PennEast Pipeline Company, LLC

PENNEAST PIPELINE PROJECT

S – ALTERNATIVES ANALYSIS
CARBON COUNTY

REVISED OCTOBER 2019

Submitted by:

PennEast Pipeline Company, LLC

TABLES OF CONTENTS

1.0 Introduction ... 6
2.0 Purpose and Need ... 6
3.0 Facility Description and Locations ... 7
3.1 Pipeline Facilities in Pennsylvania ... 7
3.2 Aboveground Facilities in Pennsylvania ... 7
4.0 Applicable Regulations ... 7
5.0 No-Action Alternative ... 7
6.0 Energy Conservation ... 8
7.0 Energy Alternatives ... 9
8.0 System Alternatives in Pennsylvania ... 10
8.1 Transco Leidy Line Loop ... 10
8.2 Columbia Gas ... 11
8.3 Texas Eastern ... 11
8.4 Other System Alternatives ... 11
9.0 Key Route Alternatives and Pipeline Deviations ... 12
9.1 Key Route Alternatives ... 13
9.1.1 Original Route ... 13
9.1.2 Alternative 1 to Original Route with Elizabethtown Gas (ETG) Spur ... 14
9.1.3 Alternative 2 to Original Route with NJ Loop (Initial Preferred Route) ... 14
9.1.4 November 2014 Preferred Route ... 15
9.1.5 January 2015 Preferred Route ... 15
9.1.6 March 2015 Preferred Route ... 15
9.1.7 September 2015 Preferred Route ... 15
9.1.8 September 2016 Preferred Route ... 16
9.1.9 Proposed Revised PA Route ... 16
9.2 Pipeline Deviations ... 17
9.3 Aboveground Facilities – Alternative Sites ... 19
9.3.1 Kidder Compressor Station ... 19
9.3.2 Blue Mountain Interconnect ... 21
9.3.3 Mainline and Side Valves ... 22
10.0 Avoidance Measures ... 22
11.0 Minimization Measures ... 23
11.1 Construction Methods ... 23
11.1.1 Trenchless Construction Methods ... 23
11.1.2 Conventional Open-Cut Construction Methods ... 26
11.2 Best Management Practices ... 30
11.2.1 Wetland Crossing BMPs ... 30
11.2.2 Wetland Restoration ... 31
11.2.3 Watercourse Crossing BMPs ... 32
11.2.4 Watercourse Restoration ... 33
11.2.5 Wetland and Riparian Buffer Reforestation ... 33
11.2.6 Operation and Maintenance ... 34
12.0 Trenchless Feasibility Analyses ... 34
12.1 Lehigh River/Francis E. Walter Reservoir (MP 23.0) ... 34

12.2 Mosey Wood Wetland Complex (MP 27.1R2) 35
12.3 Mud Run (MP 33.2R2) 36
12.4 Beltzville Lake (MP 43.5R3) 36
12.5 Aquashicola Creek (MP 49.3R3) 37
13.0 Alternatives Summary 39
14.0 References 41

TABLES

Table CA-S-1 Data Resources for Desktop Analysis - Pennsylvania 12
Table CA-S- 2 Summary of Pipeline Deviations in Carbon County 18
Table CA-S- 3 Wetlands and Watercourses Avoided Through Workspace Change in Carbon County 22
Table CA-S-4 Summary of Proposed Crossing Methods for Select Sensitive Areas in Carbon County 34

APPENDICES

CA-S-1 Key Route Alternative Figures
CA-S-2 Route Deviation Figures
CA-S-3 Aboveground Facility Alternative Figures (Replaced October 2019)
CA-S-4 Site-Specific Alternatives Analysis Tables (Replaced October 2019)
CA-S-5 Susquehanna River Crossing Alternatives Analysis (Not Applicable to Carbon County)
CA-S-6 HDD Design and GDR Reports

Acronyms and Abbreviations

°F	degrees Fahrenheit
Algonquin	Algonquin Gas Transmission, LLC
ATWS	additional temporary workspace
BCFD	billion cubic feet per day
Blue Mountain	UGI Central Penn Gas, Inc.
BMP	best management practice
BWA	Bethlehem Water Authority
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
HDD	horizontal directional drilling
hp	horsepower
HQ	High-Quality
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 designation
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 that 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. The Project will connect to various delivery points 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), 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 route pipeline will be a 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 in Luzerne, Carbon, Northampton, Monroe, and Bucks Counties, Pennsylvania Approximately 28 miles of the mainline pipeline, from milepost (MP) 23.0 to 50.7R3, is proposed in Carbon County, Pennsylvania. The 4-inch Blue Mountain Lateral will be approximately 0.5 mile of new pipeline in Carbon County, Pennsylvania, and the 24-inch Hellertown Lateral will be approximately 2 miles of new pipeline in Northampton County, Pennsylvania.

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. Within Carbon County, PennEast proposes to also construct the Blue Mountain Interconnect (UGI Central Penn Gas, Inc.) and two MLVs. The locations of these aboveground facilities are shown on the Project Location Map in JPA Section I.

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 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 CA-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 CA-S-1 provides an overview of the data sources that were used for desktop analysis in Pennsylvania.

