PennEast Pipeline Company, LLC

PENNEAST PIPELINE PROJECT

S – ALTERNATIVES ANALYSIS
BUCKS COUNTY

REVISED OCTOBER 2019

Submitted by:

PennEast Pipeline Company, LLC

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Acronyms and Abbreviations

°F	degrees Fahrenheit
Algonquin	Algonquin Gas Transmission, LLC
ATWS	additional temporary workspace
Blue Mountain	UGI Central Penn Gas, Inc.
BMP	best management practice
BWA	Bethlehem Water Authority
CO-RD	County Road
EA	Environmental Assessment
EI	Environmental Inspector
E&SCP	Erosion and Sediment Control Plan
ETG	Elizabethtown Gas
EV	Exceptional Value
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FERC's Plan	Upland Erosion Control, Revegetation, and Maintenance Plan
FERC's Procedures	Wetland and Waterbody Construction and Mitigation Procedures
GHG	Greenhouse Gas
GIS	geographic information system
GNIS	Geographic Names Information System
HQ	High-Quality
HDD	horizontal directional drill
hp	horsepower
ISO	International Standards Organization
JPA	Joint Permit Application
LNG	Liquefied Natural Gas
MLV	mainline valve
MMD	Million Dekatherms per Day
MP	milepost
N/A	not applicable
NJ	New Jersey
NHD	National Hydrography Dataset
NPS	National Park Service
NRHP	National Register of Historic Places
NRIS	National Register Information System
NWI	National Wetland Inventory
OHWM	Ordinary High Water Mark
PA	Pennsylvania
PADCNR	Pennsylvania Department of Conservation and Natural Resources
PADEP	Pennsylvania Department of Environmental Protection
PaGS	Bureau of Topographic and Geologic Survey
PaGWIS	Pennsylvania Groundwater Information System
PEM	palustrine emergent
PennEast	PennEast Pipeline Company, LLC
PFBC	Pennsylvania Fish and Boat Commission
PFO	palustrine forested

PGC	Pennsylvania Game Commission
PNHP	Pennsylvania Natural Heritage Program
Project	PennEast Pipeline Project
PSS	palustrine scrub-shrub
PSU	Pennsylvania State University
ROW	right-of-way
RQD	rock quality designations
SGL	State Game Land
SR	State Route
Texas Eastern	Texas Eastern Transmission, LP
TGD	Technical Guidance Document
Transco	Transcontinental Gas Pipe Line Company, LLC
U.S.	United States
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WPC	Western Pennsylvania Conservancy

1.0 Introduction

In accordance with the requirements contained within the Pennsylvania Department of Environmental Protection's (PADEP) Comprehensive Environmental Assessment of Proposed Project Impacts for Chapter 105 Water Obstruction and Encroachment Permit Applications Technical Guidance Document (TGD) (Document No. 310-2137-006, 12/16/2017) and the assessment criteria detailed in Module 3 of the Environmental Assessment (EA) Form (EA Form) Instructions (Document No. 3150-PM-BWEW0017, Revised 6/2017), PennEast Pipeline Company, LLC (PennEast) has prepared this Alternatives Analysis to support its Joint Permit Application (JPA) for the PennEast Pipeline Project (Project). PennEast analyzed practicable alternatives to the proposed Project, including route and aboveground site alternatives, which avoid and minimize adverse environmental effects while still satisfying customer needs. Where temporary impacts are unavoidable, PennEast will implement the specialized mitigation measures and best management practices (BMPs) discussed in this analysis. Permanent impacts will be mitigated through the implementation of an off-site compensatory mitigation plan that is provided in JPA Appendix L-4B.

2.0 Purpose and Need

PennEast proposes to construct, install, and operate the Project facilities to provide approximately 1.1 million dekatherms per day (MMDth/day) of year-round transportation service from northern Pennsylvania to markets in eastern and southeastern Pennsylvania, New Jersey and surrounding states. The Project is designed to provide a long-term solution to bring the lowest cost natural gas that is produced and available in northern Pennsylvania's Marcellus Shale region to homes and businesses in Pennsylvania, New Jersey, and surrounding states. The Project will extend from various receipt point interconnections in the eastern Marcellus region, including interconnections with Transcontinental Gas Pipe Line Company, LLC (Transco) and gathering systems operated by Williams Partners L.P., Energy Transfer Partners, L.P. (formerly Regency Energy Partners, LP), and UGI Energy Services, LLC, all in Luzerne County Pennsylvania, to various delivery point interconnections in the heart of major northeastern natural gas-consuming markers, including interconnections with UGI Central Penn Gas, Inc. (Blue Mountain) in Carbon County, Pennsylvania, UGI Utilities, Inc. and Columbia Gas Transmission, LLC in Northampton County, Pennsylvania, and Elizabethtown Gas, NRG REMA, LLC, Texas Eastern Transmission, LP (Texas Eastern) and Algonquin Gas Transmission, LLC (Algonquin), all in Hunterdon County, New Jersey. The terminus of the proposed PennEast Project will be located at a delivery point with Transco in Mercer County, New Jersey.

The Project was developed in response to market demands in New Jersey and Pennsylvania, and interest from shippers that require transportation capacity to accommodate increased demand and greater reliability of natural gas in the region. The Project is designed to provide a new pipeline to serve markets in the region with firm, reliable access to the Marcellus supplies, versus the traditional, more costly Gulf Coast regional supplies and pipeline pathways. An additional supply of natural gas to the region will provide a benefit to consumers, utilities and electric generators by providing enhanced competition among suppliers and pipeline transportation providers. The Project will provide shippers additional opportunities to buy and sell supplies and to transport natural gas to where it is needed and valued most. The Project also offers shippers a reliable, short-haul transportation option for direct access to Marcellus Shale natural gas supplies absent several risks associated with long-haul pipelines originating and traversing other regions of the county. A more detailed Purpose and Need for the Project is provided in JPA Section J.

3.0 Facility Description and Locations

3.1 Pipeline Facilities in Pennsylvania

The Project's facilities in Pennsylvania include the PennEast mainline 36-inch diameter pipeline route, the 4-inch diameter Blue Mountain Lateral, and the 24-inch diameter Hellertown Lateral (Project Location Map provided in JPA Section I). The PennEast mainline pipeline will be 115-mile long new pipeline starting in Luzerne County, Pennsylvania and extending to Mercer County, New Jersey. Approximately 77 miles of the mainline route pipeline is located Luzerne, Carbon, Northampton, Monroe, and Bucks Counties, Pennsylvania. Approximately 2 miles of the mainline route pipeline, from milepost (MP) 75.9 to 77.7, is proposed in Bucks County, Pennsylvania. The 4-inch diameter Blue Mountain Lateral will be approximately 0.5 mile of new pipeline in Carbon County, Pennsylvania, and the 24-inch diameter Hellertown Lateral will be approximately 2-miles of new pipeline in Northampton County, Pennsylvania. No lateral pipelines are proposed in Bucks County.

3.2 Aboveground Facilities in Pennsylvania

The proposed Project includes construction of a new compressor station facility identified as the Kidder Compressor Station, which is located on approximately 74-acres of an undeveloped forested site (of which approximately 20 acres will actually be developed) south of MP 26.8R2 in Kidder Township, Carbon County, Pennsylvania. The proposed Kidder Compressor Station will serve the entire Project, providing sufficient throughput with an aggregate of approximately 47,700 International Standards Organization (ISO) horsepower (hp) of compression. The proposed facility components at the Kidder Compressor Station include three gas turbine-driven Solar Mars 100 units rated at 15,900 hp each under ISO conditions (47,700 total ISO hp).

The construction of various associated aboveground facilities including interconnects, launchers, receivers, and mainline valves (MLVs) are proposed to support the pipeline system. There are no proposed aboveground facilities within Bucks County.

4.0 Applicable Regulations

This Alternatives Analysis specifically discusses the measures undertaken to avoid and minimize the overall Project's impact on waters of the Commonwealth to the maximum extent practicable in accordance with 25 Pa. Code §105.18(a) and (b), depending upon whether the wetland is classified as an exceptional value (EV) wetland or an "other" wetland, respectively. Where avoidance was not practicable, compensatory mitigation for permanent wetland impacts will be completed at approved off-site locations.

