PennEast Pipeline Company, LLC
One Meridian Boulevard, Suite 2C01
Wyomissing, PA 19610

March 31, 2016

Ms. Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: PennEast Pipeline Company, LLC, Docket No. CP15-558-000
Second Supplemental Response to November 24, 2015 Environmental Information Request
OEP/DG2E/Gas 2

Dear Ms. Bose:

On November 24, 2015, the Federal Energy Regulatory Commission (FERC or Commission) issued an Environmental Information Request (November Data Request) to the PennEast Pipeline Company, LLC (PennEast) related to the above-referenced proceeding. PennEast provided responses to a majority of items contained in the November Data Request on December 14, 2015 (December Data Response) and on March 25, 2016 (First Supplemental Data Response), and noted in certain responses that it would provide additional information by the end of the first quarter of 2016 in a supplemental filing.

PennEast hereby submits its second supplemental response to the Commission's November Data Request and provides attachments herewith. The attachments address and incorporate, when relevant, the information reflected in the updated alignment sheets that PennEast has provided to FERC at this time.

To date, PennEast has provided responses to the majority of the Commission's November Data Request and is working diligently to provide the Commission with the remaining information and materials according to the schedule provided in the December Data Response.

Pursuant to Section 385.2010 of the Commission's regulations, 18 C.F.R. § 385.2010 (2015), PennEast is contemporaneously serving copies of this transmittal letter and the supplemental narrative responses to persons whose names appear on the Official Service List in this proceeding. Due to the size of the attachments to this filing, PennEast is not serving the attachments to the persons on the Official Service List. PennEast will provide the attachments to those persons upon request.

Should you have any questions concerning this filing, please contact me at (610) 406-4322.

Sincerely,
/s/ Anthony C. Cox
Anthony C. Cox
PennEast Pipeline Company, LLC,
By its Project Manager
UGI Energy Services, LLC

cc: Medha Kochhar (FERC)

VERIFICATION

THE STATE OF PENNSYLVANIA)
)
COUNTY OF BERKS)

Anthony C. Cox, being first duly sworn, states that he is the Project Manager for PennEast Pipeline Company, LLC; that he is authorized to execute this Verification; that he has reviewed the second supplemental responses to the November 24, 2015 Data Request in Docket No. CP15-558-000; and that after reasonable diligence and review, the information provided in such responses constitutes a complete and accurate response to the best of his knowledge, information and belief.

PennEast Pipeline Company, LLC,
By: UGI Energy Services, LLC
Its Project Manager

Anthony C. Cox
Project Manager

Subscribed and sworn to before me this 31st day of March, 2016.

Notary Public,
State of Pennsylvania

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
Marisue Good, Notary Public
Spring Twp., Berks County
My Commission Expires March 7, 2020
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

My Commission Expires:

3/7/20

ENVIRONMENTAL INFORMATION REQUEST

Data Request 70

As described in Section 6.3.4, the results of a geophysical study completed Hager-Richter included a recommendation that PennEast complete additional electrical resistivity imaging (ERI) at a number of locations, including possible karst impacted areas. Provide the results of these additional studies, or a schedule for when these will be completed and filed with FERC.

Second Supplemental Response 70

In PennEast's First Supplemental Response to Data Request 70, PennEast provided a "Terrain Mapping and Geohazard Risk Evaluation" report as Attachment 7 to the First Supplemental Data Response. The "Terrain Mapping and Geohazard Risk Evaluation" report identifies, categorizes, and evaluates the geological hazards within the vicinity of the proposed pipeline alignment. The report discussed the initial ERI survey results available prior to September 2015, which were reflected in the report titled "Interim Report: Electrical Resistivity Imaging Survey Karst Investigation" prepared by Hager-Richter Geoscience, Inc. dated September 2015 and filed as Attachment F of Appendix O to PennEast's Resource Reports. From September 2015 through March 1, 2016, Hager-Richter Geoscience, Inc. conducted additional ERI surveys and prepared a second interim report, which is titled "Draft Interim Report 2: Electrical Resistivity Imaging Survey Karst Investigation," dated March 2016, and provided herein as Attachment 1.

As noted in its First Supplemental Data Response, PennEast was unable to conduct ERI surveys at a number of additional identified parcels due to a lack of survey permission. Upon receiving the necessary access to these parcels, PennEast will complete ERI surveys at the remaining parcels and provide the results of those studies to FERC when complete.

Data Request 72

PennEast states that it is developing a Karst Mitigation Plan to address any potential impacts and hazards from karst features. Provide a copy of the Karst Mitigation Plan, or provide a schedule for when the plan will be filed with FERC. The plan should address the following:

a. measures to identify areas of known or potential karst;
b. avoidance, minimization and mitigation measures for sinkholes and caves within 200 feet of the pipeline centerline;
c. best management practices to prevent contamination of groundwater and karst systems from run-off from within and off the ROW toward a karst feature;
d. pre- and post-construction monitoring of water quality and yield of wells and springs used for domestic supplies within 150 feet of the ROW;
e. identify the construction set-back from wells, springs, and karst surface expressions;
f. blasting in karst terrain, and potential impact on wells and springs;
g. equipment storage, fueling, and maintenance procedures;
h. procedures in the event of an unanticipated discovery of karst features during construction; and
i. description of measures that would be implemented to repair or mitigate the development of a sinkhole in proximity to the pipeline, and the monitoring of these features during Project operation.

Supplemental Response 72

An interim Karst Mitigation Plan is provided herein as Attachment 2. PennEast was unable to conduct karst studies at a number of parcels due to a lack of survey permission. Upon receiving the necessary access to these parcels, PennEast will complete surveys at the remaining parcels and provide a finalized Karst Mitigation Plan to FERC when complete.

Attachment 1

Draft Interim Report 2: Electrical Resistivity Imaging Survey and Karst Investigation for the PennEast Pipeline Project

HAGER-RICHTER
GEOSCIENCE, INC.

DRAFT
INTERIM REPORT 2

ELECTRICAL RESISTIVITY IMAGING SURVEY
KARST INVESTIGATION
PENNEAST PIPELINE PROJECT
CARBON, NORTHAMPTON, & BUCKS COUNTIES, PENNSYLVANIA AND HUNTERDON COUNTY, NEW JERSEY

Data Acquired between September 1, 2015 and March 1, 2016

Prepared for:

PennEast Pipeline Company, LLC
1 Meridian Blvd. 2C01
Reading, Pennsylvania 19610

Prepared by:

Hager-Richter Geoscience, Inc.
8 Industrial Way - D10
Salem, New Hampshire 03079

File 15JCC19
March, 2016

HAGER-RICHTER
GEOSCIENCE, INC.

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8 INDUSTRIAL WAY - D10
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March 24, 2016
File 15JCC19

Jeffrey England
Project Manager
PennEast Pipeline Company, LLC
1 Meridian Blvd. 2C01
Reading, Pennsylvania 19610

Tel: 610-568-1360
Email: JEngland@ugies.com

RE: *Draft Interim Report 2*
Electrical Resistivity Imaging Survey
Karst Investigation
PennEast Pipeline Project
Carbon, Northampton & Bucks Counties, PA
and Hunterdon County, NJ

Dear Mr. England:

In this draft report, we summarize the interim results of an electrical resistivity imaging survey being conducted by Hager-Richter Geoscience, Inc. (Hager-Richter) along portions of the proposed alignment of the PennEast Pipeline Project located in Carbon, Northampton, and Bucks Counties in Pennsylvania, and Hunterdon County in New Jersey for PennEast Pipeline Company, LLC (PPC). A previous Interim Report (Interim Report 1) for the project was submitted to PPC on September 21, 2015.[1] This Interim Report (Interim Report 2) provides the results of electrical resistivity imaging data acquired for the project between September 1, 2015 and March 1, 2016. The scope of work and areas of interest for the project were specified by PPC.

INTRODUCTION

The proposed alignment of the PennEast Pipeline Project extends through areas that have been identified as at risk for ground subsidence associated with karst conditions. The karst impacted areas include sections of the alignment in Northampton, and Bucks Counties in Pennsylvania, and Hunterdon County in New Jersey and total approximately 14.4 miles of the proposed alignment. PPC required an electrical resistivity imaging (ERI) survey along selected portions of the alignment to evaluate the subsurface conditions where ground subsidence

[1] Hager-Richter Report entitled "Interim Report, Electrical Resistivity Imaging Survey, Karst Investigation, Penneast Pipeline Project, Carbon, Northampton, & Bucks Counties, Pennsylvania and Hunterdon County, New Jersey," dated September 23, 2015.

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associated with karst conditions has been identified as a potential risk based on the results of a preliminary geologic hazards assessment. PPC also requested costs for conducting ERI along a 0.3 mile section of the alignment in Carbon County, Pennsylvania where the alignment crosses the Appalachian Trail. Figure 1 shows the proposed pipeline route from approximately Mile Post 48 through approximately Mile Post 86. The specified sections of the alignment where PPC required the ERI survey are noted in Table 1 below.

Table 1
Possible karst Impacted Sections of the PennEast Alignment

Line	Milepost		Terrain Description	Objective	Profile Distance (miles)
	Start	End			
Hellertown Lateral	1.7	2.1	Field, Moderate Hill	Karst	0.4
PennEast - Mainline	51.0	51.3	Wooded, hills	Appalachian Trail Section	0.3
PennEast - Mainline	61.2	71.6	Mostly Flat, Mostly Fields	Karst	10.4
PennEast - Mainline	74.3	75.3	Mostly Flat, Mostly Fields	Karst	1.0
PennEast - Mainline	76.0	77.4	Mostly Fields, Hills	Karst	1.4
PennEast - Mainline	77.9	78.8	Woods, Hills	Karst	0.9
Total Miles					**14.4**

The survey for the section of the alignment between MP 51.0 and MP 51.3 is in a wooded area crossing a ridge and the Appalachian Trail. PPC requested the survey in this area to detect possible geologic conditions that could impact the installation activities in this area. Much of the remainder of the specified alignment has been identified as at risk for karst areas and is located in cultivated farm fields that generally exhibit rolling topography. However, some portions of the at-risk alignment are located in wooded areas, streams, roadways and developed land where geophysical data cannot be acquired due to surface conditions.

Significant portions of the specified alignment could not be surveyed as of the date of this interim report due to access limitations and landowner restrictions. Much of the work covered by this Interim Report 2 was conducted along segments of the alignment that were previously surveyed with ERI, but had to be re-surveyed where the new alignment differed significantly from the original alignment. In addition, deep ERI data were acquired as directed by PPC at the locations of the Freemansburg Avenue and Lehigh River horizontal directional drilling (HDD) crossings to help characterize the karst risk at depth in these areas. No new segments of the alignment were surveyed as part of this Interim Report. The remaining accessible portions of the specified sections of the proposed pipeline alignment are to be surveyed as access limitations and landowner restrictions are resolved.

GENERAL GEOLOGIC DESCRIPTION

In general, the possible karst impacted portions of the PennEast Pipeline alignment are underlain by the Jacksonburg, Epler, Rickenbach, Allentown, and Leithsville Formations. All of which are formations considered susceptible to karst formation and have mapped sinkholes related to the geology.

A description of the specific geology of the selected portions of the pipeline alignment taken from the Pennsylvania State Bedrock Geologic map and from Dr. Robert Starcher of Hatch Mott MacDonald (HMM) follows:

"Much of the Hellertown Lateral portion of the alignment (MP 1.7 to 2.1) is mapped as mafic gneiss. The last 0.05 mile appears to be in the Leithsville Dolomite. The section between MP 1.4 and 1.7 is within a few hundred feet of an area mapped as the Leithsville.

