Attachment 11

Supplemental Information to Appendix O

HDD Drilling Plan for Karst Terrain

Preliminary
HDD Drilling Plan for Karst Terrain
PennEast Pipeline Project

Issue and Revision Record

Rev	Date	Originator	Checker	Approver	Description
A	12/14/2015	V. Shah	S. Crouse	M. Wilcox	Issued for Information

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1.0 INTRODUCTION

PennEast Pipeline Company, LLC (PennEast) is proposing to construct the PennEast Pipeline Project. The Project facilities include a 36-inch diameter mainline pipeline, extending from Luzerne County, Pennsylvania, to Mercer County, New Jersey. The Project will extend from various receipt point interconnections in the eastern Marcellus region to various interconnections. The Project is designed 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.

During the construction of the Project, the use of horizontal directional drilling ("HDD") methods of construction may be used for the purpose of avoiding environmentally sensitive resources or obstructions that occur along the Project pipeline route. As such, this HDD Drilling Plan for Karst Terrain ("Plan") has been developed 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. The purpose of this document is to provide 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. In addition, the Plan provides discussion of drilling practices which will be implemented while installing through karst terrain which may be a local feature of several crossing locations.

2.0 HDD DRILLING PRACTICES

Though adequate planning, care, and precaution during design and construction are held paramount for installation of each HDD crossing, there still exists potential for HDD operations to have a potential to release drilling fluids into the surface environment through inadvertent returns or unexpected losses. An inadvertent return is the condition where drilling mud travels through the overlying soils or bedrock formations towards the ground surface as opposed to traveling through the HDD bore. An unexpected loss may be the loss of drilling fluid during the crossing of a subsurface void feature, such as a sinkhole or conduit. Because drilling muds consist largely of a bentonite clay-water mixture, they are not classified as toxic or hazardous substances. While drilling fluid seepage associated with an inadvertent return is most likely to occur near the bore entry and exit points where the drill head is shallow, these losses may occur in any location along a directional bore.

This Plan establishes operational procedures and responsibilities for the prevention, containment, and clean-up of inadvertent returns and losses associated with the directional drilling on the Projects through areas of karst terrain.

2.1 General Description of HDD Activities

The HDD method of construction involves creating staging areas (workspaces) at both the entry and exit points such the drilling can commence with the drilling of a pilot hole along a predetermined path beneath the sensitive resource to be crossed. Once the pilot hole has been installed, the drilled hole may be enlarged through a series of one or more passes of a reamer tool until the diameter of the hole has been opened up to a size to allow pull-back and installation of the pipeline. This pipeline is installed using pre-fabricated pipe segments.

2.2 Drilling Fluids Used

Drilling fluids consisting of a carrier fluid (water) and drilling fluid additives (bentonite and/or polymers) are used to complete the HDD process. Proportions of drilling fluid slurry are generally 95% water, and remaining portion bentonite, a naturally occurring clay mineral that forms a mud when mixed with water. The role of the drilling fluid is to transport drill "cuttings", and soil removed from the drill path which are suspended in the mud and transported back to the surface, as well as cleaning the drill bit face, cooling downhole tools and equipment, and lubrication to reduce the friction between the drill pipe and the bore wall. The drill fluid additionally aids in stabilizing the bore, especially in loose or soft soils (such as residuum or soils within voids in karst terrain) by building a low permeability filter cake and exerting a positive hydrostatic pressure against the bore wall.

The filter cake, along with the fluid pressure, reduces potential for collapse of the bore and prevents fluids from the formation, such as groundwater passing through underground karst topography, from flowing into the bore or exiting out into the formation. When the drilling fluid is pumped into the hole, the fluid, similar to water, will attempt to flow into any available flow path; however, the bentonite within the fluid will start to plaster or shingle off the wall of the borehole and form a filter cake that seals off the flow of fluid from the bore into the native soil. This function reduces migration of drilling fluid into the formation and reduces the intrusion of outside groundwater from entering or mixing with bore.

Depending on subsurface conditions encountered, certain additives may also be introduced in the drilling fluid mixture. These additives include lost circulation materials and special polymers. Lost circulation materials may be used during inadvertent return events and/or in certain cases when drilling fluid circulation seems to be diminishing. Lost circulation materials (LCMs) may be used to attempt to seal conduits or to aid in reestablishment of drilling fluid returns to the entry and/or exit pits. Many types of LCMs are available for use during HDD operations that are inert and environmentally benign. These materials may include wood fibers, cotton seed husks, ground walnut shells and other natural materials. Special polymers that swell to several times their original size when introduced to water can also be used. These polymers are industrial grade equivalents of food grade polymers that are used to swell and absorb fluids in the food industry.

The specific type of products which PennEast will use is typically left to the discretion of the HDD Contractor retained for the project, as well as the HDD foreman, operator, and environmental inspector; however, the drilling mud and polymers to be used will be NSF/ANSI 61 approved and/or food grade quality to ensure the product is safe should it come in contact with groundwater or drinking water.

3.0 HDD CROSSINGS AND KARST TERRAIN

PennEast understands the proposed pipeline will cross through several areas where karst terrain may be possible, and which may affect the installation of pipeline both by open-cut and HDD methods of construction. By definition, karst topography is an underground landscape formed by the dissolution of soluble bedrock. Karst features form as the result of minerals dissolving out of the rock through rainwater. Over long periods of time, slightly acidic rainwater leaches through the soil zone becoming more acidic. This acidic groundwater slowly dissolves the soluble bedrock, a process that commonly occurs along fractures, bedding planes, and layers of rock more prone to dissolution, where groundwater may be flowing through continuously. The result of these on-going physical earth and geologic cycles produces karst terrain that have surface drainage systems that are established by sinkholes, springs, caves, disappearing streams, and underground drainage channels and caverns.

The collapse of a cavern over a large area can create a solution valley or basin. These caverns may be filled in with soil which is washed into the cavity over time, or remain covered under a crust of soil.

Once sufficient erosion occurs, on-going dissolution of rock reaches a critical state, or outside physical forces occur, the soil within and above the cavity may collapse and cause a sinkhole to form at the ground surface. As solution of carbonate rock occurs, new flow paths from the solution channels and existing interconnected flowpaths allow groundwater to transmit freely through the karst terrain. Where the ground surface elevations are low and the pressure head of groundwater is artesian, a spring may occur. This ground flow through karst terrain may be expressed in two different types of flow-conduit flow and diffuse flow. In conduit flow, the discharge between maximum discharge and base flow discharge is very high, indicating that discharge through these flow paths responds rapidly to rainfall and infiltration. Conduit flow is generally turbulent and characteristics such as turbidity may be variable and therefore able to be monitored. In diffuse flow systems, the groundwater flow is generally laminar and baseline flow remains fairly constant.

As the installation of pipeline through karst or sinkhole-prone areas produce significant risks if not adequately addressed, PennEast understands it is imperative that precautions during planning, design, construction, and operation be taken to prevent unanticipated impacts to environment during construction and the pipeline during its service life. Prior to the location of the preferred alignment and selection of HDD crossings, PennEast attempted to minimize the potential for crossing karst areas and previously expressed, remnant sinkholes and formations. PennEast began by inventorying these areas based on available data and attempted to avoiding them in the preferred alignment, where possible. PennEast reviewed multiple local data sources, including mine and subsidence mapping prepared by the New Jersey Department of Environmental Protection (NJDEP) and Pennsylvania Department of Conservation and Natural Resources (PADCNR) while selecting a preferred alignment route. These included, but were not limited to, such maps as NJDEP Open File Map “DGS03-2 Abandoned Mines of New Jersey”, Open File Map “DGS06-3 Landslides in New Jersey”, 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”, PA Department of Environmental Protection “Abandoned Mine Land Inventory” mapping, and other relevant geologic mapping while performing siting and planning for pipeline and facilities.

Once the preferred alignment was established, PennEast began undertaking a program to evaluate the specific subsurface geology and features which would be crossed by its pipeline. Historic mapping of karst features as provided by USGS and PA DCNR were evaluated by further geophysical and/or geotechnical field investigations to investigate the potential for encountering these features as well as extents of each, if crossed. Geophysical investigations, conducted by Hager-Richter Geoscience, Inc., included acquiring electrical resistivity data along a series of geophysical lines across each area with potential to exhibit karst terrain.

Currently, the survey has been conducted along portions of the proposed pipeline alignment where access was granted and continues to be performed as additional permissions become available. The geophysical survey was conducted using an AGI SuperSting R8 system and 55 electrodes spaced at 8-foot centers along the granted survey areas. The results of geophysical investigations completed have been provided as Attachment F (Karst Investigation Interim Report) under Resource Report 6, Appendix O in the September 2015 FERC filing by PennEast. As of December 2015, a total of nine resistivity anomalies indicative of karst features were detected along the alignment; however, the detected features were small in nature and were not considered significant by Hager Richter.

Upon locating potential geophysical anomalies indicative of possible karst, geotechnical test borings consisting of overburden sampling and rock coring were subsequently advanced at the anomaly location. Through these borings, additional reliability was gathered which will ultimately provide information which can be provided to PennEast’s HDD contractor for the planning and construction of safe HDD crossings.

4.0 MONITORING AND RESPONSE FOR DOWNGRADIENT RECEPTORS

4.1 TRAINING

Prior to start of drilling operations at any of the crossings, the HDD drilling foreman, driller, contractor personnel, and inspectors shall all receive site-specific training including, but not limited to a review of the crossing, review provisions of this plan and site-specific permit requirements, and review and identify sensitive environmental resources at the site. The training shall indicate that the chief environmental inspector or their representative should perform a pre-condition survey and document existing conditions of each of the delineated sensitive resources within vicinity of the site prior to work and routinely during the course of the drilling operations. In addition, the training will review drilling procedures for release prevention, review location and operation of clean up supplies and release control equipment and materials, and the protocols for reporting observed inadvertent returns.

4.2 MONITORING AND REPORTING

During the course of work, if the HDD driller observes a loss of circulation, the driller will notify the foreman and field crews of the event and approximate position of the cutting head. It is noted that, when the driller observes a loss of return of drilling fluid, it may be an indicator that seepage may be occurring outward of the hole.

Loss of drilling fluid returns is only an indicator as some loss of drilling fluid is expected, such as where loose sediments are encountered and more drilling fluid is required to be added to fill the voids.

At this instant, once noticed, the driller may decrease pump pressure, penetration rate, retract the drill string to restore circulation, or any combination of these activities. The driller may also elect to introduce lost circulation additives, install casing, or install a vertical well ahead of the drill operation through the karst opening to grout and seal the cavity to allow the HDD to continue through solid material.

In parallel with methods to restore drill fluid pressure and return circulation, an environmental inspector or member of the field crew will attempt to ground-truth to the drill cutting location at the surface and visually inspect the ground surface near the position of the cutting head. Named surface waters and mapped wells and springs within 500 feet of the HDD site will also be visually inspected. Should a release be observed, the inspection team will notify the drill foreman and drill operator of the event and instructions to temporarily cease the pumping of drilling fluid to the borehole. At this time the environmental inspector or field crew team will coordinate a response to stabilize and contain the incident and, within 24 hours, will notify FERC and appropriate permitting authorities as necessary to document the event and proposed remediation strategy. Final clean-up will occur once the HDD installation is completed. The environmental inspector and/or construction inspector will prepare a report which summarizes the incident and final clean-up activities conducted.

4.3 Monitoring Plan for Nearby Receptors

The monitoring program proposed by PennEast for nearby mapped waterbodies and groundwater sources includes establishing baseline turbidity levels and measuring changes in turbidity and sediment levels with respect to baseline conditions. Although it was suggested that a region of 2,500 feet within vicinity of the HDD be evaluated, PennEast notes that, should drilling fluids be released, as the fluid mixture travels greater lengths, it is likely to contain a lower concentration of bentonite when they surface because the mixture may be filtered and somewhat diluted as it passes through volumes of groundwater and existing sediments of various types. Once diluted, measuring of turbidity or levels of impact may be imperceptible. PennEast therefore will implement an inspection radius of 500 feet around each HDD area and, if these areas indicate impact, inspection will continue radially outward until impacts are no longer observed.

4.3.1 Mapped Streams, Wetlands, Waterbodies, and Springs

PennEast's monitoring program for mapped streams, wetlands, waterbodies, and springs shall involve the establishment of a baseline turbidity level in water resource areas that are within a 500 feet radius of planned HDD activities. Prior to the start of HDD activity, 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.

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.

4.3.2 Wells

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.

Prior to the start of HDDs, land agents and environmental inspectors will speak to property owners to gather if they will permit the collection of a pre-HDD turbidity sample. The monitoring program proposed by PennEast for wells within 500 feet of the HDD activity shall then include turbidity sampling, using the portable turbidity meter noted for springs and following the same testing and calibration protocols. A baseline sampling will be conducted to establish a baseline turbidity level for each well. If an inadvertent release from the HDD activity is confirmed, 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.

5.0 EVALUATION OF POTENTIAL FOR IMPACT AND MITIGATION STRATEGIES

Typically, the release or loss of recirculation will be observed and assessed by the HDD foreman and driller piloting the HDD and monitoring flow rate and drill fluid pressure. Through this monitoring, the driller and foreman are able to evaluate the estimated volume of the release, should it occur. Throughout the course of the HDD the drilling foreman and driller will continually assess the drilling parameters (depth of cutter head, fluid flow rate, return fluid characteristics) and formation being crossed. They will also assess the potential of the release to reach adjacent sensitive resources such as wells, seeps, springs, and wetlands, the potential for impact to these resources, and pro-active measures to prevent the migration of fluid should a release begin to be suspected.

As the location and environment in which inadvertent releases are unpredictable, PennEast notes that this Plan may not encompass all possible approaches which will be used to mitigate lateral movement of drilling during trenchless crossings. Should a material movement of drilling fluid occur, the method of mitigation will depend significantly on the ability to access for personnel and equipment the location where the drill fluid has exited. Typically, containment and mitigation is achieved by excavating a small sump pit several cubic yards in size at the location of the release and surrounding with appropriate soil erosion and sediment control devices such as hay bales, sand bags, and/or silt fence. Once contained, the drilling fluid can be extracted from the surface seep through the spring or water resource, or through pumping extraction of the well using vacuum truck or similar equipment. Extracted drilling fluids may then be transported to a disposal site.

