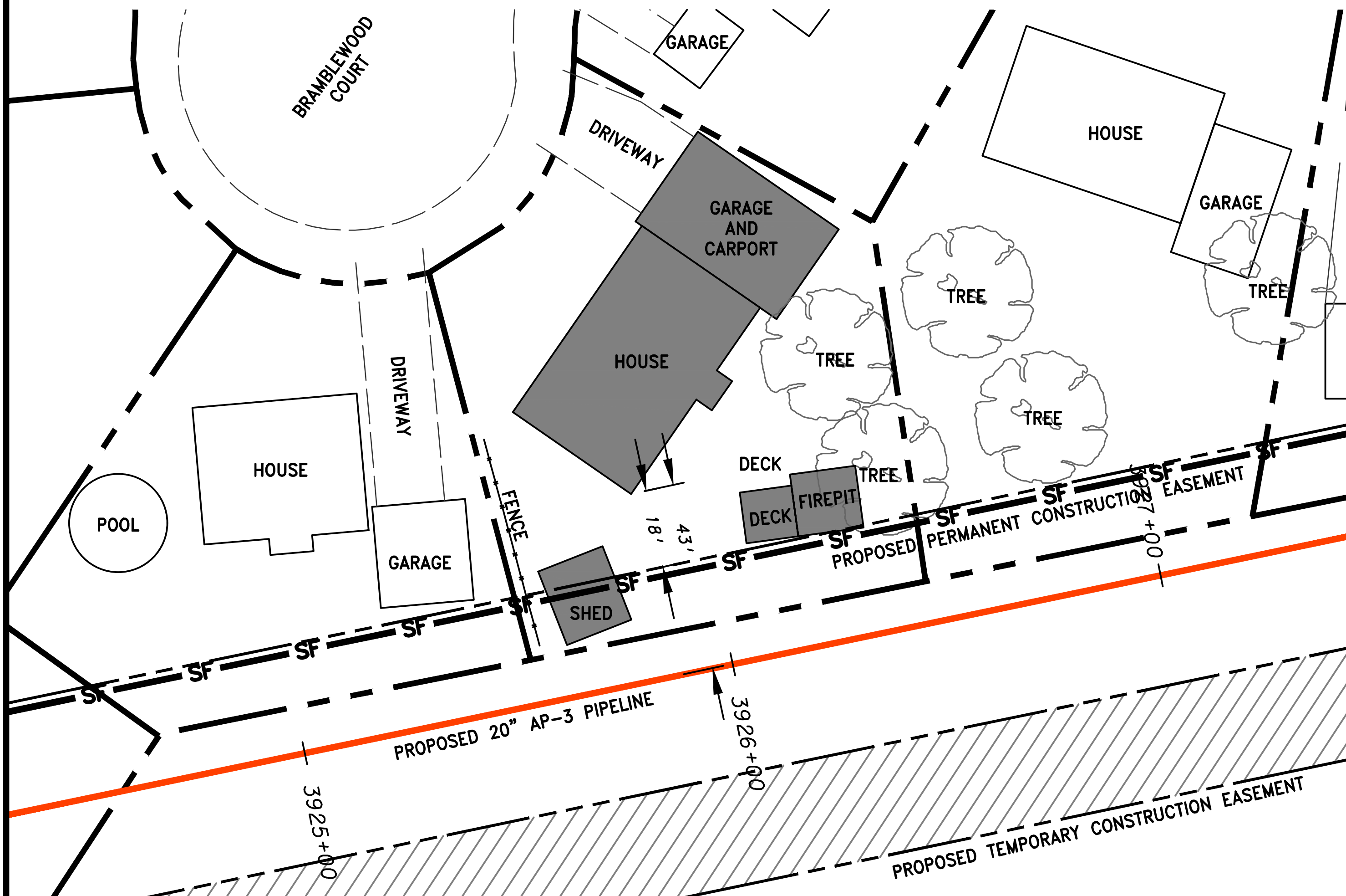
DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-27-142-A001			REV

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A001.DWG

7/18/2016 1:39 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A002
1205 BRAMBLEWOOD CT
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000100
AP-3 PIPELINE
MILE POST 80.07



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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724-873-3545

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monaloh basin engineers
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PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01

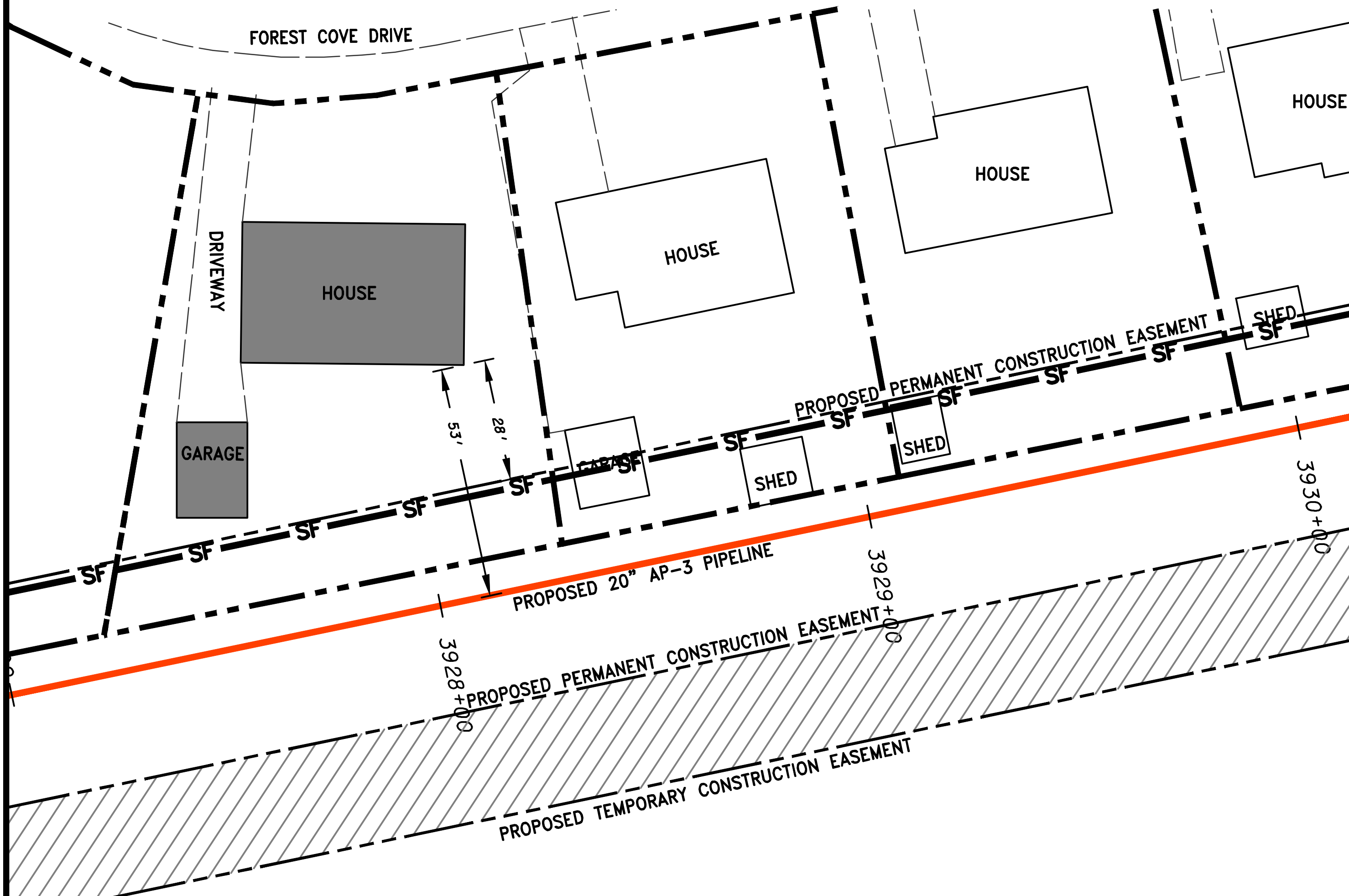
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A002
REV

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A002.DWG

7/18/2016 1:45 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A005
1537 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000130
AP-3 PIPELINE
MILE POST 80.11



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
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PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