"The PennEast Mainline between MP 51.0 and 51.3 is mapped as the Decker. Bloomsburg, and Shawangunk Formations, which are predominantly sandstones and shales. These are not bedrock formations that have carbonate rocks in them, nor are they considered karstic.

"Between MP 61.2 and 71.6 starts in an area mapped as Martinsburg Formation, which is a shale with some interbedded siltstones and fine sandstones. The alignment then traverses the mapped outcrop areas of the Jacksonburg, Epler, Rickenbach, Allentown and Leithsville Formations, all of which are carbonates that exhibit local karst features. This portion of the alignment ends in the Hardyston Formation, which is a quartzite that is not subject to karst formation.

"The PennEast Mainline alignment between MP 74.3 and 75.2 appears to start at the contact between an area mapped as felsic to mafic gneiss and the Allentown Formation and ends at the contact between the Leithsville and the Hardyston Formations between MP 75.2 and 75.3.

"The PennEast Mainline alignment between MP 76.0 and 77.4 begins near the contact of the Hardyston and Leithsville formations and ends near the contact between the Allentown Formation and Quatenary sediments described as the Trenton Gravels.

"The PennEast Mainline alignment between MP 77.9 and 78.8 is entirely in Hunterdon County, New Jersey and appears to start in an area mapped as quartz-oligoclase gneiss (within a few hundred feet north of the edge of a thrust-fault-bound area underlain by Leithsville Formation dolomite) and traverses eastward into an area mapped as hornblende gneiss, and then

enters the outcrop area of the Leithsville Formation in the vicinity of Church Road, at about MP 78.3."

OBJECTIVE

The objective of the geophysical survey was to detect, and if detected, to locate geologic conditions such as karst features along the planned pipeline alignment that could impact the proposed pipeline.

THE SURVEY

Hager-Richter personnel conducted the geophysical field operations covered by this Interim Report 2 between December 21, 2015 and January 13, 2016. The project was coordinated with Mr. Jeffrey England, P.E., and Mr. Kevin Kelleher of PPC and Dr. Vatsal Shah, P.E. of Hatch Mott MacDonald (HMM). Mr. Daniel Murphy and Mr. John Coughlin of Western Land Services (WLS) coordinated owner notification and land access for the ERI surveys and directed Hager-Richter for access. Original data and field notes reside in the Hager-Richter files and will be retained for a minimum of three years.

As discussed above, the geophysical survey was conducted using the Electrical Resistivity Imaging (ERI) method. ERI data were acquired along nine traverses ranging in length from 220 feet to 1,336 feet. Electrode spacing ranged from a minimum of 4 feet to a maximum of 8 feet depending on access. For traverses over 440 feet in length, the data were acquired in roll-along mode. Roll-along ERI surveying consists of installing 56 electrodes, measuring the apparent resistivity as discussed below for those electrodes, then advancing the array along the traverse by moving 14 electrodes and continuing the measurements. ERI data were acquired along two additional traverses for the HDD crossings that were each 1,100 feet long using an electrode spacing of 20 feet.

EQUIPMENT & PROCEDURES

We use an Advanced Geosciences, Inc. (AGI) Super Sting R8 earth resistivity instrument with an addressable multi-electrode system for the electrical imaging survey. Resistivity imaging incorporates both vertical electrical sounding and lateral profiling to produce a data set suitable to create a two-dimensional resistivity model. The Super Sting allows automatic measurement of several types of array, i.e. most combinations of current and voltage electrode connections can be controlled by the Super Sting system. Fifty-six electrodes, or any multiple of 14 electrodes (with a maximum of 254 electrodes) can be used with the Super Sting system.

The data for the current project were acquired using the dipole-dipole array, 56 electrodes per set-up, and an electrode spacing of 3-20 feet. The electrode array is advanced by moving 14 electrodes from the beginning of the survey line to the end of the survey line. This roll-along procedure provides a continuous resistivity profile for the length of the survey line with an approximate depth of exploration of about 10 times the electrode spacing, or approximately 30 feet for an electrode spacing of 3 feet, and 200 feet for an electrode spacing of 20 feet. Data were acquired along 11 traverses totaling 6,500 feet. The approximate locations of the ERI traverses covered by this Interim Report 2 are shown on insets on each of the plates. The individual traverse lengths, starts and ends of the traverses, electrode spacings, and other line specific information are provided in Table 2 below.

Table 2
Interim Report 2
Resistivity Imaging Traverse Information
PennEast Pipeline Alignment

Line Name	Length (ft)	Electrode Spacing (ft)	UTM Easting Start (m)	UTM Northing Start (m)	UTM Easting End (m)	UTM Northing End (m)	Model Iterations	RMS Error (%)
61.7 A	330	6	468405.0	4509150.8	468503.2	4509168.3	10	4.54
61.8 A	1336	8	468502.1	4509168.2	468905.0	4509109.5	10	6.43
62.0 A	440	8	468925.9	4509107.3	469057.7	4509085.0	10	3.93
62.1 A	330	6	469034.8	4509132.8	469037.4	4509032.3	10	3.71
62.2 A	220	4	469042.8	4508935.4	469045.9	4508869.1	10	4.21
62.2 B	330	6	469035.5	4508908.8	469132.2	4508883.6	10	2.82
62.3 A	432	8	469157.1	4508879.0	469285.2	4508851.7	10	4.13
62.3 B	330	6	469305.0	4508842.7	469402.3	4508819.8	10	2.26
62.4 B	552	8	469361.6	4508839.1	469502.3	4508747.4	10	3.24
70.2 A - Deep	1100	20	475858.2	4500314.9	476075.3	4500062.2	10	4.71
71.2 A - Deep	1100	20	476330.5	4498852.2	476354.2	4498526.1	7	6.18

The line naming convention was based on the mile post information provided by HMM via Google Earth© KMZ as of March 7, 2016. UTM coordinates were determined by GPS and are relative to Zone 18 North and the datum is NAD 1983 CORS96.

The Super Sting R8 earth resistivity instrument measures the contact resistance of each electrode, and, if the resistance of any electrode is judged to be excessive, salt water is poured on the ground around that electrode to decrease the surface resistance. After the contact resistance of all electrodes is satisfactory, the data are acquired under program control. The electrodes are

moved to the next survey line or advanced along the traverse and the procedures repeated.

The resulting data sets are inverted using AGI EarthImager 2D, commercially licensed software, to create two-dimensional resistivity models. Apparent resistivity values are calculated with a forward modeling subroutine, and a smoothness-constrained least-squares optimization routine is used to invert the data. Both finite-difference and finite-element forward modeling techniques are available in the software. The number of iterations and the root mean square error of the fit of the final inversion are provided in Table 2. In general, ten inversions were required to achieve a RMS error of less than 5%

Although there are many ways to display the results of 2D resistivity inversions, the essential element is a plot of the distribution of resistivity as a function of depth and distance along the survey line. The choice of color scale representing resistivity affects the appearance of the plots and further emphasizes particular aspects of the results, and the choice is most commonly between linear and logarithmic scales, although others could be made. A resistivity image profile can be made to highlight either local detail or regional information. For the subject survey, a color scale emphasizing local features such as possible air-filled cavities was selected.

The interpretation of resistivity plots is based on the experience of the interpreter, his/her knowledge of typical values or ranges of values of resistivity for the types of geologic materials expected below a survey line. The interpreter uses the measured values to infer what materials are present - including soil and/or rock types, porosity, permeability, presence or absence of contamination, the presence of such geological features as faults and fracture zones, and the presence of such man-made features as tar pits, concrete walls, slurry walls, and former lagoons.

GEOPOSITIONING

The positions of the resistivity survey lines were surveyed using a Trimble Geo7X CM GPS receiver outfitted with a Zephyr-2 external antenna. The GPS survey data were superimposed on Google Earth KMZ files provided by HMM. The horizontal datum used for determining the positions of the resistivity survey lines is UTM Zone 18N, NAD 1983 CORS96 and the vertical datum used for the topographic profiles is NAVD 88.

LIMITATIONS OF THE METHOD

As with any of the electrical geophysical methods, resistivity data are subject to certain limitations, including site surface and subsurface conditions and structures, electrical and "geological" noise, and target depth and size. Interference from such cultural features as buildings, fencing, and underground and overhead power lines is common at many sites,

particularly at active industrial sites. Thus, for certain applications, the use of the resistivity method in urban settings might be inappropriate.

The subsurface is three dimensional in character, and although the resistivity data are acquired along a line, the data are affected by resistivity changes off-line. Therefore, unless there are parallel survey lines that are spaced appropriately, resistivity changes off-line may be interpreted as changes below the survey line. This limitation is particularly significant for single survey lines. A further limitation of the resistivity method arises at the ends of a survey line where the data density is necessarily reduced.

The target depth, size, and of course, resistivity contrast may pose limitations. These three parameters, generally characterized as large or small , are important in the survey design[2], and extreme values can limit the usefulness of the resistivity method. For example: a small target, a granite boulder 2 ft in diameter at a large depth of 20 ft or more, even with very high resistivity contrast, 10^5 Ohm-m in a medium of 0.2 Ohm-m, cannot be detected. A target of reasonable size, a granite boulder 2 ft in diameter at a shallow depth of 6 ft or less, may not be detectable where the resistivity contrast is low, 10^5 Ohm-m in a medium of 10^4 Ohm-m.

RESULTS

The geophysical survey results presented by this interim report consist of 11 Electrical Resistivity Imaging (ERI) survey transects totaling 6,500 feet. The processed resistivity profiles are shown in Plates 1-3. Resistivity data were acquired using electrode spacings ranging from 3 feet to 20 feet, and many resistivity lines were acquired as roll-along profiles. The resistivity profiles shown in Plate 1 are shown at 2x vertical exaggeration. The deep resistivity profiles shown in Plates 2 and 3 are superimposed on the HDD profiles for the Freemansburg Avenue and Lehigh River Crossings, respectively. The deep resistivity profile for the HDD crossing of the Lehigh River is shown without vertical exageration.

The upper surface of the resistivity profiles represents the approximate surface topography. Surface elevations were determined from GPS locations of the resistivity profiles recorded at the time of the survey. The horizontal distance along the ground and horizontal distance relative to the pipeline project Mile Posts are shown below and above the horizontal

[2] The parameters depth and size scale to the electrode spacing. A "large depth" is any depth greater than 10 times the electrode spacing. A "small depth" is any depth less than 3 times the electrode spacing. Depths less than 10 but greater than 3 times the electrode spacing are termed "intermediate depths." A "large size" is any size greater than 2½ times the electrode spacing. A "small size" is any size less than 1 times the electrode spacing. Sizes less than 2½ but greater than 1 times the electrode spacing are termed "intermediate sizes." Resistivity contrast refers to the ratio of the resistivity of one material to that of the second material. A large resistivity contrast is any such ratio of at least 100. A small resistivity contrast is any such ratio no greater than 0.5. Ratios less than 100 but greater than 0.5 are termed "intermediate ratios."

axis, respectively. The vertical axis is elevation. A 2x vertical exaggeration was used for resistivity profiles on Plates 1 and 2 while no exaggeration was used for Plate 3. The resistivity profiles shown in Plates 1-3 are the inverted resistivity sections, which are plots of the distributions of resistivity as a function of depth and distance along the survey line determined from the measured apparent resistivity of the subsurface. As noted previously, the number of iterations and RMS error for each profile are reported in Table 2.