Site topography in conjunction with access for personnel and equipment to the release site are major factors in determining the methods used for containment and disposal. Once an inadvertent release is recognized, the HDD driller will suspend drilling operations until modifications are made and/or appropriate containment is in place. Typically, containment is achieved by excavating a small sump pit (approximately 5 cubic yards) at the site of the release and/or surrounding the release with hay bales, silt fence and/or sand bags. Once contained, the drilling fluid is either collected by vacuum trucks or pumped to a location where vacuum trucks can be accessed. The fluids are then transported either back to the HDD Drilling Rig or to a disposal site.

5.1 Mapped Streams, Wetlands, and Waterbodies

At locations of wetlands, sensitive springs, and habitats, PennEast's environmental inspector, construction inspector, and drilling foreman will first evaluate the amount of fluid released to determine if standard soil erosion containment barriers (hay bales, silt fence, turbidity barriers) are warranted and if they will effectively contain the release. Efforts to contain the drilling fluid may be recommended; however, if the recovery efforts are deemed to result in further disturbance by clean-up personnel and equipment and the benefit gained in removing the slurry are offset, the fluid may be diluted with fresh water or allowed to dry and dissipate naturally.

For inadvertent releases near waterbodies, PennEast will install soil erosion and sediment control devices such as silt fence, core logs, or sandbags at the overland point of entry before the waterbody to reduce or stop the flow of material into the waterbody. Should the release vent into the waterbody, using vacuum trucks or pumps, PennEast will remove suspended bentonite by working from downstream to upstream. Hand tools may be used to separate sediments and attempt to recover as much material as possible. As necessary, and approved by FERC or other regulatory stakeholder, water may be diverted using temporary barriers to isolate the impact area. To the extent practical the stream will only be bifurcated at the area of impact so as to allow water to pass through the site in its natural condition elsewhere. If it is deemed impractical to remove the drilling fluid which has entered into the waterbody through seeps and springs, PennEast will provide a written explanation for submission to the applicable regulatory agency along with plan for additional restoration for approval.

5.2 Mapped Springs

Should a release occur to a spring, the installation of soil erosion and sediment control measures such as silt fencing, sand bags, core logs, or turbidity barrier may be implemented so as to contain the release of drilling fluid stemming from the spring. Subsequently, PennEast may remove the contained drilling fluid using vacuum truck or pump and use hand tools to collect sediment from the drill fluid.

5.3 WELLS

Should a release occur to a well, PennEast will evaluate the size of the release to determine the mitigation strategy to be implemented. For small releases, PennEast may implement a vacuum or pump removal strategy where the well will be pumped using submersible pump until the drill fluid is flushed and removed for off-site disposal. For larger impacts, PennEast will provide an alternate source of water to the landowner until the well water quality returns to pre-construction conditions. If the well water quality does not return to pre-construction conditions after a suitable length of time, PennEast will compensate the landowner for the installation of a new well or otherwise arrange for provision of a suitable water supply.

6.0 REFERENCES

Bennett, David, and Samuel T. Ariaratnam. Horizontal Directional Drilling: Good Practices Guidelines. S. L.: CRC Taylor & Francis Group, 2008. Print.

Najafi, Mohammad, and Sanjiv B. Gokhale. Trenchless Technology: Pipeline and Utility Design, Construction, and Renewal. New York: McGraw-Hill, 2005. Print.

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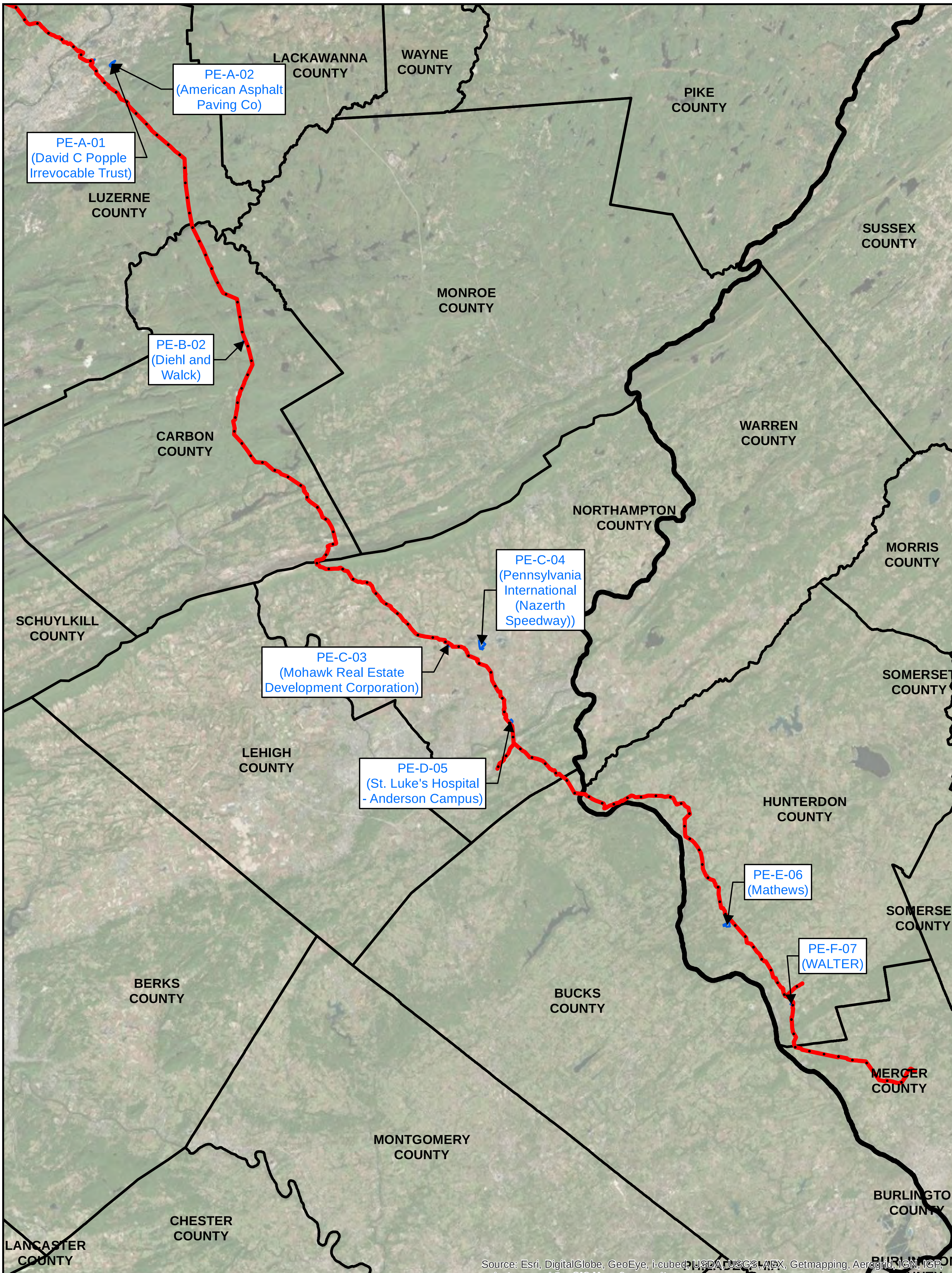
USEPA, 1989. Groundwater Monitoring in Karst Terranes, Recommended Protocols & Implicit Assumptions, EPA 600/X-89/050, February.

Attachment 12

Geology Mapping for PennEast Wareyards



Proposed Alignment

Wareyard

0 5 10 20 Miles

N S W E

NOTE: Proposed Alignment Current as of December 8, 2015

Hatch Mott MacDonald

111 Wood Avenue South
Iselin, New Jersey, 08830

Figure 1. Wareyard Locations
PennEast Pipeline Project

Designed	Drawn	Checked	Approved	Date
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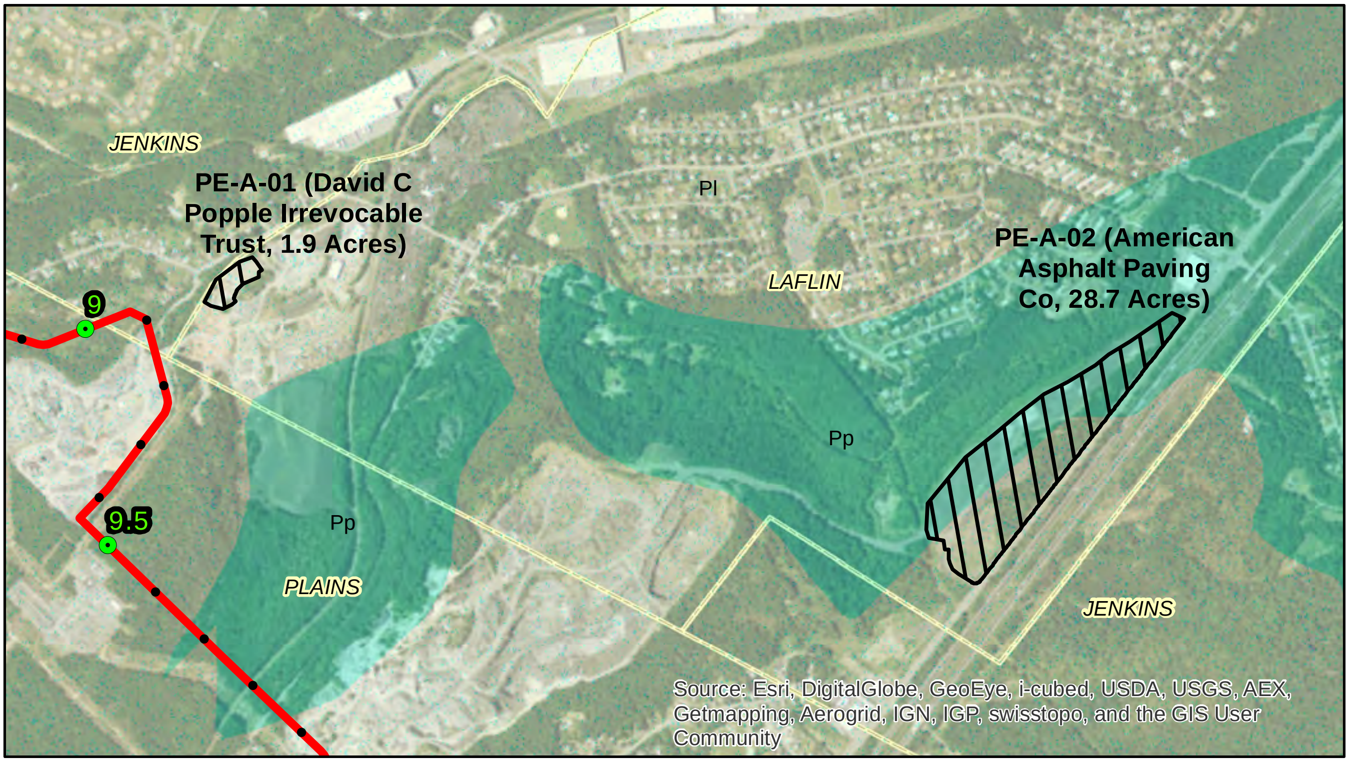

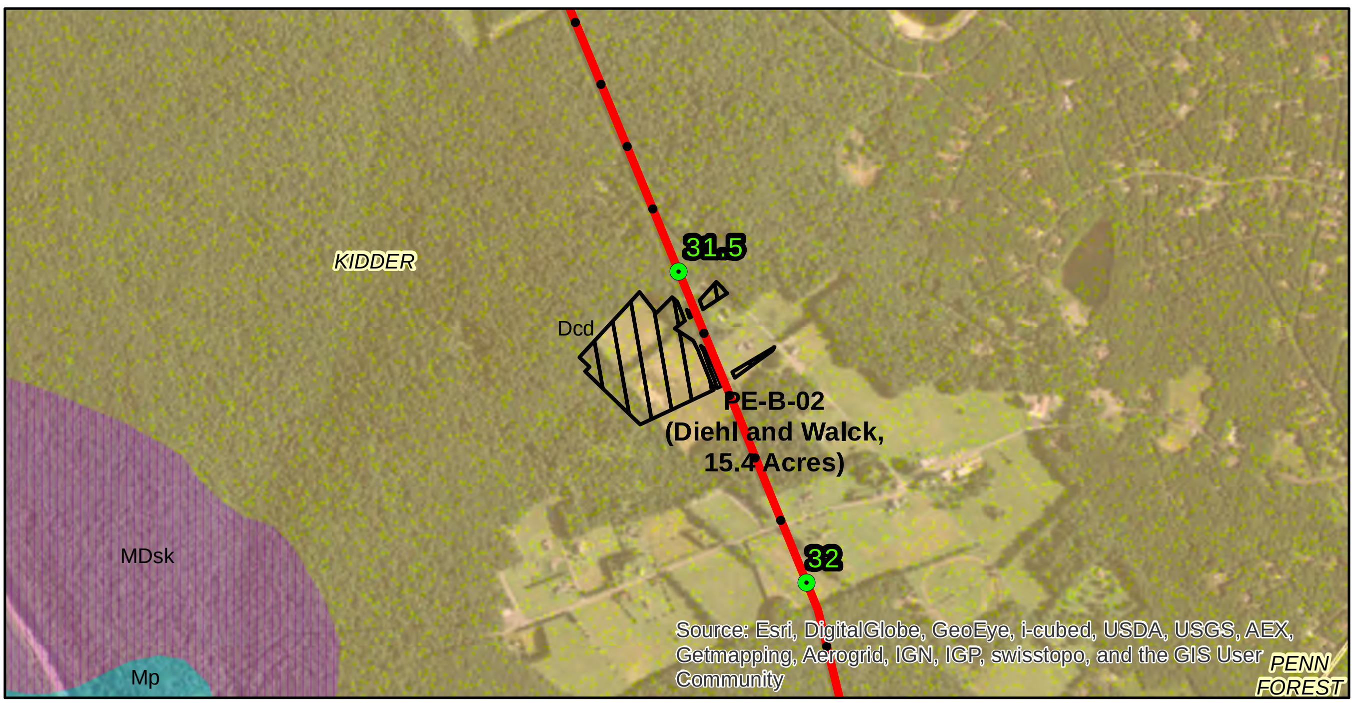

0 1,000 2,000 4,000 Feet

LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- Municipal Boundaries

Bedrock Geology

- Pl - Llewellyn Formation
- Pp - Pottsville Formation
- Dcd - Duncannon Member of Catskill Formation
- MDsk -Spechty Kopf Formation
- Mp - Pocono Formation