5.0 No-Action Alternative

The no-action alternative would involve not constructing the Project, which would not meet the Project shippers' need for the firm transportation capacity as reflected in their commitments in the precedent agreements, which are discussed in greater detail in the Project Description in JPA Section J. Accordingly, this option would have adverse consequences on the markets they serve.

The no-action alternative would completely avoid temporary and permanent environmental impacts associated with the Project. However, the Project shippers and local distribution companies would likely pursue alternate natural gas transportation projects that could potentially result in similar environmental impacts. Potential examples of these impacts include the construction of additional or greenfield natural gas pipeline facilities in other locations; dependence on alternate higher emission fuel sources, such as coal or oil; and increased demand for already limited electrical resources.

The 2013/2014 and 2017/2018 winter seasons demonstrated that there were significant constraints in the natural gas supply system created by a combination of increased demand from residential, commercial and industrial conversions due to colder than normal weather temperatures increasing traditional demand; lower than average storage inventories; and new natural-gas fired power generation. While natural gas prices have steeply declined over the last several years, constraints between supply and demand areas due to lack of sufficient pipeline capacity, particularly on days where demand is highest, led to unprecedented spikes in the cost of natural gas and electricity for the market region. The region would therefore benefit from additional pipeline capacity to stabilize costs and mitigate the higher and volatile pricing.

Given the Project shippers' need for additional pipeline capacity, the potential benefit to regional economic growth from the proposed Project, and the potential for significant increase in regional air emissions or similar or greater environmental impacts resulting from an alternate natural gas transportation project if the Project was not constructed, no further analysis of this alternative was conducted. Therefore, the no-action alternative is not considered a viable alternative to the proposed Project, because it would not accomplish the stated Project purpose and need to provide the volumes of natural gas transportation services to the expanding mid-Atlantic market in an efficient, safe, reliable, and environmentally sound manner.

6.0 Energy Conservation

The energy conservation alternative discussed in this section will not meet the needs of the Project shippers and, therefore, is not preferable to the proposed action. However, together with an increased supply of natural gas, energy conservation will continue to contribute to meeting the overall future energy needs of the marketplace.

The use of the energy conservation alternative for meeting the demands of PennEast's customers includes the following potential results:

- Potential for improvements in energy conservation in the residential, commercial, and industrial sectors beyond the current energy conservation measures already being practiced; and
- Potential for increasing the efficiency of the existing natural gas transmission systems through system optimization, which includes the use of load management techniques at both the end-use consumer and utility level, and the identification and elimination of bottlenecks in the existing gas transmission system that decrease the effective capacity of the system.

Energy conservation continues to be encouraged in the residential, commercial, and industrial sectors. However, natural gas continues to be considered the preferred non-renewable fuel because of its inherent clean-burning properties and, because it is produced and abundant in North America, it reduces the Country's reliance on foreign-produced oil. The implementation of air quality legislation enhances fuel conservation in numerous energy use sectors. In many cases, legislation encourages the use of natural gas over other more environmentally taxing fuels, such as oil and coal. Increases in population, and commercial and industrial uses of natural gas have contributed to the increased demand for natural gas.

The Project will help to increase the efficiency of the current natural gas transmission system by reducing bottlenecks in the system. Furthermore, this is primarily a market-driven project that is designed to provide a pipeline transportation solution to Marcellus Shale production. Programs designed to encourage fuel conservation are unlikely to eliminate the need to construct a new pipeline infrastructure to serve this emerging production area.

In summary, natural gas demand in the marketplace is continuing to grow despite programs designed to encourage fuel conservation. Conservation alone will not address the growing demand for natural gas in the relevant markets in the Project timeframe. Fuel conservation should continue to be an ongoing alternative used in concert with the development of additional, more efficient natural gas transportation and distribution systems. The modifications proposed by the Project can be considered steps to accomplishing this part of the energy conservation alternative.

7.0 Energy Alternatives

The alternative energy sources discussed in this section would not meet the Project needs and, therefore, would not be preferable to the proposed action. Alternative energy sources used together with natural gas could contribute to meeting the overall future energy needs of the marketplace.

Potential alternative energy sources include coal, oil, nuclear energy, liquefied natural gas (LNG), and electricity generated from these sources, as well as electricity generated from renewable sources such as solar, wind, and geothermal energy. Coal, although an available option, does not burn as cleanly as natural gas, and its use may contribute to the formation/pollution associated with acid rain unless costly air pollution controls are applied to coal-burning power plants. Area states have stringent air quality regulations and thresholds for stack emissions, fugitive emissions, and particulate handling that likely preclude coal as a viable option.

A large amount of oil consumed in the United States is produced and purchased from overseas sources. Therefore, the use of additional foreign oil supplies to meet future energy demands in the expanding mid-Atlantic markets could further increase the reliance on overseas crude petroleum and petroleum products. This could subsequently increase the potential economic and national security risks in the event of an emergency or a supply curtailment. Moreover, if new or expanded refineries were required to process the crude oil, various additional environmental problems could result (e.g., air pollution, visual intrusion, and noise). Much of the region's oil supply is transported by rail, which is statistically not as safe as natural gas transported by pipeline.

Although nuclear power is seen by some as a means of reducing greenhouse gas (GHG) emissions, other stakeholders are concerned with the environmental and regulatory challenges concerning safety and security, the disposal of toxic materials, and alterations to the natural hydrological and biological systems would need to be addressed before any new nuclear power generation facilities could be constructed. As a result, proposals and any subsequent plans to construct new, or expand existing, plants in the northeast would likely involve prolonged review periods that would not meet the objectives of the projects. For these reasons, nuclear power is not currently a practicable alternative to the Project and was eliminated from further review.

LNG is a developing energy alternative in the northeast. Several LNG facilities are being proposed as a means of addressing some of the energy needs in New England, New Jersey, and New York. However, many of these projects are still in the developmental stages, and the timing for these projects to receive approvals and be constructed does not address the current purpose and need of the Project. An LNG system alternative would not only require the construction of a liquefaction and vaporization facility, but also transportation of the necessary volume of LNG to the delivery point by pipeline, truck, or train. Given the requirement for the construction of liquefaction and vaporization facilities as well as pipelines and/or the number of truck and train trips that would be required on a continuous basis, the transportation of the required amount of natural gas is not preferable to the proposed Project.

Wind, geothermal, and solar power have not been developed in the eastern United States (U.S.) for large-scale application, partly because the energy sources associated with these forms of power are reliable in only certain parts of the country or are not generally available. These forms of energy, which are typically converted to electricity, may not substitute easily for natural gas in equipment and processes designed for using natural gas. In addition, once converted, the electricity must be transported to the consumer, which could require construction of new power lines. Moreover, land requirements for wind and solar power generation is considerable; once converted, the land cannot be restored to its prior use in the same way that land used for natural gas pipelines can be restored. Given the pace of development for these resources in the eastern U.S., they will not meet the future demand for energy in the Project timeframe. Therefore, these particular alternative energy sources do not represent viable options for replacing the natural gas that will be supplied by the Project.

8.0 System Alternatives in Pennsylvania

PennEast investigated a number of system alternatives to the proposed Project which are discussed below. This report focuses only on the alternatives, or portions thereof, that are located in Pennsylvania, including looping Transco's Leidy Line pipeline system, utilizing the existing Columbia Gas facilities or the Texas Eastern facilities.

8.1 Transco Leidy Line Loop

PennEast considered a loop of Transco's Leidy Line pipeline system as a system alternative to the proposed Project. A loop of Transco's Leidy Line could access the same production region that the Project accesses. However, the Transco Leidy Line does not offer the same access to specific delivery point locations provided by the Project.