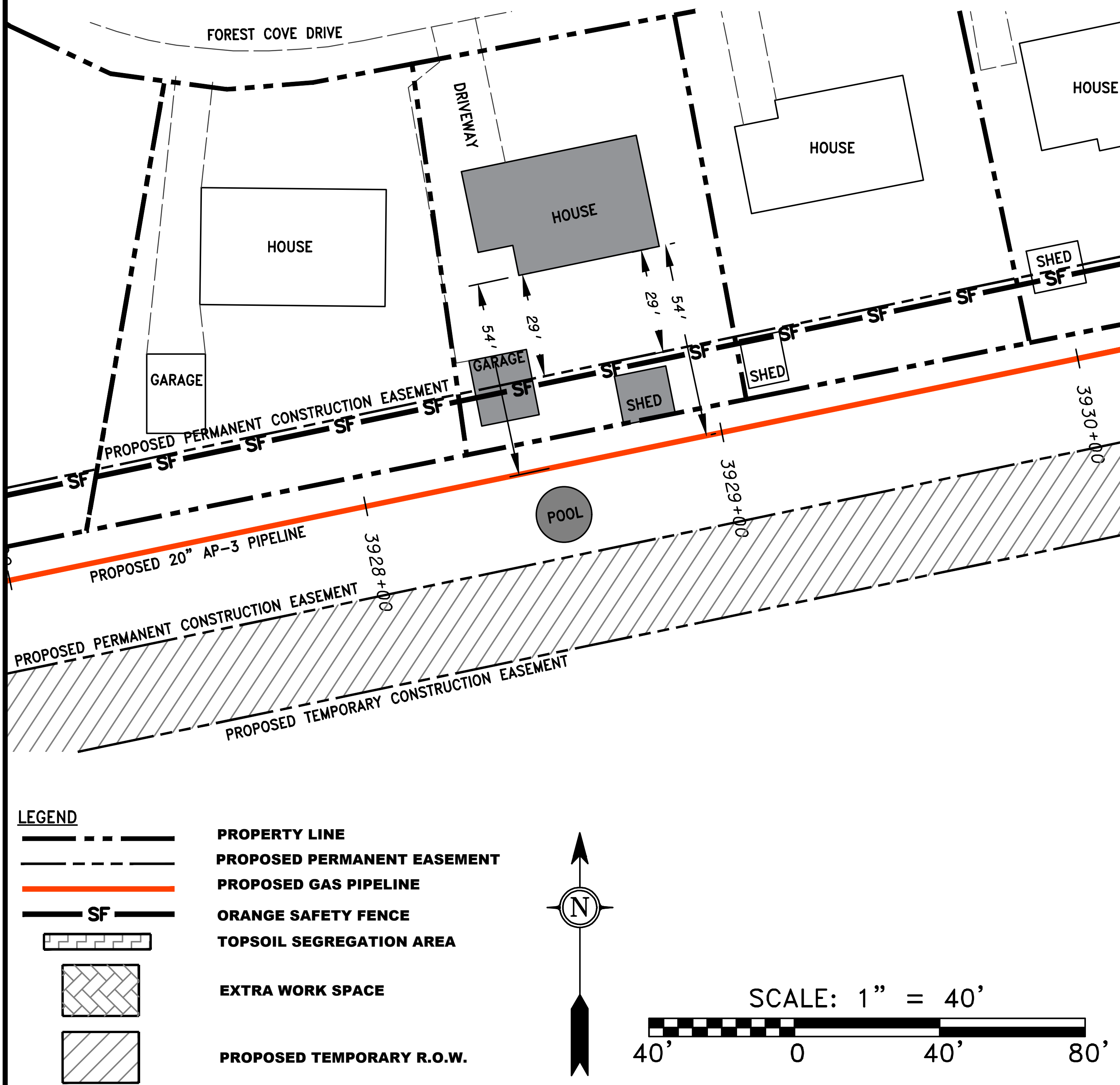
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A005 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A005.DWG

7/18/2016 1:48 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A007
322 EVANSVILLE RD
BERWICK, PA 18603
TAX MAP # 034301300140
AP-3 PIPELINE
MILE POST 80.13



gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01

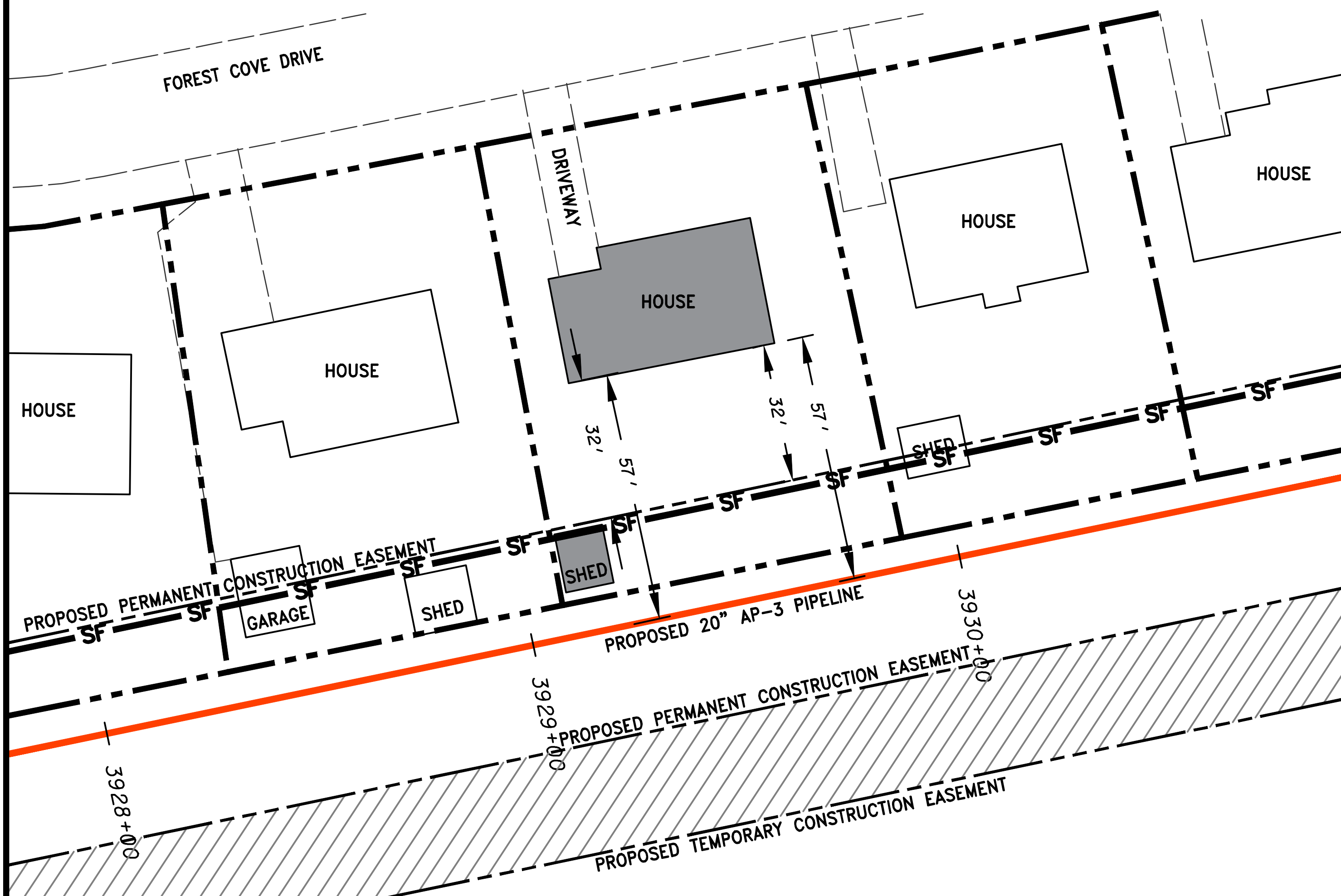
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A007 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A007.DWG

7/18/2016 1:53 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A009
1533 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000150
AP-3 PIPELINE
MILE POST 80.14



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

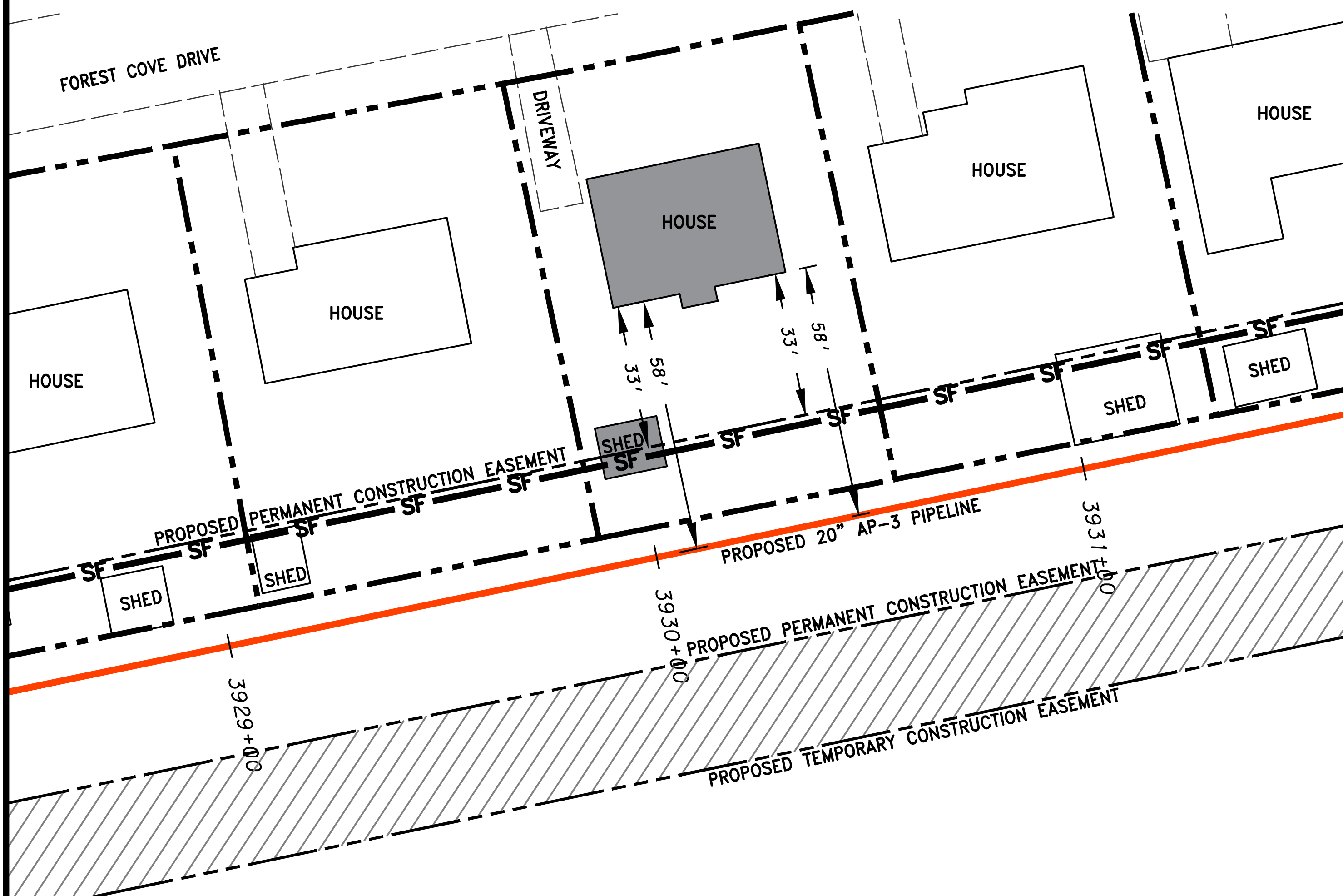
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A009 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A009.DWG

