MVP Southgate Project

Docket No. PF18-4-000

Draft

Resource Report 6 – Geologic Resources

August 2018

MVP Southgate Project
Draft Resource Report 6 – Geologic Resources

Resource Report 6 - Filing Requirements	
Information	**Location in Resource Report**
Minimum Filing Requirements	
1. Identify the location (by milepost) of mineral resources and any planned or active surface mines crossed by the proposed facilities. (§380.12 (h) (1 & 2)). • Describe hazards to the facilities from mining activities, including subsidence, blasting, slumping or landslides or other ground failure.	Section 6.4
2. Identify any geologic hazards to the proposed facilities. (§380.12 (h) (2)) • For the offshore, this information is needed on a mile-by-mile basis and will require completion of geophysical and other surveys before filing.	Section 6.5
3. Discuss the need for and locations where blasting may be necessary in order to construct the proposed facilities. (§380.12 (h) (3))	Section 6.3
4. For LNG Projects in seismic areas, the materials required by "Data Requirements for the Seismic Review of LNG Facilities," NBSIR84-2833. (§380.12 (h) (5))	Not Applicable (not an LNG project)
5. For underground storage facilities, how drilling activity by others within or adjacent to the facilities would be monitored, and how old wells would be located and monitored within the facility boundaries. (§380.12 (h) (6))	Not Applicable (no underground storage proposed)
Additional Information Often Missing and Resulting in Data Requests	
6. Identify any sensitive paleontological resource areas crossed by the proposed facilities. (Usually only if raised in scoping or required by land-managing agency.)	Section 6.6
7. Briefly summarize the physiography and bedrock geology of the project area.	Section 6.2
8. If proposed pipeline crosses active drilling areas, describe plan for coordinating with drillers to ensure early identification of other companies' planned new wells, gathering lines, and aboveground facilities.	Not Applicable
9. If the application is for underground storage facilities: • Describe monitoring of potential effects of the operation of adjacent storage or production facilities on the proposed facility, and vice versa; • Describe measures taken to locate and determine the condition of old oil wells within the field and buffer zone and how the applicant would reduce risk from failure of known and undiscovered wells; and • Identify and discuss safety and environmental safeguards required by state and federal drilling requirements	Not Applicable (no underground storage proposed)

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LIST OF ACRONYMS AND ABBREVIATIONS

FERC or Commission	Federal Energy Regulatory Commission
MLV	mainline valve
MP	milepost
Mountain Valley	Mountain Valley Pipeline, LLC
Project	MVP Southgate Project
USGS	United States Geological Society

DRAFT RESOURCE REPORT 6
GEOLOGIC RESOURCES

6.1 INTRODUCTION

Mountain Valley Pipeline, LLC ("Mountain Valley") is seeking a Certificate of Public Convenience and Necessity ("Certificate") from the Federal Energy Regulatory Commission ("FERC" or "Commission") pursuant to Section 7(c) of the Natural Gas Act to construct and operate the MVP Southgate Project ("Project"). The Project will be located in Pittsylvania County, Virginia and Rockingham and Alamance counties, North Carolina. Mountain Valley proposes to construct approximately 72 miles of 24-inch-diameter natural gas pipeline (known as the H-650 pipeline) to provide timely, cost-effective access to new natural gas supplies to meet the growing needs of natural gas users in the southeastern United States ("U.S."), including for the Project's anchor shipper, a local distribution company serving customers in North Carolina. See Resource Report 1 (General Project Description) for additional Project information.

6.1.1 Environmental Resource Report Organization

Resource Report 6 is prepared and organized according to the FERC *Guidance Manual for Environmental Report Preparation* (February 2017). This report is organized by Project components and describes the existing geologic setting and resources, potential impacts, and mitigation in relation to the Project components. Section 6.2 describes the geologic setting; Section 6.3 describes locations along the pipeline with blasting potential; Section 6.4 describes mineral resources; Section 6.5 discusses geologic hazards; Section 6.6 discusses paleontological resources; and Section 6.7 presents the list of references that formed the basis for Resource Report 6.

6.2 GEOLOGIC SETTING

6.2.1 Pipeline Facilities

The H-650 pipeline is located in Pittsylvania County, Virginia and Rockingham and Alamance Counties, North Carolina in the Piedmont Uplands Section of the Piedmont Physiographic Province (United States Geological Survey ["USGS"], 2004a). The Piedmont Province is the non-mountainous portion of the Appalachian Highland, one of the eight major geologic divisions of the United States. The Piedmont Province consists of deeply weathered bedrock and a relative paucity of solid outcrop. Bedrock is generally buried under a thick (6 to 65 feet) blanket of weathered rock that has formed clay-rich soils. Outcrops are commonly restricted to stream valleys where the soil layer has been removed by erosion. A variety of igneous and metamorphic rocks comprise the bedrock of the Piedmont province including schists, gneiss, and granite. Most of these rocks range in age from Proterozoic to Paleozoic and form the internal core of the ancient Appalachian mountain belt. The province is bounded on the east by the Fall Zone, which separates the province from the Coastal Plain (Fenneman, 1938).

The typical landscape of the Piedmont Upland is a rolling surface of gentle slopes without significant relief (i.e., 50 feet more or less elevation change) cut by or bounded by valleys of steeper slope and greater depth, often up to several hundred feet. The general slope is eastward toward the Coastal Plain. The inner (western) boundary of the province rises in elevation to 700 or 800 feet above mean sea level in northern Virginia and increases to 1,500 feet near the North Carolina boundary. Elevations fall below 1,500 feet in the Carolinas and reach 1,800 feet in Georgia (Fenneman, 1938). Elevations along the H-650 pipeline range from approximately 470 to 880 feet above mean sea level. Resource Report 1, Appendix 1-B includes topographic maps of the Project area.

6.2.2 Aboveground Facilities

Proposed aboveground facilities include the construction of two new compressor stations, four new meter (interconnect) stations, pig launchers and pig receivers, and mainline valves ("MLVs") that will be installed at various locations along the pipeline. Table 1.2-2 of Resource Report 1 provides a summary by location of the aboveground facilities for the Project, and these facilities are depicted on the topographic maps in Resource Report 1, Appendix 1-B. The aboveground facilities for the Project are located within the Piedmont Uplands Section of the Piedmont Physiographic Province as described in Section 6.2.1 above (USGS, 2004a). Elevations at these facilities are identified in Table 6.2-1 below.

Table 6.2-1

Elevations at the MVP Southgate Project Aboveground Facilities

Facility	Milepost	State / County	Approximate Minimum Elevation (feet above mean sea level)	Approximate Maximum Elevation (feet above mean sea level)
Lambert Compressor Station / Interconnect / Mainline valve	0.2 mile east of MP 0.3	Virginia / Pittsylvania	648	668
Russell Compressor Station	1.2 miles west of MP 26.9	North Carolina / Rockingham	570	580
LN 3600 Interconnect	1.1 miles west of MP 27.4	North Carolina / Rockingham	500	510
T-15 Dan River Interconnect	30.5	North Carolina / Rockingham	498	506
T-21 Haw River Interconnect / Mainline valve	72.6	North Carolina / Alamance	482	492
Mainline valve	12.5	Virginia / Pittsylvania	706	712
Mainline valve	18.4	Virginia / Pittsylvania	693	695
Mainline valve	28.4	North Carolina / Rockingham	506	508
Mainline valve	43.5	North Carolina / Rockingham	632	638
Mainline valve	53.4	North Carolina / Alamance	720	722
Mainline valve	67.7	North Carolina / Alamance	562	566

6.2.3 Surficial Geologic Materials

A review of surficial geologic databases provided information regarding the nature of surficial deposits expected in the Project area. The H-650 pipeline transects primarily Holocene and Tertiary residual materials formed by weathering and breakdown of underlying rock in areas of steep to moderate slopes

(Soller and Reheis, 2004). These sediments are poorly sorted and stratified ranging from clay to boulders in size and may contain organic material. Table 6.2-2 below summarizes surficial geology by milepost ("MP") in the vicinity of the proposed Project facilities. Figure 6-A in Appendix 6-A illustrates surficial geology in the Project areas.

Table 6.2-2

Surficial Materials in the MVP Southgate Project Areas

Project Facilities	From Milepost	To Milepost	Surficial Geology Material
Pipeline Facilities			
H-650 Pipeline	0.0	0.4	Residual materials developed in sedimentary rocks, discontinuous
	0.4	0.6	Residual materials developed in bedrock, discontinuous
	0.6	2.3	Residual materials developed in sedimentary rocks, discontinuous
	2.3	15.3	Residual materials developed in igneous and metamorphic rocks
	15.3	31.0	Residual materials developed in bedrock, discontinuous
	31.0	72.6	Residual materials developed in igneous and metamorphic rocks
Aboveground Facilities			
Lambert Compressor Station / Interconnect / Mainline Valve	0.2 mile east of MP 0.3		Residual materials developed in bedrock, discontinuous
Russell Compressor Station	1.2 miles west of MP 26.9		Residual materials developed in bedrock, discontinuous
LN 3600 Interconnect	1.1 miles west of MP 27.4		Residual materials developed in bedrock, discontinuous
T-15 Dan River Interconnect	30.5		Residual materials developed in bedrock, discontinuous
T-21 Haw River Interconnect / Mainline valve	72.6		Residual materials developed in igneous and metamorphic rocks
Mainline valve	12.5		Residual materials developed in igneous and metamorphic rocks
Mainline valve	18.4 and 28.4		Residual materials developed in bedrock, discontinuous
Mainline valve	43.4, 53.5, and 67.7		Residual materials developed in igneous and metamorphic rocks
Source: Soller et. al. 2009			

6.2.3.1 Pipeline Facilities

Residual materials developed in bedrock, discontinuous - These materials were formed by the partial chemical dissolution and physical disintegration of bedrock and, to a lesser extent, colluvial sediments. They include the modern soil profile and extend downward to unweathered rock. Depending on the composition of the source rock or colluvium, these materials can be generally fine- to coarse-grained and commonly are poorly sorted. Unlike mass-movement sediments (e.g., colluvium), these materials were not transported. This material is generally less than 10 feet thick and is patchy in distribution. Particularly in mountainous areas, exposed rock can more commonly be found than residual material (Soller et. al., 2009).