PennEast will offer direct delivery to UGI Central Penn Gas, Inc. and UGI Utilities, Inc., both in Pennsylvania, which cannot be made by utilizing the Transco system. PennEast's proposed route is also uniquely capable of providing an interconnection with both Algonquin and Texas Eastern at one location, which will provide supply for growing markets served by each transmission system in the capacity-constrained northeastern U.S. The Transco Leidy Line cannot make these direct deliveries to UGI Central

Penn Gas, Inc. and UGI Utilities, Inc. and does not access Algonquin and Texas Eastern at one location; therefore, any Transco system alternative does not satisfy the purpose and need of the Project. Furthermore, if Transco were to loop its Leidy Line pipeline system as an alternative to the Project, an additional pipeline would not be available in the region to deliver added production to the markets served by the Project; thus providing a further reason why this system alternative does not satisfy the purpose and need of the Project.

In addition to the foregoing, a loop of Transco's Leidy Line is not a viable alternative in light of the current circumstances and the environmental impact associated with constructing the facilities. PennEast analyzed an alternative involving a loop of Transco's Leidy Line and agrees with Transco's statement indicating that the existing line cannot be expanded: "The existing Transco pipeline system is extremely capacity constrained in New Jersey and Southern Pennsylvania, operating in very densely populated areas. […] because of encroachment of residential and commercial structures along the Transco system, certain areas would be nearly impossible to loop and would require other greenfield portions to be constructed, further increasing the overall impact of the project" (Transco Atlantic Sunrise FAQ at http://atlanticsunriseexpansion.com/get-the-facts/get-the-facts). A figure that shows the Transco Leidy Line Route in relation to the proposed Revised PA Route (introduced in Section 9.1.9 below) is presented as Figure 1 in Appendix BU-S-1.

8.2 Columbia Gas

The existing Columbia Gas facilities lack the capability to receive gas in the production region in which PennEast's receipt points will be located. In order to access the same production region that the Project will access and to deliver the production at all the same delivery points that PennEast proposes for the Project, Columbia Gas would be required to construct greenfield pipeline facilities nearly identical to the facilities that comprise the Project. Accordingly, Columbia Gas does not provide an alternative to the Project.

8.3 Texas Eastern

The existing Texas Eastern facilities lack the capability to receive gas in the production region in which PennEast's receipt points will be located. In order to access the same production region that the Project will access and to deliver the production at all the same delivery points that PennEast proposes for the Project, Texas Eastern would be required to construct greenfield pipeline facilities nearly identical to the facilities that comprise the Project. Accordingly, Texas Eastern does not provide an alternative to the Project.

8.4 Other System Alternatives

The purpose and need of the Project includes satisfying the service that was subscribed to by the Project shippers under long-term firm contracts, which include multiple, unique receipt and delivery point combinations located along the proposed PennEast system. PennEast is not aware of any other pipeline alternative that could satisfy the unique receipt and delivery point combinations subscribed under its agreements with the project shippers.

9.0 Key Route Alternatives and Pipeline Deviations

Initially, PennEast estimated that the proposed Project would be approximately 100 miles in length with a 400-foot wide study corridor. For the initial Critical Issues Analysis, PennEast performed a desktop analysis across an area of consideration approximately one half-mile in width along the length. This allowed PennEast to obtain a clear understanding of potential engineering and environmental constraints within the Project area, and the expanded geography encompassed the necessary area for access roads and staging areas.

For desktop analysis of the Pennsylvania portion of the Project, PennEast used resources such as the Pennsylvania Spatial Data Access, Pennsylvania Geographic Information System (GIS) and Mapping Directory, and the Pennsylvania Department of Conservation and Natural Resources (PADCNR) Map Viewer. Table BU-S-1 provides an overview of the data sources that were used for desktop analysis in Pennsylvania.

Table BU-S-1
Data Resources for Desktop Analysis - Pennsylvania

Desktop Category	Data Source[1]
Bridges - Structurally Deficient or Functionally Obsolete	FHA NBI
Cemeteries	USGS GNIS
Churches	USGS GNIS
Coal Mines	PADEP
Commercial Hazardous Waste Operations	PADEP
Core Habitat	WPC PNHP
County Boundaries	PennDOT
Exceptional Value or High Quality Waters	PADEP, PSU
Explore PA Trails	PADCNR
Farmland Preservation - Agricultural Security Areas	PSU
FEMA 100-yr Flood Zone	FEMA
Historic Buildings and Structures	NRIS - NRHP
Karst/Sinkholes	PADCNR PaGS
Slopes > 30%	LiDAR
Existing transmission, gas, and product utility lines	Platts POWERmap®
National Wetlands Inventory (NWI) Wetlands	USFWS, NWI
Parcels	Assessor Office within each county
Provisional species of concern sites	WPC PNHP
Railroads	PADCNR
Schools	USGS GNIS
State Forests	PADCNR
State Gamelands	PADCNR
State Parks	PADCNR
Streams Chapter 93 Designated Use Warm Water Fishes Waters	PADEP, PSU
Supporting Landscape	WPC PNHP
Watercourses	NHD
Wells	PaGWIS

[1] See Acronyms and Abbreviations Table at beginning of document

9.1 Key Route Alternatives

PennEast carefully examined existing utility corridors (natural gas, liquid pipeline, electric transmission, water, and sewer) to identify potential areas where the proposed pipeline could parallel or be co-located within existing maintained right-of-ways (ROWs). This assessment found that residential and commercial development had encroached upon some of these ROWs, resulting in inadequate area for the staging and construction of an additional pipeline between the existing facilities and the neighboring developments. In locations where environmental impacts would not increase, PennEast aligned the Project with as many existing utility corridors as possible, while providing adequate workspace to safely construct and operate the Project.

Since the Project was initiated in the spring of 2014, nine key alternative routes in Pennsylvania and New Jersey have been reviewed and evaluated using a combination of desktop and field survey data. Each key route alternative incorporated several route deviations at the request of regulatory agencies, stakeholders, and/or landowners. The route deviations specific to Bucks County are discussed in Section 9.2. If a requested route change was constructible and resulted in comparable or fewer environmental impacts, the deviation was accepted and incorporated in the Project design. The nine key alternatives include:

1. Original Route
2. Alternative 1 to Original Route with Elizabethtown Gas (ETG) Spur
3. Alternative 2 to Original Route with NJ Loop (Initial Preferred Route)
4. November 2014 Preferred Route
5. January 2015 Preferred Route
6. March 2015 Preferred Route
7. September 2015 Preferred Route
8. September 2016 Preferred Route
9. Proposed Revised PA Route (Current Route)

9.1.1 Original Route

The Original Route was designed to bring locally produced Marcellus Shale gas from UGI's supply point in northeastern Pennsylvania, through 29 municipalities, to its Transco Trenton-Woodbury interconnect in Mercer County, New Jersey, allowing it to serve customers in metropolitan East Coast markets. PennEast considered multiple factors when evaluating potential alignments. The Original Route was aligned to avoid standing structures, densely populated areas and planned development projects, thereby minimizing the potential cumulative impacts of the pipeline. In Pennsylvania, the Original Route had a centerline of 84.7 miles and crossed 106 publicly-mapped streams. One hundred thirty-nine acres of National Wetland Inventory (NWI) wetlands fell within 200 feet of the line, which equated to 3.4 percent of the total 400-foot wide corridor within Pennsylvania being mapped as wetland. A figure that shows the Original Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 2 in Appendix BU-S-1.

9.1.2 Alternative 1 to Original Route with Elizabethtown Gas (ETG) Spur

PennEast's Original Route was reviewed to assess potential critical (environmental) issues, permitting requirements, and risks. A desktop analysis, as described in Section 9.0, evaluated areas of potential impact. PennEast also conducted an aerial reconnaissance of the study corridor on May 20, 2014 to identify additional, potentially critical issues and risks that were not identified through desktop review, including wetland and watercourse crossings. The aerial reconnaissance allowed for a clearer understanding of possible engineering and environmental constraints along the Original Route. Following the aerial reconnaissance, site visits were performed at publicly-accessible potential road and watercourse crossings as well as other critical areas along the proposed alignment. Both the aerial and ground reconnaissance surveys highlighted areas of potential concern and allowed for further investigation into solutions such as reroutes. The areas that were focused on in the reconnaissance included:

- Private and public roads, railroads, bridges, and trail crossings;
- Wetland and watercourse crossings;
- Clearing requirements;
- Land use (including agricultural lands);
- Socio-economic issues;
- Commercial and industrial areas; and
- Existing infrastructure.