The resistivity profiles are characterized by relatively low resistivity soils overlying relatively high resistivity bedrock. The approximate bedrock surface, as interpreted from the resistivity data, is shown on the Plates as a dashed line. The bedrock surface is indicated by a sharp increase in resistivity values. An inferred bedrock surface is not shown where the elevation of the bedrock surface is less clear due to a gradual change is resistivity values or where anomalously low resistivity anomalies are located at or near the interpreted bedrock surface.

Typical resistivity values for limestone and dolomite bedrock range from approximately 100 to 10,000 ohm-m. Many of the resistivity profiles exhibit a relatively thin veneer of high resistivity bedrock (>1000 ohm-m) overlying lower resistivity bedrock (100-1000 ohm-m). The decrease in resistivity may be due to an increase in water content of bedrock, a change in bedrock lithology, a higher degree of weathering of the bedrock, or a combination of the above.

Anomalously high and low resistivity anomalies interpreted to be due to possible karst features within bedrock along the surveyed portions of the alignment are evident in the ERI profiles and are shown as possible karst zones on the Plates. Anomalously low resistivity values interpreted to be due to the presence of clay or heavily weathered bedrock within competent bedrock. Anomalously high resistivity values are interpreted to be due to the presence of air-filled voids within bedrock.

Anomalously low resistivity anomalies are defined as areas within the bedrock having resistivity values between 10 and 100 ohm-m, which are typical resistivity values for moist to wet clay or heavily weathered limestone bedrock. The presence of clay or heavily weathered bedrock at the locations of the anomalously low resistivity is supported by results from borings conducted along the alignment by HMM. In general, both core recovery and RQD are lower in zones that exhibit anomalously low resistivty.

High resistivity anomalies are areas within bedrock having resistivity values greater than 40,000 ohm-m, shown as white areas on Plates 1-3. The 40,000 ohm-m cut-off value used to define these areas is far greater than the expected resistivity values of limestone or dolomite bedrock (approximately 100 to 10,000 ohm-m). Some high resistivity zones have resistivity values greater than 70,000 ohm-m.

All such high resistivity anomalies were originally interpreted as being due to possible air-filled voids within bedrock. The presence of significant open voids in bedrock at the locations of the anomalously high resistivity has not been supported by results from borings conducted along the alignment by HMM at the locations of such anomalies. In general, ~~the~~ high core recovery and high RQD have been reported in the logs for the borings at such locations. The resistivity of dry competent limestone and air filled voids may be very similar to one another. Because the of the non-uniqueness of the resistivity response to the very competent bedrock and the possible air filled voids, we cannot differentiate between the two interpretations.

Significant anomalies for the ERI Lines shown on Plate 1 have been classified into three ranks based on inferred aerial extent and depth. Rank 1 anomalies are generally the largest and shallowest of the features that pose the greatest risk to construction and stability of the pipeline. Rank 2 and 3 anomalies are generally smaller and deeper and likely pose lower risk. As indicated above, because the of the non-uniqueness of the resistivity response to the very competent bedrock and the possible air filled voids, we cannot differentiate between the two interpretations. As such, we note the locations of shallow high resistivity anomalies as Rank 1 as a conservative interpretation as they cloud represent open air filled voids.

The locations of the ERI anomalies and their categories are provided below in Table 3. We understand that HMM will be installing several borings at the locations of the larger inferred air filled voids in the coming weeks to assist with further refining the geophysical interpretation of such anomalies.

Table 3
Significant ERI Anomalies
PennEast Pipeline Alignment

Line Name	Distance along Profile (ft)	Anomaly Type	Anomaly Rank	Estimated Size (ft)	Estimated Depth (ft)	UTM Easting (m)	UTM Northing (m)
61.7 A	167	Clay-Filled	3	20	>20	468455.1	4509159.7
61.8 A	120	Clay-Filled	3	25	10-20	468538.3	4509162.9
61.8 A	433	Clay-Filled	2	25	>20	468632.7	4509149.2
61.8 A	535	Air-Filled	1	25	10-20	468663.5	4509144.7
62.0 A	137	Clay-Filled	2	30	10-20	468967.1	4509100.3
62.0 A	220	Clay-Filled	3	20	>20	468992.0	4509096.1

Anomalously low resistivity anomalies indicative of moist to wet clay or heavily weathered limestone bedrock are present along the proposed paths of the HDD alignments shown in Plates 2 and 3. Several such areas are noted on the plates. The presence of clay or heavily weathered bedrock at the locations of the anomalously low resistivity is supported by results from borings conducted along the alignment by HMM and shown on the Plates. In general, both core recovery and RQD are lower in zones that exhibit the anomalously low resistivity.

CONCLUSIONS

On the basis of the Electrical Resistivity Imaging survey conducted between September 1, 2015 and March 1, 2016 by Hager-Richter Geoscience, Inc. along portions of the proposed alignment of the PennEast Pipeline Project located in Northampton County, Pennsylvania for PennEast Pipeline Company, LLC, we conclude the following:

- Several areas of low resistivity anomalies attributed to the presence of possible clay-filled voids or heavily weathered bedrock are present within the bedrock at the site.

- Multiple areas of very high resistivity anomalies attributed to possible air-filled voids are present within the bedrock at the site.

RECOMMENDATIONS

- The electrical resistivity survey should be completed for the remaining portions of the possible karst impacted section of the pipeline alignment.

- Borings should be installed at the locations of all Rank 1 resistivity anomalies to determine whether air-filled voids are present at such locations and to further refine the interpretation of such anomalies.

- Borings should be installed at selected locations of Rank 2 resistivity anomalies to determine whether clay-filled voids are present at such locations and to further refine the interpretation of such anomalies.

- Additional electrical resistivity imaging data should be acquired in areas of Rank 1 anomalies and at locations of voids identified on the basis of the drilling program to further refine the extent of the features causing the anomalies.

LIMITATIONS ON USE OF THE REPORT

This Draft Interim Report2 was prepared for the exclusive use of PennEast Pipeline Company, LLC (Client). No other party shall be entitled to rely on this Report or any information, documents, records, data, interpretations, advice or opinions given to Client by Hager-Richter Geoscience, Inc. (H-R) in the performance of its work. The Report relates solely to the specific project for which H-R has been retained and shall not be used or relied upon by Client or any third party for any variation or extension of this project, any other project or any other purpose without the express written permission of H-R. Any unpermitted use by Client or any third party shall be at Client's or such third party's own risk and without any liability to H-R.

H-R has used reasonable care, skill, competence and judgment in the preparation of this Report consistent with professional standards for those providing similar services at the same time, in the same locale, and under like circumstances. Unless otherwise stated, the work performed by H-R should be understood to be exploratory and interpretational in character and any results, findings or recommendations contained in this Report or resulting from the work proposed may include decisions which are judgmental in nature and not necessarily based solely on pure science or engineering. It should be noted that our conclusions might be modified if subsurface conditions were better delineated with additional subsurface exploration including, but not limited to, test pits, soil borings with collection of soil and water samples, and laboratory testing.

Except as expressly provided in this limitations section, H-R makes no other representation or warranty of any kind whatsoever, oral or written, expressed or implied; and all implied warranties of merchantability and fitness for a particular purpose, are hereby disclaimed.

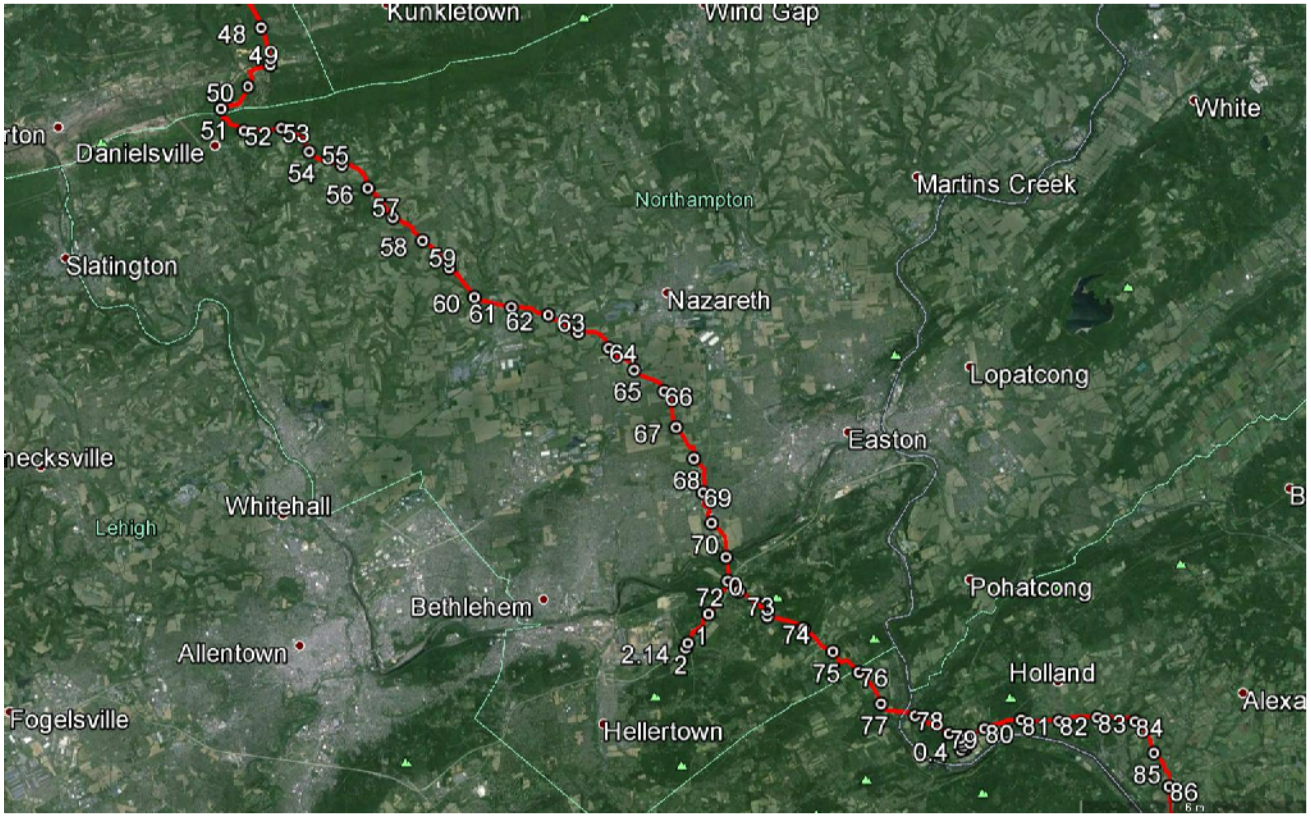
If you have any questions or comments on this letter Report, please contact us at your convenience. It has been a pleasure to work with PPC on this project. We look forward to continuing to work with you.

Sincerely yours,
HAGER-RICHTER GEOSCIENCE, INC.