N W E S

NOTE: Proposed Alignment Current as of December 8, 2015

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Iselin, New Jersey, 08830

Figure 3. Bedrock Geology
PennEast Pipeline Project
Wareyard PE-A-01 and PE-A-02
Luzerne Cty, PA
Wareyard PE-B-02, Carbon Cty, PA

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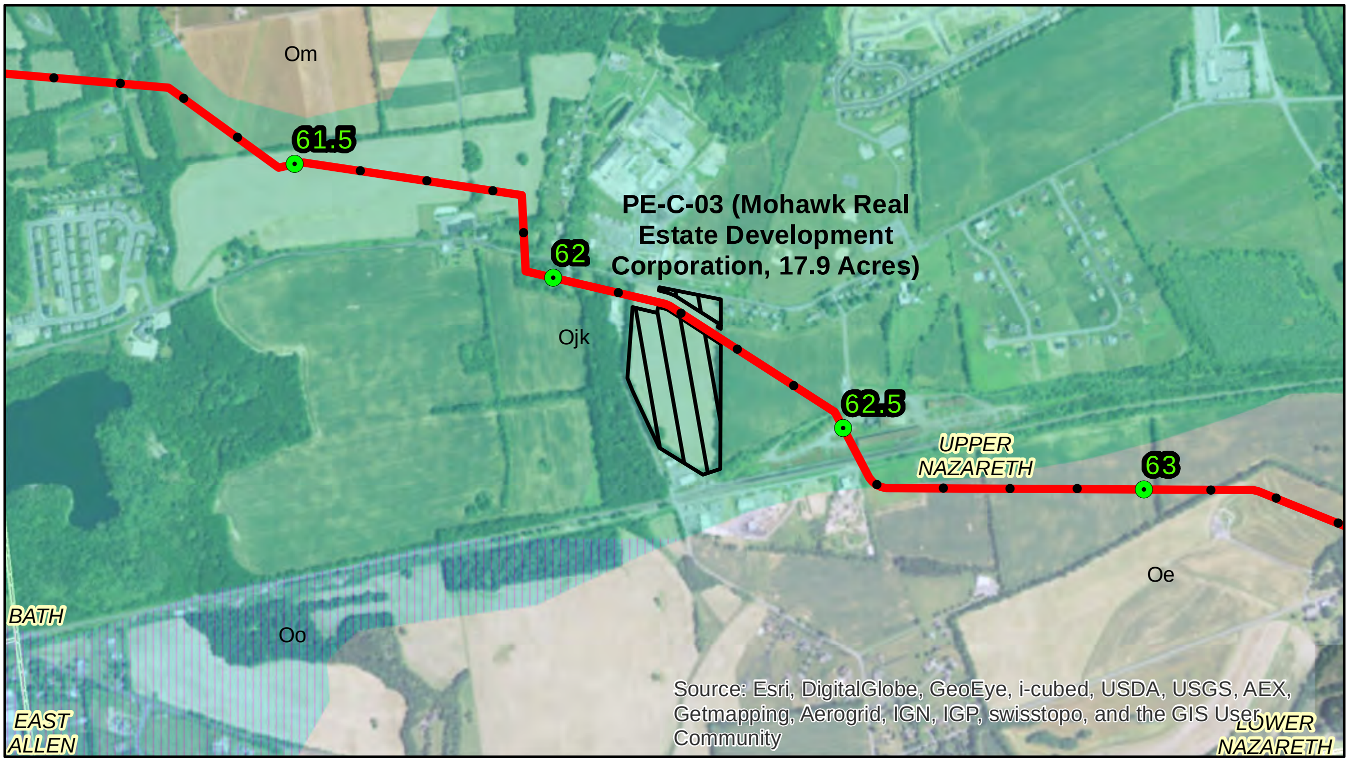

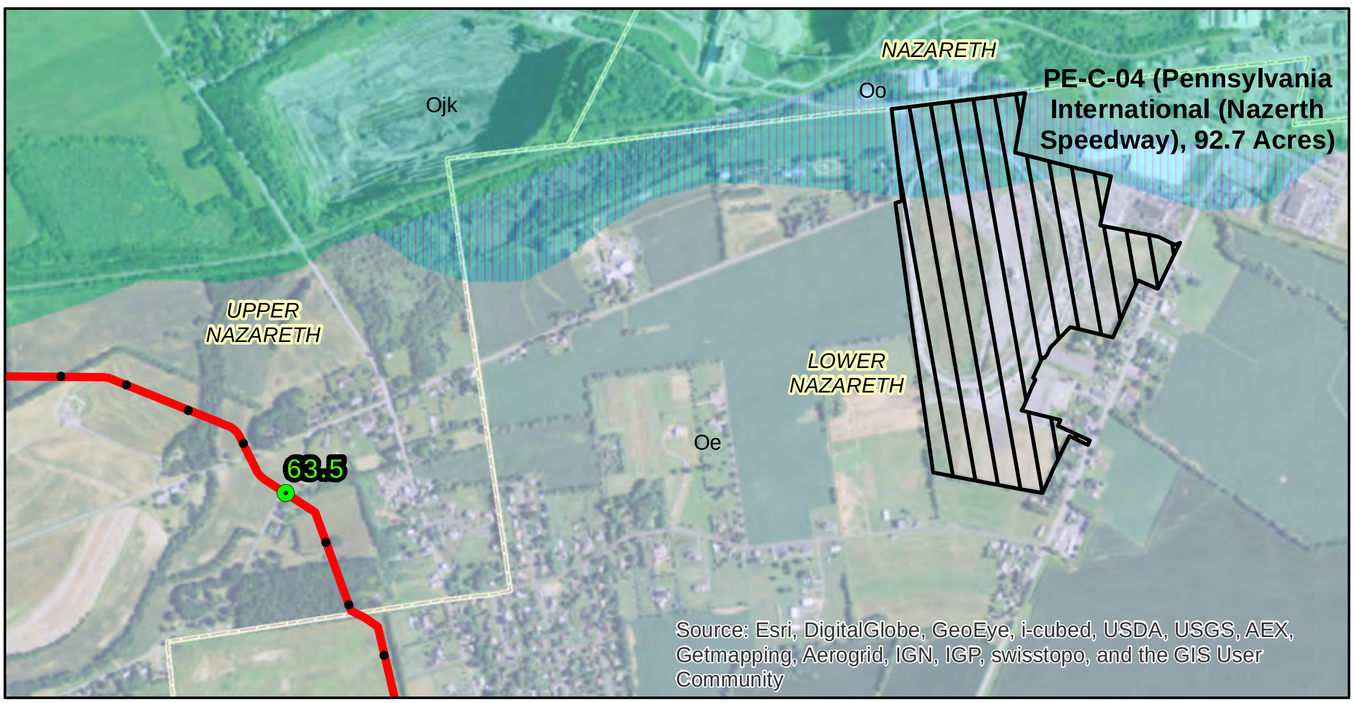

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LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- MunicipalBoundaries

Bedrock Geology

- Oe - Epler Formation
- Ojk - Jacksonburg Formation
- Om - Martinsburg Formation
- Oo - Ontelaunee Formation

N W E S

NOTE: Proposed Alignment Current as of December 8, 2015

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Figure 3. Bedrock Geology
PennEast Pipeline Project
Wareyard PE-C-04 & Wareyard PE-C-04
Northampton County, PA

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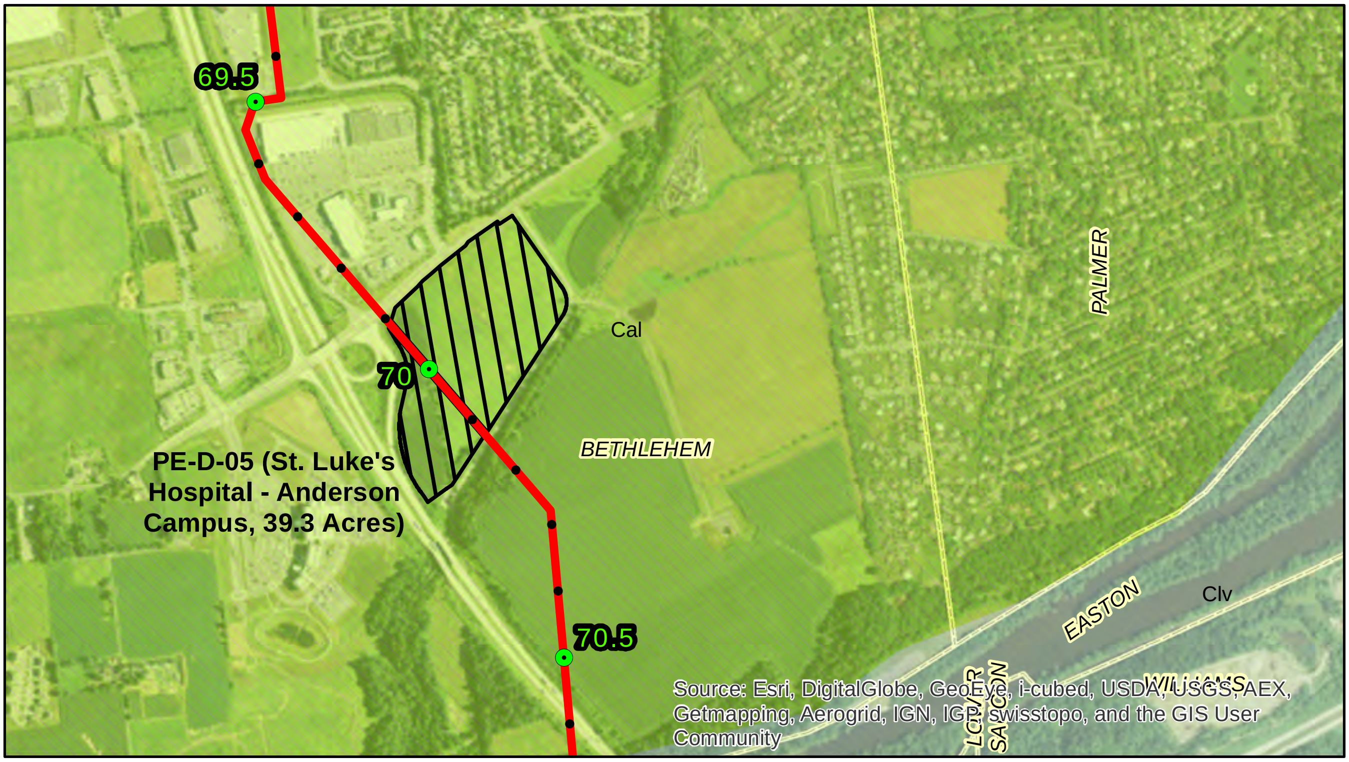

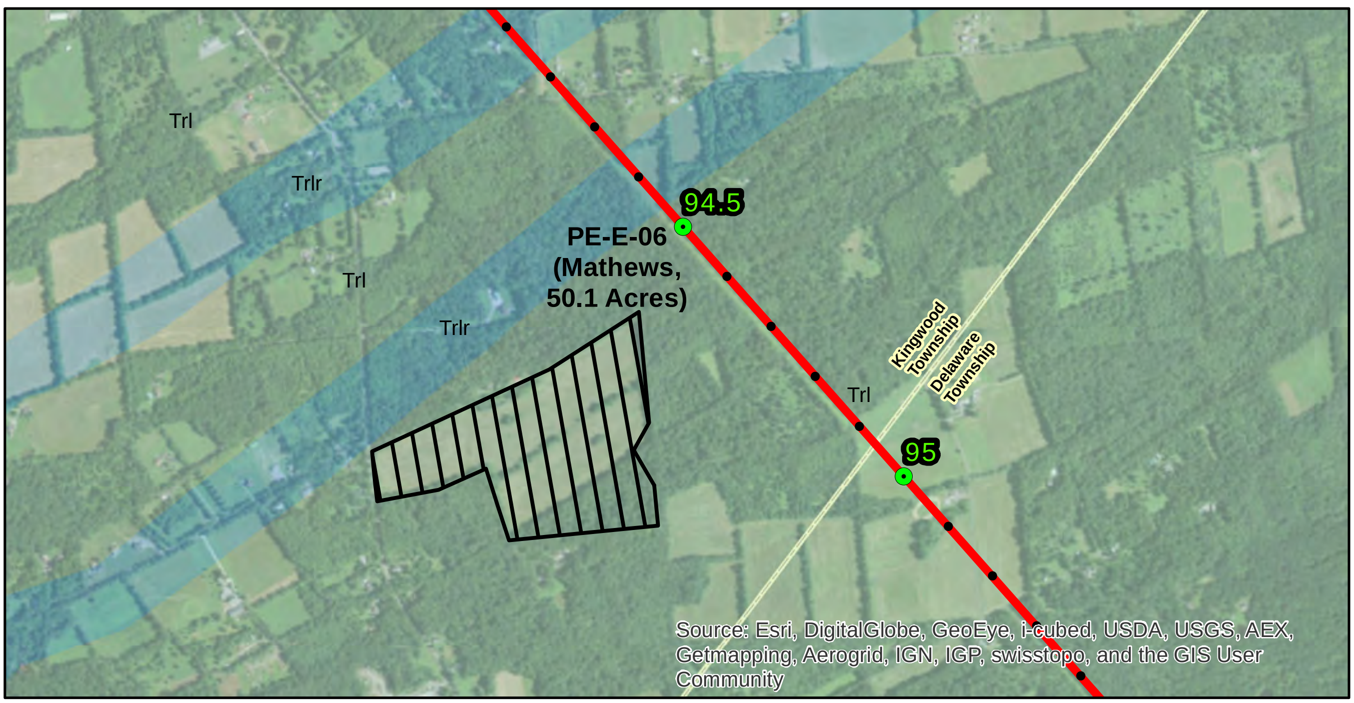

0 1,000 2,000 4,000 Feet

N W E S

LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- Municipal Boundaries

Bedrock Geology

- Cal - Allentown Formation
- Clv - Leithsville Formation
- Trl - Lockatong Formation
- Trlr - Red bed of Lockatong Formation

NOTE: Proposed Alignment Current as of December 8, 2015

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Figure 3. Bedrock Geology
PennEast Pipeline Project
Wareyard PE-D-05, Northampton County, PA
Wareyard PE-E-06, Hunterdon County, NJ