Table CA-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 Carbon 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 CA-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 surveys, 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 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 CA-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 CA-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 CA-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 CA-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 CA-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 CA-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 CA-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 will 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 Carbon County are outlined and further detailed in Table CA-S-2 below, with figures corresponding to each Route Deviation Number provided in Appendix CA-S-2.

Table CA-S- 2
Summary of Pipeline Deviations in Carbon County

Route Deviation No.	Begin MP	End MP	Associated Key Alternative[1]	Reason for Deviation
CA-1	8.4R3	37.5	November 2014 Preferred Route	This deviation was approximately 2 miles longer than the prior alternative along the Initial Preferred Route. There were greater environmental impacts, including additional wetland and watercourse crossings as well as an increase in overall land requirements. In addition, there were more existing structures within 50 feet of the construction work area and a greater number of impacted landowners when compared to the Initial Preferred Route. However, this deviation increased co-location by approximately 22 miles which reduced interior forest impacts and maximized use of previously disturbed areas. Despite the increased length and impacts to mapped wetlands and watercourses, the increased co-location with existing utility ROWs was determined to be the least damaging practicable alternative.
CA-2	32.5R2	33.4R3	Proposed Revised PA Route	The pipeline and workspace were realigned at the request of the USACE and PADCNR to avoid a large PFO wetland complex north of Hickory Run State Park and a rock outcropping along Mud Run within Hickory Run State Park.
CA-3	39.3R2	40.9	September 2016 Preferred Route	This deviation is a route optimization and increases collocation of the proposed pipeline route with the power line corridor. Additionally, this deviation avoids having to install the pipeline parallel to a watercourse corridor. Although the overall Project length and land use impacts will increase slightly, minimizing the potential impacts to the watercourse corridor was a significant consideration when implementing this deviation.
CA-4	42.1R2	42.6R2	Proposed Route September 2016	This deviation is a landowner accommodation. This minor route modification reflects additional collaboration with the landowner to relocate the proposed route alongside the road ROW to the north (Lovitt Road). This deviation is located in previously surveyed areas and will not cause any additional adverse environmental impacts. In addition, the differences in overall Project length and required land use impacts are negligible. Landowners associated with Deviation No. P-1404 were identified in the April Landowner Lists as “Affected Landowners.” This deviation does not impact any new landowners.
CA-5	43.1R3	44.6R2	Proposed Revised PA Route	The pipeline was realigned due to constructability issues and safety concerns. The drill pad was shifted northeast to a flatter location to avoid construction activities on a side slope with severe benching. The original drill pad location would have required significant grading. The shift in drill pad location modified the HDD path, which caused the pipeline route and workspace area to change. This slight modification will provide safer conditions during construction and pullback.
CA-6	44.2R3	44.8R2	September 2016 Preferred Route	This deviation was incorporated in response to feedback that PennEast received in collaboration with the Bethlehem Water Authority (BWA), which operates a water supply system in Carbon and Northampton Counties. Deviation No. C-6 provides a means of crossing under the BWA waterline using the HDD method and avoids the need to locate temporary workspace near the waterline. This deviation also includes a single HDD crossing of Beltzville Lake, instead of the two crossings that were proposed in the September 2015 Preferred Route, which minimizes impacts within Beltzville State Park.
CA-7	47.1	57.5	All	Multiple route deviations were evaluated as alternatives to address stakeholder comments and reduce impacts in the area of the Appalachian Trail Crossing. The addition of the interconnect at Blue Mountain also provided a need to be able to accommodate this delivery point in the routing of the PennEast Mainline. These deviations were developed by taking into account stakeholder comments, working collaboratively with affected property owners in the immediate vicinity of the Appalachian Trail, evaluating regulatory and timing constraints with regard to deed restrictions and easements, and evaluating overall environmental and landowner impacts. The intent of these deviations was to focus on co-location in to minimize impacts to the Appalachian Trail viewshed. In this effort, multiple alternatives were considered incorporating co-location with existing utility easements, State Road ROW, and also utilizing the previously disturbed area of the Blue Mountain Ski Resort.

[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, a side valve, 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. Within Carbon County, the following five aboveground facilities are proposed:

- Kidder Compression Station – MP 26.7
- MLV 3 – MP 32.3R2
- MLV 4 – MP 46
- Blue Mountain Side Valve – BL- MP 0R3
- Blue Mountain Interconnect – BL-MP 0.51R3

9.3.1 Kidder Compressor Station

Initially, PennEast considered constructing a 30-inch diameter pipeline with three compressor stations. With the various route changes, increased pipe diameter, and pipeline coating, PennEast now proposes a single compressor station in Pennsylvania.

PennEast initially evaluated compressor options with an internally coated 30-inch diameter pipeline at 1.0 BCFD, which included the following:

- Compressor Station Option 1
  - Available (ISO) = 26,733 HP
  - (3) Taurus 70s
- Compressor Station Option 2
  - Available (ISO) = 7,224 HP
  - (2) Centaur 40s

Following this analysis, as a result of the increased demand for natural gas during the Open Season and the corresponding increase in the diameter of the pipeline from 30-inches to 36-inches, the requirements for compression changed, and two compressor stations were no longer necessary.