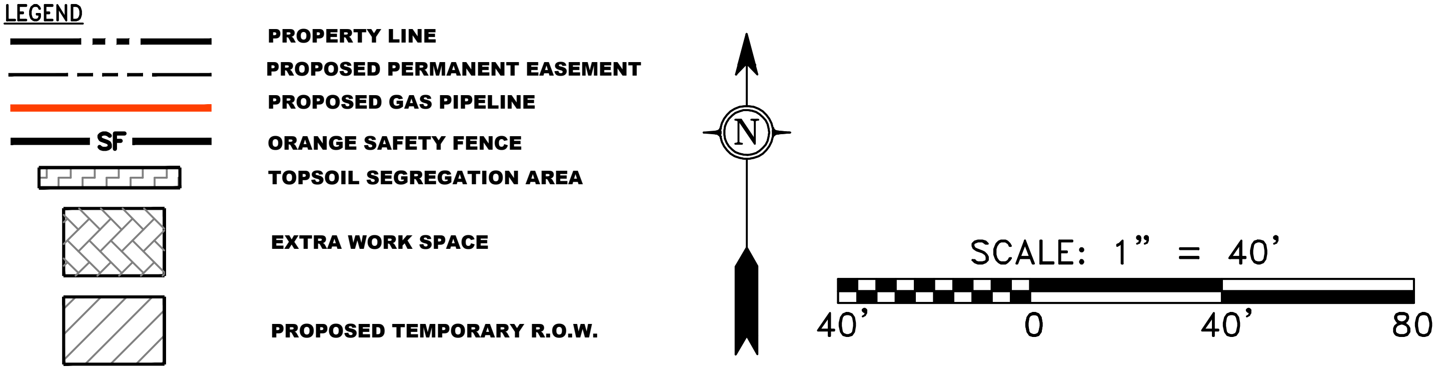
7/18/2016 1:59 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A011
1531 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000160
AP-3 PIPELINE
MILE POST 80.16



LEGEND



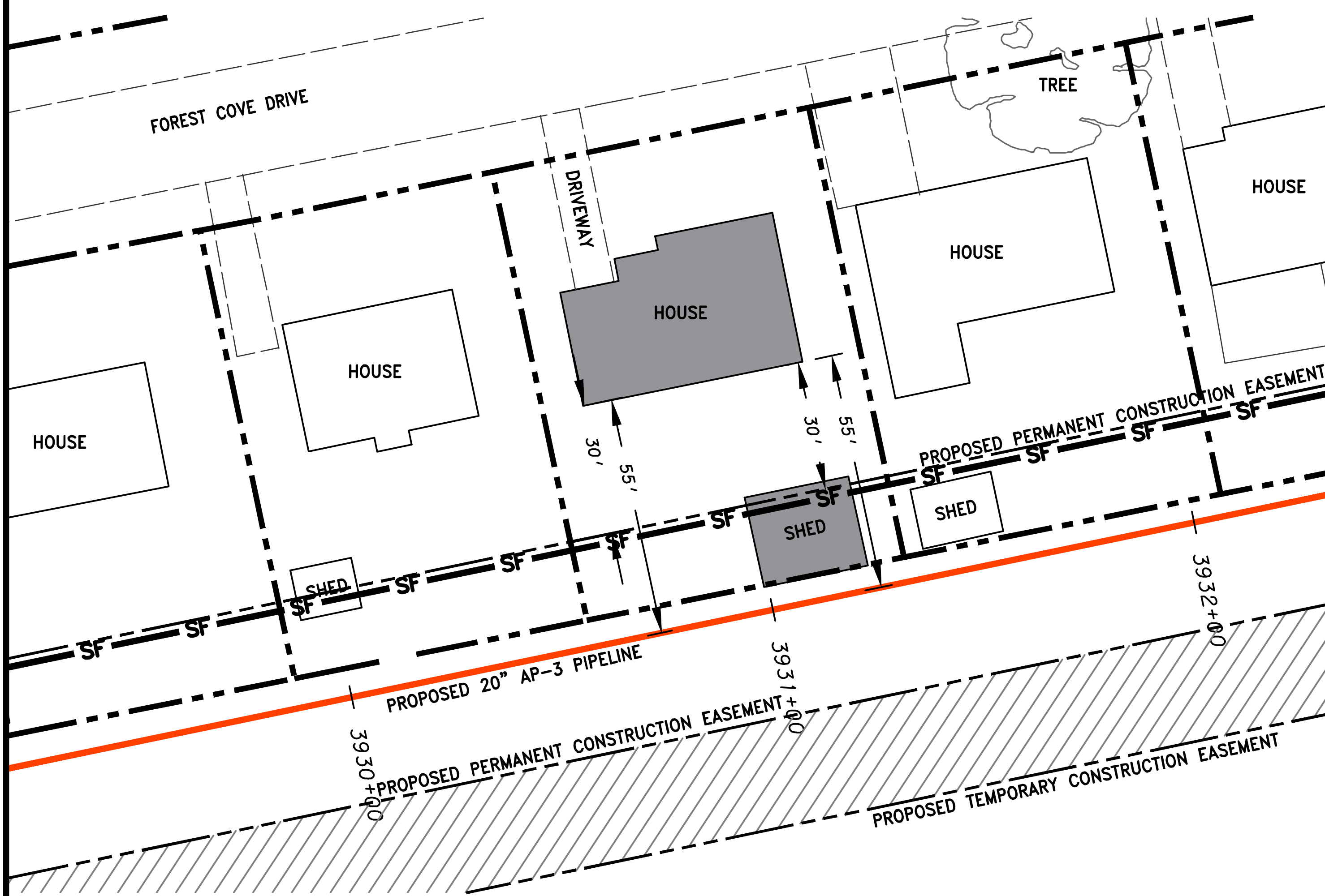
gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA	DWN. RDC CHKD. DLH APPD. NET DATE 7/18/16 SCALE: AS SHOWN TASK NO. 01
		ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. 140468 DRAWING NO. LL-27-142-A011 REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A011.DWG

7/18/2016 2:01 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A013
1529 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000170
AP-3 PIPELINE
MILE POST 80.17



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

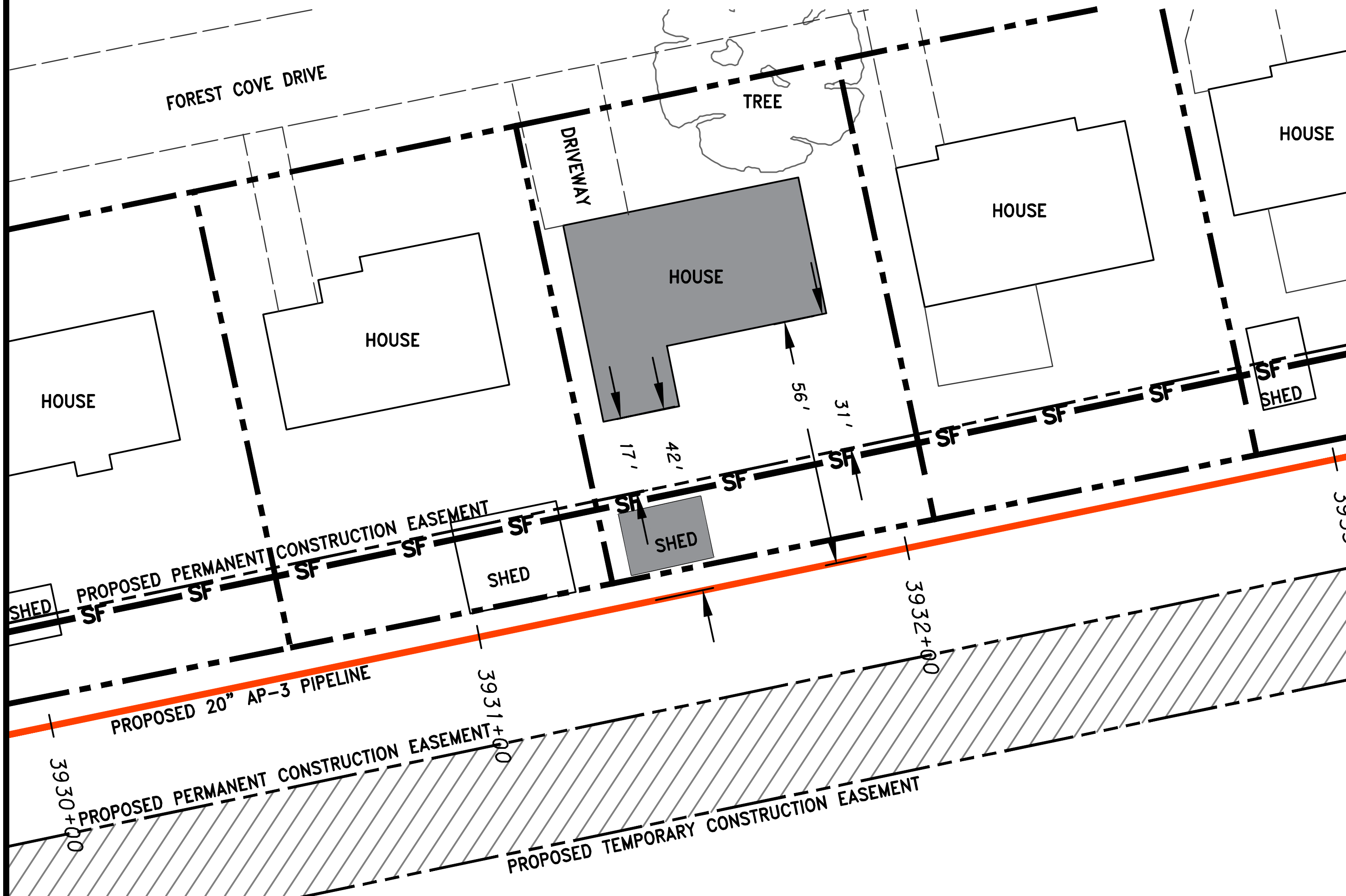
gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	DWN. RDC CHKD. DLH APPD. NET DATE 7/18/16 SCALE: AS SHOWN TASK NO. 01 PROJECT NO./DASH NO. 140468 DRAWING NO. LL-27-142-A013 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A013.DWG