The findings of the aerial and ground reconnaissance were integrated and used to propose modifications that were incorporated into Alternative 1 to the Original Route with ETG Spur.

Alternative 1 to the Original Route with ETG Spur was preferred to the Original Route because it would result in fewer environmental impacts. Specifically, Alternative 1 Route reduced the total acreage of Pennsylvania State Game Lands (SGL) that were located within 200 feet of the centerline by 45 acres. The route also avoided 58 acres of NWI-mapped wetlands within 200 feet of the centerline that would have been affected by the Original Route. A figure that shows the Alternative 1 to the Original Route with ETG Spur in relation to the proposed Revised PA Route (introduced below) is presented as Figure 3 in Appendix BU-S-1.

9.1.3 Alternative 2 to Original Route with NJ Loop (Initial Preferred Route)

PennEast conducted further analysis of environmental constraints, resulting in Alternative 2 to Original Route with NJ Loop (Initial Preferred Route). To reduce potential environmental impacts related to the ETG Spur, PennEast eliminated the Alternative 1 to Original Route with ETG Spur. Along with exclusion of the ETG Spur, which would have resulted in two Delaware River crossings, the Initial Preferred Route also shifted the alignment between MP 70 and MP 90 from Bucks County, Pennsylvania to Hunterdon County, New Jersey. The Initial Preferred Route was preferred to the previous route because it crossed less densely populated areas and fewer wetlands and watercourses. A figure that shows the Initial Preferred Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 4 in Appendix BU-S-1.

9.1.4 November 2014 Preferred Route

Along the Initial Preferred Route, reroutes were considered that incorporated co-location opportunities. The centerline was shifted to co-locate with various utility ROWs, including gas pipeline and electric transmission. Co-location reduces the amount of vegetation clearing and environmental impacts and concentrates them into a smaller area. Between MP 10 and MP 20, an area where the pipeline crossed SGLs, the alignment was moved to co-locate with Transco's existing pipeline ROW. This route change decreased the new permanent ROW requirements and reduced cumulative land use impacts. The November 2014 Preferred Route incorporated other significant co-location segments between MP 20 and MP 40 in Luzerne and Carbon Counties. The route was further refined to incorporate landowner input and environmental survey results. The November 2014 Preferred Route also included the addition of the Hellertown Lateral in Northampton County. A figure that shows the November 2014 Preferred Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 5 in Appendix BU-S-1.

9.1.5 January 2015 Preferred Route

After PennEast filed its initial draft Resource Reports 1 and 10 with the Federal Energy Regulatory Commission (FERC) in November 2014, PennEast considered a number of route alternatives based on input from local, county, and township officials. PennEast also took into account comments and concerns from individual landowners and members of the general public that were raised during Open Houses held in November 2014. PennEast also made necessary adjustments to the route to account for engineering, environmental, and land use constraints that were identified during the initial environmental survey process. As a result of this process, a route modification in Pennsylvania was implemented to include a shift in the proposed route for approximately 2.5 miles to the north side of State Route 33 near the city of Bethlehem in Northampton County, Pennsylvania to accommodate future expansion plans of the St. Luke's Hospital complex. A figure that shows the January 2015 Preferred Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 6 in Appendix BU-S-1.

9.1.6 March 2015 Preferred Route

Following feedback from FERC's scoping meetings held in February 2015 and conversations with landowners, state and local agencies, and other stakeholders, PennEast revised and refined portions of the Preferred Route in March 2015. The most significant variations to the route were incorporated to improve upon the design crossings of the Bethlehem Water Authority (BWA) water supply mainline (between MP 44 and MP 45) in Carbon County and the Appalachian Trail (between MP 46 and MP 55) in Carbon and Northampton Counties, and to accommodate future subdivision and housing development plans in Luzerne County. Smaller adjustments were also incorporated in the Project design to address engineering constraints, reduce environmental impacts, and respond to individual landowner requests. A figure that shows the March 2015 Preferred Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 7 in Appendix BU-S-1.

9.1.7 September 2015 Preferred Route

Following PennEast's filing of the remaining draft Resource Reports in April 2015, PennEast continued to evaluate potential alternatives to the proposed pipeline alignment based on comments received during the formal scoping process, ongoing dialogue with federal, state, regional and local agencies, landowners, and the results of continued field surveys and engineering analyses.

For the Preferred Route filed in its September 2015 FERC Application, PennEast made a significant effort to refine the alignment within the 400-foot survey corridor. In Pennsylvania, two major reroutes and more than 40 minor reroutes were evaluated. The resulting alignment adjustments were incorporated in the Project design to avoid and/or minimize impacts to wetlands and watercourses, cultural resources, preserved agricultural lands, and sensitive habitats.

The major reroutes included an alternative route for crossing the Appalachian Trail and Pennsylvania SGL No. 168 in Carbon and Northampton Counties, and a realignment to avoid active quarrying operations near Wilkes-Barre, Luzerne County. The reroute associated with the Appalachian Trail included a new delivery interconnection with UGI Central Penn Gas, Inc. These new alternatives and reroutes went through the same detailed assessment as the previous routes. A figure that shows the September 2015 Preferred Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 8 in Appendix BU-S-1.

9.1.8 September 2016 Preferred Route

After filing the September 2015 FERC Application, PennEast continued to evaluate potential alternatives to the proposed pipeline alignment based on comments received during ongoing dialogue with federal, state, regional and local agencies, landowners, and the results of continued field surveys and engineering analyses.

In Pennsylvania, more than 26 minor deviations were evaluated and adopted since the September 2015 Preferred Route. The minor deviations included an additional adjustment to the crossing of the Appalachian Trail in Carbon and Northampton Counties, several realignments to avoid potential habitat to sensitive species, avoidance of geotechnical hazards, and realignments to avoid future land use impacts. These new minor reroutes were subjected to the same detailed assessment as those assessed in the FERC Application. A figure that shows the September 2016 Preferred Route in relation to the proposed Revised PA Route (introduced below) is presented as Figure 9 in Appendix BU-S-1.

9.1.9 Proposed Revised PA Route

Since the September 2016 Preferred Route, PennEast has incorporated several route and workspace modifications to avoid and minimize impacts to sensitive resources, respond to landowner requests, and address constructability concerns. The Proposed Revised PA Route, which is the currently proposed route for which environmental impacts are quantified and assessed in this JPA, includes a deviation of approximately 5-miles from MP 48.6R3 to MP 53.6R3 that crosses Lower Towamensing Township in Carbon County, Eldred Township in Monroe County, and Moore Township in Northampton County. This modification was implemented to address concerns from several agencies, specifically the BWA, the National Park Service (NPS), and the Pennsylvania Game Commission (PGC). This route would be co-located with two existing power line ROWs, including the existing high voltage power line ROW (approximately 100-feet wide) that crosses the Appalachian Trail. This co-location will result in reduced visual impacts to trail users.

The majority of the Project changes since the September 2016 Preferred Route involved workspace reductions, resulting in a Project footprint reduction of 336 acres or 20 percent in Pennsylvania. The Proposed Revised PA Route is approximately 1 mile shorter in length than September 2016 Preferred Route. Implementation of the Proposed Revised PA Route increases co-location and reduces impacts to wetlands, watercourses, and forest habitats. Approximately 31 miles, or approximately 39 percent, of the total length of the Revised PA Route is proposed to be co-located with existing utility ROWs, in comparison to approximately 28 miles, or approximately 35 percent, of the September 2016 Preferred Route. The Revised PA Route will impact 37 fewer wetlands, resulting in a 4.6 acre (15 percent) reduction in wetland impacts. The route would also impact 23 fewer watercourses. There will be a 39-acre reduction in forest impacts, including a 40-acre reduction of impacts within Important Bird Areas.