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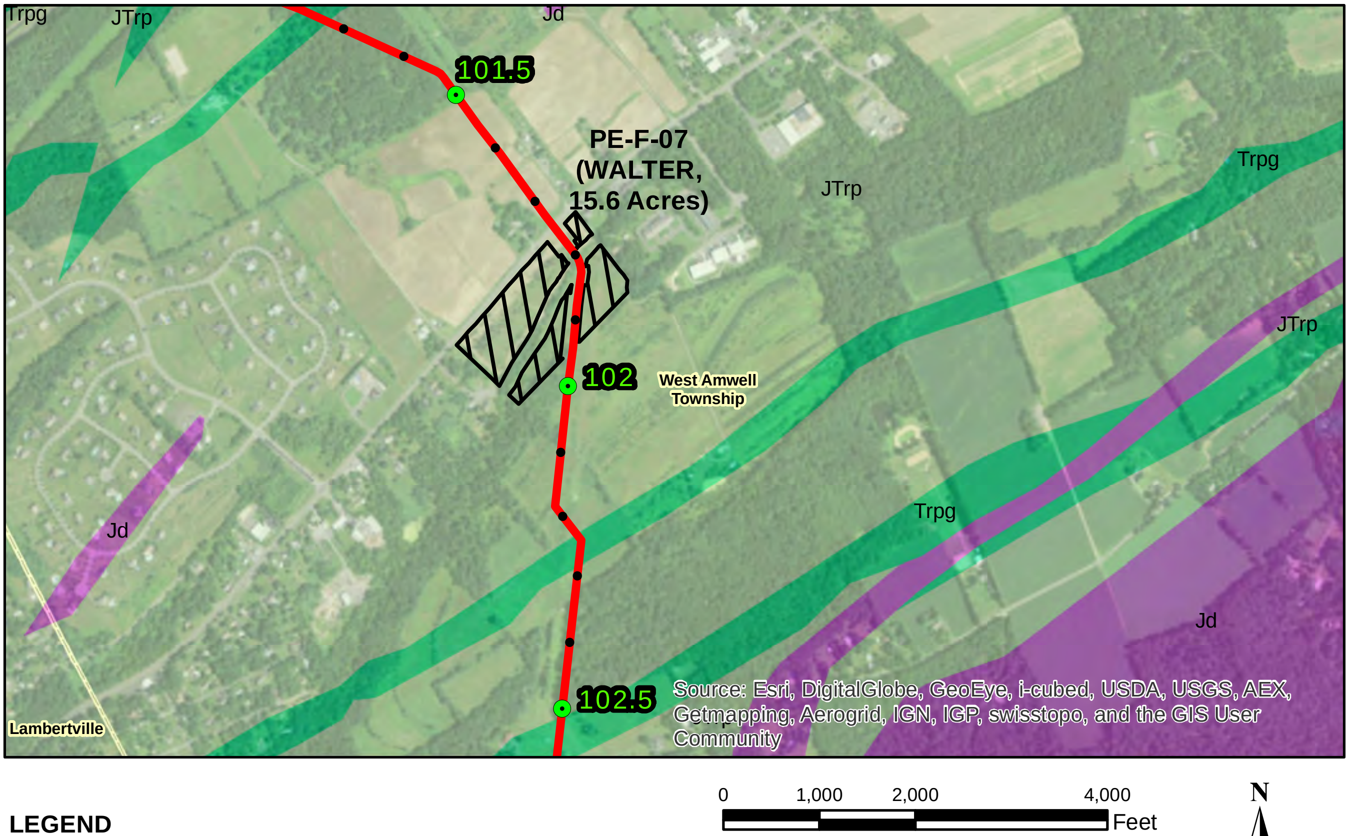

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LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- Municipal Boundaries

- JTrp - Passaic Formation
- Jd - Jurassic Diabase
- Trpg - Passaic Formation Gray bed

NOTE: Proposed Alignment
Current as of
December 8, 2015

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Figure 3. Bedrock Geology
PennEast Pipeline Project
Wareyard PE-F-07
Hunterdon County, NJ

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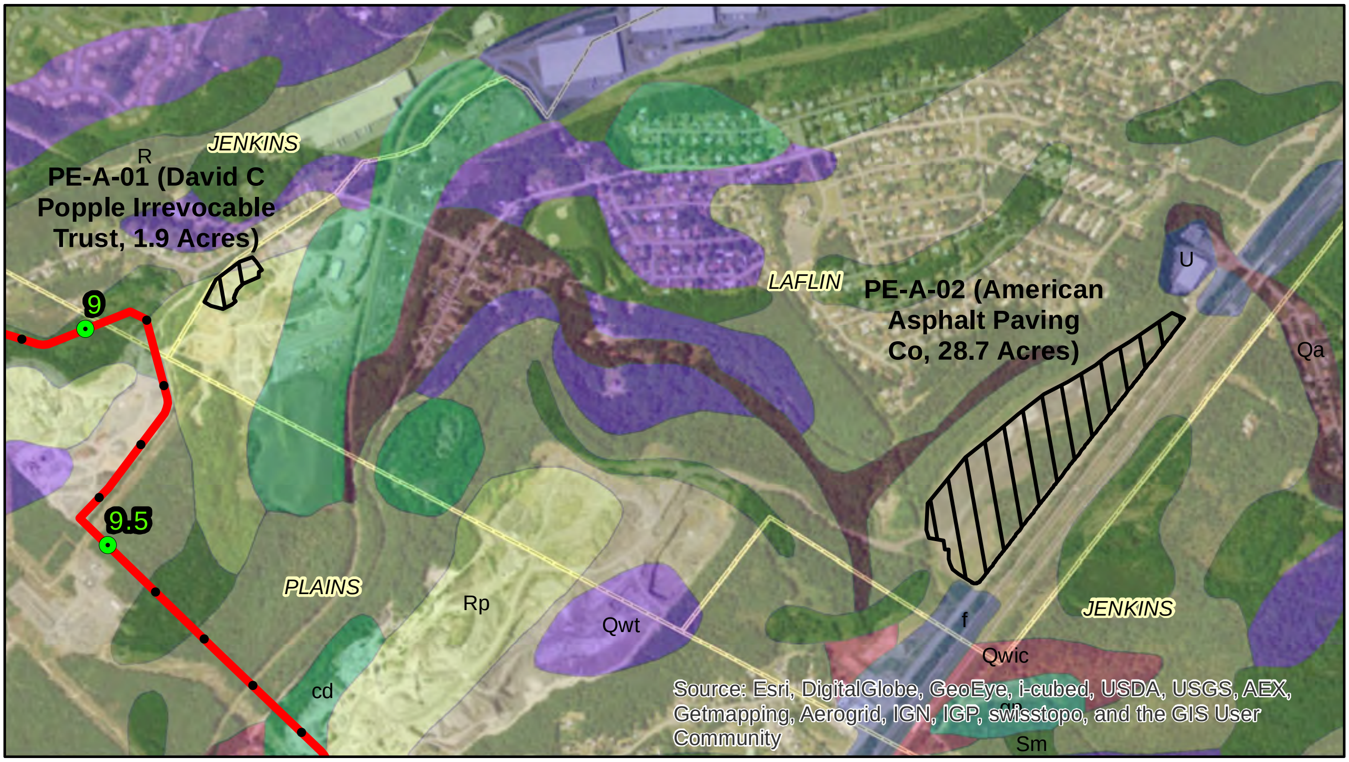

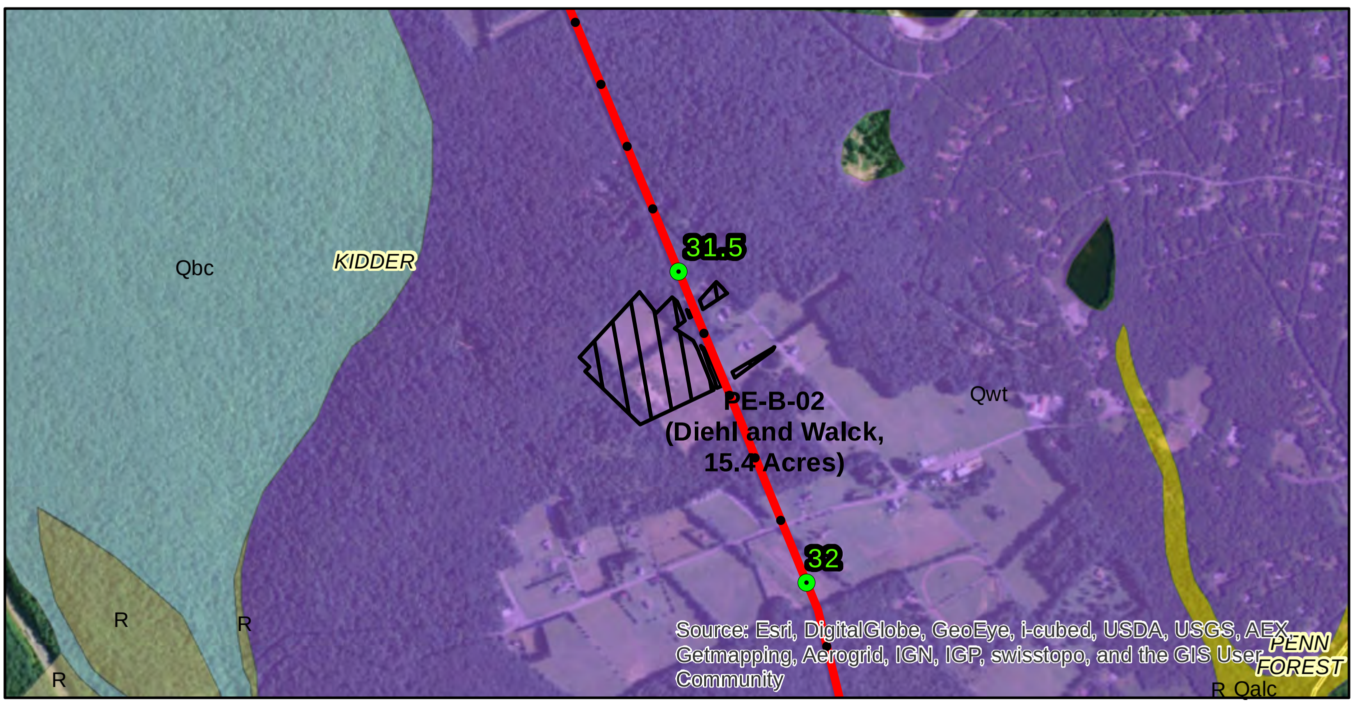

0 1,000 2,000 4,000 Feet

LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- Municipal Boundaries

Surficial Geology

- Qa - Alluvium
- R - Bedrock
- cd - Coal Dump
- f - Fill
- Rp - Rock Pit
- Qalc - Alluvium and Colluvium
- Qbc - Boulder Colluvium
- gp - Sand and Gravel Pit
- Sm - Strip Mine
- U - Urban Land
- Qwic - Wisconsinan Ice-Contact Stratified Drift
- Qwt - Wisconsinan Till

N W E S

NOTE: Proposed Alignment Current as of December 8, 2015

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111 Wood Avenue South
Iselin, New Jersey, 08830

Figure 2. Surficial Geology
PennEast Pipeline Project
Wareyard PE-A-01 and PE-A-02
Luzerne Cty, PA
Wareyard PE-B-02, Carbon Cty, PA

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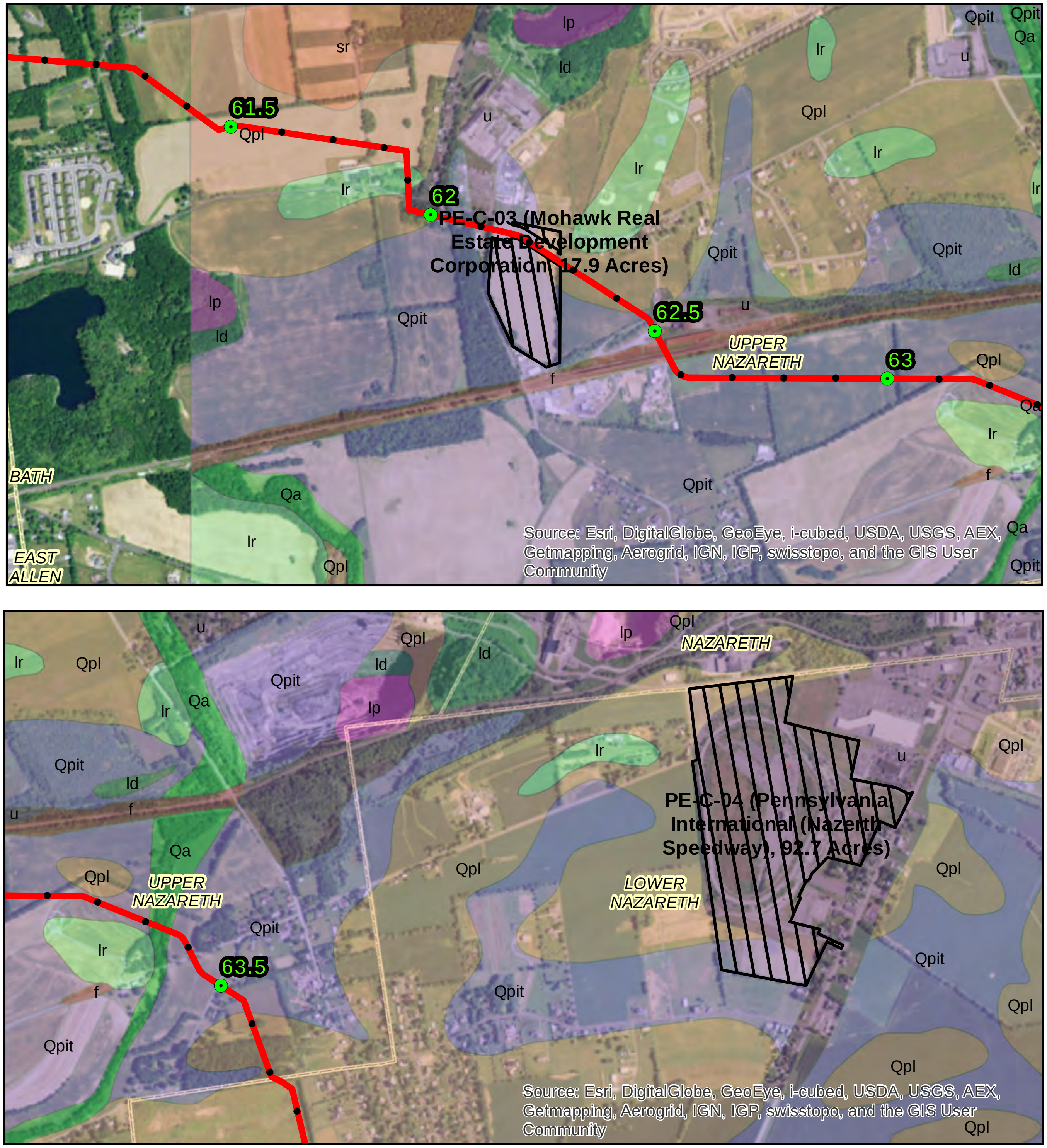

LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- MunicipalBoundaries

Surficial Geology

- Qa - Alluvium
- Qpit - Pre-Illinoian Till
- Qpl - Pre-Illinoian lag
- f - Fill
- ld - Limestone and/or iron ore dump
- ld - Limestone and/or iron ore pit
- lr - Limestone bedrock
- sr - Shale bedrock
- u - Urban land

0 1,000 2,000 4,000 Feet

N S W E

NOTE: Proposed Alignment Current as of December 8, 2015

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Figure 2. Surficial Geology
PennEast Pipeline Project
Wareyard PE-C-04 & Wareyard PE-C-04
Northampton County, PA

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JMF	JMF	VAS		12-8-15	2 of 4

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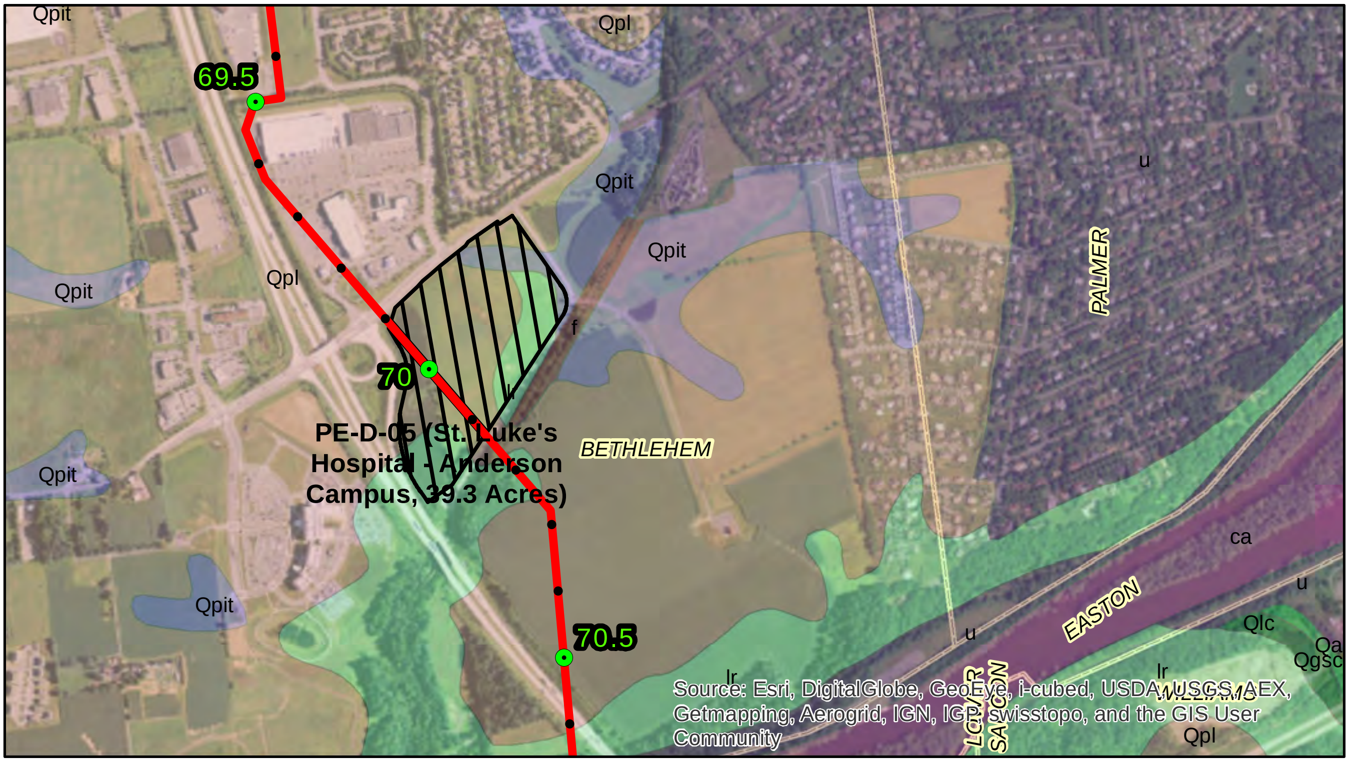

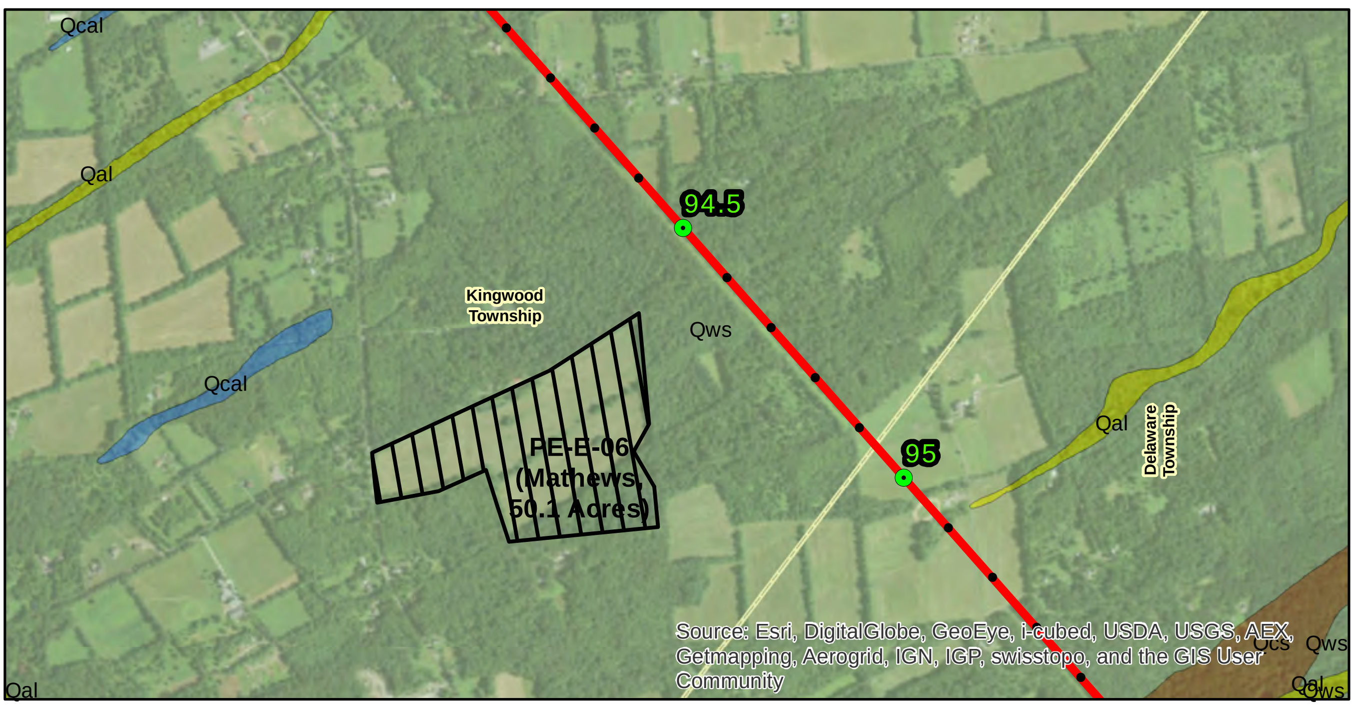

LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- Municipal Boundaries

NOTE: Proposed Alignment Current as of December 8, 2015

Surficial Geology

- Qa - Alluvium
- Qgsc - Colluvium derived from granitic gneiss and sandstone
- Qpit - Pre-Illinoian Till
- Qpl - Pre-Illinoian Lag
- lr - Limestone bedrock
- ca - Coaly alluvium
- u - Urban land
- f - fill
- Qcs - Shale, Mudstone, and Sandstone Colluvium
- Qws - Weathered Shale, Mudstone and Sandstone
- Qal - Alluvium
- Qcal - Alluvium and Colluvium

0 1,000 2,000 4,000 Feet

N W E S

Hatch Mott MacDonald

111 Wood Avenue South
Iselin, New Jersey, 08830

Figure 2. Surficial Geology
PennEast Pipeline Project
Wareyard PE-D-05, Northampton County, PA
Wareyard PE-E-06, Hunterdon County, NJ

Designed	Drawn	Checked	Approved	Date	Page
JMF	JMF	VAS		12-8-15	3 of 4

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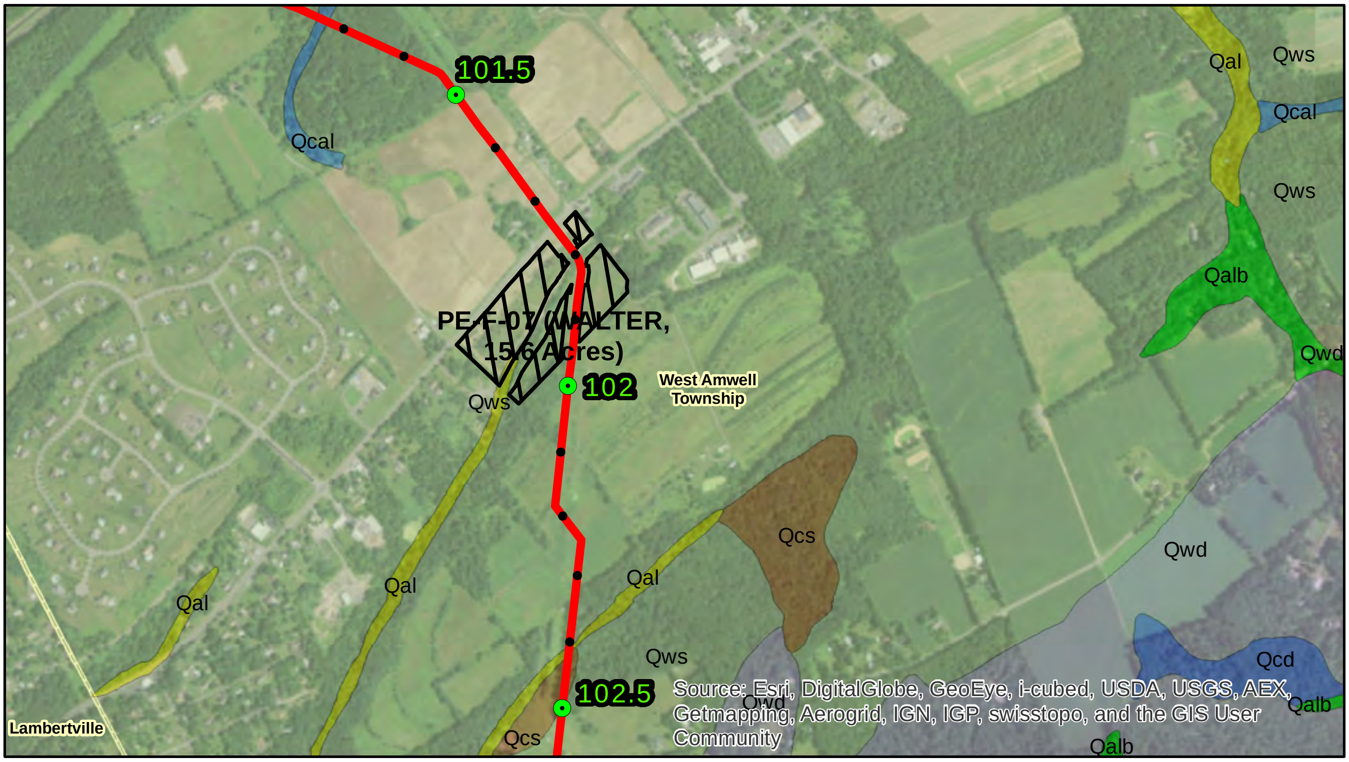

0 1,000 2,000 4,000 Feet

N W E S

LEGEND

- Proposed Alignment
- Milepost
- 1/10 Milepost
- Wareyard
- Municipal Boundaries

NOTE: Proposed Alignment Current as of December 8, 2015

Surficial Geology

- Qal - Alluvium
- Qcal - Alluvium and Colluvium
- Qalb - Alluvium and Boulder Lag
- Qcd - Diabase Colluvium
- Qwd - Weathered Diabase
- Qws - Weathered Shale, Mudstone, and Sandstone
- Qcs - Shale, Mudstone, and Sandstone Colluvium

Hatch Mott MacDonald

111 Wood Avenue South
Iselin, New Jersey, 08830

Figure 2. Surficial Geology
PennEast Pipeline Project
Wareyard PE-F-07
Hunterdon County, NJ

Designed	Drawn	Checked	Approved	Date	Page
JMF	JMF	VAS		12-8-15	4 of 4

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Attachment 13

Supplemental Information to Appendix O

Blasting Study at Laflin Quarry

REPORT

ANALYSIS OF GROUND MOTIONS AND STRAINS GENERATED BY TWO BLASTS AT LAFLIN QUARRY

WILKES BARRE MATERIALS

WILKES BARRE, PENNSYLVANIA

Prepared by:

AECOM
625 West Ridge Pike
Conshohocken, Pennsylvania 19428

September 23, 2015

AECOM Job No. 60414094

INTRODUCTION

Vibra-Tech Engineers, Inc. (Vibra-Tech), subcontractor to AECOM, recorded ground motions from two blasts at the Laflin Quarry owned by Wilkes-Barre Materials in Wilkes-Barre, Pennsylvania. The purpose of the monitoring was to provide data for estimating strains that might be induced in a proposed PennEast gas pipeline during future blasting. The locations of the proposed alignments around the quarry are shown in Figure 1.