7/18/2016 2:03 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A015
1527 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343013000180
AP-3 PIPELINE
MILE POST 80.19



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

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mbe monaloh basin engineers
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PITTSBURGH, PA 15205
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CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 6/23/2016
SCALE: AS SHOWN			TASK NO. 01

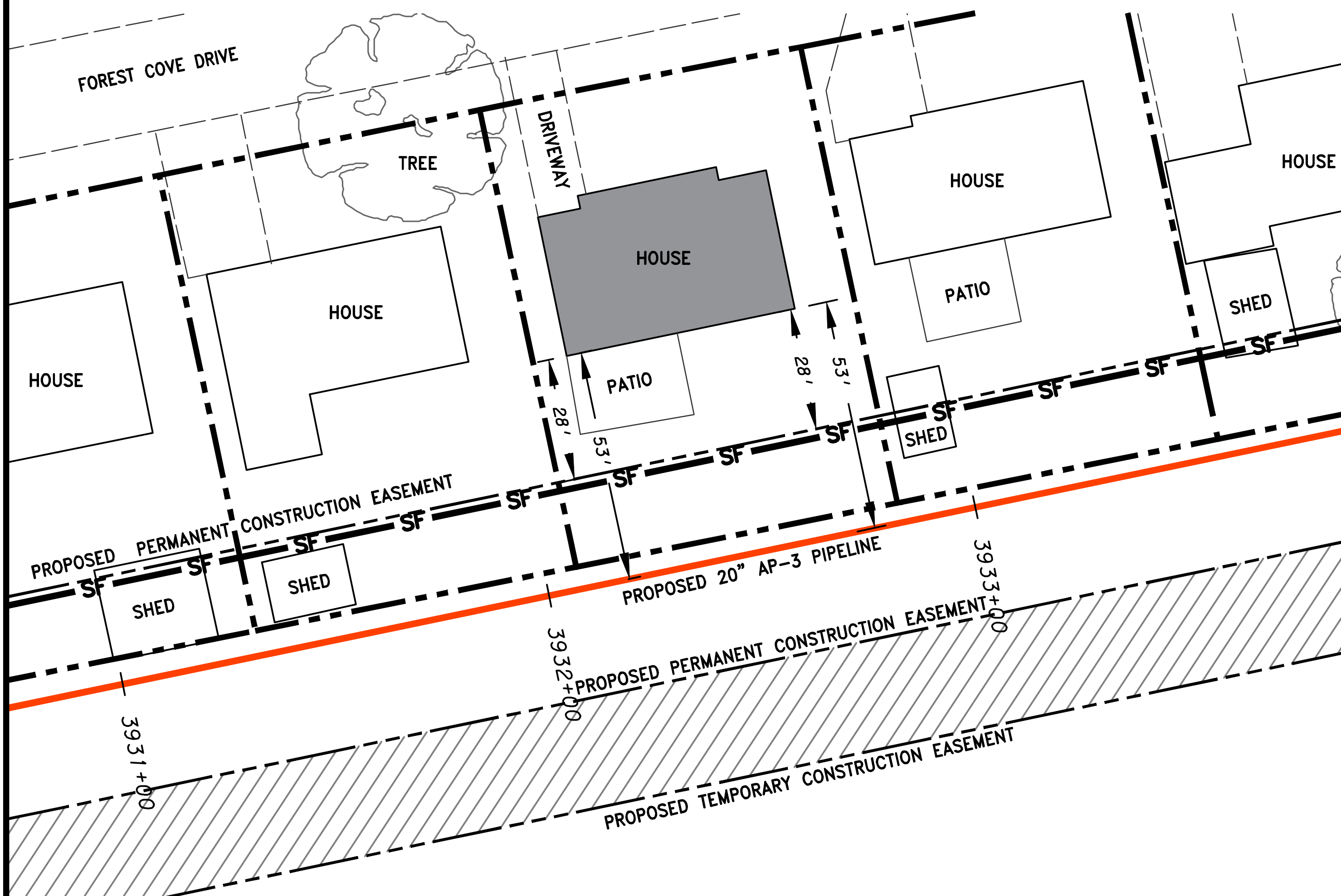
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A015 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A015.DWG

6/28/2016 1:06 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL–27–142–A016
1525 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000010
AP–3 PIPELINE
MILE POST 80.20



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

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724–873–3545

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monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412–788–2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 6/23/2016

SCALE: AS SHOWN | TASK NO. 01

PROJECT NO./DASH NO. 140468

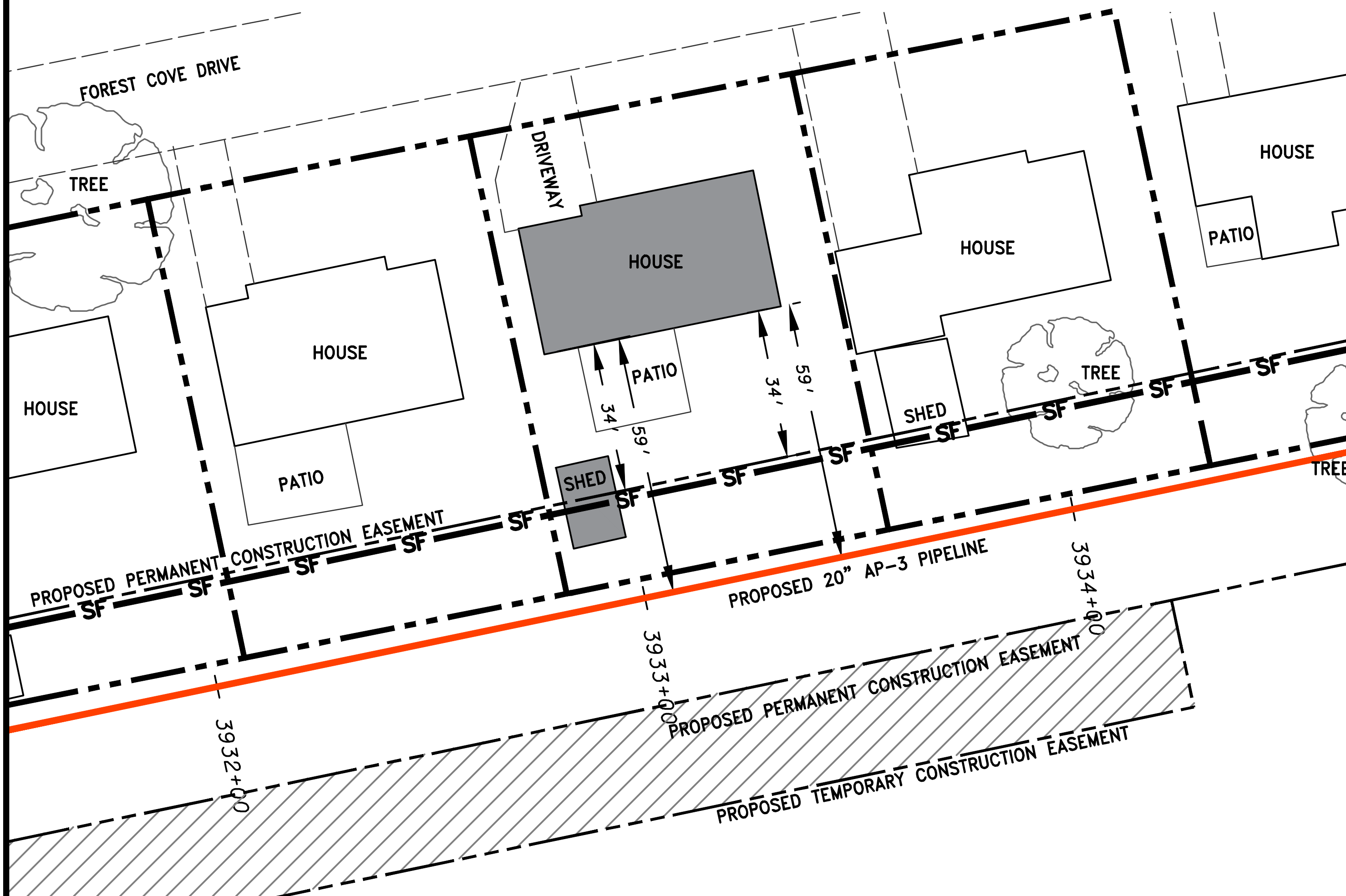
DRAWING NO. LL–27–142–A016 REV 1

GAI CAD FILE: J:\2665 –GAI\WORK ORDER 07 – SOUTHEAST PIPELINE (SECTION 8)\3 – CAD DRAWINGS\BUILDING CONFLICTS\2665–07 SPREAD–8 – BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665–07 SPREAD–8 – LL–27–142–A016.DWG

6/28/2016 1:04 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWELINE R/W.