Residual materials developed in igneous and metamorphic rocks - These materials were formed by the partial chemical dissolution and physical disintegration of igneous and metamorphic rock and include the modern soil profile and extend downward to unweathered rock. Depending on the composition of the source rock or colluvium, these materials can be generally fine- to coarse-grained and commonly are poorly sorted. Unlike mass-movement sediments (e.g., colluvium), these materials were not transported. This material is generally less than 10 feet thick and, in many places, is patchy in distribution. Particularly in mountainous areas, exposed rock can more commonly be found than residual material (Soller et. al., 2009).

Residual materials developed in sedimentary rocks, discontinuous - These materials were formed by the partial chemical dissolution and physical disintegration of sedimentary rocks and include the modern soil profile and extend downward to unweathered rock. Depending on the composition of the source rock, these materials can be generally fine- to coarse-grained, and commonly are poorly sorted. Unlike mass-movement sediments (e.g., colluvium), these materials were not transported. This material is generally less than 10 feet thick, and is patchy in distribution. Particularly in mountainous areas, exposed rock can more commonly be found than residual material (Soller et. al., 2009).

6.2.3.2 Aboveground Facilities

Surficial materials underlying the Lambert Compressor Station / Interconnect / MLV, Russell Compressor Station, LN 3600 Interconnect, T-15 Dan River Interconnect, and MLVs at MPs 18.4 and 12.4 consist of residual materials developed in bedrock, discontinuous. This surficial material is described in Section 6.2.3.1 above.

Surficial materials underlying the T-21 Haw River Interconnect / MLV and MLVs at MPs 12.5, 43.5, 53.5, and 67.7 consist of residual materials developed in igneous and metamorphic rocks. This surficial material is described in Section 6.2.3.1 above.

6.2.4 Bedrock

Bedrock located in the vicinity of the proposed Project facilities is summarized by MP in Appendix 6-B and illustrated on Figure 6-B in Appendix 6-A. The bedrock types potentially encountered are described below (USGS, 2018).

6.2.4.1 Pipeline Facilities

Cambrian Leatherwood Granite (CAlw): Light-gray, medium- to coarse-grained, porphyritic biotite granite.

Proterozoic Z-Cambrian Alligator Back Formation (CAZab): Light-gray, medium- to coarse-grained porphyroblastic garnet-mica schist; contains interbeds of dark-gray graphitic mica schist, calc-gneiss, mica gneiss, feldspathic quartzite with blue quartz granule beds, and garnet-hornblende schist.

Proterozoic Z-Cambrian Fork Mountain Formation (CAZfm): Light- to medium-gray, fine- to medium grained, polydeformed and polymetamorphosed porphyroblastic aluminosilicate-mica schist, interlayered with medium-gray irregularly-layered garnetiferous biotite gneiss, migmatitic in part; calcsilicate granofels; amphibolite; rare white marble; and, coarse calc-quartzite lenses.

Cambrian/Late Proterozoic Biotite Gneiss and Schist (CZbg): Inequigranular and megacrystic; abundant potassic feldspar and garnet; interlayered and gradational with calc-silicate rock, sillimanite-mica schist, mica schist, and amphibolite. Contains small masses of granitic rock.

Cambrian/Late Proterozoic Felsic Mica Gneiss (CZfg): Interlayered with graphitic mica schist and mica-garnet schist, commonly with kyanite; minor hornblende gneiss.

Cambrian/Late Proterozoic Felsic Metavolcanic Rock (CZfv): Metamorphosed dacitic to rhyolitic flows and tuffs, light gray to greenish gray; interbedded with mafic and intermediate metavolcanic rock, meta-argillite, and metamudstone.

Cambrian/Late Proterozoic Garrisonville Mafic Complex (CZg): Fine- to coarse-grained, massive to foliated amphibolite and hornblendite with lesser metapyroxenite, metawebsterite, and metanorite.

Cambrian/Late Proterozoic Mafic Metavolcanic Rock (CZmv): Metamorphosed basaltic flows and tuffs, dark green to black; interbedded with felsic and intermediate metavolcanic rock and metamudstone.

Cambrian/Late Proterozoic Phyllite and Schist (CZph): Locally laminated and pyritic; includes phyllonite, sheared fine-grained metasediment, and metavolcanic rock. In Lilesville granite aureole, includes hornfels.

Proterozoic – Paleozoic Mylonite Gneiss (my): Includes protomylonite, mylonite, ultramylonite, and cataclastic rocks. Lithology highly variable, depending on the nature of the parent rock, and on intensive parameters and history of deformation.

Permian/Pennsylvanian Granitic Rock (PPg): Megacrystic to equigranular. Castalia, Lillington, Medoc Mountain, Sims, Contentnea Creek, and Elm City intrusives.

Paleozoic/Late Proterozoic Metamorphosed Gabbro and Diorite (PzZg): Foliated to massive.

Upper Triassic Newark Supergroup; Conglomerate, mixed clasts (TRc): Rounded to subangular pebbles, cobbles, and boulders of mixed lithologies including quartz, phyllite, quartzite, gneiss, schist, greenstone, and marble in a matrix of medium- to very-coarse-grained, reddish-brown to gray, locally arkosic, sandstone.

Triassic Newark Supergroup; Triassic Sandstone, Siltstone, Shale, and Coal (TRcs): Sandstone, fine- to coarse-grained, reddish-brown to gray, arkosic in places, micaceous, displays channel-type primary features. Siltstone light- to dark-gray, micaceous. Shale, light- to dark-gray, carbonaceous, micaceous, fossiliferous. Coal, bituminous, banded, moderate- to well-developed, fine- to medium-cleat, partings and inclusions of shale, siltstone, and sandstone

Triassic Newark Supergroup, Dan River Group; Cow Branch Formation (TRdc): Mudstone with minor sandstone, gray, laterally-continuous bedding. Intertongues with Stoneville and Pine Hall formations.

Triassic Newark Supergroup Dan River Group; Pine Hall Formation (TRdp): Sandstone, mudstone, and conglomerate, yellowish orange to brown.

Upper Triassic Newark Supergroup; Sandtone, undifferentiated (TRs): Fine- to coarse-grained, reddish-brown to gray, primary bedding features such as cross-beds, channel lags, and ripple marks , minor conglomerate, siltstone, and shale beds.

Upper Triassic Newark Supergroup; Triassic Sandstone, Siltstone, and Shale (TRss): Sandstone, very fine- to coarse-grained, reddish-brown to gray, micaceous, minor conglomerate beds. Siltstone, reddish-brown to gray, micaceous. Shale, reddish-brown, greenish-gray, gray, yellowish-brown, laminated, fossiliferous. Upward-fining sequences, discontinuous vertically and horizontally.

Proterozoic Z Ashe Formation (Zau): Light-gray, medium-grained muscovite and muscovite biotite gneiss with thick interbeds of muscovite schist and pebbly feldspathic quartzite. Thick lenses of garnet-hornblende schist locally mark the basal and upper contacts with the underlying basement gneiss and the overlying metapelites respectively. The unit is cut by dikes, sills and thick sheets of pegmatite and alaskite, especially concentrated along the zone of transitional contact with Alligator Back mica schist units.

6.2.4.2 Aboveground Facilities

Lambert Compressor Station / Interconnect / Mainline valve

Upper Triassic Newark Supergroup; triassic sandstone, siltstone, and shale (TRss): See description in Section 6.2.4.1 above.

Russel Compressor Station

Triassic Newark Supergroup, Dan River Group; Cow Branch Formation (TRdc): See description in Section 6.2.4.1 above.

Triassic Newark Supergroup, Dan River Group; Pine Hall Formation (TRdp): See description in Section 6.2.4.1 above.

LN 3600 Interconnect

Triassic Newark Supergroup, Dan River Group; Pine Hall Formation (TRdp): See description in Section 6.2.4.1 above.

T-15 Dan River Interconnect

Triassic Newark Supergroup, Dan River Group; Pine Hall Formation (TRdp): See description in Section 6.2.4.1 above.

T-21 Haw River Interconnect / Mainline valve

Paleozoic/Late Proterozoic Metamorphosed Gabbro and Diorite (PzZg): See description in Section 6.2.4.1 above.

Mainline Valves

Bedrock underlying the MLV locations are identified in Appendix 6-B and are described in Section 6.2.4.1 above.

6.2.5 Geotechnical Engineering Investigations

Mountain Valley is conducting geotechnical investigations to identify the subsurface conditions in the vicinity of the proposed horizontal directional drill crossings (see Resource Report 1, Section 1.4.1.1) and aid in determining the feasibility of this construction method at those specific locations along the H-650 pipeline. *[Note: Mountain Valley continues to conduct geotechnical investigations for the MVP Southgate Project. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*

6.3 BLASTING

Areas where shallow bedrock may be encountered along the pipeline route were based on attribute data obtained from the U.S. Department of Agriculture, Natural Resources Conservation Service Web Soil Survey (USDA/NRCS, 2018a) and are provided in Resource Report 7, Appendix 7-A. Appendix 7-A identifies the depth to bedrock along the entire pipeline route and at aboveground facilities. This information, along with geology information provided in Appendix 6-B, provides preliminary locations of areas crossed by the pipeline where shallow depth to bedrock (less than five feet) may be present. These areas may require blasting or other methods of mechanical rock removal during excavation of the pipeline trench. Based on this information, approximately 5.6 miles (8 percent) of the pipeline alignment is located in areas where shallow depth to bedrock may be present. If required, blasting will be completed in accordance with applicable State and local regulations and performed by Virginia and North Carolina State-licensed blasters. Blasting activities will be monitored by experienced blasting inspectors. Large rock not suitable for use as backfill material will be disposed off-site or may be windrowed along the edge of the right-of-way in upland areas where the landowner has authorized placement.