9.2 Pipeline Deviations

Throughout the routing process, PennEast completed field surveys to assess potential impacts to wetlands, watercourses, cultural resources, and threatened and endangered species. The survey results were incorporated into the Project design. Throughout the planning process, PennEast staff continually evaluated how to minimize overall Project impacts and altered the pipeline route or workspace limits to avoid wetlands and watercourses wherever practicable. In addition, PennEast has continued to work with individual landowners to avoid sensitive features on properties and address their concerns. Deviations that were considered for Bucks County are outlined and further detailed in Table BU-S-2 below, with figures corresponding to each Route Deviation Number provided in Appendix BU-S-2.

Table BU-S-2
Summary of Pipeline Deviations in Bucks County, PA

Route Deviation No.	Begin MP	End MP	Associated Key Alternative[1]	Reason for Deviation
BU-1	67.5	98.9	Alternative 1 to Original Route with ETG Spur	This deviation was evaluated based on feedback from FERC during the pre-filing process. The route was approximately 2.9 miles shorter than the corresponding portion of the proposed Revised PA Route. The deviation has fewer environmental and land use impacts. In addition, there are more structures within 50 feet of the construction work area but a fewer amount of landowners impacted when compared to the corresponding portion of the Revised PA Route. The deviation was presented to FERC in the Draft Resource Reports filed in October 2014. This deviation has greater forested impacts, more residences within 50 foot of the workspace, and requires an additional lateral to feed the Gilbert Station and ETG delivery point. This deviation was not adopted due to multiple crossings of the Delaware River and the additional impacts described above that would be required with this deviation.
BU-2	75.4	98.9	Alternative 2 to Original Route with NJ Loop (Initial Preferred Route)	The Initial Preferred Route was preferred to the Alternative 1 to Original Route because it crossed less densely populated areas, fewer wetlands and watercourses, and only crossed the Delaware River once. This alternative resulted in a substantially shorter PennEast Mainline route in Pennsylvania.
BU-3	76.8	77.2R2	September 2016 Preferred Route	This deviation is a minor route modification based on a landowner request. The primary consideration for implementation was to avoid a future development. Despite slight increases in the overall Project length and land use requirements, there are no additional environmental impacts associated with this deviation.

[1] The route deviation was considered for implementation into the corresponding "Associated Key Alternative". If implemented, the deviation was included in all subsequent routes.

9.3 Aboveground Facilities – Alternative Sites

A total of 14 new aboveground facilities are proposed in Pennsylvania, including interconnect meter stations (interconnects), MLVs, internal inspection facilities, and a compressor station. These facilities are necessary to provide interconnects with existing pipelines, compression to move natural gas through the pipeline system, and infrastructure to safely operate the pipelines in accordance with the safety standards established by the U.S. Department of Transportation in 49 CFR Part 192. The aboveground facilities are described further in the Project Description in JPA Section J. No aboveground facilities are proposed within Bucks County.

10.0 Avoidance Measures

After determining that the Proposed Revised PA Route was the most constructible corridor, PennEast further assessed potential impacts to wetlands and watercourses within the 400-foot wide study area. Within the designated corridor, the centerline alignment and workspace limits were altered to avoid wetlands and watercourses to the extent practicable. Within Bucks County, PennEast was unable to route the pipeline or adjust workspace to avoid crossing under wetlands or watercourses; however, surface impacts to one wetland, the Delaware Canal, and the Delaware River will be avoided using the HDD method. As discussed in Module 3 (JPA Section L-3), the Project will only result in surface impacts to one ephemeral watercourse and no wetlands.

11.0 Minimization Measures

Where crossing under wetlands and watercourses could not be avoided, PennEast designed the Project to minimize the impacts through workspace changes and/or construction methods. PennEast reduced the construction ROW to 75 feet through wetlands, watercourses, floodways, and forested riparian buffers. The tables in Appendix BU-S-4 present minimization measures that have been implemented to minimize impacts, including site-specific considerations for each wetland and watercourse crossed by the Project in Bucks County.

11.1 Construction Methods

PennEast evaluated each wetland and watercourse crossing location to determine whether conventional open-cut or trenchless construction techniques would be the most suitable crossing method. Several criteria were considered in determining the most appropriate crossing method:

- Geologic conditions;
- Topographic conditions;
- Available workspace; and
- Practicality.

For each feature crossed within Bucks County, the table in Appendix BU-S-4 presents the proposed primary crossing method and a trenchless feasibility analysis based on the constraints listed above. If the trenchless feasibility of a crossing location was limited by one of these four factors, additional information regarding the specific crossing location is provided in the "Justification" column.

11.1.1 Trenchless Construction Methods

PennEast evaluated using trenchless construction technology to cross sensitive resources, including horizontal directional drill (HDD), Direct Pipe®, microtunneling, and conventional bore. These trenchless construction methods would eliminate surface impacts to wetlands and watercourses.

Horizontal Directional Drill

The HDD method is a trenchless installation technique used to install pipelines beneath the ground surface in areas where neither traditional open-cut excavations nor conventional bores are feasible due to sensitive resource areas or logistical reasons. This technique involves drilling a pilot bore, reaming the bore (with multiple passes) to a certain diameter, swabbing the bore to gauge the condition of the drilled bore, and pulling in a product pipe to complete the installation. Drilling fluids (consisting of water and bentonite) are pumped downhole during all phases of the installation process.

Controlling and managing the drilling fluid pressures is the key to a successful HDD installation. When the soils encountered by an HDD installation provide sufficient strength to resist the required drilling fluid pressures, flow of drilling fluids occurs within the HDD bore created with the drilling tools. However, if the soils encountered by the HDD bore are not capable of providing sufficient strength to resist the required drilling fluid pressures, flow of drilling fluids within the HDD bore cannot be controlled or maintained, resulting in drilling fluid migration into the surrounding soils. Design of an HDD installation must consider the depth of cover beneath the critical feature, the entry and exit locations, the allowable bend radius, the anticipated geotechnical materials, and the setback distance from the critical feature. As such, HDD installations typically require longer installation lengths than other trenchless methods. This longer length increases the setback distance from the critical feature.

HDD installations are typically completed with entry angles between 10 and 15 degrees, and exit angles between 8 and 12 degrees. The bending radius is typically 1200 times the outer diameter (feet) of the product pipe. For a typical 36-inch pipeline, the bending radius would be 3,600 feet. Vertical curves are inherent to all HDD installations.

Workspace requirements include a launch/entry area of approximately 200 feet wide by 200 feet long to stage the necessary equipment. The exit area requires an approximate workspace area of 150 feet by 150 feet, unless a drill and intersect approach is used. In this case, a similar entry workspace is required at the exit location. The pipe string is staged on the opposite side of the HDD rig. A pipe staging area of 50 feet wide with a length equal to the HDD installation length is typically required to fully fabricate a preferred single pipe string. Where insufficient work space exists, multiple pipe strings can be used as opposed to fabricating a single string. For these installations, the width of the pipe staging area typically needs to be increased by an additional 25 feet for each pipe string. Multiple pipe strings increase installation risks associated with prolonged stoppages to perform intermediate welds. For this reason, the number of pipe strings should be kept to a minimum.

Direct Pipe®

The Direct Pipe® installation method is a trenchless installation technique used to install pipelines beneath the ground surface in areas where neither traditional open-cut excavations nor other trenchless methods (HDD or conventional bore) are feasible, due to sensitive resource areas or for logistical reasons.

Direct Pipe® installation method involves using a pipe thruster to push a steel product pipeline with a microtunnel machine attached to the lead pipe from the entry location through to the exit location. The thruster is set up within a shallow shaft or on the ground surface at the entry location. As the microtunnel machine is pushed through the ground, the encountered geotechnical materials are consumed through the cutterhead of the machine and removed through the installed pipe using a closed-loop slurry system.

Water is pumped to the front of the machine where it entrains the produced cuttings to create a slurry that is then pumped back up to the ground surface for processing and removal. Bentonite is often added to the slurry system to help with processing and removal of the cuttings within the machine. The cutterhead at the front of the microtunnel machine excavates a larger bore diameter than that of the product pipe. Lubrication is pumped into this annular space to help reduce frictional forces acting on the pipe string. Water jets directed within the crushing chamber of the machine and cutterhead are often used to help process the encountered geotechnical materials within the crushing chamber, especially within cohesive soils.