LL-27-142-A018
1523 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000020
AP-3 PIPELINE
MILE POST 80.21



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 7/18/16
SCALE: AS SHOWN			TASK NO. 01

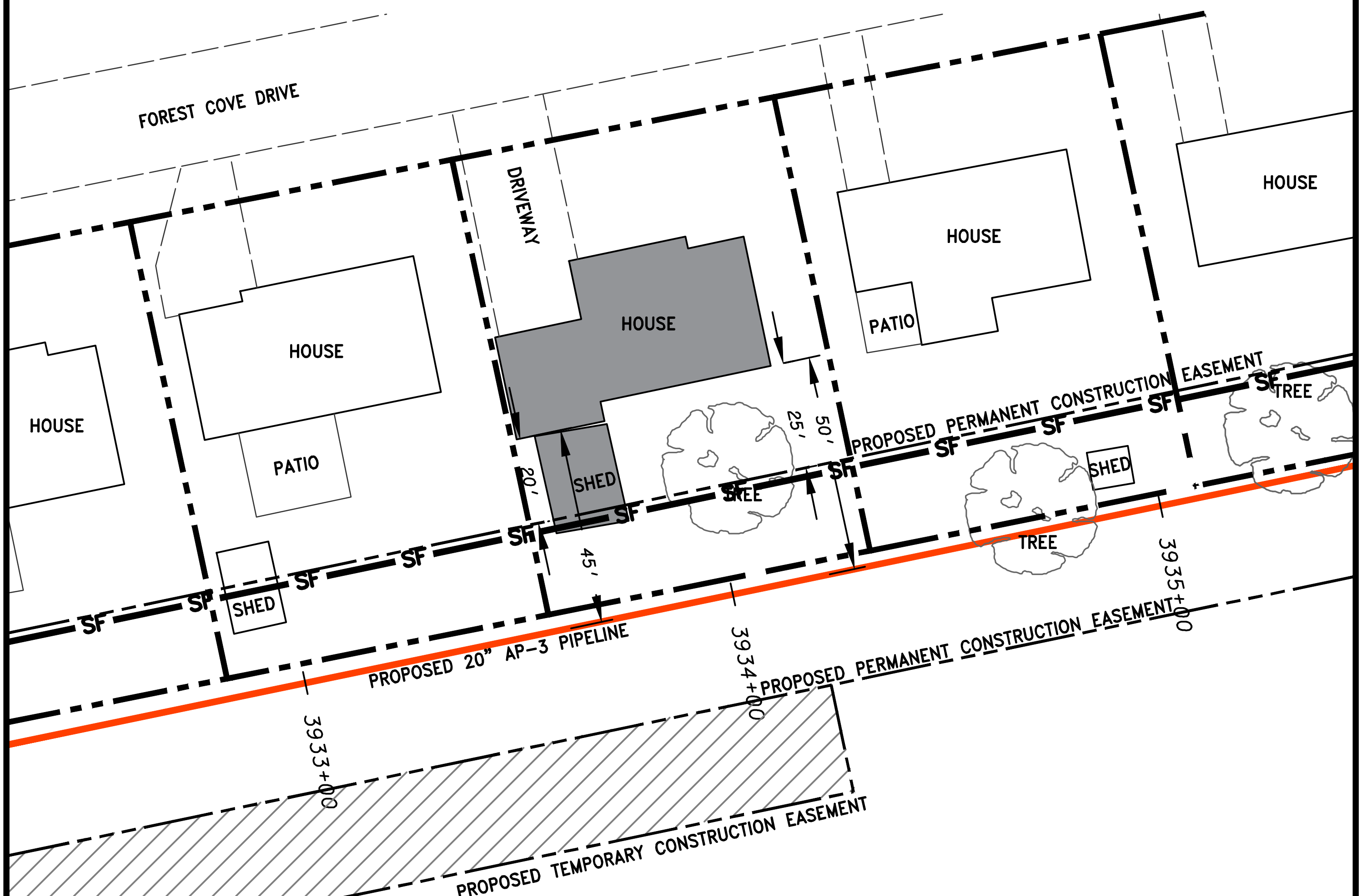
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A018 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A018.DWG

7/18/2016 2:07 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A020
1521 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000030
AP-3 PIPELINE
MILE POST 80.23



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
SF ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'
40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

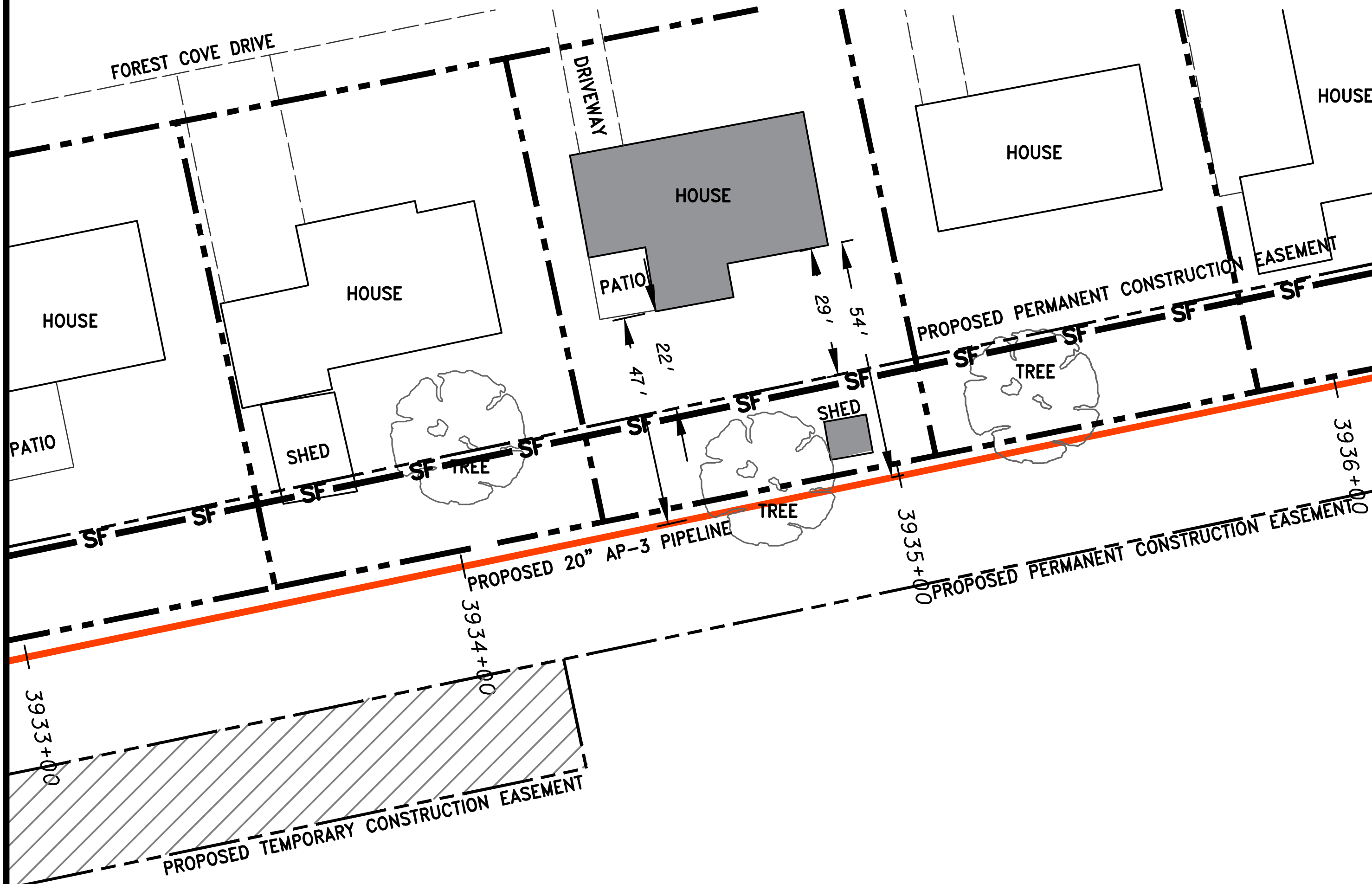
CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA	DWN. RDC	CHKD. DLH	APPD. NET
	SCALE: AS SHOWN		DATE 6/23/2016 TASK NO. 01
ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	PROJECT NO./DASH NO. 140468		
	DRAWING NO. LL-27-142-A020		REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A020.DWG

6/28/2016 1:02 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A022
1519 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000040
AP-3 PIPELINE
MILE POST 80.24



LEGEND

Property line symbol	PROPERTY LINE
Easement line symbol	PROPOSED PERMANENT EASEMENT
Orange line	PROPOSED GAS PIPELINE
SF line	ORANGE SAFETY FENCE
Pattern	TOPSOIL SEGREGATION AREA
Pattern	EXTRA WORK SPACE
Hatched pattern	PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