[Note: Mountain Valley continues to prepare its Blasting Plan for the MVP Southgate Project. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]

6.4 MINERAL RESOURCES

Mineral resources mined in the Piedmont Province in Virginia include kyanite, slate, vermiculite, granite, gabro, diabase, and feldspar (VDEQ, 2018a). Uranium deposits identified in the vicinity of the Project area are located at Coles Hill, in Pittsylvania County, Virginia (VDEQ, 2018b). The total amount of land permitted for the Coles Hill deposit is 194.0 acres with two distinct areas for exploration: North Coles Hill, approximately 99.5 acres, and South Coles Hill, approximately 94.5 acres. The Coles Hill deposit is located approximately 3.6 miles northeast of MP 0.0 of the H-650 pipeline. Based on the distance from the Project, no impacts on the uranium deposits are anticipated. Based on the distance of the uranium deposits from the Project area, no impacts from construction or operation of the Project on the uranium deposits are anticipated.

North Carolina leads the industrial minerals industry in the U.S. in the production of feldspar, lithium minerals, scrap mica, olivine, and pyrophillite and also leads in the production of clay used for brick manufacturing. North Carolina ranks second in phosphate rock production. Additional mineral production in North Carolina consists of crushed stone, sand and gravel, dimension stone, kaolin, peat, and gem stones (NCDEQ, 2018). Mineral resources within 0.25 mile of the Project were identified from a review of topographic maps, USGS information and state databases (USGS, 2016a and VDMME, 2018a). One site was identified within 0.25 mile of the Project. The site is identified by the USGS as a plant including a rotary kiln and with a commodity type of bloating materials (i.e., for lightweight aggregate concrete products). The USGS database locates the plant approximately 0.2 mile west of MP 26.6 in Rockingham County, North Carolina. No active plant site is visible in this location based on review of available aerial photography. If currently active, based on the distance of the mine from the Project area, no impacts from construction or operation of the Project on the mining operation are anticipated.

One crushed stone operation was identified on the parcel associated with the Russel Compressor Station in Rockingham County, North Carolina (USGS, 2016a). The operation is located approximately 600 feet northwest of the compressor station site. Mountain Valley has sited the Russell Compressor Station outside of the existing quarry operations; therefore, no effects on the quarry operation are anticipated from construction or operation of the Russell Compressor Station.

No oil or gas wells were identified within 0.25 mile of the Project areas based on review of Virginia and North Carolina databases (VDMME, 2018b and NCGS, 2016).

6.5 GEOLOGIC HAZARDS

Geologic hazards are natural physical conditions that, when active, can impact environmental features and man-made structures and may present public safety concerns. Such hazards typically include seismicity, soil liquefaction, landslides, subsidence, and volcanism. Mountain Valley anticipates conducting seismic testing for the Project and also will review the Project alignment for landslide or slip-prone areas. Additionally, Mountain Valley has contracted a geotechnical firm to assess the soil and rock composition at major waterbody crossings. *[Note: Mountain Valley continues to study the potential for the presence of geologic hazards in Project workspace areas. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*

6.5.1 Karst

The USGS has prepared maps illustrating karst or the potential for development of karst and pseudokarst features (USGS, 2004b). These maps show areas underlain by soluble rocks and also by volcanic rocks, sedimentary deposits, and permafrost that have potential for karst or pseudokarst development. Karst terrain maps are presented on Figure 6-C in Appendix 6-A and illustrate potential karst terrain underlying the H-650 pipeline. Karst terrain crossings are identified by MP in Table 6.5-1 below.

Karst terrain is a landscape formed by the dissolution of soluble bedrock. Karst features form as the result of minerals dissolving out of the rock through rainwater. Slightly acidic rainwater leaches through the soil zone becoming more acidic. This acidic groundwater slowly dissolves the soluble bedrock. Over time, this persistent process can create extensive systems of underground fissures and caves. The surface of karst terrain is often pocked with depressions, and in well-developed karst terrain, chains of sinkholes form what are known as solution valleys and streams that frequently disappear underground. Karst terrain in the Project area consists of narrow marble belts in the Piedmont Province of Virginia (VDMME, 2015). No karst terrain was identified as mapped in the Project area in North Carolina (USGS, 2004b).

Table 6.5-1

Potential Karst Terrain crossed by the MVP Southgate Project Pipeline Facilities

County, State	From Milepost	To Milepost	Crossing Length (feet)	Rock Type	Construction Method
Pittsylvania, Virginia	0.05	0.38	1,759	Carbonate Rocks	Open-cut
Pittsylvania, Virginia	0.60	1.17	2,978	Carbonate Rocks	Open-cut and bore (road crossings)
Pittsylvania, Virginia	15.02	16.32	6,839	Carbonate Rocks	Open-cut and bore (road crossings)
Pittsylvania, Virginia	18.14	18.81	3,510	Carbonate Rocks	Open-cut and bore (road crossing)

Source: Weary and Doctor, 2014.

Qualified geologists contracted by Mountain Valley are currently evaluating the Project alignment to confirm the presence of karst terrain. *[Note: Mountain Valley continues to study the potential for the presence of karst terrain in Project workspace areas. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*

6.5.2 Seismic Risk

During an earthquake, seismic waves travel out from an earthquake epicenter through the surrounding rock. Ground motion is higher closer to the event, or epicenter. In general, ground motion decreases away from the epicenter, though the amount of ground motion at the surface is related to more than just distance from the epicenter. Some natural materials can amplify ground motion; that is, ground motion is typically less on solid bedrock and greater on thick deposits of clay, sand, or artificial fill.

Seismic hazards can be assessed based on peak ground acceleration. During an earthquake, a particle attached to the earth will move back and forth irregularly. The horizontal force a structure must withstand during an earthquake is related to ground acceleration. Peak ground acceleration is the maximum acceleration experienced by a particle during an earthquake.

The USGS produces ground motion hazard maps at a given level of probability. Peak horizontal acceleration values are represented as a factor of "g". The factor "g" is equal to the acceleration of a falling object due to gravity. Review of the USGS Seismic Hazard Maps (USGS, 2014a and 2014b) for the Project areas indicates the following:

- There is a 2 percent probability of a 6-8 percent "g" exceedance in 50 years in the Project areas (illustrated on Figure 6-D in Appendix 6-A); and
- There is a 10 percent probability of a 2-3 percent "g" exceedance in 50 years in the Project areas.

The USGS Quaternary Fold and Fault database was searched to identify any Quaternary faults that would be crossed or encountered by the Project facilities. No faults were identified in the vicinity of the Project facilities through review of the USGS database. The nearest fault area is located approximately 60 miles northwest of the Project in Giles County, Virginia (USGS, 2006).

Seismic activity has been known for several decades to be strongest in and around Giles County and in central Virginia (VTSO, 2018), and earthquakes have also occurred in North Carolina (Taylor, 2014). Historical earthquakes within 50 miles of the Project facilities are presented in Appendix 6-E. The proposed Project facilities are located in a relatively lower seismic risk area as compared to other seismically active areas of the United States such as California and Alaska. Further, the proposed facilities will be constructed to meet or exceed federal standards for natural gas pipeline safety (49 Code of Federal Regulations Part 192), and will be constructed in accordance with International Building Code IBC 2012 (Chapter 16 and Section 1613) and American Society of Civil Engineers ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Based on the absence of quaternary faults crossed by the Project, the relatively low seismic risk in the Project area, and Mountain Valley's operation of existing facilities in the region, impacts from earthquake-related ground shaking are not anticipated to affect construction or operation of the Project.

6.5.3 Soil Liquefaction

Soil liquefaction is a process whereby the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. The result is a transformation of soil to a liquid state. Typically, three general factors are necessary for liquefaction to occur and can be used as a liquefaction hazard screening (USGS, 2014c). These factors are as follows:

- Presence of young (Pleistocene) sands and silts with very low or no clay content, naturally deposited (beach or river deposits, windblown deposits) or man-made land (hydraulic fill, backfill).
- Soils must be saturated where the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that influences how tightly the particles themselves are pressed together. This is most commonly observed near bodies of water such as rivers, lakes, bays, and oceans, and the associated wetlands.
- Severe shaking. This is most commonly caused by a large earthquake. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other. This factor is limited by the distance from the large earthquake epicenter. That is, liquefaction potential decreases as location increases from the epicenter of a large earthquake.

No Pleistocene sands and silts were identified in the Project area (see Resource Report 7). While saturated soils are crossed by the pipeline alignment in some locations (see Resource Report 2), due to the relatively low seismic risk in the Project areas and low probability for severe ground shaking, the likelihood of soil liquefaction to occur in the Project area is low.

6.5.4 Landslides

Landslides occur when rock, sediments, soils, and debris move down steep slopes. Such gravity-induced flow is usually precipitated by heavy rains, erosion by rivers, earthquakes, or human activities (e.g., man-made structures or piles of rock or ore). Areas of unstable soils that may be susceptible to landslides may be characterized by soils which shrink or swell with changes in moisture content and are located in areas with steep relief. Portions of the H-650 pipeline will cross areas of steep slope. Mountain Valley identified areas potentially requiring steep slope construction through assessment of Lidar from Project flown imagery (April 2018). Mountain Valley is currently assessing the Lidar imagery and field verifying areas that may require steep slope construction. A table identifying potential locations of steep slopes crossed by the H-650 pipeline is provided in Appendix 6-F [*Note: Mountain Valley continues to assess steep slopes crossed by the pipeline alignment and proposed mitigation measures for steep slope construction. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*.