Only one compressor station is required to transport the gas from the major receipt interconnections – Transco and gathering systems operated by Energy Transfer Partners, L.P., and UGI Energy Services, LLC, all in Luzerne County, Pennsylvania. Major delivery interconnections include the following: UGI Utilities, Inc. and Columbia Gas, in Northampton County, Pennsylvania; Elizabethtown Gas, Texas Eastern; Algonquin, and Gilbert Electric Generation facility, all in Hunterdon County, New Jersey; and Transco, in Mercer County, New Jersey. The compressor station will include three gas turbine-driven Solar Mars 100 units rated at 15,900 hp each under ISO conditions (47,700 total ISO hp).

PennEast evaluated two locations to site the compressor station in Kidder Township, Carbon County, and identified a preferred location at approximate MP 26.7. A figure showing the two alternative locations is provided in Appendix CA-S-3. The proposed site and its alternative were reviewed for impacts to environmental and cultural resources, noise and visual impacts, as well as compliance with local zoning ordinances. Although the two sites are in close proximity to one another, there are some key differences in the environmental and community impacts associated with each site.

The alternative site is located on a forested, undeveloped tract approximately 0.25 mile north of State Route 940. The site and associated access would have directly abutted or been within approximately 500 feet of commercial and residential properties including the current and/or former County Place Inn and Suites, Alpina Ski Shop, Alpine Ski, Storage King, Econolodge and Pizza shop to the south of the access road and east of the site. This alternative site was also approximately 1,000 feet west of one of the Jack Frost National Golf Club fairways. A small forested buffer of approximately 100 feet would have remained between this site and an existing 100 foot wide open corridor to the east on the Jack Frost property. The alternative site is located higher on the landscape than the proposed Kidder Compressor Station site and likely would have required additional earthwork for site development. The alternative site would have resulted in 0.42 acres of impacts to one palustrine scrub-shrub (PSS) wetland.

The proposed Kidder Compressor Station site is located on a forested, undeveloped tract approximately 0.4 mile south of State Route 940 and directly adjacent to Interstate 80 (I-80). The site is approximately 1,000 feet south of the commercial and residential properties discussed above and more than 2,500 feet southwest of the Jack Frost National Golf Club fairways. An approximately 100 foot forested buffer would separate the southern edge of the site from I-80. The proposed Kidder Compressor Station site is located lower on the landscape and is surrounded by wetlands and watercourses. PennEast has sited the compressor station to avoid and minimize impacts to these wetlands to the greatest extent practicable. Construction of the station and the suction/discharge pipelines that connect the station to the PennEast mainline would result in approximately 0.306 acres of wetland impacts. However, all but 0.060 acre of impacts will be restored after construction is complete. Approximately 0.036 acres of palustrine emergent (PEM) wetlands and 0.024 acres of palustrine forested (PFO) wetland mosaic will be filled to construct and operate the compressor station. Additionally, approximately 0.155 acre of PFO wetlands will be converted to PEM and PSS wetlands to maintain the integrity of the suction/discharge pipelines and to maintain an approximately 30-foot wide corridor along the station fence for security purposes. One watercourse, an unnamed tributary to Black Creek, would also be impacted by the construction of a permanent road crossing. As discussed in greater detail in the Hydrology and Hydraulics Analysis in JPA Section N, PennEast proposes to construct a box culvert with alternating baffles along its floor, which will be covered with at least 1 foot of natural substrate. This design will create a natural channel bottom that supports erosion resilience while facilitating fish passage.

Despite the additional wetland and watercourse impacts at the proposed Kidder Compressor Station Site, the site location was selected primarily based on its increased distance from nearby commercial and residential properties and the proximity to I-80, which is an existing noise source thereby minimizing noise impacts to noise sensitive areas near the compressor station. Compared to the alternative site, a greater forested buffer will remain between the station and the surrounding community. The site is also zoned as light industrial and has received conditional approval from the Kidder Township Zoning Hearing Board and Planning Commission.

9.3.2 Blue Mountain Interconnect

The Blue Mountain Interconnect on the September 2016 Preferred Route was strategically located to service natural gas for the proposed expansion of the Blue Mountain Ski Resort. Throughout the FERC-review process, PennEast received comments from several agencies and stakeholders, specifically, the PGC, BWA, NPS, and ATC, requesting relocation of the proposed PennEast Mainline Route to avoid potential impact to buried infrastructure and to minimize vegetation clearing near the Appalachian Trail. These agencies and stakeholders encouraged PennEast to consider the currently proposed Appalachian Trail Crossing associated with the Revised PA Route. PennEast initiated engineering and environmental studies, as well as landowner outreach, along this section of the Revised PA Route to evaluate the feasibility of incorporating the realignment.

During this feasibility assessment, discussions were held with Blue Mountain Ski Resort and UGI Utilities regarding firm gas service to Blue Mountain and a potential alternate location for the Blue Mountain Interconnect. Based on these discussions, two alternate locations were provided by PennEast for review by UGI Utilities. One of these locations was located on Blue Mountain Ski Resort, directly south of the snow tube runs and snow-making ponds. The other location was located across the Lower Smith Gap Road, on a private property. A figure showing the two alternatives is provided in Appendix CA-S-3.