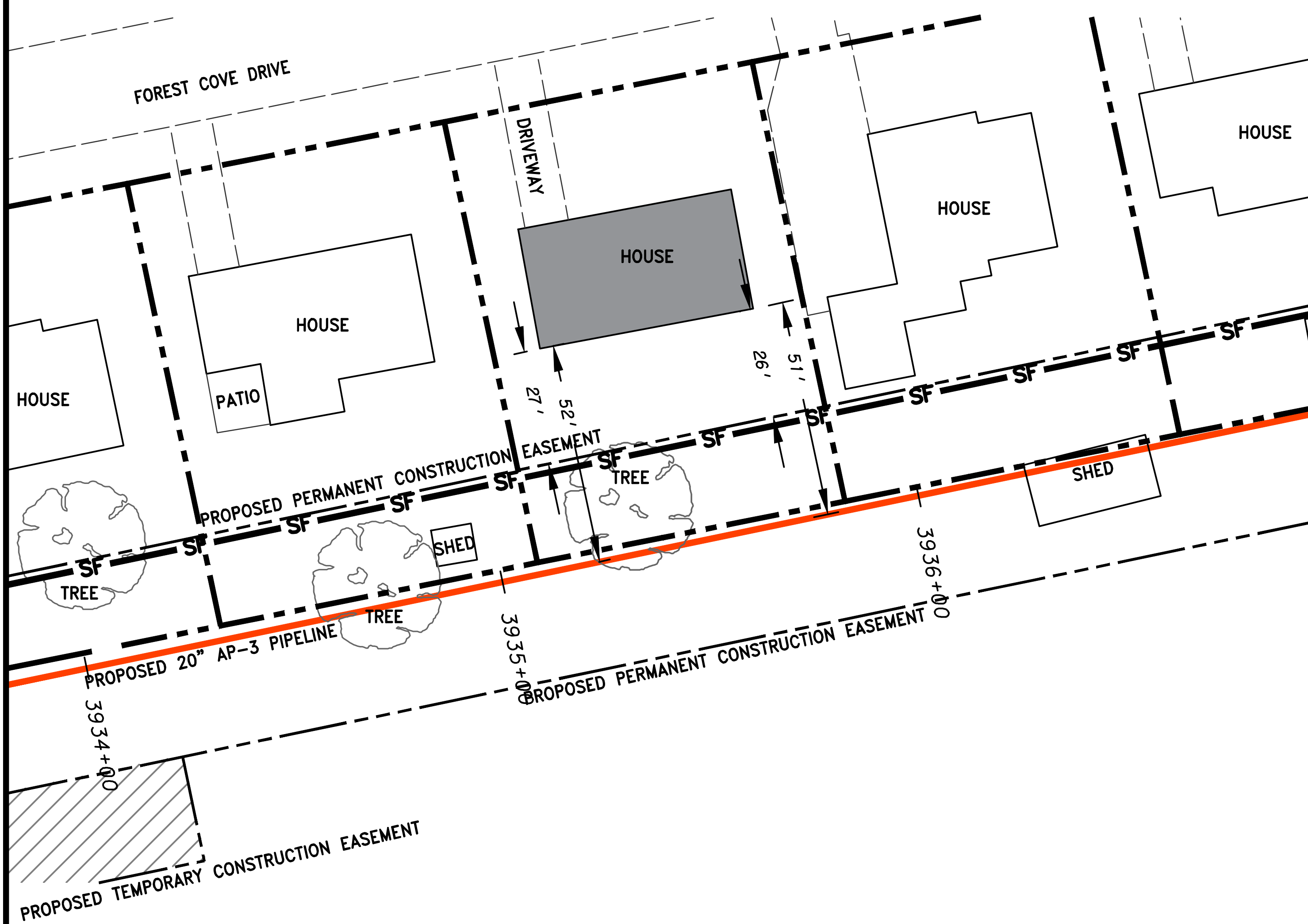
ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A022 REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A022.DWG
7/18/2016 2:11 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A024
1517 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000050
AP-3 PIPELINE
MILE POST 80.26



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

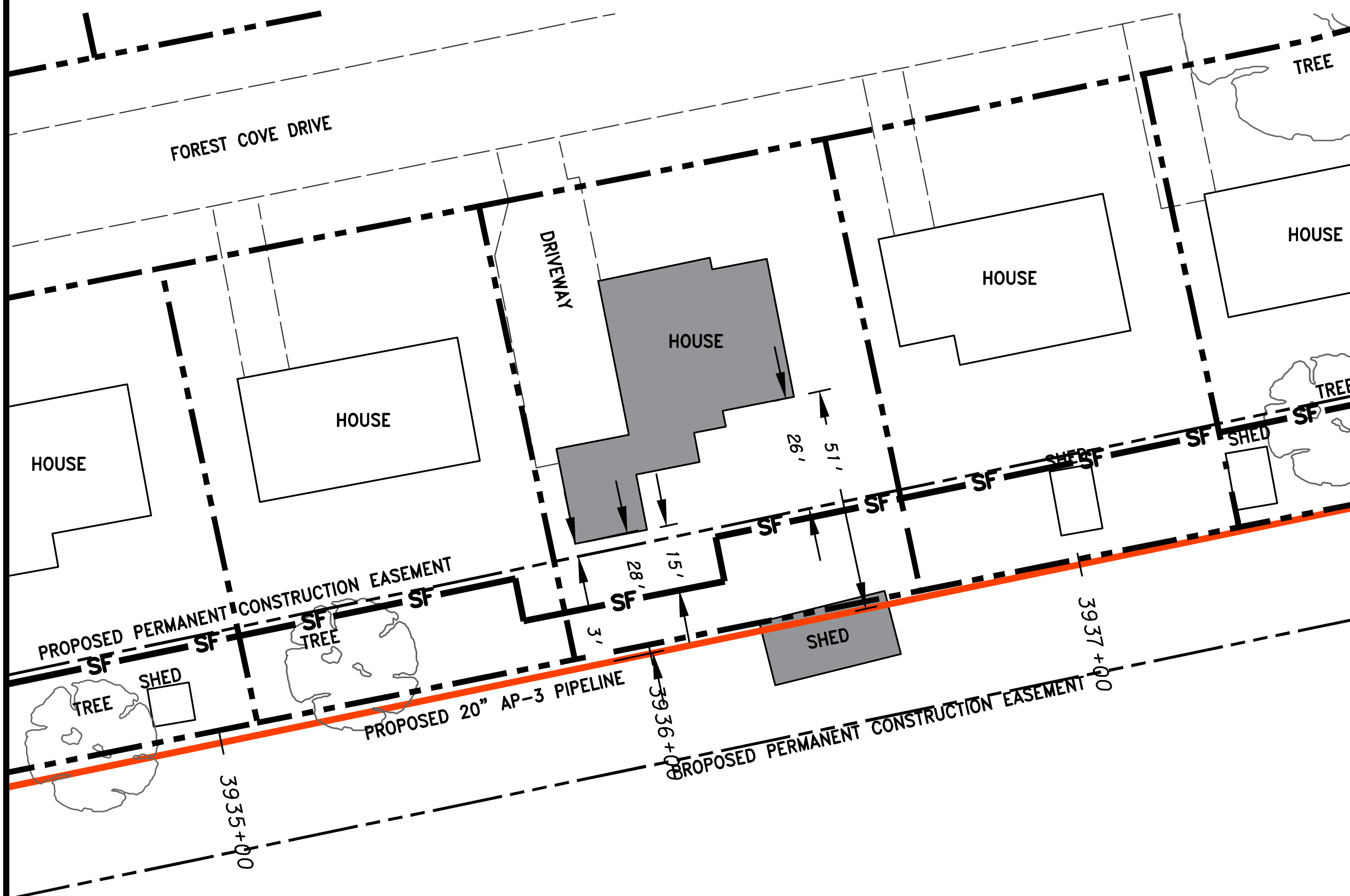
gai consultants SOUTHPOINTE OFFICE 6000 TOWN CENTER BLVD. CANONSBURG, PA 15317 724-873-3545	mbe monaloh basin engineers 300 BUSINESS CENTER DRIVE PITTSBURGH, PA 15205 412-788-2433	CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES CITY OF CHESAPEAKE, VIRGINIA ATLANTIC COAST PIPELINE LLC C/O DOMINION TRANSMISSION, INC. 445 W. MAIN STREET CLARKSBURG, WEST VIRGINIA 26301	DWN. RDC CHKD. DLH APPD. NET DATE 6/23/2016 SCALE: AS SHOWN TASK NO. 01 PROJECT NO./DASH NO. 140468 DRAWING NO. LL-27-142-A024 REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A024.DWG

6/28/2016 12:59 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A026
1515 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000060
AP-3 PIPELINE
MILE POST 80.27



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe
monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