Landslide incidence and susceptibility mapping has been completed by the USGS for the Project areas and is presented on Figure 6-E in Appendix 6-A (USGS, 2016b). A review of this mapping indicates landslide incidence / susceptibility is high to moderate from MP 0.0 to MP 11.1 and is moderate from MP 11.1 to MP 72.6. *[Note: Mountain Valley continues to evaluate potential slope stability issues for the MVP Southgate Project. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*

6.5.5 Land Subsidence

Subsidence is the local downward movement of surface material with little or no horizontal movement. Common causes of land subsidence include dissolution of limestone in areas of karst terrain, over-pumping of groundwater aquifers, extraction of oil and gas from underground formations, and collapse of underground mines. Underground mining, oil and gas well production and large groundwater withdrawals were not identified in the Project areas. Karst terrain can increase the potential for land subsidence and is addressed in Section 6.5.1. *[Note: Mountain Valley continues to evaluate potential land subsidence for the MVP Southgate Project. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*

6.5.6 Flooding

Flash floods result from significant rapid increases in water volume and flow rate within waterbodies and onto adjacent floodplains. A flash flood follows heavy or excessive rainfall in a short period of time, generally less than 6 hours. They can occur within minutes or a few hours of excessive rainfall, based on the size of the rain event and/or contributing watershed after a levee or dam has failed (NWS, 2010). Flash floods are more common in the western United States, because the soil is generally dry, sandy, and unable to absorb large amounts of water in a short period of time. Heavy precipitation events can fill dry stream and river beds quickly, sending significant volumes of water downstream. Review of the National Weather Service Experimental Long-Range River Flood Risk map (NWS, 2018) for the Project areas indicates the following:

- There is a moderate (i.e., greater than 10 percent) long-range (July, August, September 2018) flood risk in the vicinity of the Project in Virginia; and,
- There is a less than 10 percent long-range (July, August, September 2018) flood risk in the vicinity of the Project in North Carolina.

Flooding can increase the buoyancy of pipelines, causing them to rise toward the land surface where they may be exposed. Buoyancy effects are probably of greatest concern in areas such as floodplains and river bottoms. To minimize the buoyancy effect upon the pipeline due to flooding in those areas, the pipeline will be designed with concrete coating, concrete weights or gravel-filled blankets, as applicable. In floodplain areas adjacent to waterbodies (see Resource Report 2), the topographic contours will be restored to as close to previously existing contours as practical such that there will be no net loss of flood storage capacity. Banks will be restored in accordance with the FERC (2013) Wetland and Waterbody Construction and Mitigation Procedures and the Project-Specific Erosion & Sediment Control Plan (see Resource Report 1, Appendix 1-G) to prevent scouring during rain events.

6.6 PALEONTOLOGICAL RESOURCES

In the Piedmont Province, fossils of dinosaur footprints, freshwater fish, and insects are found in rift basin deposits of the Triassic (William and Mary, 2015). Areas where fossils might be encountered along the pipeline alignment include shallow areas of sedimentary rock (see discussion of shallow bedrock in Section 6.3). Sedimentary rocks of Triassic age (i.e., sandstone, siltstone, and conglomerate) are generally present from approximate MP 0.0 to MP 1.2 and MP 15.0 to 18.8 in Pittsylvania County, Virginia and from MP 24.7 to MP 31.2 at the border of Pittsylvania County, Virginia and Rockingham County, North Carolina.

Elsewhere in the Project areas metamorphic rocks including granite, gneiss, and schist are present. However, these rocks are not expected to contain fossils.

In the vicinity of the Project, the Solite Quarry is known for a variety of insect fossils from the Triassic as well as preserved plant parts, fish, and reptiles. The Solite Quarry straddles the North Carolina-Virginia border approximately two miles west of Project alignment at MP 26.3. Fossils from the quarry are well preserved in lacustrine shales, mudstones, and sandstones in the Cow Branch Formation (William and Mary, 2018). No dinosaur body fossils have been found at the Solite Quarry; however, trace fossils indicate that dinosaurs were present in the area (Speights, 2018).

While a portion of the Project alignment crosses the Cow Branch Formation (MP 29.1 to MP 29.5 in Rockingham, North Carolina), depth to bedrock in this same area is anticipated to be greater than five feet (see Resource Report 7). Based on the depth to bedrock and the anticipated pipeline trench depth of eight to ten feet, paleontological resources are not anticipated to be excavated during Project construction. Although excavation of paleontological resources is not anticipated, Environmental Inspectors will be trained regarding response if suspected paleontological resources are identified during site preparation or trench excavation. Additionally, Mountain Valley will provide pre-construction training to the construction contractors on the procedures to be followed should an unanticipated paleontological discovery be made. Mountain Valley's Unanticipated Discovery Plan for Paleontological Resources is included in Appendix 6-G.

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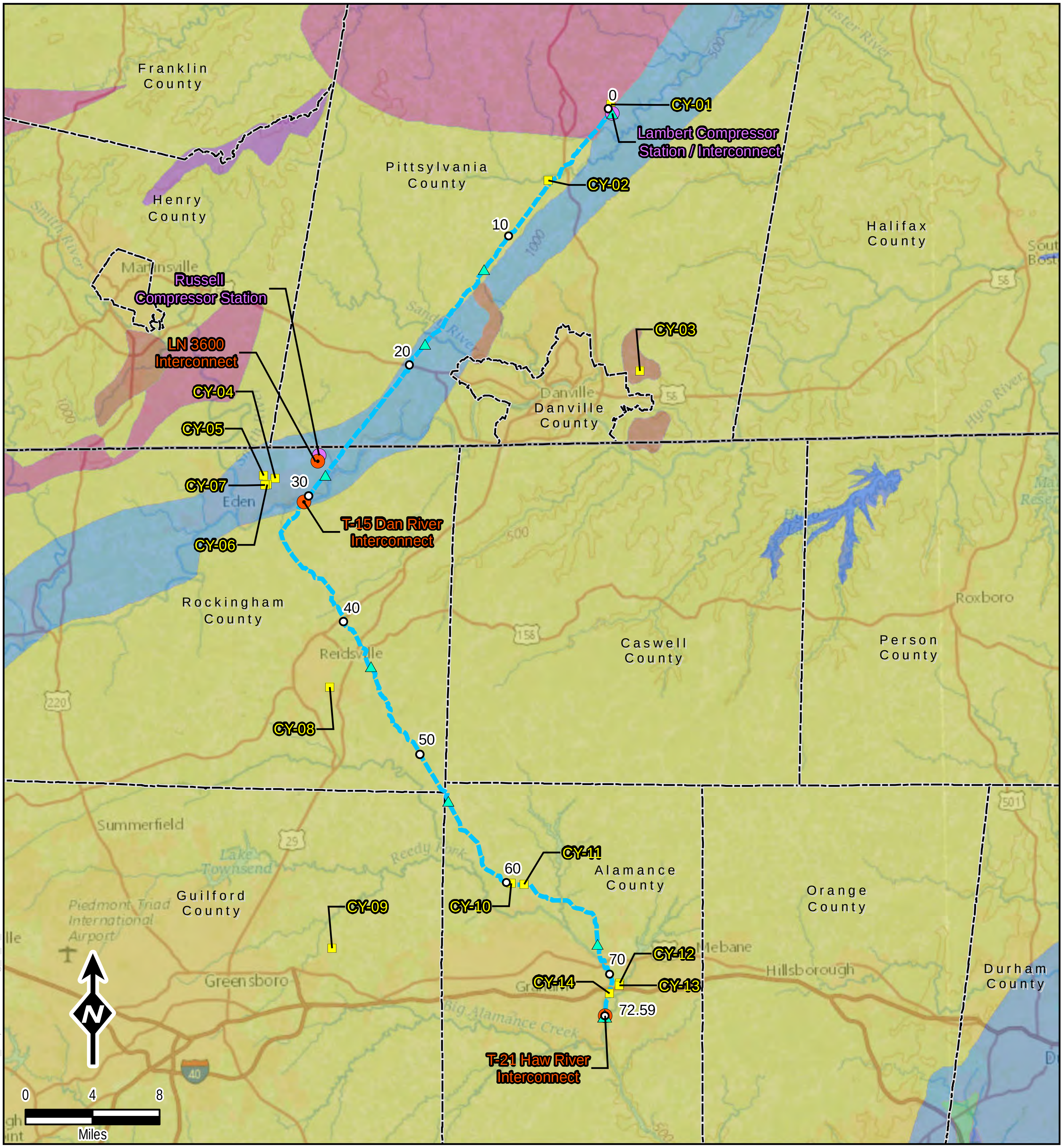
Appendix 6-A

Figures



Legend

- Mileposts
- Compressor Station
- Contract Yard
- Meter Station
- Valve Site
- Proposed Pipeline Route
- State Boundary
- County Boundary

Surficial Geology

- Alluvial sediments, thin
- Colluvial sediments, discontinuous
- Residual materials developed in alluvial sediments
- Residual materials developed in bedrock, discontinuous
- Residual materials developed in igneous and metamorphic rocks
- Residual materials developed in sedimentary rocks, discontinuous
- Water