Jeffrey Reid, P.G.
Vice President/Senior Geophysicist

Dorothy Richter, P.G.
President

Attachments: Figure 1, Plates 1-3



N

APPROXIMATE SCALE (mile)

0 5 10

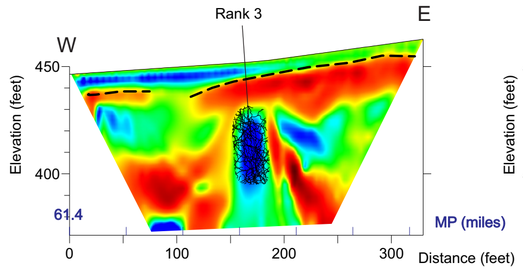
NOTE:

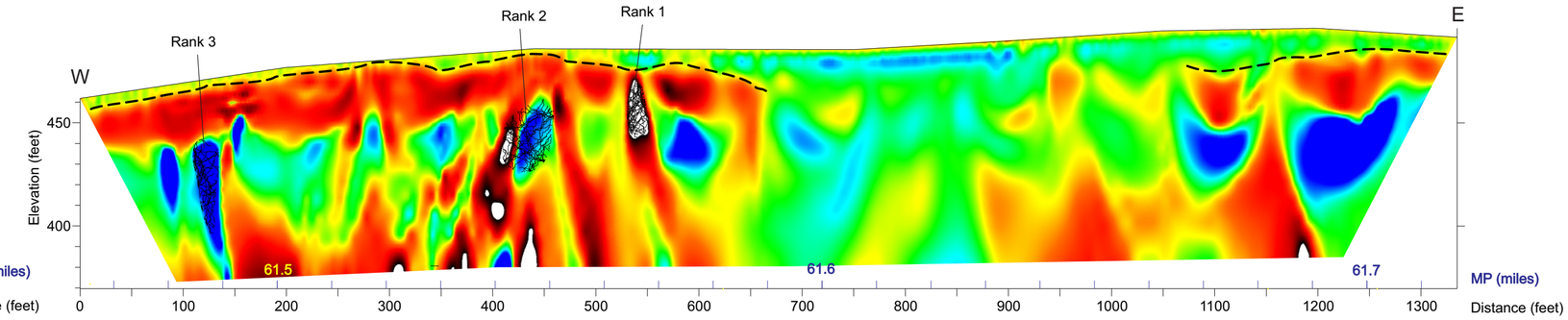
Modified from Google Earth Pro aerial photograph.

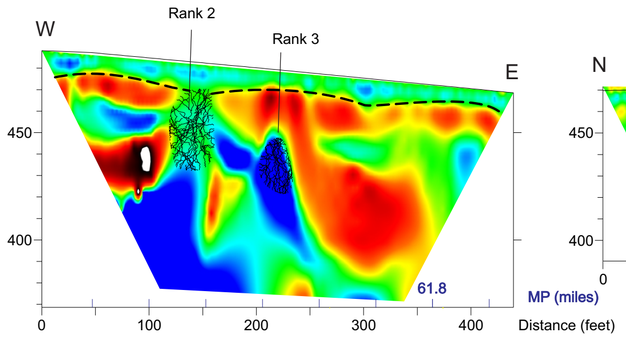
Figure 1
General Site Location
PennEast Pipeline Project
Carbon, Northampton &
Bucks Counties, Pennsylvania and
Hunterdon County, New Jersey

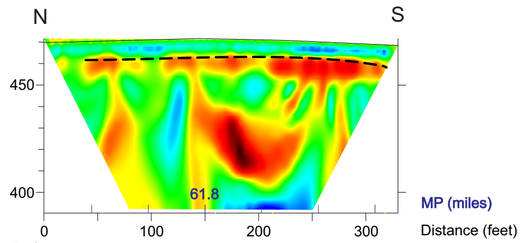
File 15JCC19	March, 2016

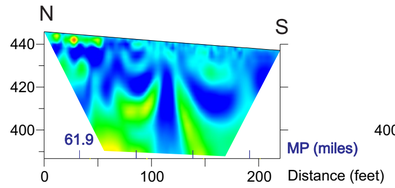
HAGER–RICHTER GEOSCIENCE, INC.
Salem, New Hampshire

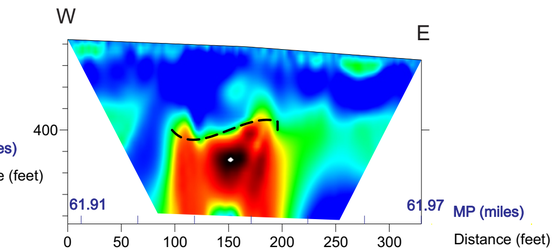


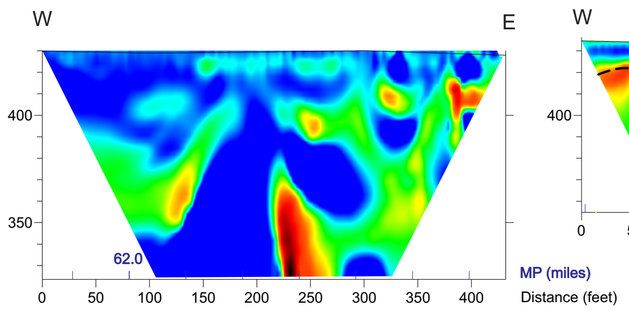


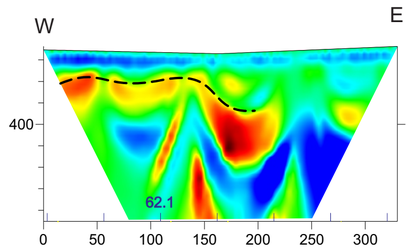


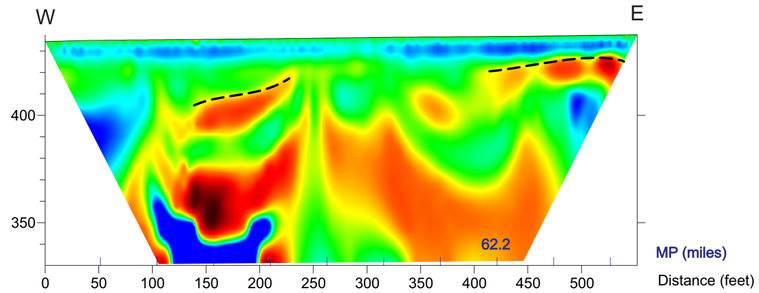








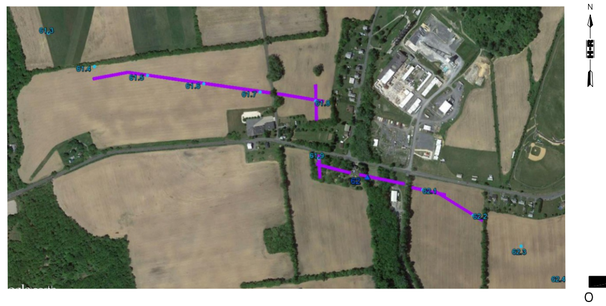




HORIZONTAL SCALE (feet)
0 100 200
0 50 100
VERTICAL SCALE (feet)

NOTES:

1. Surface elevations determined from GPS measurements
2. Resistivity data acquired using a AGI SuperSting R8 with the Dipole–Dipole electrode configuration, 56 electrodes, and 8 & 4 –foot electrode spacing.
3. Resistivity data processed and inverted using Earthimager2D Software by AGI.



SCALE (feet)
0 1000 2000

LEGEND

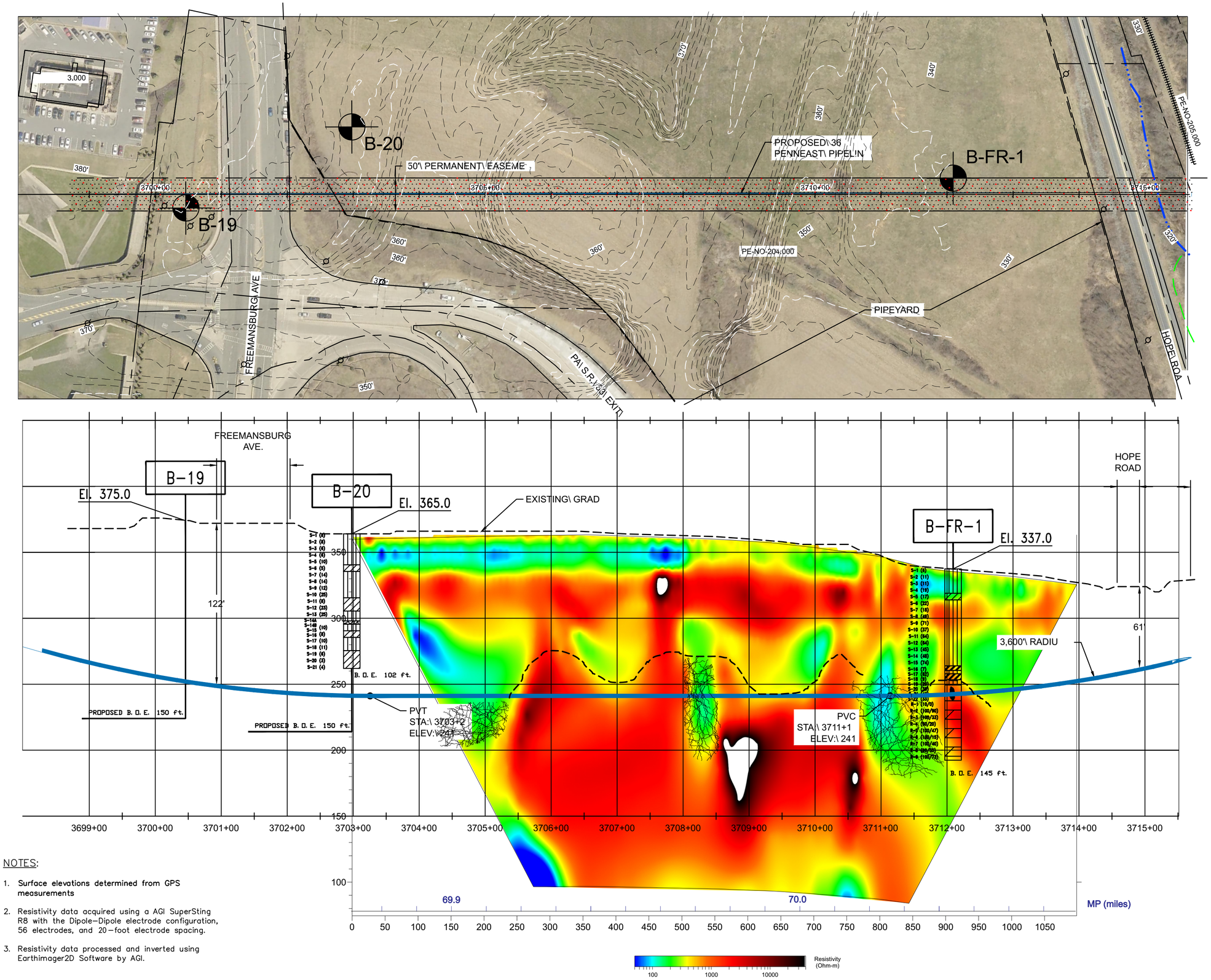
POSSIBLE COMPETENT BEDROCK SURFACE

POSSIBLE KARST ZONE WITH INDICATION OF CATEGORY RANK

Plate 1
Resistivity Lines
MP 61.3 – 62.3
Interim Report 2
PennEast Pipeline Karst Investigation
Carbon, Northampton,
& Bucks Counties, Pennsylvania

File 15JCC19 | March 2016

HAGER–RICHTER GEOSCIENCE, INC.
Fords, New Jersey



LEGEND

POSSIBLE COMPETENT BEDROCK SURFACE

POSSIBLE KARST

HORIZONTAL SCALE (feet)
0 100 200
0 50 100
VERTICAL SCALE (feet)