Figure 1 - Pipeline Routes

[The FERC-submitted route is in green with MP numbers, and the orange lines mark the bounding study corridor. The purple line represents the recently approved (by PennEast) preferred route and the red line marks off the suggested route variation sent in by PennEast.]

BLAST AND SEISMOGRAPH LOCATIONS

The first blast that was monitored occurred on July 17, 2015, and consisted of 11,918 pounds of total explosives; the second blast (18,310 pounds of total explosives) occurred on August 3, 2015. The locations of the two blasts and the array of four seismographs that recorded each blast are shown in Figure 2.

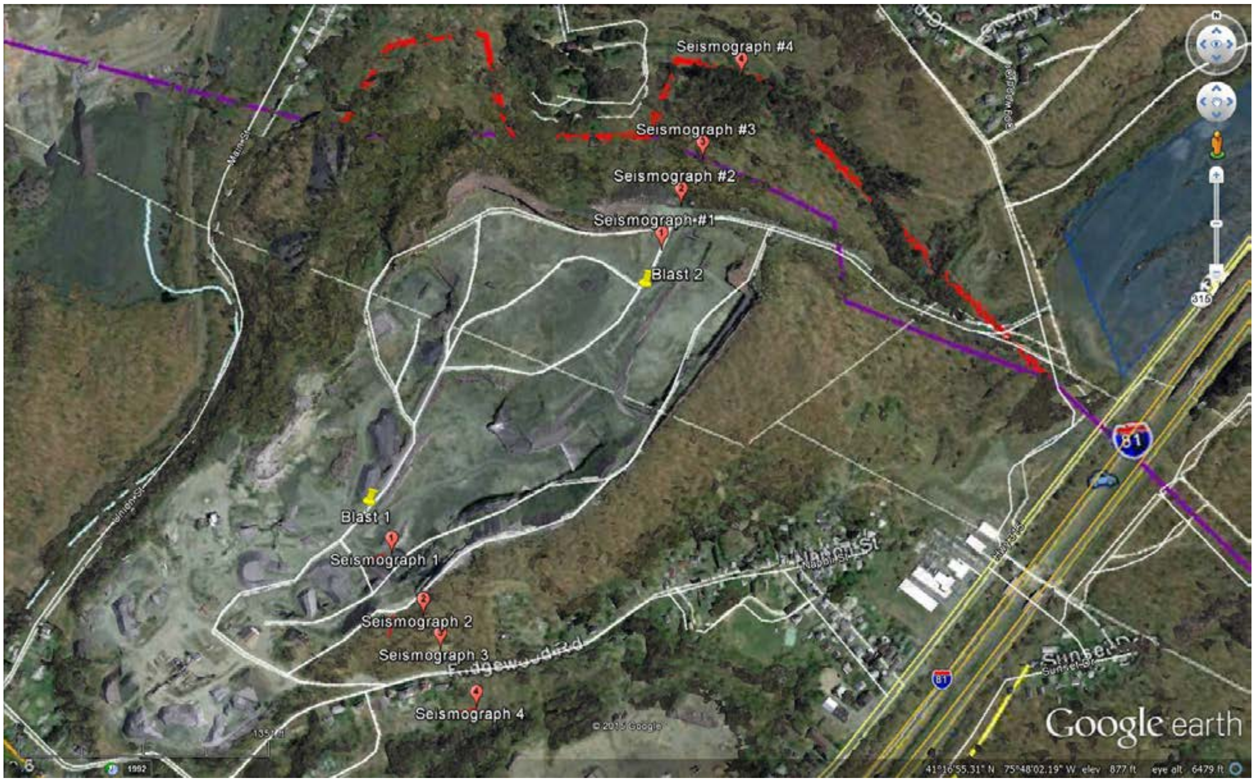


Figure 2 - Blast Locations and Seismographic Arrays

The first blast was located closer to the FERC-submitted route, while the second blast at the north end of the quarry was closer to the preferred alignment and suggested variation.

GROUND-MOTION DATA

Vibra-Tech used GeoSonics 3,000-LCP Blasting Seismographs, which recorded ground-surface (particle) velocity in three mutually perpendicular directions (Longitudinal – L, Transverse – T, and Vertical – V), as well as air overpressure levels transmitted from the quarry blast. For each blast Vibra-Tech prepared data reports that included: (1) recorded peak particle velocity (PPV) and estimated peak particle acceleration (PPA) for all three components, (2) maximum resultant PPV of the three components, (3) plots of the waveforms, and (4) plots of zero-crossing frequencies. The blast reports for the two events are presented in Appendix A. The pertinent data for the pipeline strain analyses are summarized in Table 1.

Table 1
PPV and PPA Recorded During Quarry Blasts

Blast Date	Seismograph		Peak Ground Motions						
			T		V		L		Res
	No. (Fig. 2)	Dist. to Blast (ft)	PPV (in/sec)	PPA (g)	PPV (in/sec)	PPA (g)	PPV (in/sec)	PPA (g)	PPV (in/sec)
7/17/2015	1	211	0.678	0.143	0.215	0.098	0.603	0.202	0.868
	2	581	0.115	0.033	0.095	0.039	0.100	0.033	0.165
	3	792	0.035	0.013	0.023	0.013	0.030	0.020	0.040
	4	1162	0.068	0.020	0.035	0.013	0.030	0.013	0.075
8/3/2015	1	150	2.120	0.573	1.188	0.319	2.158	0.612	2.245
	2	316	0.313	0.065	0.250	0.065	0.293	0.078	0.365
	3	580	0.065	0.026	0.035	0.026	0.060	0.026	0.068
	4	1108	0.085	0.033	0.033	0.020	0.053	0.033	0.085

Res = resultant, computed as follows: the vector sum of the three components is computed at each time increment. The maximum absolute value of these vector sums is the value of Res listed in the table.

Vibra-Tech estimated the PPA from the recorded velocity time series by (1) computing the slope of velocity time series at each time increment, and (2) taking the maximum absolute value of all computed slopes and converting the value from in/sec/sec to g. This two-step process is represented by the following equation:

$$\text{PPA (g)} = \max \left| (V_i - V_{i-1})/(t_i - t_{i-1}) \right| / (386.4 \text{ in/sec/g}) \text{ for all } i = 1,\ldots,N \qquad (1)$$

where V_i is the velocity (in/sec) at time t_i (sec) in the velocity time series, and N is the number of point in the time series.

SEISMIC VELOCITY SURVEYS

Vibra-Tech also conducted two types of seismic velocity surveys: (1) Multi-channel analysis of surface waves (MASW), and (2) apparent shear-wave velocity survey. The MASW surveys were conducted at three locations near the seismograph array recording the first blast (Figure 3), and at another three locations near the seismograph array recording the second blast (Figure 4).

Figure 3 - Locations of MASW and Apparent Shear-Wave Velocity Surveys Near Blast 1 Seismographic Array

The MASW surveys provided profiles of the shear-wave velocity to 100-ft depth. MASW profiles are presented in Appendix B.

The apparent shear-wave velocity test, which was conducted at the location of MASW 2 in Figure 3, provided an estimate of the horizontal component of shear-wave velocity across the ground surface. The shear wave source consisted of a wooden plank that was coupled to the ground by loading from the front wheels of a vehicle. Horizontal waves of opposite polarity are generated by impacting the plank on opposite ends with a sledge hammer. A string of twelve horizontal 4.5 Hz geophones were positioned along the ground surface in a line radiating away and perpendicular to the alignment of the wooden plank. The geophone spacing was 5 feet, and the offset distance from the wooden plank to the first geophone was also 5 feet. Each of the twelve geophones was oriented with their axis parallel to the wooden plank and direction of shear. The onset of the arrival time of the shear wave was picked (in milliseconds) on the seismogram, and this information was used to construct a graph plotting Arrival Time (milliseconds) vs. Distance (ft). A best fit line was generated showing measured apparent shear wave velocity. The average apparent velocity is the slope of the line through the (distance, travel time) data covering a distance of approximately 55 ft. Vibra-Tech estimated an apparent velocity of approximately 4,700 ft/sec. The apparent velocity shear-wave velocity testing is presented in Appendix C.

Figure 4 - Locations of MASW Surveys Near Blast 2 Seismographic Array

The minimum and maximum shear-wave velocities (V_S) in the upper 20 ft from the MASW surveys are summarized in Table 2.

Table 2
Minimum and Maximum V_S Values in Upper 20 ft from MASW Surveys

MASW No.	Min V_S (ft/sec)	Max V_S (ft/sec)
1	2228	2982
2	1407	2280
3	710	843
4	1604	1918
5	3263	4667
6	1191	1584

ESTIMATED BLAST-INDUCED GROUND STRAINS AND CURVATURES

Chapter 6 and Appendix B of the ASCE (1984) publication, "Guidelines for the Seismic Design of Oil and Gas Pipeline Systems," and the PRCI (2004) publication, present simple equations for computing maximum earthquake-induced dynamic ground strains (ε_g) and curvatures (κ_g). For shear waves these equations (in the notation used in this report) are:

$$\varepsilon_g = PPV/(2V_S) \quad (2)$$

$$\kappa_g = PPA/V_S^{\,2} \quad (3)$$

For dilatational and surface waves, the factor, 2, in the denominator in Eqn. (2) becomes 1.0, and the shear-wave velocity is replaced by the dilatational velocity (V_P) and surface-wave velocity (V_R), respectively. Eqn. (3) also applies to surface waves (with the V_S becoming V_R), but for dilatational waves the denominator in Eqn. (3) becomes 1.6 V_P^2 instead of V_S^2. Both equations, although from an earthquake publication, apply to blast-induced vibrations also.

To compute values for ε_g and κ_g, the following assumptions were made: (1) future blasts will not occur closer than 300 feet to the PennEast approved route, and (2) the explosive sizes and ground motions during the two monitored blasts are representative of future blasts.

Based on the data in Tables 1 and 2, the following conservative values for PPV, PPA, and V_S were selected for computing upper end estimates of ε_g and κ_g, applicable to the FERC-submitted route, and PennEast approved and variation routes:

PPV = 0.5 in/sec

PPA = 0.1 g

V_S = 1,000 ft/sec

The maximum ground strains and curvatures are:

$$\varepsilon_g = PPV/(2V_S) \sim 2 \times 10^{-5}$$

$$\kappa_g = PPA/V_S^{\,2} \sim 3 \times 10^{-7}/\text{inch}$$

These values were computed under the assumption that the waves comprising the recorded motions are entirely shear waves. Lower estimates of the ε_g and κ_g would be obtained under the assumption that the waves comprising the recorded motions are entirely dilatational, because V_P is greater than V_S by factors of ~1.6 to 3.3 depending on Poisson's Ratio for the medium. Under the assumption that the recorded motions are entirely surface waves, comparable estimates of κ_g would be obtained because V_S is comparable to V_R; but, higher estimates of ε_g would be obtained because the factor 2 in the denominator would become unity for surface waves.

However, the assumption that all the wave motion is entirely surface waves (or dilatational or shear waves) is considered extremely conservative.

PIPELINE STRAINS AND CURVATURES

The maximum ground strains and curvatures above are conservative estimates of the maximum pipeline compressive/tensile strains and curvatures. The assumptions behind this assertion are: (1) the pipeline moves with the soil without offering any resistance, i.e., interaction or slippage between the pipeline and surrounding material does not occur, (2) the pipeline is straight or nearly straight, i.e., it does not have sharp bends, and (3) the ground does not permanently deform differentially along the alignment due to the ground motion, which is considered unlikely if the blast sizes are comparable to the two that were monitored. Under these assumptions, the product of the curvature and pipeline radius is the bending strain. The radius (r) of the proposed steel pipeline is 18 inches, so the bending strain in the pipeline is

$$r\ \kappa_g = PPA/\ V_S^{\ 2} \sim 5 \times 10^{-6}$$

This strain is smaller than the $\varepsilon_g = \sim 2 \times 10^{-5}$ value above. Both values are two to three orders of magnitude smaller than the yield strain of steel, which is 2×10^{-3}.

CONCLUSIONS

1. Wilkes-Barre Materials Laflin Quarry was monitored for two blast events in July and August 2015.

2. The ground motions were recorded at distances ranging from 150 feet to about 1200 feet from the blast in the transverse, longitudinal, and vertical directions.

3. The blasts involved about 12,000 and 18,000 pounds of total explosives.

4. The peak particle velocities (PPV) and accelerations generally decreased with increasing distance from the blast.

5. It is assumed that future blasts will not occur closer than 300 feet from the pipeline (permit requirement).

6. Peak particle velocity of 0.5 inches per second is a conservative estimate at 300 feet from the recorded blast data.

7. Likewise, peak particle acceleration of 0.1g is a conservative estimate at 300 feet from the recorded blast data.

8. Shear wave velocities of the underlying soil and rock media were measured in six locations (3 near each blast).

9. Based on the measured shear wave velocities, a value of 1000 ft per second was used to estimate pipe strain.

10. The data was used to calculate the maximum strain in the 36” diameter pipe.

11. The results conservatively indicate that a peak particle velocity of 50 inches per second or higher would be required to produce strain in the pipe that would approach yielding (strain of 0.002).

12. This peak particle velocity is 100 times higher (50 vs 0.5) than what was conservatively used to compute the pipe strain.

13. Assuming that the blasts are not significantly higher than those utilized in the study and the setback distance of 300 feet is maintained, there is a significant margin of safety against damage to the pipe from blast loadings at this quarry.

14. It is concluded from this site-specific study that ground vibrations from future blasting at the quarry will not damage the proposed pipeline.

REFERENCES

ASCE, 1984. Guidelines for the Seismic Design of Oil and Gas Pipeline Systems. Prepared by the committee on Gas and Liquid Fuels Lifelines of the ASCE Technical Council on Lifeline Earthquake Engineering, American Society of Civil Engineers, New York, New York, 473 p.

PRCI, 2004. Guidelines for the Seismic Design and Assessment of Natural Gas and Liquid Hydrocarbon Pipelines. Prepared for Pipeline Design, Construction & Operations Technical Committee of Pipeline Research Council International, Inc. Prepared by D.G. Honegger Consulting, and D.J. Nyman and Associates, October 1.