1 inch = 8 miles
When Printed 8.5x11

Data Sources: ESRI, USGS, TRC, EQT

Mountain Valley PIPELINE LLC

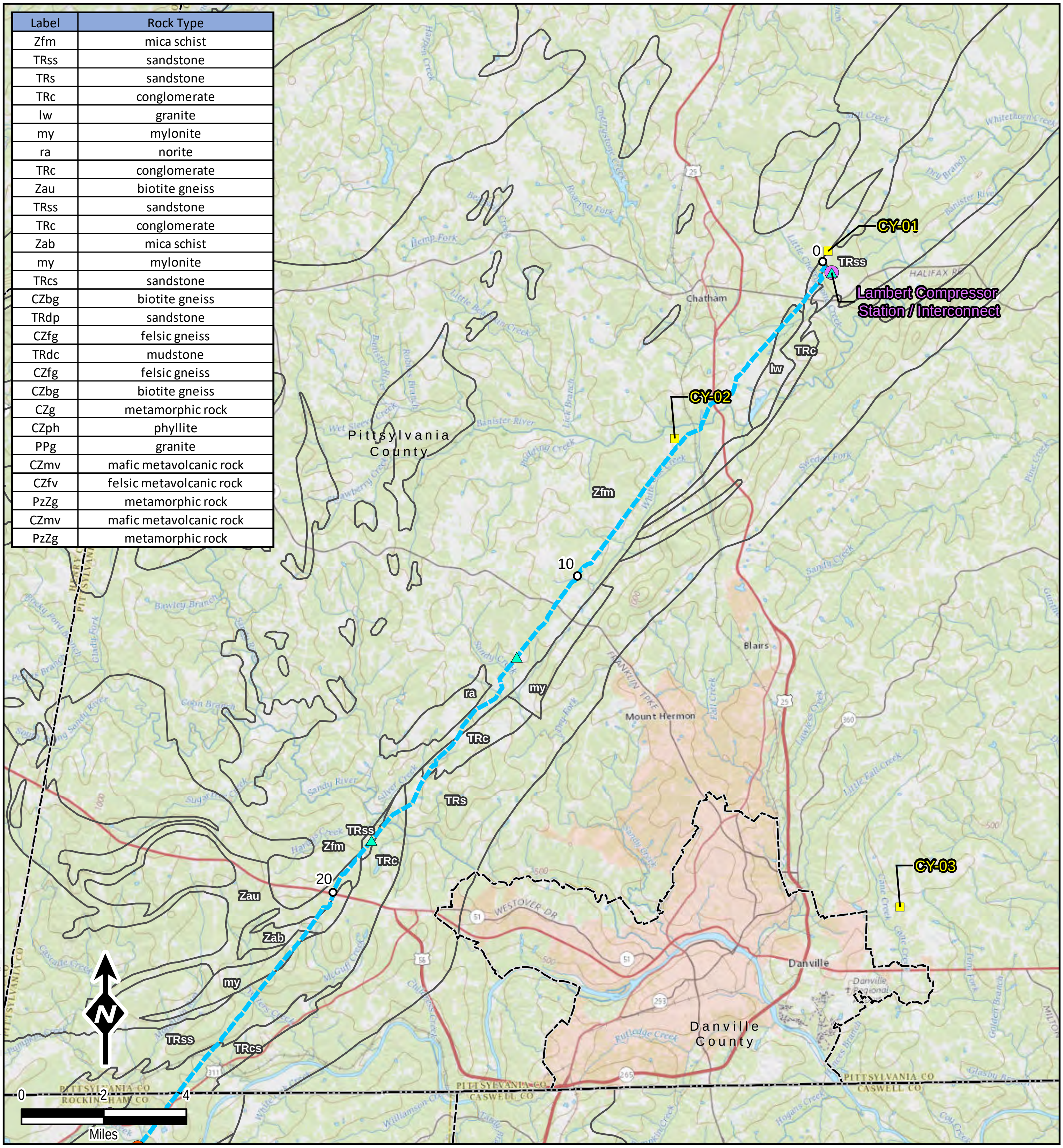
Figure 6-A

Surficial Geology of the MVP Southgate Project

TRC
600 Willowbrook Ln
West Chester, PA 19382

S:\1-PROJECTS\NEXTERA\300423_MVP_Southgate\6-MXD\Resource_Reports\RR6\Fig_6_A_Geo.mxd

Label	Rock Type
Zfm	mica schist
TRss	sandstone
TRs	sandstone
TRc	conglomerate
lw	granite
my	mylonite
ra	norite
TRc	conglomerate
Zau	biotite gneiss
TRss	sandstone
TRc	conglomerate
Zab	mica schist
my	mylonite
TRcs	sandstone
CZbg	biotite gneiss
TRdp	sandstone
CZfg	felsic gneiss
TRdc	mudstone
CZfg	felsic gneiss
CZbg	biotite gneiss
CZg	metamorphic rock
CZph	phyllite
PPg	granite
CZmv	mafic metavolcanic rock
CZfv	felsic metavolcanic rock
PzZg	metamorphic rock
CZmv	mafic metavolcanic rock
PzZg	metamorphic rock



Legend

- Mileposts
- Compressor Station
- Contract Yard
- Meter Station
- Valve Site
- Proposed Pipeline Route
- Bedrock Geology
- State Boundary
- County Boundary

Data Sources: ESRI, USGS, TRC, EQT

1 inch = 3.25 miles
When Printed 8.5x11

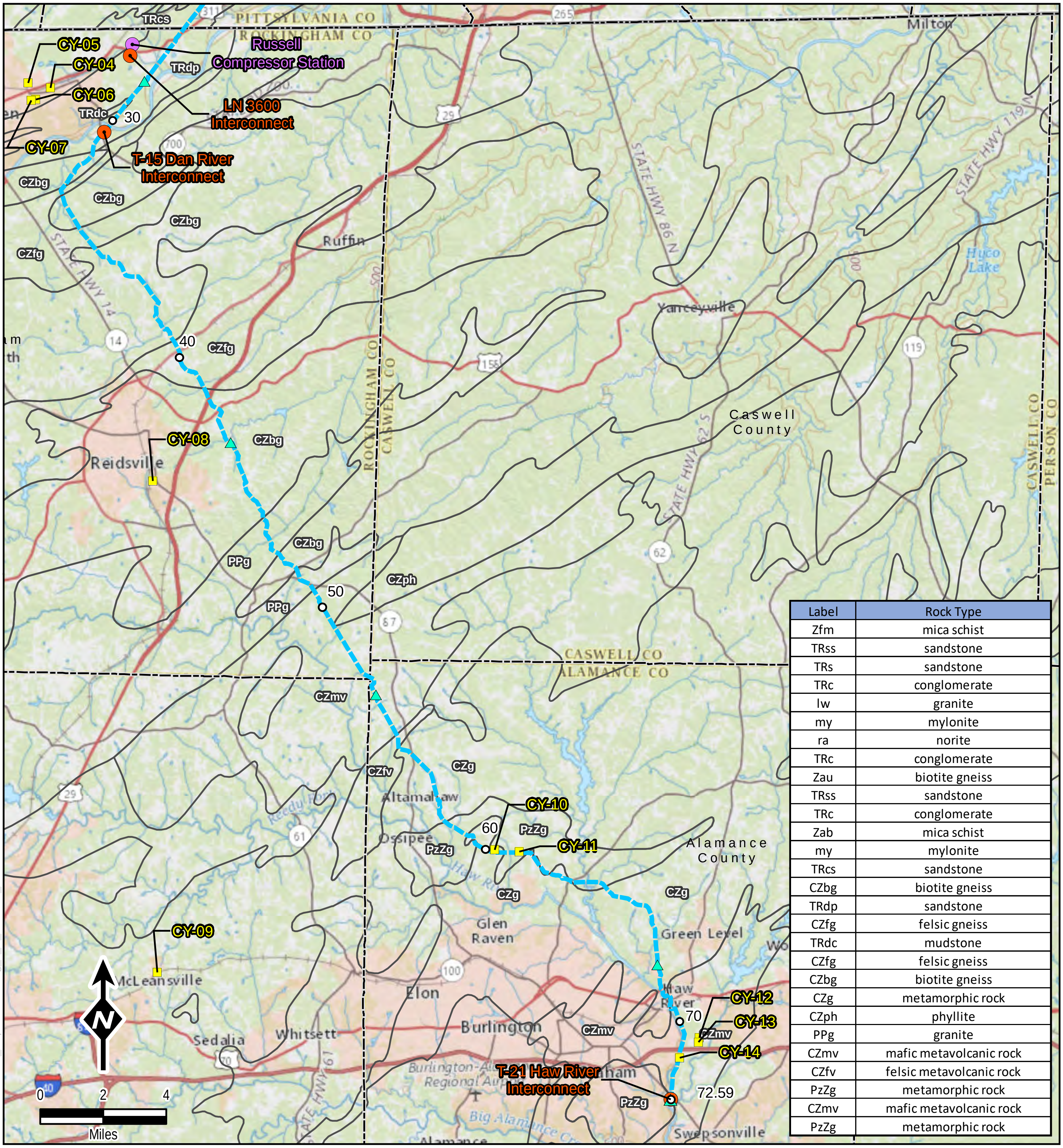
Mountain Valley PIPELINE LLC

Figure 6-B
Sheet 1 of 2

Bedrock Geology of the MVP Southgate Project

TRC
600 Willowbrook Ln
West Chester, PA 19382

S:\1-PROJECTS\NEXTERA\300423_MVP_Southgate\6-MXD\Resource_Reports\RR6\Fig_6_B_Bedrock_VA.mxd



Label	Rock Type
Zfm	mica schist
TRss	sandstone
TRs	sandstone
TRc	conglomerate
lw	granite
my	mylonite
ra	norite
TRc	conglomerate
Zau	biotite gneiss
TRss	sandstone
TRc	conglomerate
Zab	mica schist
my	mylonite
TRcs	sandstone
CZbg	biotite gneiss
TRdp	sandstone
CZfg	felsic gneiss
TRdc	mudstone
CZfg	felsic gneiss
CZbg	biotite gneiss
CZg	metamorphic rock
CZph	phyllite
PPg	granite
CZmv	mafic metavolcanic rock
CZfv	felsic metavolcanic rock
PzZg	metamorphic rock
CZmv	mafic metavolcanic rock
PzZg	metamorphic rock

Legend

- Mileposts
- Compressor Station
- Contract Yard
- Meter Station
- Valve Site
- Proposed Pipeline Route
- Bedrock Geology
- State Boundary
- County Boundary