The proposed Blue Mountain Interconnect, located on Blue Mountain Ski Resort, will require a 4-inch diameter pipeline lateral from the meter station, running approximately 0.5 mile east along an existing PPL easement, to tie into the 36-inch diameter PennEast Mainline. This option will allow for connectivity by UGI Utilities at the proposed meter station, running west along PPL's easement, and up or down the slopes using a high-density polyethylene (HDPE) pipe and servicing areas of potential expansion within the ski resort. This proposed facility location and the associated lateral are fully co-located with an existing ROW, a cleared area that supports the Blue Mountain Ski resort, and an existing access road. Construction of both the facility and the lateral will not result in any wetland impacts, and only two waterbodies, one of which currently runs through an aboveground pipe, will be crossed by the lateral.

The alternative located on the private property north of Lower Smith Gap Road would involve a facility with direct connectivity into UGI Utilities' existing Central Penn Gas High Pressure Distribution pipeline, which was previously paralleled by the September 2016 Preferred Route. Although the alternative location would have been sited on the proposed Revised PA Route, which would negate the need for the proposed 0.5-mile Blue Mountain Lateral, additional infrastructure would need to be built to transport the natural gas to the previous location of the Blue Mountain Interconnect facility on the September 2016 Preferred Route. The UGI Utilities' pipeline would have to be tapped, and an approximately 2.3-mile lateral constructed, which would presumably follow the path of the September 2016 Preferred Route across Aquashicola Creek, through the parking lot, up the ski slopes, by the ski lodge, across the parking lot, and to the previously filed proposed Blue Mountain Interconnect facility. This alternative lateral would result in a second crossing of Aquashicola Creek, associated wetlands, sensitive habitat, and increased earth disturbance.

Due to the increased environmental impacts, and through discussions with UGI Utilities, Blue Mountain Ski Resort, and the private landowner, PennEast determined that the option located on Blue Mountain Ski Resort is the preferred option. Once the facility is built, this option provides the flexibility for utility distribution lines which can be built in either direction within the ski resort to accommodate its potential expansion opportunities, and has fewer environmental and landowner impacts, both permanently and during construction. The site also remains on the property owner that the gas will service, at a location that will have the least amount of impact to Blue Mountain Ski Resort's existing operations and planned future expansion.

9.3.3 Mainline and Side Valves

The mainline valves and side valve are sited within upland areas within the permanent easement for the proposed pipeline. As a result, impacts associated with the design and use of these facilities, as well as potential alternative siting locations fall under the evaluations performed for the proposed Project alignment.

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 Carbon County, PennEast was able to avoid impacts to 8 wetlands and 4 watercourses through the implementation of these modifications. These avoided features are listed in Table CA-S-3 below. The workspace reductions are shown on the Alignment Sheets in JPA Section H.

Table CA-S- 3
Wetlands and Watercourses Avoided Through Workspace Change in Carbon County

Feature ID	MP	Description
110614_JC_004_PSS	24.1	Temporary workspace was reduced to avoid impacts to this wetland.
110415_GM_1001_I_MI	24.5	Temporary workspace was reduced to avoid impacts to this watercourse.
110614_JC_001_VP	25.2	Temporary workspace was reduced to avoid impacts to this wetland.
102214_JC_001_PEM	27.7R2	Temporary workspace was reduced to avoid impacts to this wetland.
102314_JC_003_PSS	28R2	Temporary workspace was reduced to avoid impacts to this wetland.
042415_JC_1004_PEM	30.1R2	Temporary workspace was reduced to avoid impacts to this wetland.
051115_JC_1003_D_MI	32.3R2	Additional temporary workspace was removed to avoid impacts to this watercourse.
110316_GM_1006_PEM	32.8R3	Temporary workspace was removed to avoid impacts to this wetland.
110316_GM_1008_PEM	32.9R3	Temporary workspace was removed to avoid impacts to this wetland.
050615_JC_1002_I_MI	36.5R3	Temporary workspace was reduced to avoid impacts to this watercourse.

Feature ID	MP	Description
010816_DB_1001_I_MI	36.5R3	Temporary workspace was reduced to avoid impacts to this watercourse.
041018_WA_001_PEM	44.8R2	Additional temporary workspace was reduced to avoid impacts to this wetland.

11.0 Minimization Measures

Where impacts to wetland and watercourses could not be avoided, PennEast designed the Project to minimize the impacts through route and workspace changes. PennEast aligned the Revised PA Route to co-locate with existing utility ROWs wherever practicable, thereby crossing wetlands and watercourses at or near locations that have been disturbed through construction of a previous utility project. PennEast also sited the pipeline to cross resources at their narrowest locations when practicable. Wherever site conditions would allow, PennEast reduced the construction ROW to 75 feet through wetlands, watercourses, floodways, and forested riparian buffers. In some areas, the workspace could not be reduced without jeopardizing safety. These include areas of steep terrain, areas adjacent to road crossings and other existing infrastructure, and/or where specialized construction techniques require expanded workspace for safe construction. The tables in Appendix CA-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 Carbon 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 Carbon County, the table in Appendix CA-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 (HDD)

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) and the FERC Wetland and Waterbody Construction and Mitigation Procedures (Procedures) (FERC 2013a, 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.

Flume Crossing

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.

Cofferdam

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 wetlands, PSS wetlands, and forested riparian buffers; maintaining only a 30-foot ROW easement during operation; and mitigating impacts. BMPs that are specific to wetland and watercourse crossings are described below.