Cutterheads, used to excavate the encountered geotechnical conditions, must be matched for the anticipated ground conditions along an alignment. Cutterheads used to excavate soils are not capable of excavating bedrock materials. Similarly, bedrock machines are not capable of excavating soil materials without great difficulty and high jacking forces. Mixed-face cutterheads, used to excavate soils containing some cobbles and/or boulders, do not work well within clayey soils or bedrock materials.

Direct Pipe® allows for the direct installation of the product pipeline along an alignment that resembles an HDD installation. Curves are routinely completed for these installations, with a curve radius similar or slightly tighter to that used for HDD installations. Direct Pipe® installations are conducted from a launch pit with entry angles typically between 5 and 15 degrees. Alignments are typically designed similar to the requirements for an HDD installation but at a much shallower depth, as no drilling fluid is used to convey the excavated material outside of the pipe string. Unlike HDD installations, a return line slurry pump, located within the microtunnel boring machine, pumps the cuttings out of the machine and to the ground surface. As a result, the overlying soils are not required to resist high drilling fluid pressures as they are for an HDD installation. This allows for shallower installation depths with this construction method.

Workspace requirements include a launch/entry area of approximately 150 feet wide by 200 feet long, to stage the necessary equipment and to allow for construction of a shallow launch pit. The exit area requires a workspace area of approximately 50 feet by 100 feet and a large crane to retrieve the microtunnel boring machine. The pipe string is staged on the same side as the thruster/launch pit. A pipe staging area of at least 75 feet wide by at least half of the installation length is typically required to fabricate the pipe strings and to stage the required slurry and lubrication and pipe handling equipment. This length is in addition to the staging area required for the launch pit. The width of the pipe staging area must be increased if multiple pipe strings are used for an installation.

<u>Microtunneling</u>

Microtunneling is similar to the Direct Pipe® method with the following exceptions: deep shafts are used to launch and retrieve the microtunneling bore machine; curved alignments are not typically completed; lubrication is pumped through ports/holes drilled through the jacking pipe; and a two-pass installation strategy is required. The lubrication ports/holes within the jacking pipe do not allow for the direct install of the product pipe (hence the jacking pipe must serve as a casing pipe to house the product pipe). The introduction of shafts further complicates construction as the product pipe must be fabricated within the shaft and pushed into the casing pipe one joint at a time and inclined risers may be required to avoid vertical pipelines within each shaft. Pressure testing of the product pipe within the microtunnel installation cannot occur until after it is constructed, significantly complicating construction if issues were to arise. Because of these challenges associated with microtunneling, this method is not a preferred method of construction for natural gas pipelines.

Conventional Bore

Auger boring, often referred to as “jack and bore” or “conventional boring,” involves jacking a casing pipe housing auger flights from a launch pit to a retrieval pit. A hydraulic unit located within the jacking pit thrusts the casing pipe forward as the auger flight is rotated to convey the encountered geotechnical material at the leading edge of the casing pipe back to launch pit. The leading auger flight is typically one to two pipe diameters inside the casing pipe. Operating the auger flights in this manner reduces risks associated with excessive excavation/flow of soil into the auger flight during advancement. Once brought back to the launch pit, a muck bucket/excavator is used to remove the spoil. When groundwater is present and highly permeable soils are anticipated, dewatering is often used to lower the water table to allow excavation under dry conditions and to reduce installation risks associated with unabated free-flowing water through the auger flights. In low permeable soils, the installation is typically completed with little to no dewatering. In bedrock installations, a special rock cutting head is attached to the casing pipe. Referred to as small boring units, these units are only capable of mining through very soft/weak bedrock materials.

The guided bore installation technique is a slight modification to the auger bore installation technique. It is identical to the auger bore installation methodology, with the addition of a new first step that involves pushing short five foot sections of drill rods from the launch pit through the ground surface to the retrieval pit. The auger equipment is then attached to the installed drill rods and pushed through the ground to completion. The benefit of the guided bore method is that it eliminates the line and grade inaccuracy associated with an auger bore installation. In addition, no material is removed during this phase of the work. Instead, the soil is displaced outwards as the drill rods are advanced.

Auger and guided bore installations are typically limited to installation lengths of 300 to 400 feet in soil; bedrock installations are typically shorter.

11.1.2 Conventional Open-Cut Construction Methods

In the absence of environmental or construction concerns requiring the use of other crossing methods, the conventional open-cut method is the most efficient and practical decision for crossing wetlands and watercourses.

11.1.2.1 Conventional Wetland Construction Methods

Wetland construction methods will be conducted in accordance with the FERC Upland Erosion Control, Revegetation, and Maintenance Plan (Plan) (FERC, 2013a) and the FERC Wetland and Waterbody

Construction and Mitigation Procedures (Procedures) (FERC, 2013b). Construction methods across wetlands will differ depending upon site conditions, as described below.

Standard Wetland Construction (Non-Saturated)

The Standard Pipeline Construction method is used where soils are non-saturated and able to support construction equipment at the time of crossing. This method requires segregation of topsoil from subsoil along the trenchline. Where present, a maximum of 12 inches of topsoil will be segregated from the area disturbed by trenching, except where soils are frozen, standing water is present or soils are saturated, or where shallow depth to bedrock exists. These exceptions will be identified in the field. Topsoil segregation is followed by trench excavation, pipe laying, backfilling, and grade restoration. Immediately after backfilling is complete, the segregated topsoil is restored to its original location. Erosion control measures, including site-specific contouring, silt fence, hay-bale barriers, permanent slope breakers, mulching, and reseeding or sodding with soil-holding vegetation, will be implemented. Contouring will be accomplished using acceptable excess soils from construction. Where this method is implemented for construction, the environmental inspector (EI) will measure the pre- and post-construction soil density using a penetrometer to determine if the soil has been inadvertently compacted during construction or site access. If necessary, the soil will be loosened using a harrow, paraplow, paratill, or other equipment. Deep subsoil shattering, if necessary, will be performed with a subsoiler tool having angled legs.

Conventional Wetland Construction (Saturated)

The Conventional Wetland Construction method is used for crossing wetlands with saturated soils or soils unable to support construction equipment without considerable soils disturbance. Prior to crossing and movement of construction equipment through these wetlands, the ROW will be stabilized using equipment mats to allow for stable, safe working conditions. Unless soils are inundated or saturated, a maximum of 12 inches of topsoil will be segregated from the area disturbed by trenching. Trench spoil will be stockpiled temporarily in a ridge along the pipeline trench. Gaps in the spoil pile will be left at appropriate intervals to maintain circulation or drainage of water.

The pipeline will be assembled in a staging area located in an upland area. In accordance with the FERC Procedures, the pipeline will be assembled prior to commencing trenching activities (FERC, 2013b). The pipe will then be moved from the assembly area to the ROW. After the pipeline is lowered into the trench, wide track bulldozers or backhoes supported on equipment mats will be used for backfill, final cleanup, and grading. The method will minimize the amount of equipment and travel in wetland areas.

Push-Pull Technique/Float Technique

Construction in saturated/inundated wetland areas may involve the Push-Pull also known as the Float Technique. The Push-Pull Technique is used in large wetland areas (greater than 300 feet crossing length) where sufficient water is present for floating the pipeline in the trench, and grade elevation over the length of the push-pull area will not require damming to maintain adequate water levels for flotation of the pipe. If dry conditions prevail, the push-pull method is not viable. This method involves pushing the prefabricated pipe from the edge of the wetland or pulling the pipe with a winch from the opposite bank of the wetland into the trench. For implementation of this technique, initial clearing within the wetland is minimized; the width of the ROW cleared is limited to only that necessary to install the pipeline. Grading in inundated wetlands is generally unnecessary due to the typically level topography and the absence of rock outcrops in such areas; if required, grading will be held to a minimum.