1 inch = 4.25 miles
When Printed 8.5x11

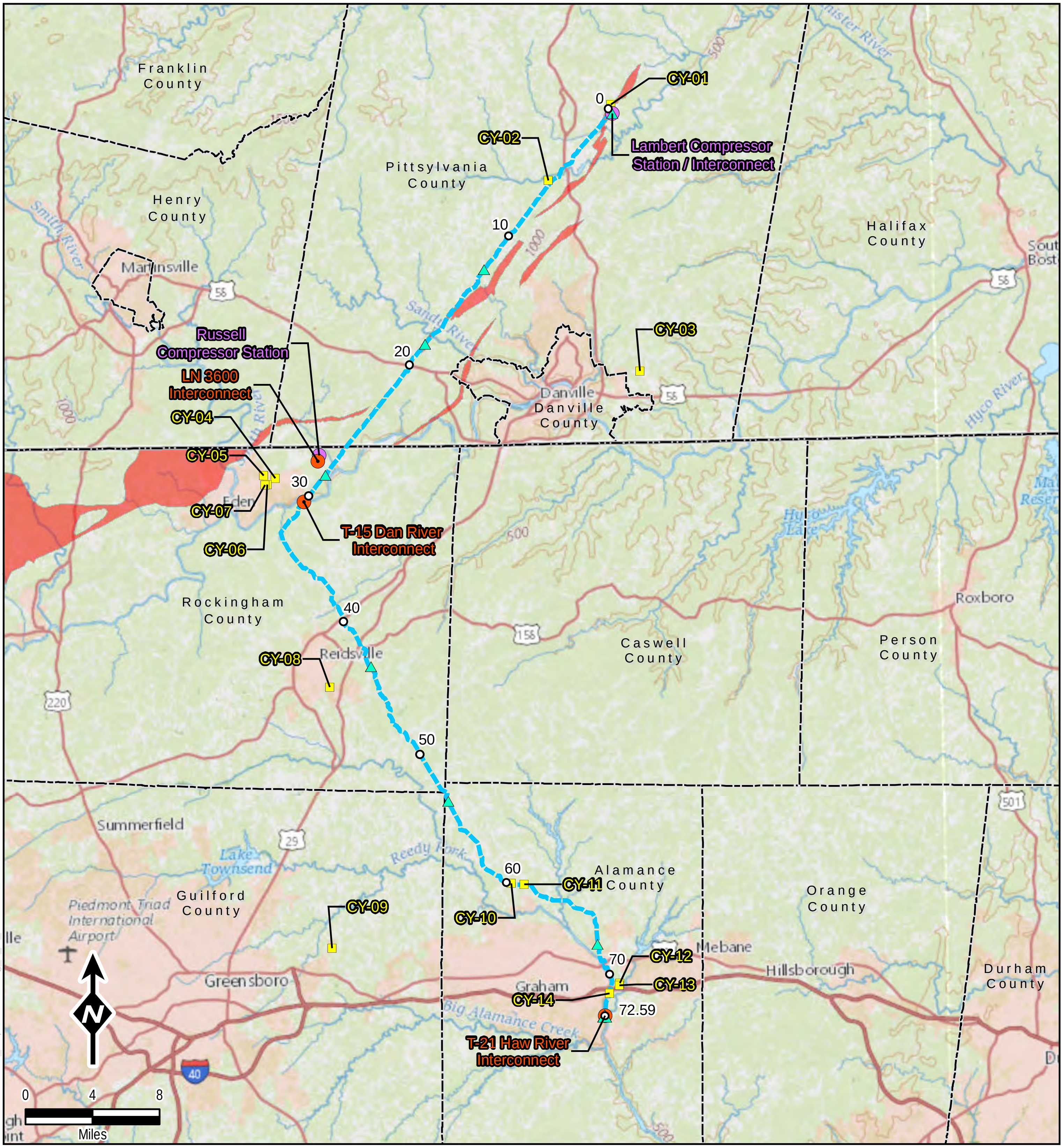
Data Sources: ESRI, USGS, TRC, EQT

Mountain Valley PIPELINE LLC

Figure 6-B
Sheet 2 of 2

Bedrock Geology of the MVP Southgate Project

TRC
600 Willowbrook Ln
West Chester, PA 19382



Legend

- Mileposts
- Compressor Station
- Contract Yard
- Meter Station
- Valve Site
- Karst Formations
- Proposed Pipeline Route
- State Boundary
- County Boundary

1 inch = 8 miles
When Printed 8.5x11

Data Sources: ESRI, USGS, TRC, EQT

Mountain Valley PIPELINE LLC

Figure 6-C

Karst Material of the
MVP Southgate Project

TRC
600 Willowbrook Ln
West Chester, PA 19382

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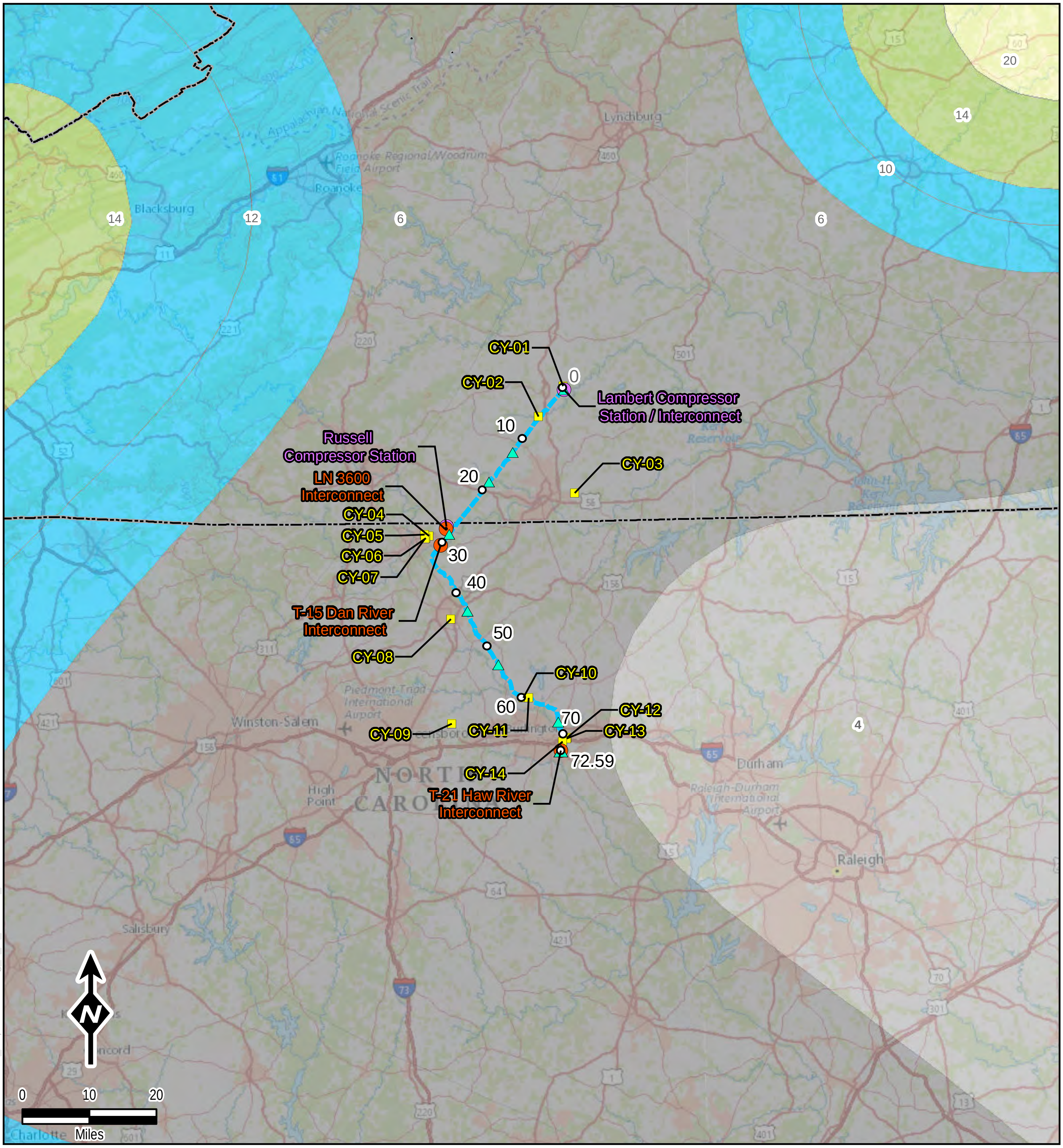
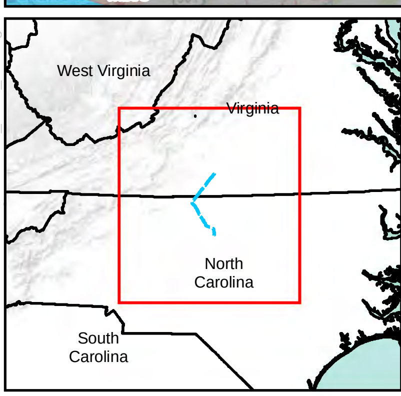




Legend

- Mileposts
- Compressor Station
- Contract Yard
- Meter Station
- Valve Site
- Proposed Pipeline Route
- State Boundary

Peak Acceleration - Expressed as a percent of standard gravity (g)