11.2.1 Wetland Crossing BMPs

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

- Standard Pipeline Construction (non-saturated wetland)
- Conventional Wetland Construction (saturated wetland)
- Push-Pull Technique (inundated wetland)

To minimize the potential for adverse effects to wetlands, PennEast will implement the following BMPs outlined in the Erosion and Sediment Control Plan (E&SCP) (JPA Section M) when conducting pipeline installation activities:

- PennEast will minimize vegetation clearing where feasible and stumps that do not interfere with travel or installation of the pipeline will be left in place to allow for re-sprouting following construction and restoration;
- PennEast will use construction mats in all wetlands to minimize impacts to the soil profile and reduce compaction in the travel lane;
- The excavation procedures used to cross unsaturated wetlands will be similar to those used in uplands;

- PennEast will segregate topsoil from the area disturbed by trenching, except in areas where standing water is present or soils are saturated;
- PennEast will install temporary trench plugs at the edges of wetlands, as necessary, to prevent the flow of upland sediments or other potential pollutants into wetlands during construction;
- PennEast will install permanent trench plugs at the edges of wetlands before the trench is backfilled to restore hydrology to preconstruction conditions;
- 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 wetlands; and
- PennEast will maintain a minimum 100-foot buffer from wetlands 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 Wetland Restoration

Restoration of the natural hydrology, soil profiles, and topography is critical to promote natural regeneration and to maintain a successful wetland ecological community. Where the original contours are reestablished within a ROW and no other impediments to the natural hydrology occur, natural revegetation of a ROW that is adjacent to an unaffected wetland plant community will usually occur within one or two growing seasons in PEM and PSS wetlands. Restoration activities in wetlands will be conducted in accordance with PennEast's approved E&SCP (JPA Section M), unless federal or state agencies require an alternative method. PennEast will use the following criteria to restore disturbed wetland areas to as close to their pre-construction condition as practical:

- All equipment mats, temporary timber bridges, and other construction debris shall be removed during the final grading of the ROW. Once backfilling is complete, segregated topsoil will be returned to affected locations, and the original surface contours and flow regimes will be restored;
- During final grading, wetlands (including areas within 100 feet of wetlands) will be restored to their pre-construction contours and the buffer areas seeded and mulched as soon after backfilling as practicable with the exception of the travel portion of the ROW, which will also be restored using these procedures after the travel way is no longer required;
- For each wetland crossed, trench breakers will be installed at the base of slopes near the boundary between the wetland and adjacent upland areas and the trench bottom will be sealed as necessary to maintain the original wetland hydrology in areas where the pipeline trench may affect the groundwater hydrology;
- Permanent slope breakers will be installed across the construction ROW at the base of slopes in accordance with the E&SCP (JPA Section M) to prevent sediment transport into the wetland.
- Sediment barriers will be installed as outlined in the E&SCP (JPA Section M) and as approved or specified by the EI;
- Wetlands will be seeded with a wetland conservation seed mix, unless standing water is present, in accordance with the procedures outlined in the E&SCP (JPA Section M);
- No fertilizers, lime or mulch will be used in wetland areas unless required in writing by applicable regulatory agencies;
- Within the temporary workspace and outside of the 30-foot maintained ROW, PFO and PSS wetlands will be planted with native woody plants that are adapted to wetland conditions; and

- After construction, disturbed wetlands and adjacent uplands will be monitored as required by state and federal permit conditions (annually for at least five years) to document long-term stabilization. Regular inspection and maintenance of erosion control measures will expedite successful restoration of the wetlands.

11.2.3 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:

- PennEast proposes to cross all watercourses 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 X) and wherever necessary, to minimize the flow of sediment into watercourses;
- PennEast will construct a temporary equipment bridge over each stream 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;
- To protect trout populations, PennEast will complete in-stream construction activities outside of the March 1 to June 15 window for trout stocked streams, outside of the October 1 to December 31 window for wild (naturally reproducing) trout streams, and outside of the October 1 to April 1 window for Class A wild trout streams, unless otherwise approved by the Pennsylvania Fish and Boat Commission (PFBC);
- PennEast will install temporary trench plugs at the edges of watercourses, as necessary, to prevent the flow of upland sediments or other potential pollutants into the 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 each watercourse, and within 100 feet of high quality (HQ) or EV watercourses 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.

11.2.4 Watercourse Restoration

PennEast will use the following criteria to restore disturbed watercourses to as close to their pre-construction condition as practical:

- Clean stone or native cobbles will be used for the upper 1-foot of trench backfill in watercourses that contain coldwater fisheries.
- 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. In general, PennEast, to the extent practical, 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 Appendix 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.

11.2.5 Wetland and Riparian Buffer Reforestation

PennEast proposes to enhance restoration in PFO and PSS wetlands and within forested riparian buffers. As stated in the Wetland and Riparian Reforestation Plan (JPA Appendix L-4A), Ernst FACW Meadow Mix (ERNMX-122), or an alternative conservation wetland seed mix that contains similar species, will be used to stabilize impacted wetlands. The Ernst Riparian Buffer Mix (ERNMX-178), or an alternative conservation riparian seed mix that contains similar species, will be used in riparian areas. Additionally, impacted PSS wetlands will be replanted with wetland shrub species, and PFO wetlands and 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 wetland or riparian buffers, but outside of the 30-foot maintained ROW.