Equipment mats may be placed over existing vegetation where grading is not required. Trees and brush will be cut to ground level by hand, with low ground pressure equipment, or with equipment supported by equipment mats.

The trench will be excavated using amphibious excavators (pontoon mounted backhoes) or tracked backhoes (supported by fabricated equipment mats or floats). The excavated material will be stored adjacent to the trench, if possible. If storage of excavated material next to the trench is not possible (i.e. workspace limitations, safety concerns), the material will be stored temporarily in one of the following locations: (1) in upland areas of the ROW as near to the trench as possible, (2) in construction vehicles, or (3) at an approved off-site staging location until needed for backfilling. The pipe will be stored and joined at staging areas (push and pull sites) located outside of the wetland. Floats may be attached temporarily to give the pipe positive buoyancy. After floating the pipe, these floats will be cut and the negative buoyant pipe will settle to the bottom of the ditch. This operation (pipe sections fabricated, welded together, and pushed into place) is repeated until the wetland crossing is complete. The excavated material will then be placed over the pipe to backfill the trench.

11.1.2.2 Conventional Watercourse Construction Methods

Various methods are available to install the pipeline across watercourses, depending on watercourse classification and flow conditions at the time of crossing. PennEast anticipates that most watercourse crossings will be completed within 24 to 48 hours.

<u>Dam and Pump</u>

The dam and pump crossing method involves constructing temporary sand or pea gravel bag dams upstream and downstream of the proposed crossing site while using a high capacity pump to divert water from the upstream side of the construction area to the downstream side. Energy dissipation devices, such as steel plates, placed on the downstream side at the discharge point will prevent streambed scour.

After installing the dams and commencing pumping, a portable pump (separate from that pumping the stream flow around the construction area) may be used to pump standing water from between the dams into a dewatering structure consisting of straw bales/silt fence or into a filter bag located away from the stream banks, thereby creating a dry construction area.

Once the area between the dams is stable, backhoes located on one or both banks would excavate a trench across the stream. Spoil excavated from the trench may be stored in the dry streambed adjacent to the trench if the stream crossing is major or in a straw bale/silt fence containment area located a minimum of 10 feet from the edge of the stream banks. Leakage from the dam, or subsurface flow from below the streambed, may cause water to accumulate in the trench. As water accumulates in the trench, it will be periodically pumped out and discharged into a dewatering structure located away from the stream banks.

After trenching across the streambed is completed, a prefabricated segment of pipe is installed in the trench. The streambed portion of the trench is immediately backfilled with streambed spoil. Once restoration of the streambed is complete, the dams are removed and normal flow is re-established in the stream.

<u>Flume Crossing</u>

The flume crossing method involves diverting the flow of the stream across the construction site through one or more flume pipes placed in the stream. The first step in the flume crossing method involves placing a sufficient number of adequately sized flume pipes in the stream to accommodate the highest anticipated flow during construction. After placing the pipes in the stream, sand or pea gravel bags would be placed in the stream upstream and downstream of the proposed trench. The bags serve to dam the stream and divert the stream flow through the flume pipes, thereby isolating the stream flow from the construction area.

Backhoes located on one or both banks of the stream would excavate a trench under the flume pipe in the isolated streambed. Spoil excavated from the stream trench would be placed or stored a minimum of 10 feet from the edge of the watercourse or in additional temporary workspace (ATWS) as necessary. Once the trench is excavated, a pre-fabricated segment of pipe would be installed beneath the flume pipes. The trench is then backfilled with native spoil from the streambed. Clean gravel or native cobbles would be used to backfill the top 12 inches of the trench in coldwater fisheries.

If trench dewatering is necessary near watercourses, the trench water would be discharged into an energy dissipation/sediment filtration device, such as geotextile filter bag or straw bale structure, away from the water's edge, preferably in a well-vegetated upland area to prevent heavily silt-laden water from flowing into the watercourse.

<u>Cofferdam</u>

A cofferdam is a temporary structure built into a watercourse to contain, or divert movement of water and to provide a reasonably dry waterbody crossing construction area. Cofferdams are commonly made of steel sheet pile, rock, gabions, concrete jersey barriers, vinyl tubes filled with water, or wood and may be lined with geotextile, plastic sheeting, or other materials to prevent water from entering the construction area. The advantages of the use of cofferdams include, maintain flow of the watercourse with phased construction approaches, minimal subsurface impacts, and short installation and breakdown times.

A typical cofferdam crossing will have two phases. Each of the phases will be conducted from opposite stream banks. Each phase will consist of placing sand bags or other equivalent cofferdam materials such that a portion of the watercourse to be crossed can be blocked from upstream and downstream water flow while at least one third of the total crossing width remains open to water flow. The area within the cofferdam area will be dewatered and pipeline work construction will be carried out in the dry. After completion of one bank (phase) the same configuration will be used from the other bank to complete a continuous pipeline crossing through the watercourse.

1) Cofferdams shall be constructed with materials that prevent sediment and other pollutants from entering the watercourse (e.g. sandbags or clean gravel with plastic liner);
2) Cofferdam and dewatering pumps shall be monitored to ensure proper operation throughout the watercourse crossing.

Dry Open-Cut Crossing

The open-cut construction method involves the excavation of the pipeline trench across the watercourse, installation of a prefabricated pipeline segment, and backfilling of the trench with excavated material. The work is performed under dry conditions; either during periods of no flow or when the watercourse is frozen. Depending upon the width of the crossing and the reach of the excavating equipment, excavation and backfilling of the trench would generally be accomplished using backhoes or other excavation equipment operating from one or both banks of the watercourse. Excavated material from the trench would be placed on the bank above the ordinary high water mark for use as backfill. The pipe segment can be weighted, as necessary to provide negative buoyancy and placed below scour depth. Typical backfill cover requirements would be met, contours would be restored within the watercourse, and the banks would be stabilized via seeding and/or the installation of erosion control matting or approved alternative, per applicable agency approvals. One of the goals of dry open-cut crossings is to complete all in-stream construction (trenching, pipe installation, backfill, and streambed restoration) within 48 hours.

11.2 Best Management Practices

In areas where trenchless construction methods are not feasible or practicable, a variety of best management practices (BMPs) will be implemented to minimize impacts. These BMPs include: reducing the construction ROW width from 100 feet to 75 feet; minimizing construction durations; adhering to construction timing windows; implementing erosion and sediment controls; replanting PFO forested riparian buffers; and maintaining only a 30-foot ROW easement during operation. As discussed above, the Project will not result in surface impacts to wetlands in Bucks County, and surface impacts are only proposed to one watercourse in Bucks County. The BMPs for watercourse crossings are described below.

11.2.1 Watercourse Crossing BMPs

Pipeline construction across watercourses will be performed in accordance with state and federal permit conditions and the FERC Procedures (FERC, 2013b). PennEast will use one of the following dry crossing methods for installing the pipeline via conventional open-cut construction techniques within watercourses during construction:

- Flume crossing
- Dam and pump
- Cofferdam
- Dry Open-Cut (conventional trenching watercourses that are dry/during periods of no flow or frozen at the time of crossing)

To minimize the potential for adverse effects to watercourses, PennEast will implement the following BMPs outlined in the E&SCP (JPA Section M) when conducting pipeline installation activities in Bucks County:

- PennEast proposes to cross any watercourse with discernible flow at the time of construction with a dry-crossing technique, except where specific conditions render a dry crossing infeasible;

- PennEast will install compost filter socks across and along the edge of the construction ROW, where indicated on the approved E&SCP (JPA Section M) and wherever necessary, to minimize the flow of sediment into watercourses;
- PennEast will construct a temporary equipment bridge over the affected watercourse to minimize direct impacts from equipment travel;
- PennEast will minimize watercourse impacts using the bypass and flumed crossing techniques, which will prevent stream flow over an open trench;
- Stream flow will be restored after the banks have been stabilized;
- Across minor watercourses, or those less than 10 feet wide from TOB to TOB, PennEast will install the pipe and restore the stream banks within 24 hours of trenching;
- For intermediate watercourses (those streams between 10 feet and 100 feet wide from TOB to TOB), PennEast will construct the crossing and restore the stream banks within 48 hours;
- PennEast will install temporary trench plugs at the edges of watercourses to prevent the flow of upland sediments or other potential pollutants into watercourses during construction;
- PennEast will install permanent trench plugs at the edges of watercourses before the trench is backfilled to restore the hydrology to preconstruction conditions;
- Erosion control fabric will be installed within 50 feet of the watercourse to help stabilize the soil until permanent vegetative cover is achieved; and
- PennEast will maintain a minimum 100-foot buffer from watercourses to refuel vehicles, store or transfer liquid hazardous materials, and field coat pipeline segments with concrete, unless otherwise approved by the EI and secondary containment is implemented.