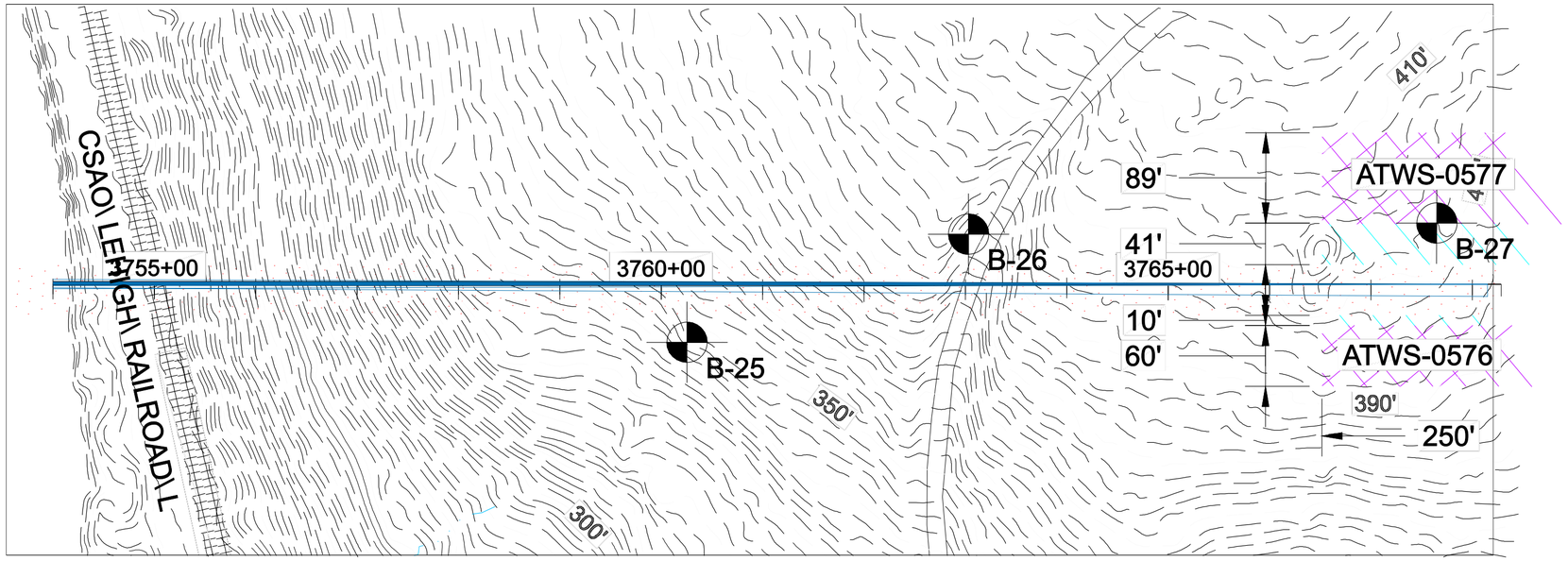
NOTES:

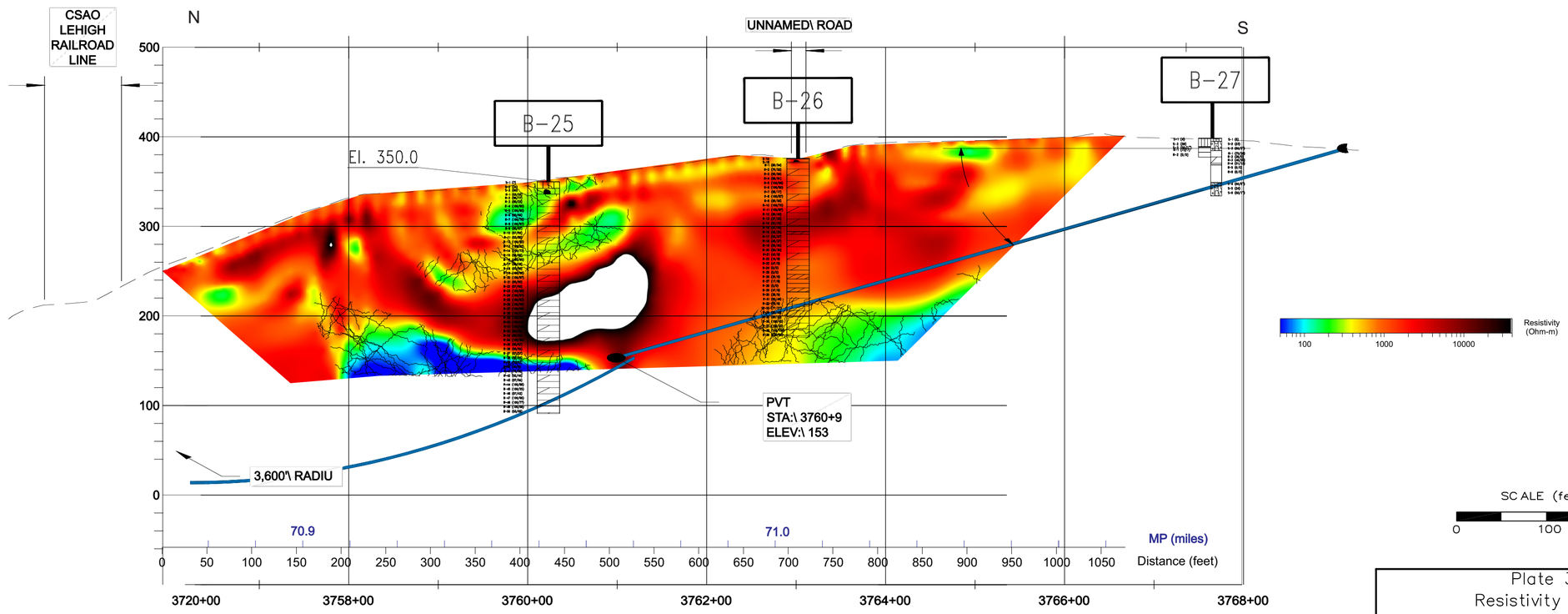
1. Surface elevations determined from GPS measurements
2. Resistivity data acquired using a AGI SuperSting R8 with the Dipole–Dipole electrode configuration, 56 electrodes, and 20–foot electrode spacing.
3. Resistivity data processed and inverted using Earthimager2D Software by AGI.

Plate 2
Resistivity Lines
MP 69.9 – 70.1
Interim Report 2
PennEast Pipeline Karst Investigation
Carbon, Northampton,
& Bucks Counties, Pennsylvania

File 15JCC19	March 2016

HAGER–RICHTER GEOSCIENCE, INC.
Fords, New Jersey





NOTES:

1. Surface elevations determined from GPS measurements
2. Resistivity data acquired using a AGI SuperSting R8 with the Dipole–Dipole electrode configuration, 56 electrodes, and 20–foot electrode spacing.
3. Resistivity data processed and inverted using Earthimager2D Software by AGI.

LEGEND

POSSIBLE COMPETENT BEDROCK SURFACE

POSSIBLE KARST ZONE

Plate 3
Resistivity Lines
Lehigh River Crossing
Interim Report 2
PennEast Pipeline Karst Investigation
Carbon, Northampton,
& Bucks Counties, Pennsylvania

File 15JCC19 | March 2016

HAGER–RICHTER GEOSCIENCE, INC.
Fords, New Jersey

Attachment 2

Karst Mitigation Plan

Karst Mitigation Plan

PennEast Pipeline Project

Issue and Revision Record					
Rev	**Date**	**Originator**	**Checker**	**Approver**	**Description**
A	3/30/2016	D. Raghu	V. Shah / K. Koch	M. Wilcox	Draft issued for internal review
0	3/30/2016	D. Raghu	V. Shah / K. Koch	M. Wilcox	Issued to PennEast for submittal to FERC

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ATTACHMENT 4 – USDA NRCS SINKHOLE REPAIR WITH SOIL COVER DETAIL

1 Introduction

PennEast Pipeline Company, LLC (PennEast) will be seeking authorization from the Federal Energy Regulatory Commission (FERC) pursuant to Section 7(c) of the Natural Gas Act for the construction and operation of the PennEast Pipeline Project (PennEast Project or Project) to be located in Pennsylvania and New Jersey. PennEast designed its Project to provide a direct and flexible path for transporting natural gas produced in the Marcellus Shale production region in eastern Pennsylvania to growing natural gas markets in eastern and southeastern Pennsylvania, New Jersey and surrounding states.

The Karst Mitigation Plan reported herein has been prepared to address potential impacts and hazards related to local karst formations crossed by the proposed Project. The Plan outlines monitoring activities and the corrective measures that PennEast and its Contractor will implement if karst features are encountered during the Project.

2 Background

Along its alignment in Pennsylvania and New Jersey, the Project will cross several geologic formations with potential karst terrain. The Counties and geologic formations with karst potential which the alignment will cross include the Rickenbach, Epler, Allentown, Jacksonburg, and Leithsville formations in Northampton County, Pennsylvania, as well as the Leithsville formation in Hunterdon County, New Jersey.

Karst terrain is formed by the solution of carbonate rock (e.g., limestone, dolostone, and marble) and evaporate deposits by percolating, surface water and groundwater along fractures, joints, and bedding planes. Karst is characterized by features such as cavern openings, sinkhole, closed depressions, and gaining and losing streams. Where present these conditions can create engineering and environmental issues due to subsidence, groundwater quality impacts, and stormwater flooding and control issues.

Sinkholes are naturally occurring phenomena in areas underlain by carbonate bedrock, such as the carbonate formations occurring in Pennsylvania and New Jersey. Most sinkholes are triggered by external factors such as significant or prolonged rainfall, periods of drought, heavy groundwater pumping, or stormwater management practices; however, activity at remnant or dormant sinkholes may be triggered by uncontrolled construction practices. Typically, installation of historic pipelines through this region has shown that the frequency of localized subsidence occurrences will be low, and the relative scale of related karst features would be small enough for standard mitigative measures.

PennEast provided detailed discussion summarizing the review of available literature in Resource Reports and separate evaluation reports filed with FERC. These reports include, but are not limited to: Resource Report 2 (Water Use and Quality); Resource Report 6 (Geologic Resource); and, Resource Report 7 (Soils).

A Sinkhole Location Map indicating known sinkholes and karst topography along the project alignment has been provided as Figure 6.3-4 of Resource Report 6.

3 Potential Karst Risks Associated with Pipeline Construction

Construction of the pipeline will include several methods of construction, including conventional trenching for pipeline construction, horizontal directional drill (HDD) crossings, and the construction of meter and compressor station facilities to support pipeline operation. The following addresses the risks associated with different aspects of Project construction.

1) Conventional Pipeline Construction

The majority of the proposed pipeline will be constructed with conventional cut and cover techniques, whereby a length of trench is excavated, the pipe is placed and connected to the previous section, and the trench is backfilled with material excavated from the trench. Although potential exists for unknown karst features to be encountered by this method of construction, the likelihood that these features will be large in scale is low as exposed karst features discovered during pipeline installation can be readily identified, evaluated and remediated. Once the pipeline is constructed, hydrostatic testing performed prior to pipeline operation can be a source which has potential to introduce significant amounts of water to the area, which can be detrimental to karst terrain if not managed properly. Recommended mitigation measures for managing hydrostatic test water in the vicinity of karst features are discussed in the Section 8.