11.2.6 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 wetlands and riparian areas, the maintained ROW would be reduced to 30 feet. Within the 30-foot maintained ROW in wetlands, trees within 15 feet of the pipeline that could compromise the integrity of the pipeline may be selectively cut and removed from the ROW. A permanent 10-foot wide cleared corridor would be maintained as herbaceous cover through wetlands in accordance with FERC's Plan and Procedures (FERC 2013a, 2013b). 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 CA-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 crossings. These crossings included the Lehigh River/Francis E. Walter Reservoir, the Mosey Wood Wetland Complex, Mud Run within Hickory Run State Park, Beltzville Lake, and Aquashicola Creek (and abutting wetlands) and are summarized in Table CA-S-4.

Table CA-S-4
Summary of Proposed Crossing Methods for Select Sensitive Areas in Carbon County

Location/Feature	MP	Approximate Length (feet)	Proposed Primary Construction Method
Lehigh River/ Francis E. Walter Reservoir	23.0	432	Dam-and-pump
Mosey Wood Wetland Complex	27.1R2	3,824	HDD
Mud Run	33.2R2	45	Dam-and-pump
Beltzville Lake	43.5R2	6,100	HDD
Aquashicola Creek and Abutting Wetlands	49.3R3	313	Conventional/Auger Bore

12.1 Lehigh River/Francis E. Walter Reservoir (MP 23.0)

PennEast proposes to use a dry open-cut crossing to construct the pipeline under the Lehigh River/Francis E. Walter reservoir. A conventional watercourse construction method was selected for this crossing due to several challenges observed during site reconnaissance and geotechnical investigations.

Challenges specific to an HDD installation include steep slopes and geotechnical conditions. The proposed crossing is sited in a steep-sided valley, and HDD launch and receiving pits would need to be sited at an elevation of 100 feet (or more) above the water's surface to conceive a feasible trajectory for a successful HDD bore. Additionally, the former Lehigh River channel may have deeply cut into the bedrock, leaving a deposit of unconsolidated alluvium. This would require a relatively steep trajectory to accommodate the steep hillside and to avoid the alluvium while drilling. Furthermore, the underlying geologic formation, through which the majority of the boring would pass, is composed of massive sandstones with friable siltstone and shales. The process of transitioning between hard massive units with friable shale layers would make it difficult to keep the HDD drill bit at the desired elevation during drilling, and increases the chance of an unsuccessful HDD bore installation.

Challenges associated with a Direct Pipe® or a microtunnel installation include steep slopes and variability of geotechnical materials. Microtunnel boring machines require an installation to be designed solely within soil or bedrock, as the cutterhead used to excavate the encountered materials needs to be matched to the geologic conditions. A soil cutterhead is not capable of mining bedrock and a bedrock cutterhead is not capable of mining soil.

Challenges associated with a conventional bore installation include the river width (440 feet between streambanks). Conventional (auger) boring operations are limited to widths of approximately 300 to 400 feet.

The conventional crossing of the Francis E. Walter Reservoir is planned for construction between mid-October and February, when the reservoir levels are drawn down and water levels are typically the lowest. During this time, the stream will be narrower and shallower. These conditions would allow the crossing to be completed within 48 hours and minimize the possibility of downstream sedimentation and impacts to wild trout migration. Additionally, recreational impacts to fishing and boating would be reduced by constructing during low-flow conditions in late fall or during the winter. The timing of construction of this crossing on U.S. Army Corps of Engineers (USACE)-administered land is dependent on PennEast obtaining the necessary state and federal approvals and permits.

12.2 Mosey Wood Wetland Complex (MP 27.1R2)

PennEast proposes to use the HDD method to construct the pipeline under I-80 under five wetlands: 102114_JC_001_PEM, 102314_JC_004_PEM, 102314_JC_002_PFC, 102314_JC_002_PFO and 102314_JC_002_PSS. The HDD installation is approximately 3,820 feet in length and the minimum depths of cover range from approximately 127 feet under wetland 102114_JC_001_PEM to 191 feet under wetland 102314_JC_002_PFC. The HDD entry point will be located in a workspace approximately 570 feet north of I-80 and the exit point will be located in a workspace approximately 2,870 feet south of I-80. An elevation difference of approximately 30 feet exists between the HDD entry and exit locations. To minimize the required drilling fluid pressure and inadvertent return risk beneath each of the critical features, this installation will be completed from the north side of the crossing and drilled to the higher elevation side of the crossing.

Geotechnical investigations along the HDD alignment revealed clay fill material north of I-80; soils consisted of medium dense clayey sand and gravel. Beneath these soils, the bedrock materials are anticipated to include alternating layers of highly to slightly weathered, weak to strong siltstone with average Rock Quality Designation (RQD) values of 79.1 percent. The HDD installation on the south side of I-80 is anticipated to encounter soils overlying bedrock materials; soils consisted of medium to dense clayey sand with gravel, hard sandy clay with gravel and hard sandy silt. Beneath these soils, the bedrock materials are anticipated to include predominately slightly weathered to fresh, medium strong to strong sandstone with average RQD values of 82.3 percent. These investigations indicated overall geotechnical conditions favorable for the installation of an HDD. The use of the HDD method to cross the Interstate and five wetlands 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 CA-S-6.