APPENDICES

Appendix A Blast Reports with Seismograph Data

Appendix B MASW Geophysical Testing

Appendix C Apparent Shear-Wave Velocity Geophysical Testing

Appendix A

Blast Reports with Seismograph Data

Vibra-Tech

VibraTechinc.com

109 E. First Street
PO Box 577
Hazleton, PA 18201

Phone 570.455.5861
Fax 570.455.0626

August 31, 2015

Mr. John C. Volk, P.E.
AECOM
625 West Ridge Pike
Suite E-100
Conshohocken, Pennsylvania 19428

Re: American Asphalt, Wilkes-Barre Materials Quarry
Laflin, Pennsylvania
Blast 2015-22; July 17, 2015

Dear Mr. Volk:

Attached you will find our report covering the monitoring and analysis of the ground vibration and air overpressure conducted by Vibra-Tech and transmitted from the blasting at the above referenced project.

The report contains the four (4) seismograph records obtained from the blasting along with the blast and seismograph field notes. The field notes summarize the pertinent blast design parameters and give detail information on the seismograph setup.

In addition, you will also find an aerial photograph showing the approximate blast and seismograph locations.

Respectfully submitted,

VIBRA-TECH ENGINEERS, INC.

Stephen Munoz, P.G.
Project Geologist

Douglas Rudenko, P.G.
Vice President

SM/ly
VT#11160135

Vibra-Tech Engineers, Inc. shall not be liable for any claims of tangible property damage where such damage is not solely, directly, and physically caused by Vibra-Tech Engineers, Inc. Additionally, Vibra-Tech Engineers, Inc. shall not be liable, in whole or in part, for any claims of tangible property damage brought by or on behalf of third-party claims.

Blast and Seismographic Report

Vibra-Tech

BLAST DATA

Client: AECOM / AMERICAN ASPHALT - WILKES BARRE MATERIALS
Job Location: LAFLIN, PA QUARRY
Date: 7-17-2015 Blast No. 2015-22 Time 9:57
Blast Location: N41°16.814', W075°48.329'
No. of Holes: 76 Diameter: 5 in. ~~Avg.~~ Depth: 27-32 ft. Subgrade: Ø ft.
Spacing: 9 ft. Burden: 9-13 ft. ~~Avg.~~ Stemming: 5-15 ft.

Make & Type of Explosives	lbs.
BULK ANFO	11,783 lbs.
BLACK CAP (3/4 lb) BOOSTERS	57 lbs.
ORANGE CAP (1 lb) BOOSTERS	78 lbs.
	lbs.
	lbs.
Total Explosives	11,918 lbs.

Delay Make: AUSTIN - Shock Stars
Delay Type & Nos.: 25/500 - SURFACE 42 ms
Min Delay Period: 8 ms.
Max.lbs/Delay Period: 340 lbs.
Blaster: JOE CIOCCO - MAURER & SCOTT
Weather: SUNNY - 69°F
Wind Direction & Speed: NORTH 0-5 MPH

Seismograph S/N (Calibration Date) Operator Name	Seismograph Location	Distance & Direction from Shot (feet)	PPV (in/sec)	Dynamic Field Calibration: Pre Blast	Dynamic Field Calibration: Post Blast	Trigger Levels & Scaled Distance
5192 LCP+ (5-26-15) S. MUÑOZ	QUARRY FLOOR (#1) ON GROUND, BEHIND SOUTH BERM OF HAULROAD. N41°16.781', W075°48.307'	211' SSE BEARING 164°	T- 0.678 V- 0.215 L- 0.603 dB- 121	pass (all)	pass (all)	Ground: 0.03 in/sec Air: 125 dB SD: 11.44
5184 LCP+ (5-26-15) S. MUÑOZ	HIGHWALL (#2) ON GROUND, APPROX. 90' SOUTH OF HIGHWALL, NEAR CREST OF RIDGE. N41°16.731', W075°48.267'	581' SSE BEARING 162°	T- 0.115 V- 0.095 L- 0.100 dB- 120	pass (all)	pass (all)	Ground: 0.03 in/sec Air: 125 dB SD: 31.51
5032 LCP+ (2-23-15) S. MUÑOZ	140 RIDGEWOOD ROAD (#3) ON GROUND, APPROX. 25' TO REAR OF REAR-LEFT CORNER OF HOME. N41°16.700', W075°48.250'	792' SSE BEARING 165°	T- 0.035 V- 0.023 L- 0.030 dB- 113	pass (all)	pass (all)	Ground: 0.02 in/sec Air: 125 dB SD: 42.95
5117 LCP+ (4-16-15) S. MUÑOZ	SOUTH FIELD (#4) ON GROUND, NEAR SE CORNER OF OPEN FIELD. N41°16.648, W075°48.210'	1162' SSE BEARING 164°	T- 0.068 V- 0.035 L- 0.030 dB- 112	pass (all)	pass (all)	Ground: 0.02 in/sec Air: 125 dB SD: 63.02
			T- V- L- dB-	pass fail	pass fail	Ground: in/sec Air: dB SD:

Please use the back of this form for additional information DISTANCE & BEARING VIA HAND-HELD GPS.

Remarks: LOCATION #1 & #2: Geophones Buried, Spiked & Weighted / LOCATION #3 & #4 Geophones Spiked & Weighted

Vibration Analysis By: [signature] Date 7-17-2015

Vibra-Tech, Inc. Seismic Analysis

Velocity Waveform Analysis

Serial No:	5192 v3.67		
Date:	07/17/2015 09:57:19		
Event No:	1		
Record Time:	5.0 s		
Client:	WILKESBARRE MATERIAL		
Operation:	LAFLIN PA QUARRY		
Location:	QUARRY FLOOR		
Distance:			
Operator:	VibraTech Engineers		
Comment:			
Seismic Trigger:	0.030 in/s		
Sound Trigger:	125 db		

Summary Data

	L	T	V
PPV (in/s)	0.603	0.678	0.215
FREQ (Hz)	9.4	12.5	15.6
PD (.001")	8.62	7.64	2.52
PPA (g)	0.202	0.143	0.098
Peak Vector Sum :	0.868 in/s		
Peak Air Pressure:	121 db		
	0.00337 PSI @ 10.4 Hz		

Additional Info:

Shaketable Calibrated: 05/26/2015

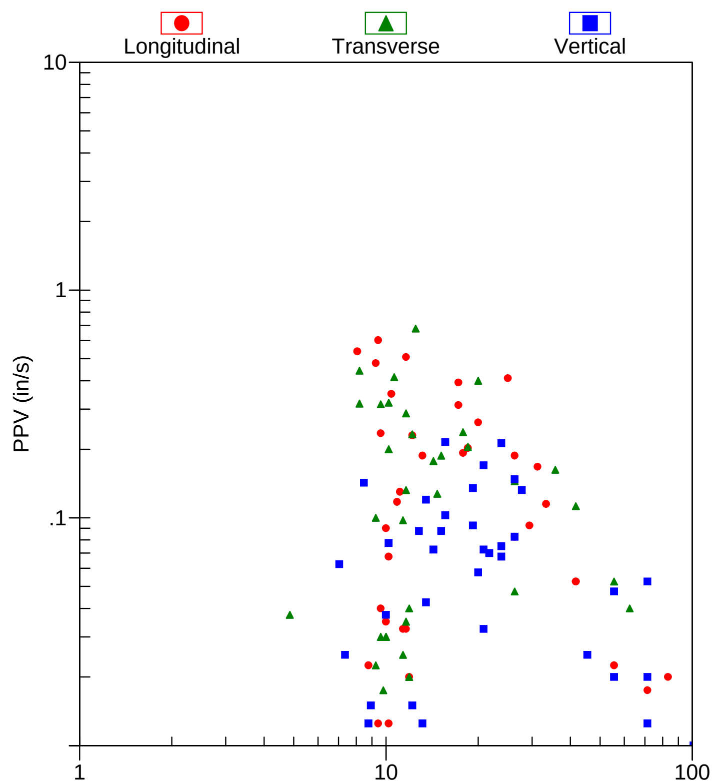
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

Velocity Waveform Graph Scale

Time Scale: 0.100 s
Seismic Scale: +/- 1.280 in/s
Sound Scale: +/- 0.0045 PSI

PPV vs Frequency

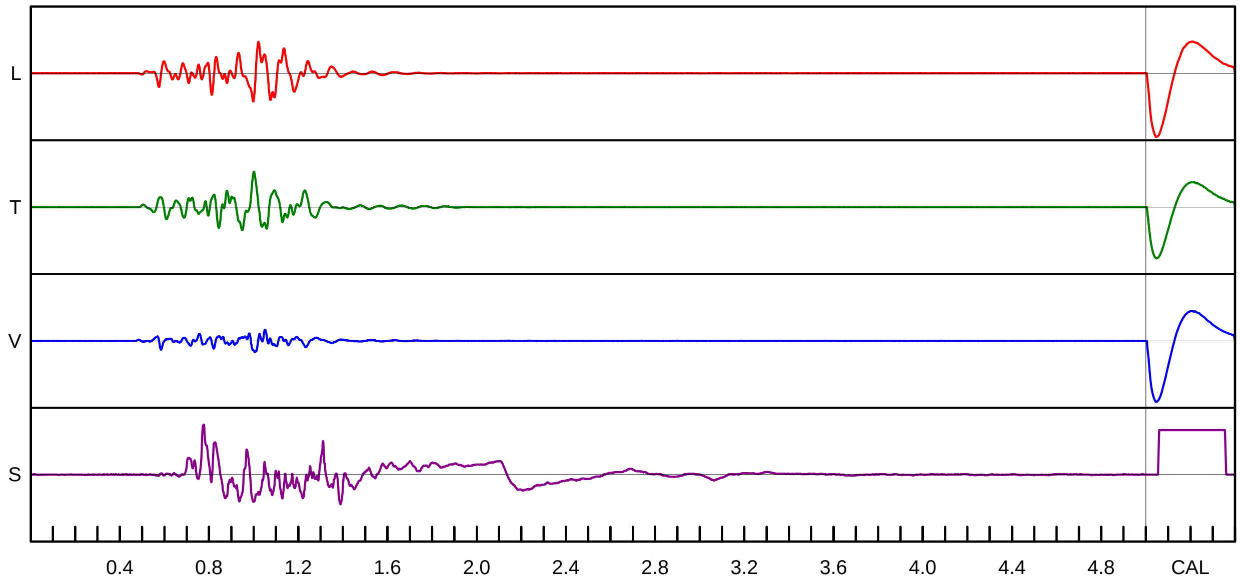
SN: 5192 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform

SN: 5192 Event: 1



Time (s)

Vibra-Tech, Inc. Seismic Analysis
Velocity Waveform Analysis

Serial No: 5184 v3.67
Date: 07/17/2015 09:57:21
Event No: 1
Record Time: 5.0 s
Client: WILKESBARRE MATERIAL
Operation: LAFLIN PA QUARRY
Location: HIGHWALL
Distance:
Operator: VibraTech Engineers
Comment:
Seismic Trigger: 0.030 in/s
Sound Trigger: 125 db

Summary Data

	L	T	V
PPV (in/s)	0.100	0.115	0.095
FREQ (Hz)	18.5	13.5	22.7
PD (.001")	0.97	1.25	0.92
PPA (g)	0.033	0.033	0.039

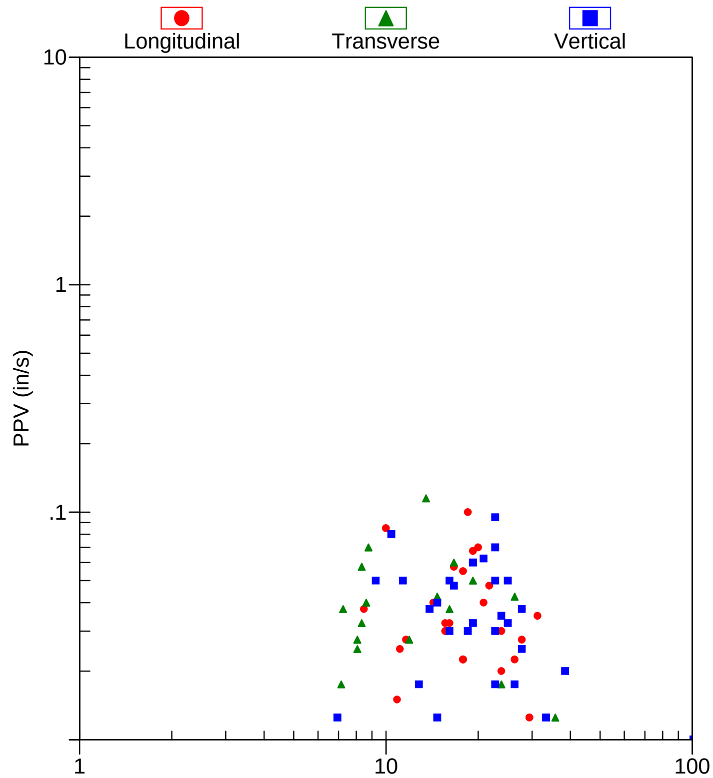
Peak Vector Sum : 0.165 in/s
Peak Air Pressure: 120 db
0.00303 PSI @ 2.9 Hz

Additional Info:

Shaketable Calibrated: 05/26/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

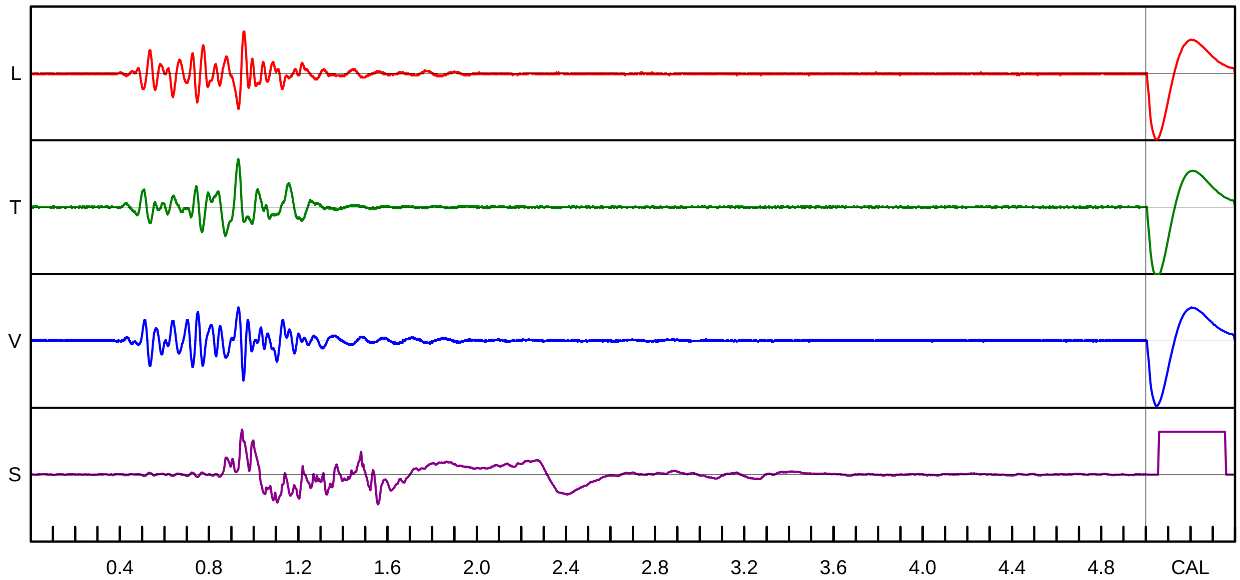
Velocity Waveform Graph Scale
Time Scale: 0.100 s
Seismic Scale: +/- 0.160 in/s
Sound Scale: +/- 0.0045 PSI