2) Horizontal Direction Drill (HDD) Crossings

During the construction of the Project, the use of HDD methods of construction may be used for the purpose of avoiding environmentally sensitive resources or obstructions that occur along the Project pipeline route. The general risks associated with HDD construction methods in karst areas include difficulties arising from very loose unstable soils and open voids along the drill path. More specifically, these risks include:

- Loss of drilling fluid into fractures, voids, and naturally occurring seepage conduits.
- Inadvertent drilling fluid returns leading to turbidity in nearby wells, springs, and rivers.
- Ground subsidence and possible sinkhole formation due to removal of soil and loosening of soils above HDD crown.
- Stuck drill tooling and the possibility of the carrier pipe becoming stuck in loose unstable zones during pullback.

It is recognized that small conduits connected to former karst voids could be encountered along the proposed HDD alignment, however these conduits are not typically “open” and are rather infilled with sediment caused by preferential groundwater flow paths. In most instances, the loss of drill fluid to these conduits will minimize over time as the drilling fluid develops a filter cake around the perimeter of the borehole and seals minor conduits from additional flow.

PennEast understands it is imperative that precautions be taken during planning, design, construction, and operation to prevent unanticipated impacts to environment during construction and during service life of the pipeline. PennEast has prepared and submitted a separate HDD Drilling Plan for Karst Terrain to minimize or quickly resolve possible inadvertent effects by identifying appropriate corrective actions for various potential scenarios that may be encountered during HDD operations through karst terrain.

PennEast's HDD Drilling Plan for Karst Terrain provides a description of proposed HDD work activities, the HDD working procedures, monitoring of inadvertent returns of drilling fluid (including training and reporting), response to HDD operations, and proposed cleanup techniques in the event that inadvertent returns occur during HDD activities through karst areas on the Project.

Additionally, PennEast has conducted geophysical investigations along the length of proposed HDD alignments to investigate the potential for karst terrain within path of the HDD. The preventative measures to identify potential karst areas and an established protocol to mitigate karst-related issues during drilling allow PennEast to minimize and control the risk of concerns related to karst terrain during HDD activities.

3) Facilities (Compressor and Meter Stations)

Above ground facilities associated with the Project will include a compressor station and 12 meter stations at specific locations along the project alignment. It is proposed that the majority of structures associated with these facilities will be constructed using conventional shallow foundations bearing on native subgrade. Construction, earthmoving, and compaction activities will follow typical procedures using conventional construction equipment. Should deep foundations at select locations with larger structural loads be necessary, heavier equipment may be required for the installation of such foundations.

As each facility site will introduce additional impervious surface, standard stormwater management practices will be employed during design and construction of basins required for stormwater retention/detention. In karst sensitive areas, PennEast has considered shallow basins with larger surface areas, where feasible, to minimize risk associated with confined aquifers and shallow karst terrain. In addition, direct rainfall on impervious areas will be diverted away from building and equipment foundations to minimize the risk of potential sinkhole activity near critical pipeline infrastructure.

4 Measures to Identify and Investigate Karst Features

In addition to review of publically available records and data, in areas with known or mapped sinkholes, or areas with carbonate formations, PennEast has completed geophysical investigations to investigate karst conditions proximate to the Project alignment. PennEast's geophysical surveys are conducted using electrical resistivity imaging (ERI).

As survey permissions become available, additional geophysical investigations continue to be conducted to identify and classify the risk of carbonate rock which the proposed pipeline crosses along its alignment.

The PennEast geophysical survey conducted by Hager Richter is presented in Appendix O of Resource Report 1. At the time of this report, the results of the ERI survey conducted by Hager-Richter indicated that several areas of low-resistivity anomalies attributed to the presence of possible clay-filled voids or heavily weathered bedrock are present within the bedrock underlying the Project. Also, several areas of very high-resistivity anomalies attributed to possible air-filled voids are present within the bedrock underlying the Project.

Once resolved, potential voids identified by geophysical testing were assigned a rank according to their size and proximity to the surface. Geotechnical borings have been subsequently advanced at all locations where ERI has identified potential air-filled and clay-filled voids to confirm their presence and to provide more information to improve the interpretation of the ERI results. PennEast continues to complete additional geophysical and install additional geotechnical borings to further refine and calibrate the data collected from geophysical investigations. The results of the geotechnical borings have been provided as supplemental information within Appendix O of Resource Report 6, as well as discussed in the Karst Investigation Interim Report provided as Attachment F of Appendix O of Resource Report 6.

5 Avoidance, Minimization, and Mitigation Measures

PennEast has implemented avoidance of karst features as a primary mitigation measure during the planning and selection of the proposed alignment. During the route selection process, PennEast's review of available data and resources including literature and mapping by the United States Geological Survey (USGS), New Jersey Department of Environmental Protection (NJDEP) and Pennsylvania Department of Conservation and Natural Resources (PADCNR). PennEast reviewed available resources such as the online-based NJDEP GeoWeb application, PADCNR Open File Reports 8701 and 8702, "Sinkholes and Karst-Related Features of Lehigh and Northampton Counties, Pennsylvania", Open File Reports 8702 & 9303, "Sinkholes and Karst-Related Features of Northampton and Bucks Counties, Pennsylvania", and the USGS Mineral Resources On-Line Spatial Database to report the presence or absence of sinkholes for the Project.

PennEast's review of available data has been focused on identifying known or documented sinkholes, caverns, and karst features within at least 200 feet of the pipeline centerline, in addition to the geophysical investigations conducted and summarized in Section 4 along the length of known karst topography along the centerline of the pipeline.

6 Best Management Practices and Construction Housekeeping

Naturally occurring karst terrain provides a subsurface drainage system for overburden soil overlaying carbonate bedrock. However, concentrations of post-development stormwater runoff from construction activities can destabilize the natural karst hydrogeologic system and

lead to potential sinkhole development, sinkhole flooding, or groundwater impacts if unmanaged.

The principal approach to avoid aggravating dormant caverns or possible areas of subsidence and karst activity is to maintain rates of recharge and discharge in the subsurface at the desired natural levels. In this context, desired natural levels refer to the pre-development recharge and discharge rates. Therefore, during construction and in areas where mapped and verified karst terrain exists, in addition to the standard erosion control Best Management Practices, PennEast will implement double layers of silt fencing and implement hay bales or core logs along the periphery of the standard workspace area to prevent outward migration of silt and reduce runoff velocity. This will help control the flow of water into underlying karst areas, which meets the intent of maintaining rates of subsurface recharge and discharge to pre-development conditions.

Stormwater control measures in areas of known and verified karst terrain will be enhanced to include include detention, diversion, or containerization to prevent construction influenced stormwater from flowing to the karst feature drainage point. Furthermore, these drainage points will not be utilized for the discharge of hydrostatic test water.

7 Pre and Post-Construction Water Quality Monitoring

It is noted that many of the wells within the New Jersey and Pennsylvania regions are undocumented domestic wells and wells used for agriculture and industrial use. Therefore, historically, the wells are not registered and readily discernable through available datasets. Notwithstanding, PennEast land agents have in the past and continue to informally discuss with homeowners if wells exist to inventory the resources of wells within the influence of the planned activities.

In karst-prone areas, PennEast will offer landowners within 150 feet of the construction workspace and within areas of documented karst terrain both pre- and post-construction testing of water wells. It is anticipated that the program will include testing of yield and turbidity parameters. For any significant differences in the well yield between pre- and post-construction sampling that cannot be attributed to naturally occurring conditions, such as seasonal groundwater level fluctuations, PennEast will compensate the landowner for the installation of a new well or otherwise arrange for provision of suitable water supplies. A baseline sampling will be conducted to establish a baseline turbidity level for each well. If construction activities affect existing subsurface hydrogeology and groundwater flow in the karst areas, water samples will be taken from these drinking water wells and tested for turbidity on a daily basis until the turbidity levels return to the baseline levels.

Prior to the start of construction activities near these documented areas, baseline turbidity levels will be established at each of the water resource areas to be monitored by collecting samples at six hour intervals over a 24 hour period.

This monitoring program will allow PennEast to determine if drilling mud and/or sediments from construction activities have entered the water resource area system, should a release occur.

Water samples will be analyzed for turbidity using a portable turbidity meter. Turbidity readings, water levels, rainfall rates, seasonal and environmental changes, and water appearance will be recorded during every sampling event. Since groundwater flow may be either conduit or diffuse flow and related to precipitation, rainfall rates will be recorded from the nearest weather station with available data. Each turbidity measuring unit will be calibrated per manufacturer recommendations prior to use.

During HDD activities in karst areas, if an inadvertent release is reported, the water resource areas will be sampled twice per day, both at morning and afternoon intervals, until the turbidity returns to background levels or until the turbidity levels are within acceptable criteria as per State and Federal requirements.

8 Buffer Areas and Considerations During Construction

It is understood that buffers around karst features generally aim to maintain vegetation, structural integrity, or drainage of the existing karst feature within the buffer area. The prohibition of most land uses within the karst feature buffers, at least for sinkholes, also helps minimize exposure to sinkhole subsidence and sinkhole flooding. PennEast intends to implement the following considerations for buffers related to certain activities within karst areas:

1) Blasting

The Natural Resources Conservation Service (NRCS) defines shallow depth to bedrock as being within 5 feet of the ground surface. Rock encountered during trenching will be removed using one of the following techniques, typically in the order listed below:

a. Conventional excavation with a backhoe.
b. Hammering with a pointed backhoe attachment or a pneumatic rock hammer, followed by backhoe excavation.
c. Ripping with a bulldozer.
d. Blasting followed by backhoe excavation.

The rock removal technique will depend on rock properties, such as relative hardness, fracture susceptibility, expected volume, and location. Areas of shallow depth to bedrock crossed by the Project were determined by review and analysis of published soil survey data from the NRCS Soil Data Mart program which includes the NRCS Soil Survey Geographic Database (SSURGO) and Web Soil Survey.

At locations where conventional methods of rock removal are not considered feasible, PennEast anticipates rock removal will be required by means of blasting.

A Blasting Plan prepared by PennEast has been developed with the intent to identify blasting operations, including safety, use, storage, and transportation of explosives, that are consistent with minimum safety requirements, as defined by applicable federal (e.g., Title 27 Code of Federal Regulations[CFR] 181 - Commerce in Explosives; Title 49 CFR 177 - Carriage by Public Highway; Title 29 CFR 1926.900 et seq. Subpart U - Safety and Health Regulations for Construction - Blasting and Use of Explosives; Title 29 CFR 1910.109 - Explosives and Blasting Agents; 29 CFR 1926.900 - General Provisions and Standards Nos. 901, 902, and 904-912), state, and local regulations consistent with the conditions of the FERC Certificate.

Notwithstanding the above, blasting in proximity to known and verified karst areas will be conducted in a manner so as not to comprise the structural integrity of pre-existing karst features or to alter subsurface hydrology through karst areas. If it is deemed that rock removal using blasting or hammering techniques is required in a karst-prone area, PennEast will carefully inspect the area to be excavated for any voids, opening, or other identifying features typical of solution activity. If the proposed rock removal is expected to intersect a karst feature such as sinkhole throat/void, cavern, or conduit, work in the area will be stopped until a location-specific assessment can be made by a qualified geotechnical engineer familiar with the project and with experience in karst terrain mitigation.

Following inspection of the area and guidance, as warranted, by the geotechnical engineer to allow blasting activities near any identified karst features, the use of all explosives will be limited to low-force charges designed to transfer a maximum charge of 2 inches per second ground acceleration and minimize propagation outside of blast area. If the percussive drill used to install blast holes encounters a single subsurface void greater than 6 inches or a group of voids greater than a combined 12 inches, explosives will not be used and PennEast will conduct a subsurface exploration to determine if the voids have connectivity with a deeper structure. It is anticipated that such investigation would consist of additional percussive probes, electrical resistivity, or other techniques capable of resolving open voids in the underlying bedrock. All open holes created by investigative activities will be grouted shut after the completion of the investigation to prevent the migration of surface water into deeper and previously unexposed karst terrain.