0	2	4	6	10	14	20	30	40	80

1 inch = 20 miles
When Printed 8.5x11

Data Sources: ESRI, USGS, TRC, EQT

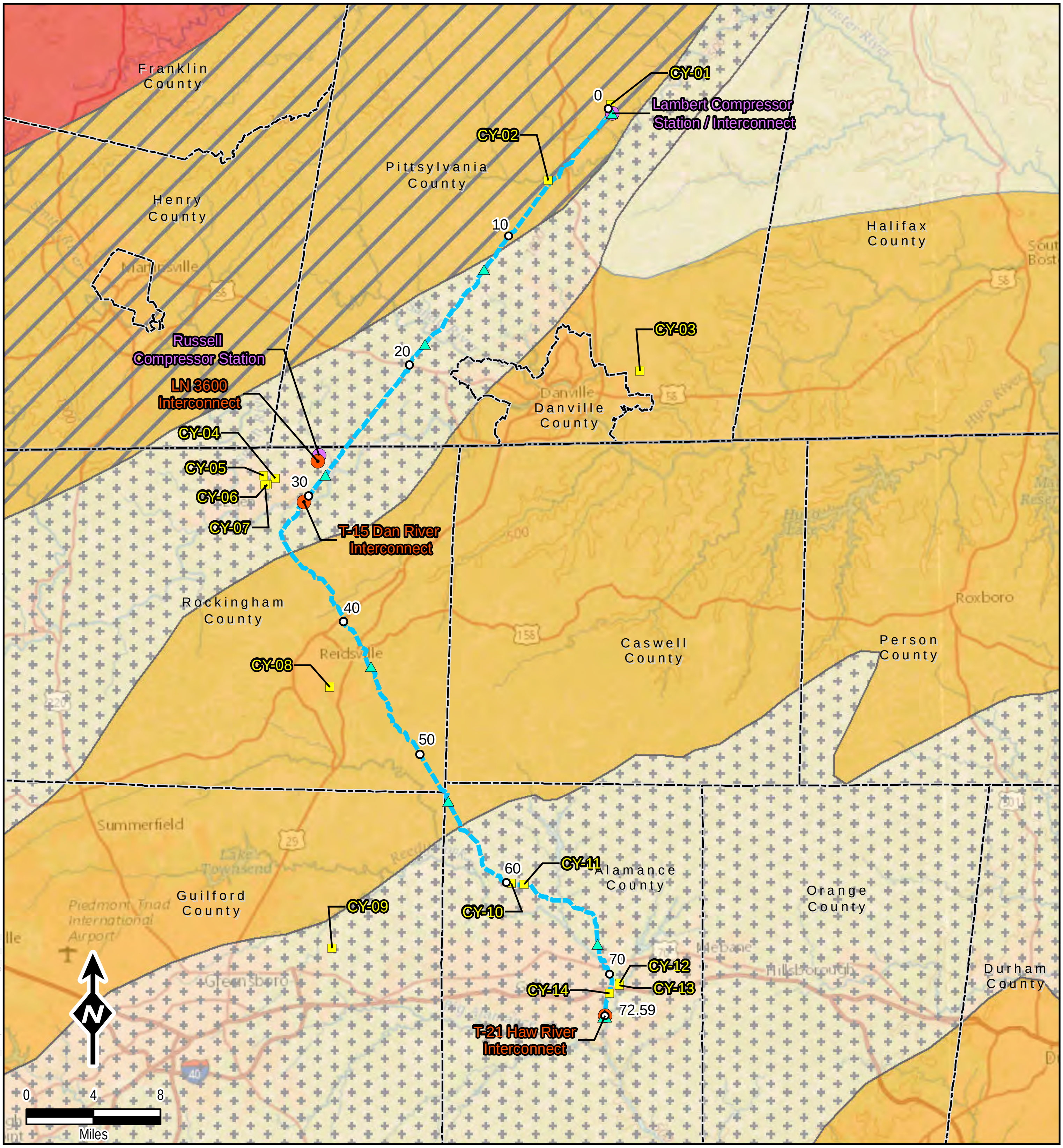
Mountain Valley PIPELINE LLC

Figure 6-D

Seismic Hazard Map of the
MVP Southgate Project
2% Probability of Exceedance in 50 years

TRC
600 Willowbrook Ln
West Chester, PA 19382

S:\1-PROJECTS\NEXTERA\300423_MVP_Southgate\6-MXD\Resource_Reports\RR6\Fig_6_D_Seismic_.mxd



Legend

- Mileposts
- Compressor Station
- Contract Yard
- Meter Station
- Valve Site
- Proposed Pipeline Route
- State Boundary
- County Boundary

Landslide Incidence

- High Landslide Indicence (Greater than 15% of Area Involved)
- Moderate Landslide Indicence (1.5% - 15% of Area Involved)
- Low Landslide Indicence (Less than 1.5% of Area Involved)

Landslide Susceptibility

- High
- Moderate

Data Sources: ESRI, USGS, TRC, EQT

1 inch = 8 miles
When Printed 8.5x11

Mountain Valley PIPELINE LLC

Figure 6-E

Landslide Hazard Map of the MVP Southgate Project

TRC
600 Willowbrook Ln
West Chester, PA 19382

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MVP Southgate Project

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Appendix 6-B

Bedrock Geology in the MVP Southgate Project Areas

Table 6-B

Bedrock Geology in the MVP Southgate Project Areas

Project Facilities	From Milepost	To Milepost	Formation Name	Primary Rock Type	Secondary Rock Type	Map Symbol
Pipeline Facilities						
H-650 Pipeline	0.00	0.05	Upper Triassic	sandstone	siltstone	TRss
	0.05	0.38	Upper Triassic	conglomerate		TRc
	0.38	0.60	Upper Triassic	sandstone	siltstone	TRss
	0.60	1.17	Upper Triassic	conglomerate		TRc
	1.17	1.42	Proterozoic Z-Cambrian	mica schist	gneiss	CAZfm
	1.42	2.07	Cambrian	granite		CAlw
	2.07	15.02	Proterozoic Z-Cambrian	mica schist	gneiss	CAZfm
	15.02	16.32	Upper Triassic	conglomerate		TRc
	16.32	17.24	Upper Triassic	sandstone		TRs
	17.24	18.14	Upper Triassic	sandstone	siltstone	TRss
	18.14	18.81	Upper Triassic	conglomerate		TRc
	18.81	20.24	Proterozoic Z	biotite gneiss	amphibolite	Zau
	20.24	20.39	Proterozoic Z-Cambrian	mica schist	amphibolite	CAZab
	20.39	20.76	Proterozoic Z	biotite gneiss	amphibolite	Zau
	20.76	21.21	Proterozoic Z-Cambrian	mica schist	amphibolite	CAZab
	21.21	22.50	Proterozoic - Paleozoic	mylonite	gneiss	my
	22.50	24.69	Upper Triassic	sandstone	siltstone	TRss
	24.69	26.26	Triassic	sandstone	siltstone	TRcs
	26.26	29.12	Triassic	sandstone	mudstone	TRdp
	29.12	29.53	Triassic	mudstone	sandstone	TRdc
	29.53	31.21	Triassic	sandstone	mudstone	TRdp
	31.21	32.74	Cambrian / Late Proterozoic	biotite gneiss	mica schist	CZbg
	32.74	33.03	Cambrian / Late Proterozoic	felsic gneiss	mafic gneiss	CZfg
	33.03	34.20	Cambrian / Late Proterozoic	biotite gneiss	mica schist	CZbg
	34.20	35.02	Cambrian / Late Proterozoic	felsic gneiss	mafic gneiss	CZfg
	35.02	39.40	Cambrian / Late Proterozoic	biotite gneiss	mica schist	CZbg
	39.40	41.37	Cambrian / Late Proterozoic	felsic gneiss	mafic gneiss	CZfg
	41.37	46.23	Cambrian / Late Proterozoic	biotite gneiss	mica schist	CZbg
	46.23	47.63	Permian / Pennsylvanian	granite		PPg

Table 6-B

Bedrock Geology in the MVP Southgate Project Areas

Project Facilities	From Milepost	To Milepost	Formation Name	Primary Rock Type	Secondary Rock Type	Map Symbol
	47.63	48.43	Cambrian / Late Proterozoic	biotite gneiss	mica schist	CZbg
	48.43	49.36	Permian / Pennsylvanian	granite		PPg
	49.36	50.64	Cambrian / Late Proterozoic	mafic metavolcanic rock	felsic metavolcanic rock	CZmv
	50.64	50.70	Cambrian / Late Proterozoic	phyllite	schist	CZph
	50.70	54.85	Cambrian / Late Proterozoic	mafic metavolcanic rock	felsic metavolcanic rock	CZmv
	54.85	55.27	Cambrian / Late Proterozoic	felsic metavolcanic rock	mafic metavolcanic rock	CZfv
	55.27	58.35	Cambrian / Late Proterozoic	metamorphic rock		CZg
	58.35	59.17	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
	59.17	59.51	Cambrian / Late Proterozoic	metamorphic rock		CZg
	59.51	59.65	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
	59.65	60.57	Cambrian / Late Proterozoic	metamorphic rock		CZg
	60.57	61.34	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
	61.34	61.56	Cambrian / Late Proterozoic	metamorphic rock		CZg
	61.56	61.61	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
	61.61	61.88	Cambrian / Late Proterozoic	metamorphic rock		CZg
	61.88	62.37	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
	62.37	63.04	Cambrian / Late Proterozoic	metamorphic rock		CZg
	63.04	64.28	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
	64.28	68.90	Cambrian / Late Proterozoic	metamorphic rock		CZg
	68.90	72.51	Cambrian / Late Proterozoic	mafic metavolcanic rock	felsic metavolcanic rock	CZmv
	72.51	72.59	Paleozoic / Late Proterozoic	metamorphic rock		PzZg
Aboveground Facilities						
Lambert Compressor Station / Interconnect / Mainline valve	0.2 mile east of MP 0.3		Upper Triassic	sandstone	siltstone	TRss

Table 6-B

Bedrock Geology in the MVP Southgate Project Areas

Project Facilities	From Milepost	To Milepost	Formation Name	Primary Rock Type	Secondary Rock Type	Map Symbol
Russell Compressor Station	1.2 miles west of MP 26.9		Triassic	sandstone	mudstone	TRdp
			Triassic	mudstone	sandstone	TRdc
LN 3600 Interconnect	1.1 miles west of MP 27.4		Triassic	sandstone	mudstone	TRdp
T-15 Dan River Interconnect	30.5		Triassic	sandstone	mudstone	TRdp
T-21 Haw River Interconnect / Mainline valve	72.6		Paleozoic / Late Proterozoic	metamorphic rock		PzZg
Mainline valve	12.5		Proterozoic Z-Cambrian	mica schist	gneiss	CAZfm
Mainline valve	18.4		Upper Triassic	conglomerate		TRc
Mainline valve	28.4		Triassic	sandstone	mudstone	TRdp
Mainline valve	43.4		Cambrian / Late Proterozoic	biotite gneiss	mica schist	CZbg
Mainline valve	53.4		Cambrian / Late Proterozoic	mafic metavolcanic rock	felsic metavolcanic rock	CZmv
Mainline valve	67.7		Cambrian / Late Proterozoic	metamorphic rock		CZg
Source: USGS, 2018						

MVP Southgate Project

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Appendix 6-C

Geotechnical Investigations
[*Not Included with this Draft*]

MVP Southgate Project

Docket No. PF18-4-000

Draft Resource Report 6

Appendix 6-D

Project Blasting Plan
[*Not Included with this Draft*]