12.3 Mud Run (MP 33.2R2)

PennEast proposes to use a dam-and-pump crossing of Mud Run (042115_JC_1001_P_IN) to construct the pipeline in a permanent easement that abuts the existing Buckeye pipeline ROW. This method includes moving the pipeline to the west side of the Buckeye pipeline easement at the Mud Run crossing to keep the working side and spoil side on the west side, and therefore, avoid disturbance to the east side of the easement. This current configuration prevents spoil from being stored on top of Buckeye's pipelines, a condition stipulated by Buckeye for co-location.

The main challenges associated with an HDD installation at this crossing are the existing geotechnical conditions. At the request of PADCNR, PennEast conducted a subsurface investigation to analyze geotechnical conditions. As part of the subsurface investigation, four borings (B-Mud-1 through B-Mud-4) were conducted along a proposed HDD conceptual alignment. The subsurface investigations in the vicinity of the North Side of Mud Run Creek (Boring B-Mud-1) proved unfavorable for an HDD due to low RQD bedrock material. Heavily weathered, joined, fractured or fissured bedrock, as found at Boring B-Mud-1, presents challenges with respect to bore stability and can present unacceptable risks in terms of constructability of an HDD installation. In areas with low RQD's, bore stability and raveling are significant issues, hampering the ability to pass tools through the bore to increase its diameter and mechanically displace the large volume of gravel and larger sized particles within the rock mass. Completing a pilot bore or passing a reamer/hole opener through these materials can cause movement of the surrounding fracture blocks and create obstructions to drilling tool movements through the bore. In addition, significant challenges can occur with maintaining and controlling drilling fluid flow within low quality bedrock materials. Based on the observed conditions in Boring B-Mud-1, an HDD alternative for the Mud Run crossing is not feasible.

Challenges associated with a Direct Pipe installation or a mircrotunnel installation include steep slope on the north side of the crossing and geotechnical conditions. Heavily weathered, joined, fractured or fissured bedrock found at Boring B-Mud-1 can present challenges to microtunnel boring machines. These conditions would increase the risk of a bore collapse.

Challenges associated with a conventional bore installation include elevation differences and steep slopes on the north side, which would require extremely deep shafts; significant dewatering effort to lower water table below shaft elevations; and the presence of low RQD rock material. All of these conditions would make for a high risk conventional bore installation.

12.4 Beltzville Lake (MP 43.5R3)

PennEast proposes to use the HDD method to construct the pipeline beneath Wild Creek, Pohopoco Creek (collectively referred to as Beltzville Lake), Penn Forested Road/T490, and unnamed streams 061715_DB_1001_I_MI and 122215_DB_1001_I_MI. The HDD installation is approximately 6,100 feet in length, and the minimum depths of cover below Wild Creek and Pohopoco Creek are 124 and 125 feet, respectively. The drill and intersect method will be used, resulting in two drill entry points. The eastern HDD entry point will be located in a workspace approximately 1,790 feet east of the eastern bank of

Pohopoco Creek and the western HDD entry point will be located in a workspace approximately 1,590 feet west of the western bank of Wild Creek. An elevation difference of approximately 16 feet exists between the east and west HDD entry locations, with the east HDD entry location lower in elevation.

PennEast also considered crossing Beltzville Lake using two shorter HDDs, rather than one single bore. Although this alternative allows for shorter drilling lengths, the pipeline would be installed adjacent to an existing waterline owned by the Bethlehem Authority. Due to the age and condition of the existing waterline, the Bethlehem Authority expressed concern for the proximity of the proposed Project.

Geotechnical investigations along the HDD alignment identified soils consisting of loose clayey gravel and very dense gravel on the west side of the crossing. Beneath these soils, the bedrock materials are anticipated to include predominantly slightly weathered to fresh, weak to very strong shale with average RQD values of 78.5 percent. The HDD installation on the east side of the crossing is anticipated to encounter residual soils consisting of loose to very dense fragments of decomposed shale. Beneath these soils, the bedrock materials are anticipated to include moderately weathered to fresh, weak to strong shale overlying fresh, medium to strong slate with average RQD values of 97.5 percent. An HDD Design Report is provided in Appendix CA-S-6.

The dry open-cut construction method using a cofferdam was evaluated for crossing Beltzville Lake. Although the installation of a cofferdam effectively isolates the workspace from the stream, construction results in direct, temporary impacts to waterbodies and adjacent uplands. Forested land within Beltzville State Park would need to be cleared within the ROW, and environmentally sensitive areas, such as wetlands, may be impacted. The installation of sediment barriers on adjacent uplands and other erosion and sediment control BMPs greatly reduce sedimentation; however, earth disturbance within and near waterbodies increases the risk of sedimentation during storm events. Additional challenges to a conventional construction strategy include impacts to public use. The open-cut crossing method would result in temporary impacts to recreational activities in this portion of Beltzville State Park; park visitors would be restricted from accessing the construction workspace area due to safety concerns. A cofferdam would also limit recreational boating and fishing access during construction of the crossings.