2) Earthmoving

During conventional installation of the pipeline, PennEast intends to conduct earthmoving activities in a manner that will minimize altering the existing grade and hydrology of existing surficial karst features. Where a known and delineated karst feature exists, earthmoving including permanent filling within 100 feet of the feature will be avoided to the extent possible, or minimized.

During routine trenching and pipe lay activities adjacent to karst features, spoils will be placed on the upgradient side of the excavation such that, if any erosion was to occur, the stockpiled soil would return into the excavation and not to the downgradient to the karst features.

3) Wells, Springs, and Karst Surface Expressions

Buffers of 100 feet around documented karst surface expressions and wells and springs recharging karst hydrology will be maintained between all work areas and the karst-related features. Surface water control measures including, but not limited to, diversion, detention, or collection and transportation will be implemented to minimize construction-influenced surface water from entering into the karst-related features. At no time will the karst features be used for the disposal or extraction of construction water.

4) Hydrostatic Testing

Following pipeline construction, hydrostatic testing will be performed prior to placing the pipeline into service. During this phase of construction, hydrostatic testing water will be prohibited from being returned into areas where known sinkholes, fissures, or other karst features or channels or surface features that flow towards those features exist. Hydrostatic testing water will be disposed of either downgradient of karst features unless on-the-ground circumstances (e.g., manmade structures, terrain, other sensitive resources) prevent such discharge, uplands greater than 300 feet from the karst features or, as far as practical from karst features with more robust sediment and water flow control devices to minimize the increase of drainage recharge and discharge into the karst feature.

9 Equipment Storage, Fueling, and Maintenance Considerations

During construction activities, PennEast will implement best management practices to minimize the potential impact of spills related to equipment storage, fueling, and maintenance within proximity to karst areas and sensitive resources.

In general, refueling of vehicles will not occur within 200 feet of any karst feature open to the surface. Additionally, equipment refueling will not be performed within flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features, except by hand-carried cans (5 gallon maximum capacity) and when deemed necessary. For equipment servicing and maintenance activities, areas will be sited outside of flagged or marked buffer areas of streambeds, sinkholes, fissures, or areas draining into these or other karst features. PennEast will instruct its contractor to avoid runoff created by equipment washing to directly enter any karst feature by locating these features outside the buffer areas listed in Section 8.

To the extent practical, no equipment or material will be stored within proximity of exposed karst features. Where storage is necessary near known karst areas, any construction equipment vehicles, materials, hazardous materials, chemicals, fuels, lubricating oils, and

petroleum products will not be parked, stored, or serviced within 300 feet of any karst feature. Should equipment require storage within this buffer area, the equipment will be checked daily for leaks by a construction inspector familiar with operation and maintenance of the specific equipment. Any damaged, defective, or leaky equipment will be removed and replaced. Should any spill occur during construction, PennEast will follow procedures in its Spill Prevention, Control, and Countermeasure (SPCC) Plan and Unanticipated Discovery of Contamination Plan.

10 Construction-Phase Karst Inspections

Prior to and throughout construction, PennEast will conduct awareness training for karst-like features such as portals, voids, or sinkholes as part of the Project's Environmental training. The training will include the Contractor's field supervisory personnel and supervisory personnel including the Chief Inspector, Craft Inspectors, and the Environmental Inspectors. These personnel will be trained on potential unanticipated karst features (i.e. features not identified through previous geophysical mapping and historic records) that could be discovered during trenching operations. The training will also provide the appropriate protocol for work stoppage if a karst feature is discovered in the immediate area and a communication plan to alert the appropriate PennEast and Contractor Supervisors of such discovery.

11 Mitigation Measures for Karst Encountered During Construction

If an unanticipated karst feature is discovered during trenching or other construction activities, work in the immediate area will be immediately stopped and PennEast and Contractor Supervisors will be notified. Erosion and sedimentation controls will be modified at the direction of an Environmental Inspector to install the measures necessary to minimize the potential for surface water runoff intrusion into the karst feature. A geotechnical engineer familiar with the project and with experience in karst terrain will be contacted and directed to the feature to conduct a detailed evaluation. The Project geotechnical engineer will develop a specific design and mitigation measures depending on the site conditions and nature of the karst feature.

If new sinkhole throats develop within the construction area while work is commencing, work in the area will be halted and the sinkhole area will be isolated and cordoned off to an area extending 100 feet radially from the feature. The sinkhole will be inspected by a geotechnical engineer and remedial measures such as filling of the sinkhole using inverted filter approach or adjustment of the pipeline alignment may be implemented. The inverted filter approach is often used for sinkhole repair, especially when the sinkhole is not located near structures. The sinkhole area is excavated to expose either bedrock or the throat of the sinkhole. A course of rock large enough to bridge the throat of the sinkhole is placed at the bottom of the excavation. Courses of progressively finer rock and gravel are compacted above the base course. A geotextile fabric may be placed above the finest gravel course to prevent excessive loss of the uppermost course, which may consist of sand and/or soil. The inverted filter method provides filtration treatment of storm water and allows controlled storm water infiltration and groundwater recharge.

If an existing subsurface void is intersected within the work area, work will similarly be halted and cordoned off for further evaluation by a qualified geotechnical engineer. As indicated earlier, the principal approach to maintain rates of recharge and discharge at pre-development conditions, a filter fabric secured over the void may be implemented in addition to an inverted filter.

Methods to mitigate sinkhole collapses and similar subsurface voids are referenced in the Pennsylvania Department of Environmental Protection's (PADEP) Erosion and Sediment Pollution Control Manual dated March 2012. A typical detail recommended by PADEP is included as Attachment 1 of this Karst Mitigation Plan and may be implemented depending on the karst feature encountered. Similar guidance details from NJDEP have not been published; however, US Department of Agriculture Natural Resources Conservation Service (USDA NRCS) has produced repair details which have been referenced by NJDEP. These Typical details are provided as Attachment 2 through 4 and may also be implemented depending on the karst feature encountered.

The mitigation methods detailed in the PADEP Manual would provide enhanced stability to the void and increase the long term stability and integrity to the pipeline right of way. Final grading of contours and any necessary permanent erosion and sediment controls will be designed to prevent runoff from accumulating in the area of the void. In addition, during the discharge of any hydrostatic test water from the pipeline, a discharge location will be selected that will prevent the discharged water from encountering any unanticipated features discovered during trenching activities.

In the event that an unanticipated karst feature or void is discovered during construction or post construction monitoring and karst mitigation is required, PennEast will notify and coordinate with applicable agencies to ensure any necessary and appropriate agency review or approvals are acquired.

12 Long-Term Monitoring and Maintenance

In addition to implementing the reference Karst Mitigation Plan to manage risk associated with construction through possible karst areas, PennEast notes that construction of the Project will be in accordance with U.S. DOT standards. The high grade steel to be used to manufacture the pipeline will minimize sinkhole risks. Piping such as that planned for the project can withstand loss of subgrade support over 100 feet in length without being compromised. Regular inspections will occur, and if evidence of subsidence is noticed in the future, corrective actions will be implemented. Should a sinkhole occur, PennEast would immediately address the situation by properly shoring the pipeline.

PennEast will conduct visual, post-construction inspections of the right of way to evaluate the success of any mitigation activities performed for any karst features or voids discovered and mitigated during construction.

The frequency of inspections will generally comply with those required under the FERC's Upland Erosion Control, Re-Vegetation, and Maintenance Plan (FERC Plan) and Wetland and Waterbody Construction and Mitigation Procedures (FERC Procedures), but would be more specifically based on severity of the mitigation activities and a geotechnical engineer's recommendations with a decreasing frequency over the two year monitoring period.

As part of post-construction monitoring, PennEast will inspect exposed parts of each private well periodically for cracked, corroded or damaged well casings; broken or missing well caps; and settling and cracking of surface seals. As required by the FERC, monitoring will be conducted for up to two years after construction completion. If a new karst feature or void were to develop within the right of way as a result of PennEast's subsequent construction activities, PennEast would contact a geotechnical engineer familiar with the project and experience with karst terrain to evaluate the feature and make additional remedial recommendations. PennEast will provide updates on the status of all discovered and mitigated karst features, including distance to known private water wells, or voids in its bi-weekly and quarterly activity reports.

13 References

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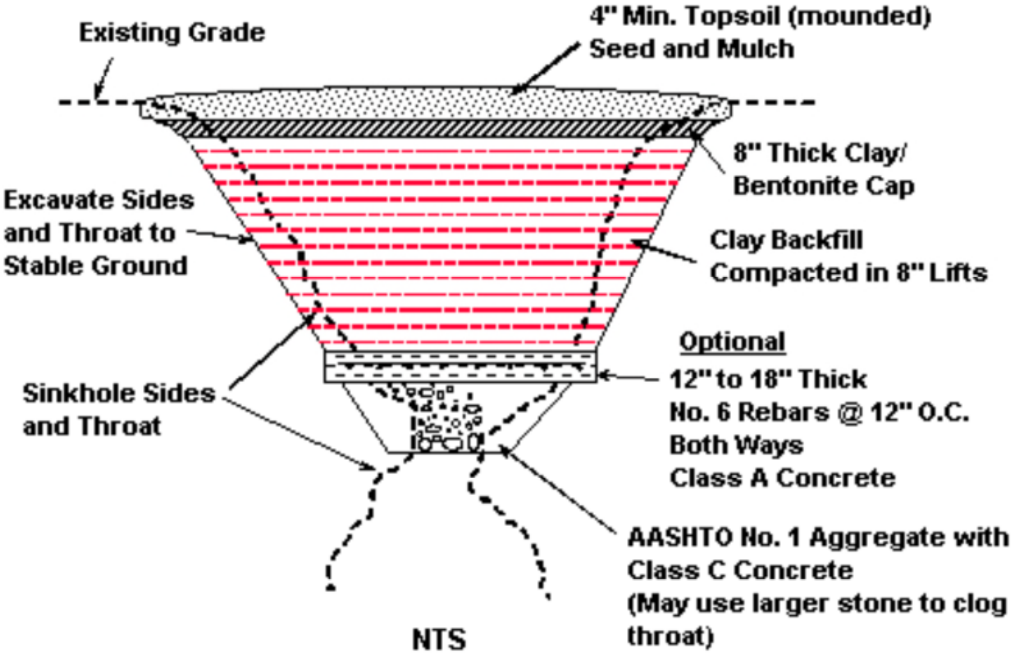
Attachment 1 – PADEP Sinkhole Repair with Bentonite Cap Detail