MVP Southgate Project

Docket No. PF18-4-000

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Appendix 6-E

Historical Earthquakes within 50 Miles of the MVP Southgate Project

Table 6-E

Historical Earthquakes within 50 Miles of the MVP Southgate Project

Facility	Distance from Route/ Facility (miles)	Date of Earthquake	Magnitude of Earthquake	Location of Earthquake
Pipeline Facilities				
H-650 Pipeline	6	1978-02-25	2.7	Virginia-North Carolina border region
	31	1981-03-04	2.8	North Carolina
	21	1993-07-12	2.7	Virginia-North Carolina border region
	42	2006-10-17	2.6	7 kilometers south of Winston-Salem, North Carolina
	44	2006-10-17	1.5	5 kilometers west, southwest of Winston-Salem, North Carolina
	44	2006-10-18	1.3	5 kilometers west of Winston-Salem, North Carolina
	44	2006-10-18	2.4	Virginia-North Carolina border region
	44	2006-11-03	2.5	5 kilometers south, southwest of Winston-Salem, North Carolina
	41	2008-08-18	2.7	2 kilometers north, northeast of Cave Spring, Virginia
	46	2009-05-16	3.0	Virginia
Aboveground Facilities				
Lambert Compressor Station / Interconnect / Mainline valve	42	1000-08-18	2.7	Virginia
Russell Compressor Station	31	1978-02-25	2.7	Virginia-North Carolina border region
LN 3600 Interconnect	28.0	1978-02-25	2.7	Virginia-North Carolina border region
T-15 Dan River Interconnect	30	1978-02-25	2.7	Virginia-North Carolina border region
T-21 Haw River Interconnect / Mainline Valve	11	1978-02-25	2.7	Virginia-North Carolina border region
Mainline valve (MP 12.5)	36	1978-02-25	2.7	Virginia-North Carolina border region
Mainline valve (MP 18.4)	33	1978-02-25	2.7	Virginia-North Carolina border region
Mainline valve (MP 28.4)	30	1978-02-25	2.7	Virginia-North Carolina border region
Mainline valve (MP 43.4)	21	1978-02-25	2.7	Virginia-North Carolina border region
Mainline valve (MP 53.4)	13	1978-02-25	2.7	Virginia-North Carolina border region
Mainline valve (MP 67.7)	7	1978-02-25	2.7	Virginia-North Carolina border region

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Appendix 6-F

Potential Areas of Steep Slopes Crossed by the MVP Southgate Project H-650 Pipeline

Table 6-F

Potential Areas of Steep Slopes Crossed by the MVP Southgate Project H-650 Pipeline a/

Milepost Begin	Milepost End	Length crossed (feet)	Proposed Mitigation Measures
8.8	8.8	136	TBD
17.4	17.4	102	TBD
17.9	17.9	155	TBD
20.5	20.5	175	TBD
21.6	21.7	181	TBD
22.6	22.6	128	TBD
22.9	23.0	318	TBD
25.3	25.3	105	TBD
29.5	29.5	354	TBD
30.9	30.9	122	TBD
31.1	31.1	172	TBD
31.1	31.1	107	TBD
31.4	31.4	143	TBD
31.7	31.8	129	TBD
31.9	32.0	216	TBD
32.0	32.0	104	TBD
32.5	32.6	105	TBD
32.6	32.6	180	TBD
32.6	32.7	164	TBD
32.7	32.7	135	TBD
33.2	33.2	152	TBD
33.8	33.9	158	TBD
34.0	34.0	122	TBD
34.3	34.3	132	TBD
34.7	34.7	152	TBD
35.2	35.3	146	TBD
35.4	35.4	144	TBD
37.1	37.1	116	TBD
42.6	42.7	126	TBD
44.1	44.1	100	TBD
44.2	44.3	151	TBD
44.6	44.6	133	TBD
45.9	45.9	166	TBD
47.0	47.0	149	TBD
47.4	47.5	139	TBD
47.5	47.5	260	TBD

Table 6-F

Potential Areas of Steep Slopes Crossed by the MVP Southgate Project H-650 Pipeline a/

Milepost Begin	Milepost End	Length crossed (feet)	Proposed Mitigation Measures
47.7	47.7	191	TBD
47.7	47.8	212	TBD
47.8	47.9	101	TBD
48.1	48.2	146	TBD
71.4	71.4	153	TBD
71.5	71.5	151	TBD
72.1	72.1	105	TBD
72.3	72.3	114	TBD

a/ Potential steep slope areas identified from LiDAR flown for the Project on April 1, 2018 [*Note: Mountain Valley continues to assess steep slopes crossed by the pipeline alignment and proposed mitigation measures for steep slope construction. Additional information will be provided in the final Resource Reports included with the Certificate application expected to be filed in November 2018.]*

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Appendix 6-G

Unanticipated Discovery Plan for Paleontological Resources for the MVP Southgate Project

Appendix 6-G

Unanticipated Discovery Plan for Paleontological Resources

MVP Southgate Project

FERC Docket No. PF18-4-000

August 2018

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1.0 INTRODUCTION

Mountain Valley Pipeline, LLC ("Mountain Valley") plans to construct an approximately 72-mile long natural gas pipeline ("MVP Southgate Project" or "Project") and associated aboveground facilities in Virginia and North Carolina. The Project is entirely situated in the Piedmont Uplands Section of the Piedmont Physiographic Province. Most of the Piedmont bedrock is composed of igneous and metamorphic rocks, which are generally buried under a thick (6 to 65 feet) blanket of weathered rock that has formed clay-rich soils, and outcrops are commonly restricted to stream valleys where the soil layer has been removed by erosion.

Although fossils are generally rare in the Piedmont, fossils of dinosaur footprints, freshwater fish, and insects are found in Triassic period rift basin deposits. Areas where fossils might be encountered along the pipeline alignment include shallow areas of Triassic-age sedimentary rock, which are generally present from approximate MP 0.0 to MP 1.2 and MP 15.0 to 18.8 in Pittsylvania County, Virginia and from MP 24.7 to MP 31.2 at the border of Pittsylvania County, Virginia and Rockingham County, North Carolina. The igneous to metamorphic rocks found elsewhere along the Project are not expected to contain fossils.

This *Unanticipated Discovery Plan for Paleontological Resources* ("Plan") has been developed to establish procedures in the event of unanticipated discoveries of paleontological resources, and summarizes the efforts Mountain Valley will employ to recognize and manage any significant fossils that may be encountered during construction.

2.0 STATE AND FEDERAL PALEONTOLOGICAL LAWS

There are no State or Federal Paleontological laws governing this plan. The Project does not cross State or Federal lands, and neither Federal (The Paleontological Resources Preservation Act [16 U.S.C. § 470]))], North Carolina (https://www.ncleg.net/gascripts/statutes/Statutes.asp), nor Virginia (https://law.lis.virginia.gov/vacode) laws govern the discovery of fossils on private lands.

3.0 UNANTICIPATED DISCOVERIES OF PALEONTOLOGICAL RESOURCES

Mountain Valley is aware that fossil remains may be encountered during construction of the Project facilities. Prior to construction, Mountain Valley will address paleontological resources as part of the environmental training provided to all Mountain Valley personnel. This training will address the nature of paleontological resources and best management practices if paleontological materials are inadvertently discovered during construction. Project personnel will be trained to notify the Environmental Inspector ("EI") if an unanticipated discovery occurs. In addition, the training will include a discussion of the policy prohibiting the collection of paleontological resources.

The following steps will to be followed in the event an unanticipated discovery of paleontological materials is made during Project construction:

1 The Contractor will immediately notify the Lead Environmental Inspector ("EI") (or Chief Inspector, if the EI is not immediately available) of an unanticipated discovery.

2 In the event of a discovery of non-vertebrate fossils, all activities can continue in and around the discovery site while notification is made. In the event of an unanticipated discovery of vertebrate fossils (including bones, teeth, or footprints), the Lead EI or Chief Inspector will

issue a *Stop Task Order* to the Contractor's Site Foreman to ensure that the activity within 100 feet of the unanticipated discovery ceases.

3 The Mountain Valley Environmental Manager, Lead EI, or a representative designated by these individuals will then notify an on-call professional paleontologist retained by Mountain Valley. Within 24 hours of notification, the paleontologist will examine the find, evaluate its significance, and determine if additional mitigation (collection and curation) are applicable.

4 If based on that inspection the paleontologist determines that the discovery is not of scientific significance, the paleontologist will report that determination to the Lead EI. The Lead EI will document that determination and notify the Chief Inspector to resume work.

5 If the paleontologist determines that the find is of scientific significance, he/she will inform Mountain Valley, the Lead EI, and the Chief Inspector of that determination.

a. Within 24 hours of that determination, Mountain Valley will notify the FERC of that determination. Work within the flagged or fenced off discovery location will not resume until authorized by the FERC.

b. In consultation with staff of the Virginia Division of Geology and Mineral Resources or the North Carolina Museum of Natural Sciences, as appropriate, the paleontologist shall then develop an appropriate plan for documentation and recovery of the find. Upon authorization by the FERC, Mountain Valley will implement the documentation and recovery plan.

All paleontological materials of scientific significance discovered during construction will be recorded using methods consistent with modern professional paleontology standards, and scientifically significant vertebrate fossils will be collected and curated into an approved museum or academic repository. Notwithstanding, if paleontological resources are in imminent danger of destruction, Mountain Valley will, without delay, apply prudent methods to preserve as much paleontological information as possible. Such salvage activities will follow standard paleontological procedures as much as possible, but human safety concerns or the immediacy of the threat to the paleontological resource may require less exact methods of material extraction, including rapid shovel excavation or use of backhoes or other heavy equipment.

c. At the conclusion of the work, a meeting or site visit may be held with the FERC, Mountain Valley, the paleontologist, and the relevant state professional staff to review the results of the work accomplished.

d. Upon receiving authorization from the FERC, the Lead EI and Chief Inspector will grant clearance to the construction team to resume work.

4.0 CONTACTS

FEDERAL AGENCY CONTACT	
Federal Energy Regulatory Commission Amanda Mardiney Office of Energy Projects 888 First Street, NE RM 62-30 Route Code PJ-11.2 Washington, D.C. 20426-0002 Tel: (202) 502-8081 Email: amardiney@ferc.gov	
STATE AGENCY CONTACTS	
Virginia	
Virginia Department of Mines, Minerals, and Energy **Division of Geology and Mineral Resources** 900 Natural Resources Drive, Ste. 500 Charlottesville, VA 22903 Tel: (434) 951-6341 Email: dgmrinfo@dmme.virginia.gov	
North Carolina	
North Carolina Museum of Natural Sciences **Paleontology Research Laboratory** 121 W. Jones Street Raleigh, NC 27601 Tel: (919) 707-8279 Email: lindsay.zanno@naturalsciences.org	