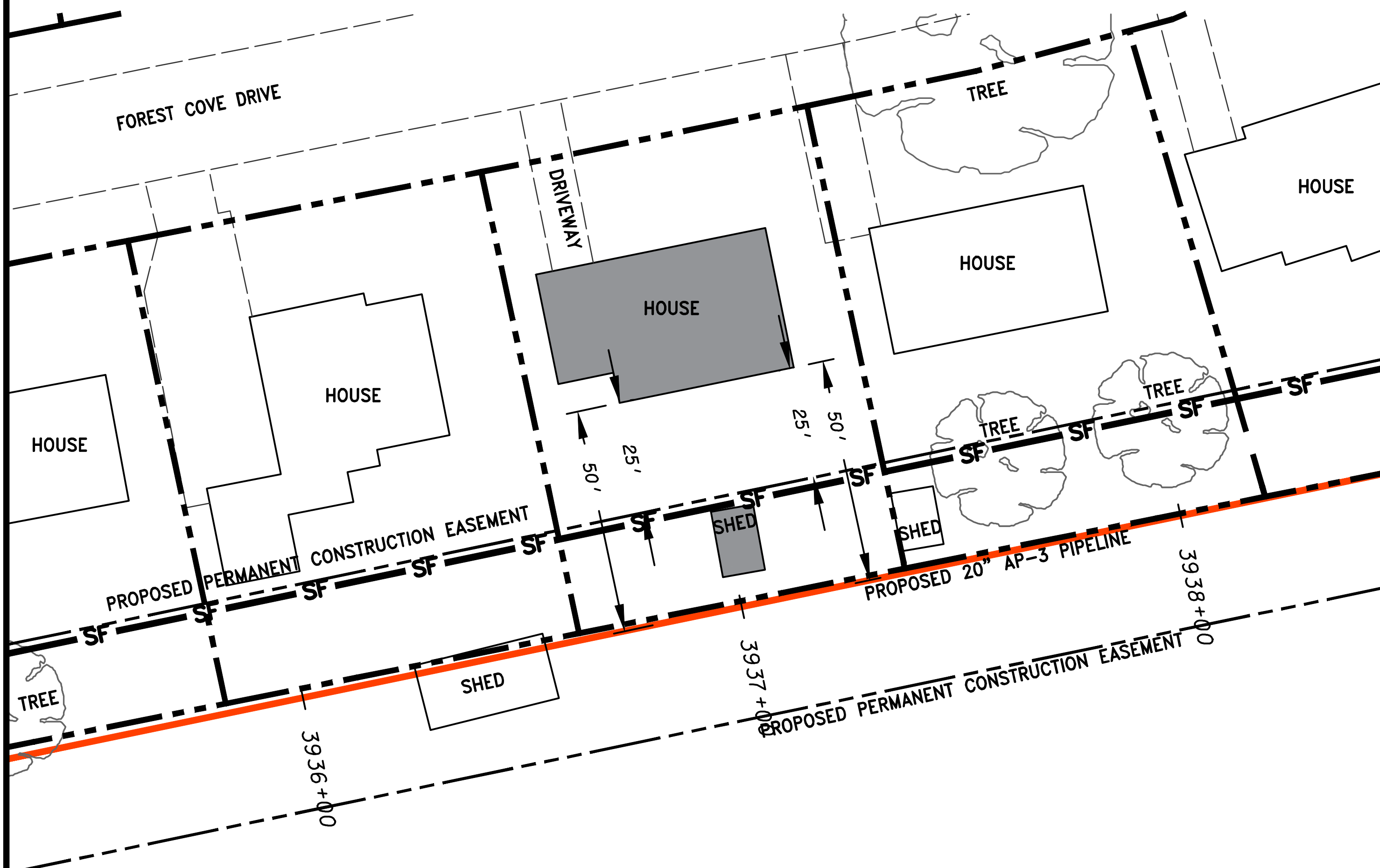
DWN. RDC | CHKD. DLH | APPD. NET | DATE 7/18/16
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A026 REV 1

CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A026.DWG

7/18/2016 2:15 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A028
4576 SCHOONER BLVD
SUFFOLK, VIRGINIA 23435
TAX MAP # 0343017000070
AP-3 PIPELINE
MILE POST 80.29



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
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CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

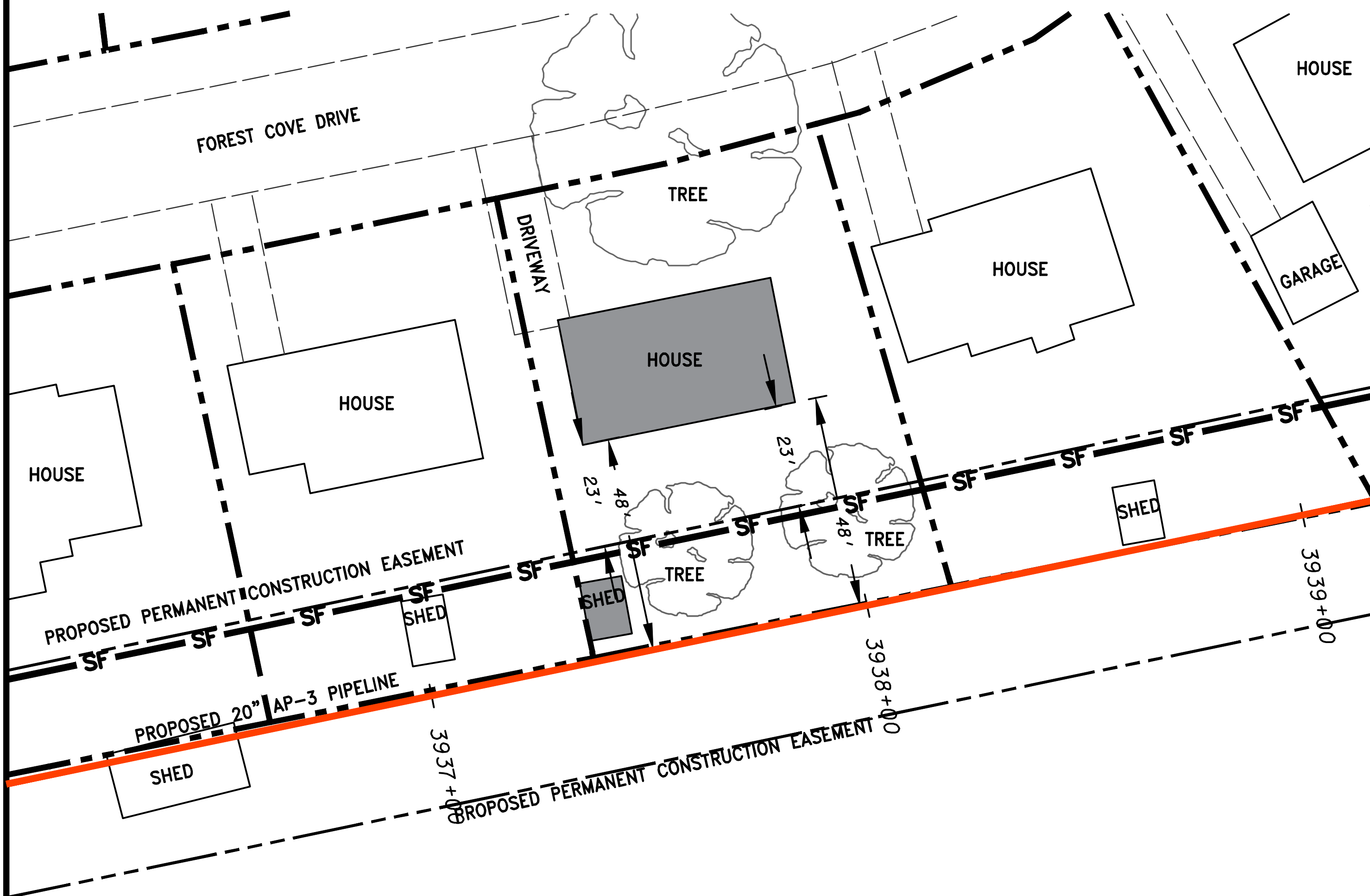
DWN. RDC | CHKD. DLH | APPD. NET | DATE 6/23/2016
SCALE: AS SHOWN | TASK NO. 01
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A028 REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A028.DWG

7/5/2016 8:01 AM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A029
1511 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000080
AP-3 PIPELINE
MILE POST 80.30



LEGEND

- PROPERTY LINE
- PROPOSED PERMANENT EASEMENT
- PROPOSED GAS PIPELINE
- SF — ORANGE SAFETY FENCE
- TOPSOIL SEGREGATION AREA
- EXTRA WORK SPACE
- PROPOSED TEMPORARY R.O.W.

N

SCALE: 1" = 40'

40' 0 40' 80'

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6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

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monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

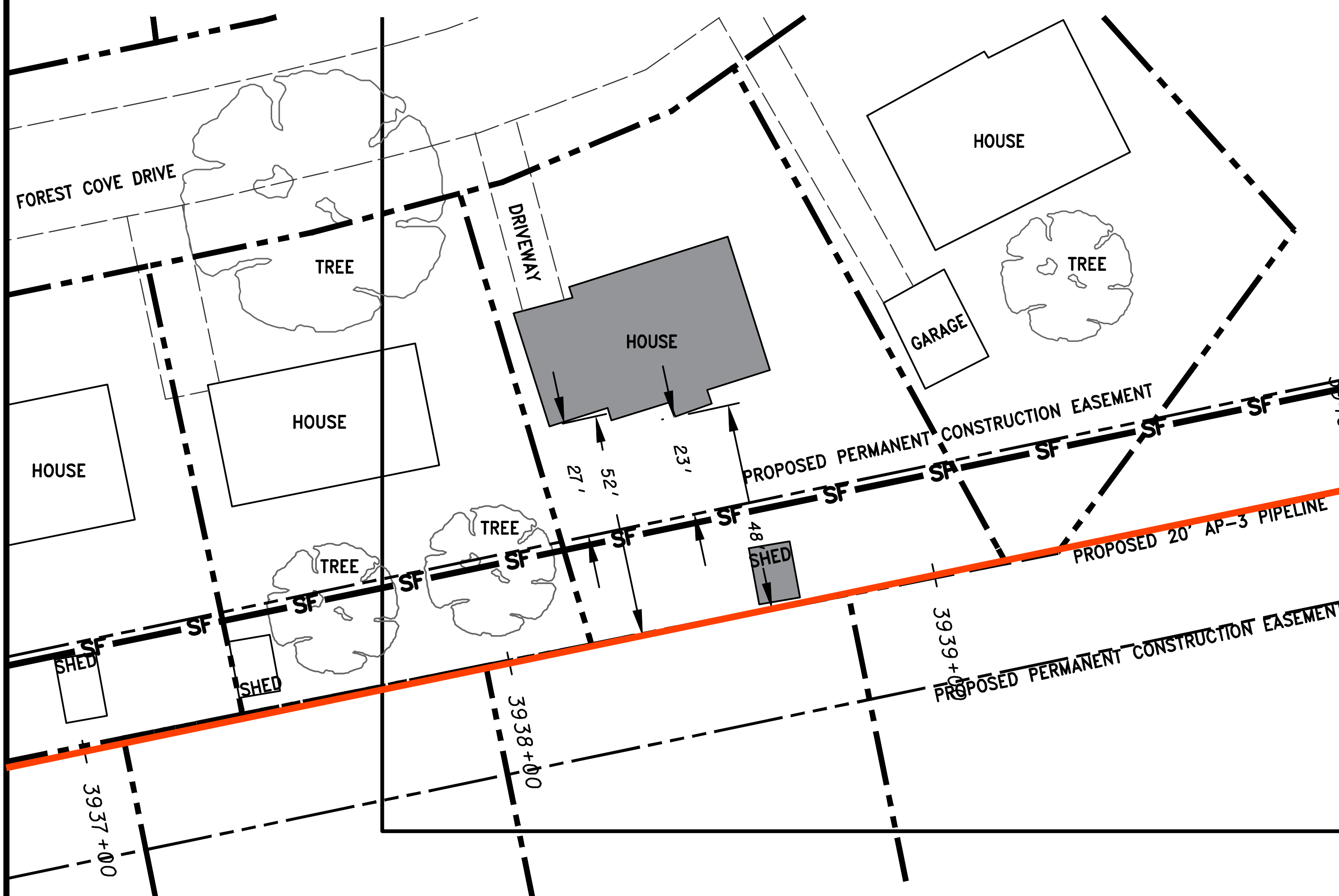
DWN. RDC	CHKD. DLH	APPD. NET	DATE 6/23/2016
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-27-142-A029			REV 1