11.2.2 Watercourse Restoration

PennEast will use the following criteria to restore the disturbed watercourse in Bucks County to as close to their pre-construction condition as practical:

- Watercourse banks will be returned to pre-construction contours or to a stable angle of repose as approved by the applicable regulatory agencies;
- Use of alternative materials for bank stabilization will comply with applicable regulatory agency approvals. To the extent practical, PennEast will employ natural stream bank restoration techniques detailed in the E&SCP (JPA Section M) before using approved alternative stabilization. The use of approved alternatives will generally be limited to areas where flow conditions preclude effective vegetative stabilization techniques such as seeding and erosion control fabric;
- Disturbed riparian areas will be revegetated in accordance with the Wetland and Riparian Reforestation Plan (JPA Section L4-A).
- Permanent slope breakers will be installed across the construction ROW at the base of slopes as described in the E&SCP (JPA Section M), or as needed to prevent sediment transport into the watercourse; and
- Sediment barriers will be installed as outlined in the E&SCP (JPA Section M) and as approved or specified by the EI.

11.2.3 Riparian Buffer Reforestation

PennEast proposes to enhance restoration in forested riparian buffers. As stated in the Wetland and Riparian Reforestation Plan (JPA Appendix L-4A), the Ernst Riparian Buffer Mix (ERNMX-178), or an alternative conservation riparian seed mix that contains similar species, will be used to reseed riparian areas. Additionally, forested riparian buffers will be replanted with tree and shrub species that are adapted to the local hydrologic conditions. Planting will occur within the impacted riparian buffers, but outside of the 30-foot maintained ROW.

11.2.4 Operation and Maintenance

The proposed facilities would be operated and maintained in a manner to provide a safe, continuous supply of natural gas reaches each of the delivery points. PennEast would maintain a 30-foot wide permanent ROW in upland areas as herbaceous and scrub shrub cover. Within riparian areas, the maintained ROW would be reduced to 30 feet. No herbicides or pesticides would be used for the clearing or maintenance of the temporary or permanent ROW or within 100-feet of a watercourse.

12.0 Trenchless Feasibility Analyses

As described in Section 11.1, PennEast evaluated site-specific conditions and determined the most appropriate crossing method for each wetland and watercourse. The results of the overall evaluation are presented in Appendix BU-S-4. Due to the sensitivity of specific resources, including wetlands, watercourses, interstates, and railroads that could not be avoided by the Project, and the complexity of the site-specific challenges that these crossings presented in the Project design, PennEast completed more extensive evaluations in several locations. In Bucks County, the Delaware River crossing (MP 77.6) was the only crossing that warranted additional evaluation.

PennEast proposes to use HDD methods to construct the pipeline beneath eight separate resources that are located within close proximity of the Delaware River: the Delaware River; wetland 110714_JC_001_PFO; Pennsylvania SR-611; the Delaware Canal Trail; wetland 051415_SO_1001_PSS; Old River Road; Belvidere & Delaware River Railway; and New Jersey County Road 627 (CO-RD 627). The HDD installation measures approximately 2,835 feet in horizontal length and the minimum depths of cover range from approximately 22 feet under CO-RD 627 to 143 under SR-611 and the Delaware Canal Trail. The eastern entry point will be located in a workspace approximately 125 feet east of CO-RD 627. The western HDD entry point will be located in a workspace approximately 950 feet west of Pennsylvania SR-611. An elevation difference of approximately 2 feet exists between the east and west HDD entry locations, with the east HDD entry location being excavated to the lower elevation. To provide sufficient depth beneath CO-RD 627, a minor excavation is proposed to lower the starting elevation of the HDD bore. This excavation is also necessary to allow for the HDD installation to avoid bedrock materials with lower rock quality designations (RQD) below the horizontal tangent of the HDD profile.

Geotechnical investigations along the HDD alignment determined the soils consisted of loose silty sand; medium stiff clay; medium dense sand with gravel; and medium dense silty brown sand. Additionally, geotechnical investigations revealed silty fill materials on the Pennsylvania (west) side of the crossing. Beneath these soils, the bedrock materials are anticipated to include predominantly slightly to highly weathered, weak to medium strong dolomite with average RQD values of 44.3 percent. The HDD installation on the New Jersey (east) side of the crossing is anticipated to encounter soils overlying bedrock materials and the geotechnical investigations determined that the soils consisted of soft to medium silt; medium dense sand; weathered quartzite; and hard sandy silt. Beneath these soils, the bedrock materials are anticipated to include predominantly slightly fresh, medium strong to strong granitic gneiss. The granitic gneiss appears to be very poor to good quality with an average RQD value of 78.3 percent. These investigations indicated overall geotechnical conditions favorable for the use of the HDD method. The use of the HDD method to cross the eight resources identified above will minimize construction impacts to the public, as well as environmental features at this crossing. An HDD Design Report is provided in Appendix BU-S-6.

13.0 Alternatives Summary

If the proposed Project is not constructed (i.e., the No-Action Alternative), PennEast will not have the ability to satisfy the service that has been subscribed by the Project shippers under long-term firm contracts, which include multiple, unique receipt and delivery point combinations located along the PennEast system. Furthermore, PennEast is not aware of any other pipeline alternative that could satisfy the unique receipt and delivery point combinations subscribed under its agreements with the Project shippers.

The use of alternative fuels to supply the energy needs of natural gas customers is not the best practicable alternative when compared to the use of cleaner-burning natural gas and may not conform to the immediate specific needs of specific customers (e.g., customers configured to burn natural gas cannot quickly switch to alternative fuels and cannot switch without considerable expense). In addition, although energy conservation is a valuable part of an overall energy supply plan, energy conservation alone will not meet the immediate energy demand for the market to be served by the Project.

PennEast evaluated route and construction method alternatives and incorporated the most practicable alternative into the Project design. Publicly available data, field reconnaissance observations, agency and public comments, and wetland and watercourse delineation results were used in the analysis. Wherever possible, PennEast avoided wetland and watercourse impacts by routing the pipeline around and siting the workspace outside of protected resources. If avoidance was not possible, PennEast minimized impacts by reducing the construction ROW width across wetlands and watercourses and crossing wetlands and watercourses at perpendicular angles and narrow locations. PennEast will use specialized open-cut crossing techniques as well as trenchless crossing methods to construct across wetlands and watercourses to reduce the duration and extent of earth disturbance associated with the Project.

To minimize impacts further, PennEast will implement BMPs outlined in the Project E&SCP (JPA Section M) and FERC Plan and Procedures (FERC 2013a, 2013b), as well as additional recommendations provided by federal and state agencies. After the pipeline is constructed, wetlands and watercourses will be restored to pre-construction contours to the greatest extent practicable, and restored locations will be monitored annually for five years, or until wetland revegetation is successful as defined by the FERC Procedures (FERC 2013b) and anticipated state and federal permit conditions, to ensure proper restoration and revegetation efforts are achieved.

14.0 References

Federal Energy Regulatory Commission (FERC). 2013a. Upland Erosion Control, Revegetation, and Maintenance Plan, May 2013 Version. Available at: www.ferc.gov/industries/gas/enviro/plan.pdf. Accessed April 17, 2018.

Federal Energy Regulatory Commission (FERC). 2013b. Wetland and Waterbody Construction and Mitigation Procedures, May 2013 Version. Available at: https://www.ferc.gov/industries/gas/enviro/procedures.pdf. Accessed April 17, 2018.