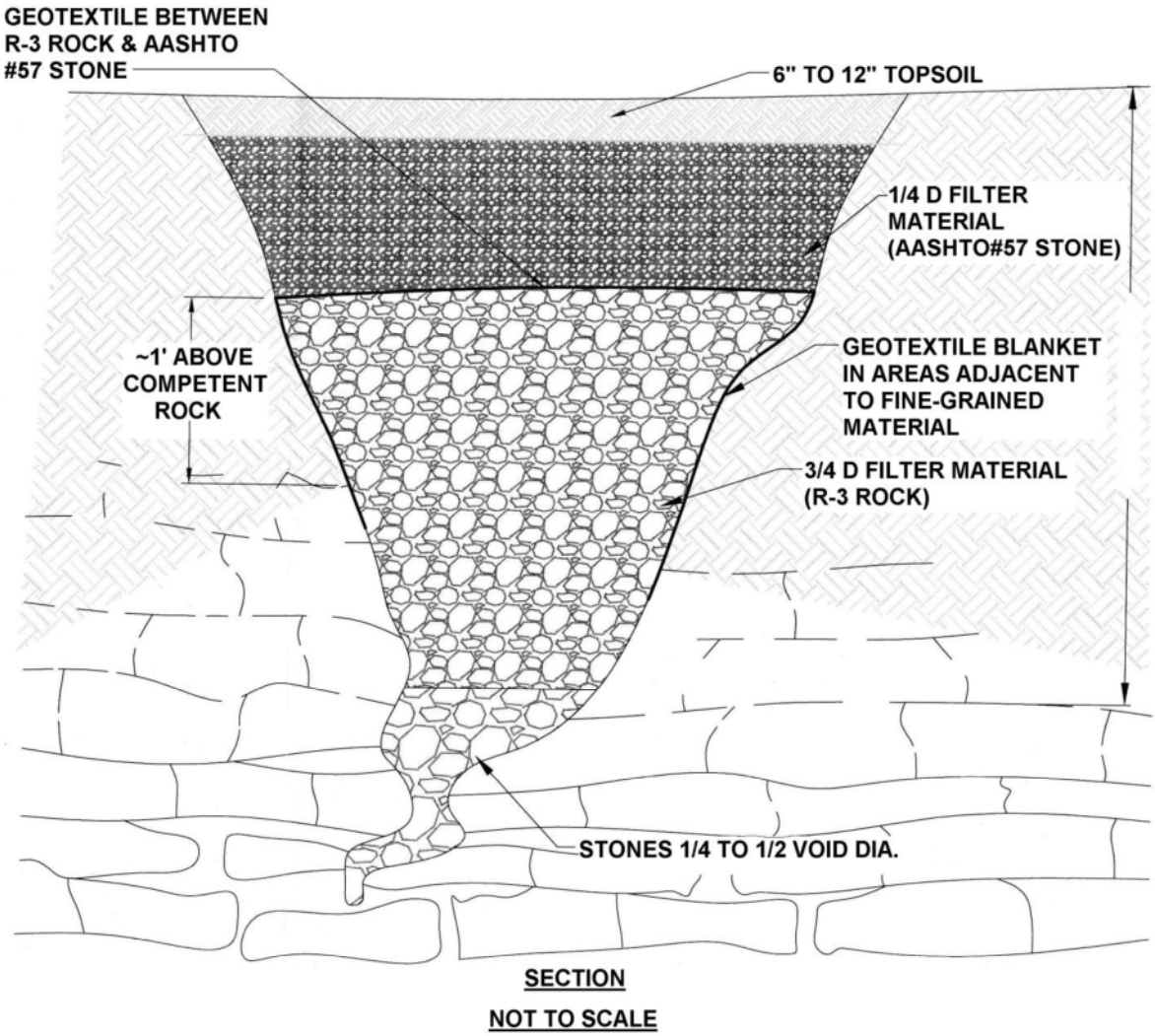
Source: Adapted from PADEP

Notes:

1. Loose material shall be excavated from the sinkhole and expose solution void(s) if possible. Enlarge sinkhole if necessary to allow for installation of filter materials. Occupational Safety and Health Administration (OSHA) regulations must be followed at all times during excavation.

2. Stones used for the "bridge" and filters shall have a moderately hard rock strength and be resistant to abrasion and degradation. Shale and similar soft and/or non-durable rock are not acceptable.

ATTACHMENT 2 – USDA NRCS Sinkhole Repair with Pervious Cover Detail



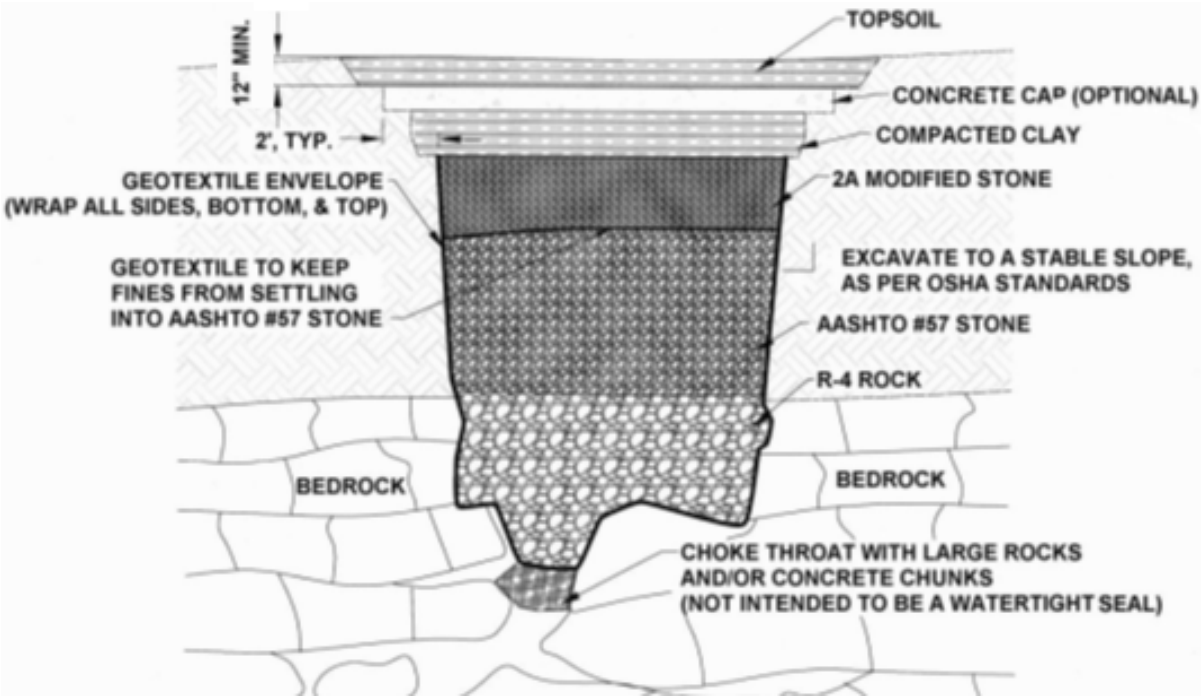
Source: Adapted from USDA NRCS

Notes

1. Loose material shall be excavated from the sinkhole and expose solution void(s) if possible. Enlarge sinkhole if necessary to allow for installation of filter materials. OSHA regulations must be followed at all times during excavation.

2. Stones used for the "bridge" and filters shall have a moderately hard rock strength and be resistant to abrasion and degradation. Shale and similar soft and/or non-durable rock are not acceptable.

ATTACHMENT 3 – USDA NRCS Sinkhole Repair with Impervious Cover Detail



Source: Adapted from USDA NRCS

Notes:

1. Loose material shall be excavated from the sinkhole and expose solution void(s) if possible. Enlarge sinkhole if necessary to allow for installation of filter materials. OSHA regulations must be followed at all times during excavation.

2. Geotextile shall be non-woven with a burst strength between 100 and 200 psi.

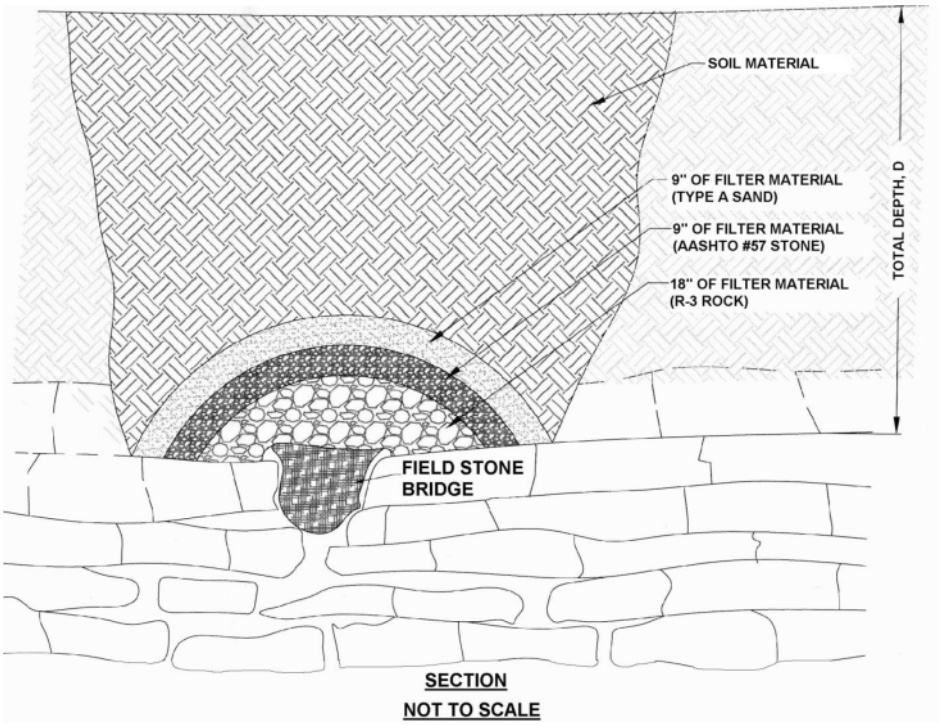
3. Select field stone(s) about 1.5 times larger than solution void(s) to form "bridge." Place rock(s) so no large openings exist along the sides. Stones used for the "bridge" and filters shall have a moderately hard rock strength and be resistant to abrasion and degradation. Shale and similar soft and/or non-durable rock are not acceptable.

4. Minimum thickness of R-4 rock is 18." AASHTO #57 stone thickness shall be ¼ to ½ that of the R-4 rock. Minimum thickness of 2A modified crushed stone shall be 9" AASHTO #57 stone and 2A modified crushed stone shall be compacted after each placement.

5. Compacted clay seal shall be a minimum of 12" thick. Clay shall be placed in 6" to 9" lifts and thoroughly compacted. Concrete cap, which is optional, shall be a minimum of 8" thick. Use 4,000 psi concrete with 6" X 6" - 6 gauge welded wire fabric, or # 3 rebar on 18" O.C. both ways.

6. Topsoil shall be a minimum of 12" thick. Grade for drainage away from sinkhole area.

ATTACHMENT 4 – USDA NRCS Sinkhole Repair with Soil Cover Detail



Source: Adapted from USDA NRCS

Notes:

1. Loose material shall be excavated from the sinkhole and expose solution void(s) if possible. Enlarge sinkhole if necessary to allow for installation of filter materials. OSHA regulations must be followed at all times during excavation.

2. Select field stone(s) about 1.5 times larger than solution void(s) to form “bridge.” Place rock(s) so no large openings exist along the sides. Stones used for the “bridge” and filters shall have a moderately hard rock strength and be resistant to abrasion and degradation. Shale and similar soft and/or non-durable rock are not acceptable.

3. Minimum thickness of R-3 rock is 18” AASHTO #57 stone thickness shall be a minimum of 9” thick. Minimum thickness of type A sand shall be 9”. NOTE: A non-woven geotextile with a burst strength between 100 and 200 psi may be substituted for the AASHTO#57 stone and type A sand.

4. Soil shall be mineral soil with at least 12% fines and overfilled by 5% to allow for settlement. Suitable soil from the excavation may be used. Any available topsoil shall be placed on top surface.