GAI CAD FILE: J:\2665 -GA\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A029.DWG

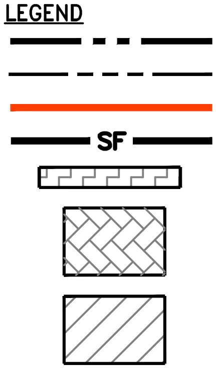
6/28/2016 12:52 PM

1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A031
1509 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000090
AP-3 PIPELINE
MILE POST 80.32



LEGEND



PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.

SCALE: 1" = 40'

40' 0 40' 80'

gai consultants
SOUTHPOINTE OFFICE
6000 TOWN CENTER BLVD.
CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 6/28/2016
SCALE: AS SHOWN			TASK NO. 01

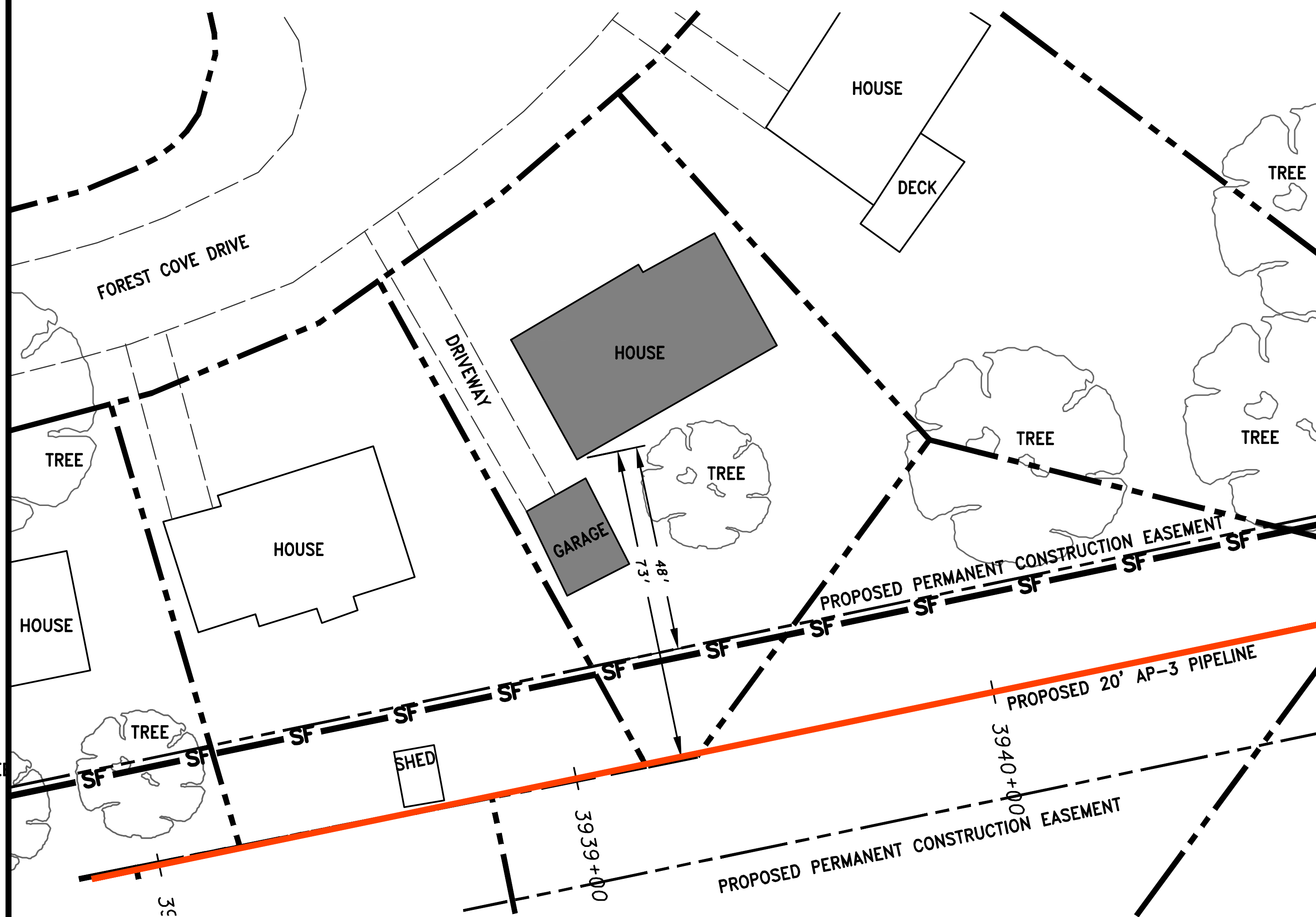
PROJECT NO./DASH NO. 140468
DRAWING NO. LL-27-142-A031 REV 1

GAI CAD FILE: J:\2665 -GAI WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A031.DWG

6/28/2016 12:49 PM

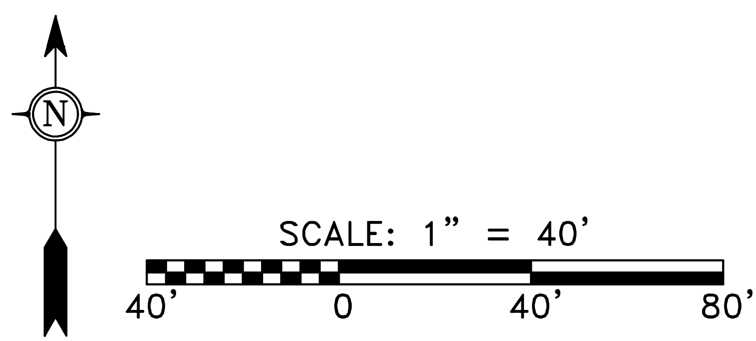
1. CONSTRUCTION TECHNIQUE WILL BE STOVE PIPE OR DRAG SECTION.
2. ORANGE SAFETY FENCE WILL BE INSTALLED A MINIMUM OF FIFTEEN FEET FROM RESIDENCE ALONG CONSTRUCTION R/W, 100' TO EITHER SIDE OF STRUCTURE.
3. VEHICLE ACCESS TO RESIDENCE WILL BE MAINTAINED AT ALL TIMES DURING THE CONSTRUCTION PERIOD.
4. PIPELINE LOD IS WITHIN POWERLINE R/W.

LL-27-142-A032
1507 FOREST COVE DRIVE
CHESAPEAKE, VIRGINIA 23323
TAX MAP # 0343017000090
AP-3 PIPELINE
MILE POST 80.32



LEGEND

PROPERTY LINE
PROPOSED PERMANENT EASEMENT
PROPOSED GAS PIPELINE
ORANGE SAFETY FENCE
TOPSOIL SEGREGATION AREA
EXTRA WORK SPACE
PROPOSED TEMPORARY R.O.W.



gai consultants
SOUTHPOINTE OFFICE
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CANONSBURG, PA 15317
724-873-3545

mbe monaloh basin engineers
300 BUSINESS CENTER DRIVE
PITTSBURGH, PA 15205
412-788-2433

CONSTRUCTION TECHNIQUES NEAR RESIDENTIAL STRUCTURES
CITY OF CHESAPEAKE, VIRGINIA

ATLANTIC COAST PIPELINE LLC
C/O DOMINION TRANSMISSION, INC.
445 W. MAIN STREET
CLARKSBURG, WEST VIRGINIA 26301

DWN. RDC	CHKD. DLH	APPD. NET	DATE 6/22/2016
SCALE: AS SHOWN			TASK NO. 01
PROJECT NO./DASH NO. 140468			
DRAWING NO. LL-27-142-A032			REV 1

GAI CAD FILE: J:\2665 -GAI\WORK ORDER 07 - SOUTHEAST PIPELINE (SECTION 8)\3 - CAD DRAWINGS\BUILDING CONFLICTS\BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - BUILDING CONFLICT EXHIBITS INDIVIDUAL\2665-07 SPREAD-8 - LL-27-142-A032.DWG

7/5/2016 8:14 AM