12.5 Aquashicola Creek (MP 49.3R3)

PennEast proposes to use the conventional (auger) boring method to cross beneath the Aquashicola Creek and abutting wetlands. The length of this bore is approximately 313 feet. The entry bore pit will be located in a workspace approximately 40 feet north of the creek. The receiving pit will be located in a workspace approximately 255 feet south of the creek. A 5-foot minimum depth of cover will be maintained beneath the creek. The depth of launch and retrieval pits will be approximately 18 and 20 feet below grade, respectively. The use of conventional boring methods will avoid surface impacts to Aquashicola Creek and the abutting wetlands.

PennEast evaluated alternative trenchless construction methods to cross the wetland-watercourse complex including HDD and Direct Pipe® methods. Challenges specific to an HDD installation include site topography and geotechnical conditions. Assuming a typical entry angle of 12 degrees, an exit angle of 10 degrees, similar entry and exit elevations, and a bend radius of 3,600 feet, the required installation length of an HDD alternative is approximately 1,700 feet, centered on the wetland-watercourse complex crossing. This required installation length is greater than the available straight alignment between alignment bends and would require a reroute to re-align the pipeline along a straight alignment for the required installation length. Any re-alignment would need to consider the length necessary to stage the product pipe on the south side of the complex, in line with a proposed crossing alignment. Due to the steep slopes directly south of the complex, this length cannot be accommodated for the required crossing.

The results of geotechnical and geophysical investigations found loose to dense sand, and medium dense to very dense gravel with sand within 18 feet of the surface. The loose sands present challenges in terms of avoiding an inadvertent return in the vicinity of the entry and exit locations. The presence of gravels, cobbles and boulders can present challenges associated with bore stability, raveling, and inducing steering corrections to maintain the design alignment. While casing can be used to bridge and support the gravel materials, if casing pipe is required on both sides of a crossing, the HDD installation would need to be completed as a drill and intersect approach, due to the requirement for drilling through the casing pipe from the ground surface (i.e., it is not possible to drill into a casing pipe installed below the ground surface). The use of a drill and intersect method would require an additional 600 feet of installation length to provide a sufficient horizontal tangent to intersect the individual pilot bores started from each side of the crossing. In addition, entry location staging areas would be needed on both sides of the crossing to support independent drilling operations. As discussed above, a longer installation length is not feasible due to topographic constraints.

The challenges associated with a Direct Pipe® installation are similar to those that would be encountered for an HDD installation. The Direct Pipe® method would allow the installation length to be shortened; however, site topography could also not accommodate the minimum installation length of approximately 740 feet, given the steep slope that is directly adjacent to the wetland on the south side of Aquashicola Creek. The gravels, cobbles, and boulders are anticipated to present challenges to the boring process and in maintaining bore stability if damaged equipment must be replaced. In highly abrasive ground conditions, significant wear can occur outside and inside the microtunnel boring machine. Soils with high percentages of gravels, cobbles and/or boulders can present challenges. For larger diameter boulders, the cutting tools on the cutter wheel are required to break down the boulder to smaller sizes such that they can pass through the cutter wheel and into the crushing chamber. The ability to break down large boulders is highly dependent upon the type of cutters incorporated into the cutter wheel and the ability of the soil mass to hold/grip the boulder in place to allow the cutters to break down the larger particle into smaller pieces. If the soil mass does not have sufficient strength to keep the boulder in place, the boulder will tend to be pushed in front of the microtunnel machine. This can lead to serious issues associated with over excavation, significant line and grade deviations, and the requirement for a rescue shaft to be excavated directly over the obstruction to break up the boulder. Soil materials containing gravels, cobbles and boulders are anticipated to present significant challenges in terms of maintaining bore stability in the event the machine is required to be removed from the bore to address any worn cutters as a result of excavating large quantities of soil materials. Replacement of worn cutters would require removal of the microtunnel boring machine from the ground. Removal of the machine and pipe string removes the support of the borehole.

The primary challenges associated with an auger bore include dewatering bore bits, and line and grade control. Due to the proximity of the bore pits to the edge of the wetlands, groundwater dewatering is anticipated for completion of the auger bore installation. For installations in sands, groundwater can typically be managed with the use of dewatering structures. Keeping a soil plug in the leading casing pipe (by operating with the auger flights located within the casing pipe and not leading the casing pipe) will help to minimize the amount of groundwater entering the casing pipe and flowing towards the launch pit during operations. Dewatering in the launch and retrieval pit can typically be accomplished with sump pumps and dewatering points. Watertight shaft supports can also limit the amount of groundwater entering a pit. Groundwater dewatering can also be minimized by completing construction activities in drier months. Maintaining the bore line and grade control may also be a challenge, as auger bore installations are not steerable installations. Proper control of line and grade requires proper setup of equipment on the design alignment and grade prior to launching. The uniformity of the soil as indicated in the borehole logs suggests that challenges associated with maintaining the proper line and grade are not anticipated to be a significant issue. In addition, the installation depth can be modified slightly to allow for greater accommodation of any vertical deviation in the auger installation.

While challenges have been identified, an auger bore installation is deemed feasible for this proposed wetland crossing. Additional detail is provided in the Trenchless Crossing Assessment in Appendix CA-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