PPV vs Frequency
SN: 5184 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform
SN: 5184 Event: 1



Time (s)

Printed: September 01, 2015 **File:** 071715-2.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Vibra-Tech, Inc. Seismic Analysis

Velocity Waveform Analysis

Serial No: 5032 v3.66
Date: 07/17/2015 09:57:26
Event No: 1
Record Time: 5.0 s
Client: WILKESBARRE MATERIAL
Operation: LAFLIN PA QUARRY
Location: 140 RIDGEWOOD ROAD
Distance:
Operator: VIBRA TECH ENGINEERS
Comment:
Seismic Trigger: 0.020 in/s
Sound Trigger: 125 db

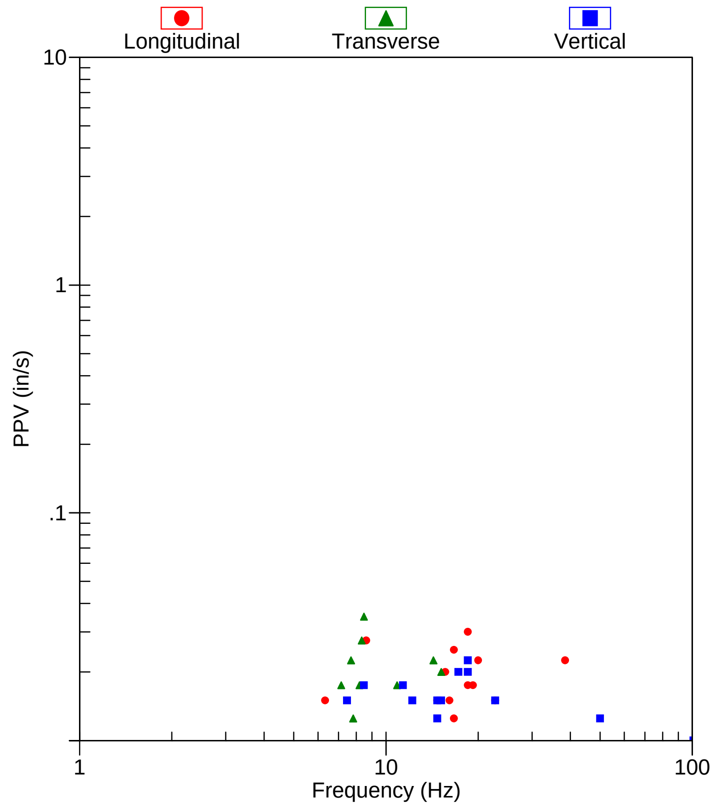
Summary Data

	L	T	V
PPV (in/s)	0.030	0.035	0.023
FREQ (Hz)	18.5	8.5	18.5
PD (.001")	0.37	0.52	0.33
PPA (g)	0.020	0.013	0.013

Peak Vector Sum : 0.040 in/s
Peak Air Pressure: 113 db
0.00137 PSI @ 2.4 Hz

Additional Info:

PPV vs Frequency
SN: 5032 Event: 1

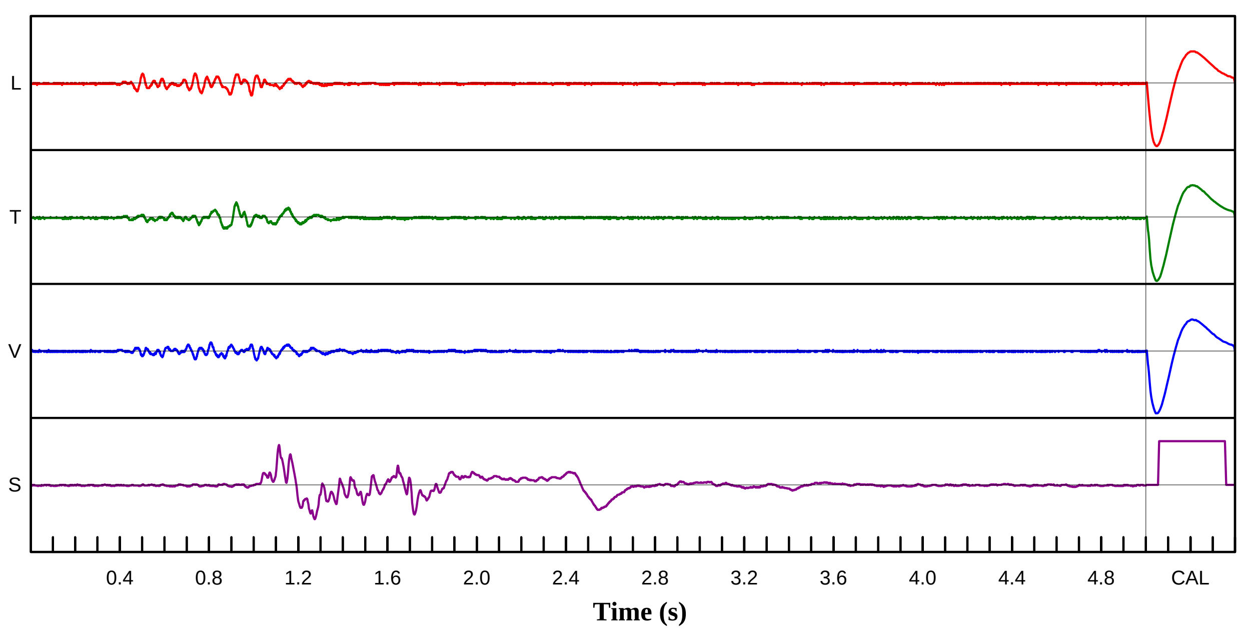


Zero Crossing Half-Wave Frequency Analysis

Shaketable Calibrated: 02/23/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

Velocity Waveform Graph Scale
Time Scale: 0.100 s
Seismic Scale: +/- 0.160 in/s
Sound Scale: +/- 0.0023 PSI

Velocity Waveform
SN: 5032 Event: 1



Printed: September 01, 2015 **File:** 071715-3.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Vibra-Tech, Inc. Seismic Analysis
Velocity Waveform Analysis

Serial No: 5117 v3.67
Date: 07/17/2015 09:57:20
Event No: 1
Record Time: 5.0 s
Client: WILKESBARRE MATERIAL
Operation: LAFLIN PA QUARRY
Location: SOUTH FIELD
Distance:
Operator: VibraTech Engineers
Comment:
Seismic Trigger: 0.020 in/s
Sound Trigger: 125 db

Summary Data

	L	T	V
PPV (in/s)	0.030	0.068	0.035
FREQ (Hz)	6.4	8.9	10.2
PD (.001")	0.62	1.60	0.55
PPA (g)	0.013	0.020	0.013

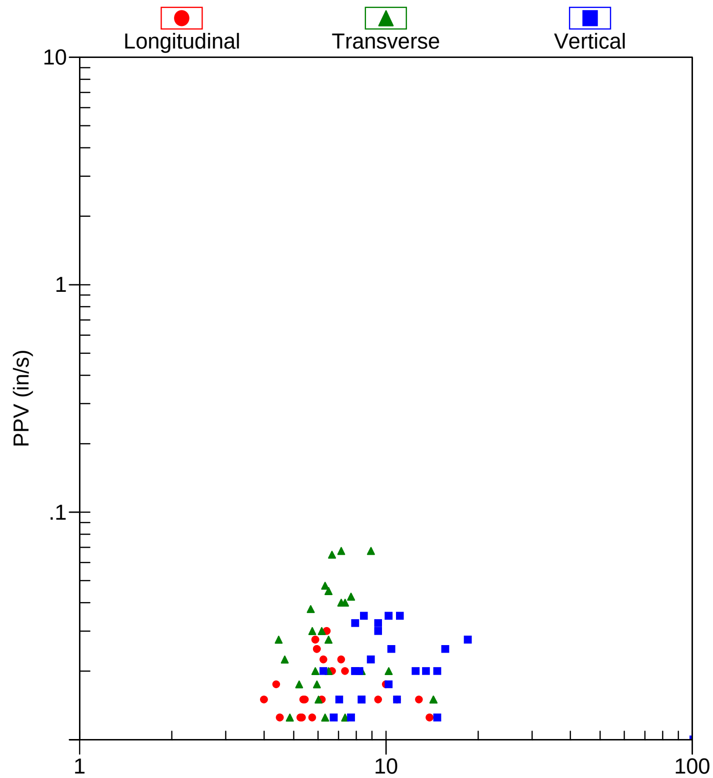
Peak Vector Sum : 0.075 in/s
Peak Air Pressure: 112 db
0.00121 PSI @ 2.9 Hz

Additional Info:

Shaketable Calibrated: 04/16/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

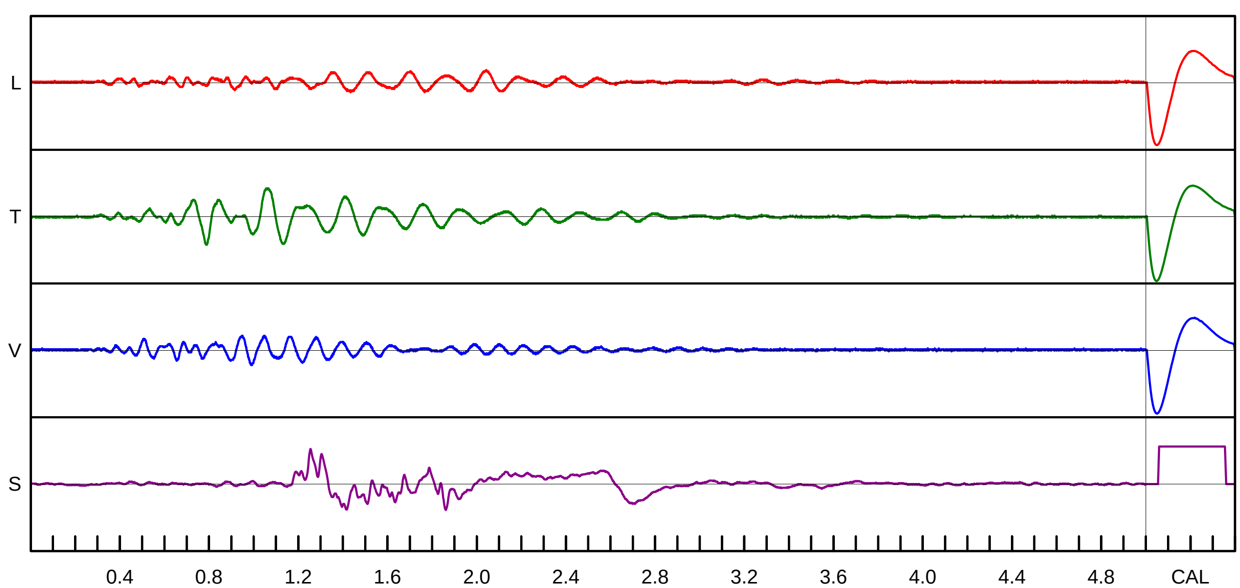
Velocity Waveform Graph Scale
Time Scale: 0.100 s
Seismic Scale: +/- 0.160 in/s
Sound Scale: +/- 0.0023 PSI

PPV vs Frequency
SN: 5117 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform
SN: 5117 Event: 1



Time (s)

Printed: September 01, 2015 **File:** 071715-4.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)


Union St
Blast 1
Seismograph 1
Seismograph 2
Seismograph 3
Ridgewood Rd
Seismograph 4
587 ft
1992
© 2015 Google
Google earth
Imagery Date: 5/10/2014 41° 16.747' N 75° 48.286' W elev 831 ft eye alt 3267 ft

Vibra-Tech

VibraTechinc.com

109 E. First Street
PO Box 577
Hazleton, PA 18201

Phone 570.455.5861
Fax 570.455.0626

August 31, 2015

Mr. John C. Volk, P.E.
AECOM
625 West Ridge Pike
Suite E-100
Conshohocken, Pennsylvania 19428

Re: American Asphalt, Wilkes-Barre Materials Quarry
Laflin, Pennsylvania
Blast 2015-25; August 3, 2015

Dear Mr. Volk:

Attached you will find our report covering the monitoring and analysis of the ground vibration and air overpressure conducted by Vibra-Tech and transmitted from the blasting at the above referenced project.

The report contains the five (5) seismograph records obtained from the blasting along with the blast and seismograph field notes. The field notes summarize the pertinent blast design parameters and give detail information on the seismograph setup.

In addition, you will also find an aerial photograph showing the approximate blast and seismograph locations.

Respectfully submitted,

VIBRA-TECH ENGINEERS, INC.

Stephen Munoz

Stephen Munoz, P.G.
Project Geologist

Douglas Rudenko

Douglas Rudenko, P.G.
Vice President

SM/ly
VT#11160135

Vibra-Tech Engineers, Inc. shall not be liable for any claims of tangible property damage where such damage is not solely, directly, and physically caused by Vibra-Tech Engineers, Inc. Additionally, Vibra-Tech Engineers, Inc. shall not be liable, in whole or in part, for any claims of tangible property damage brought by or on behalf of third-party claims.

VIBRA-TECH ENGINEERS BLAST AND SEISMOGRAPHIC REPORT

BLAST DATA

Client: AECOM / WILKES BARRE MATERIALS

Job Location: LAFLIN, PA QUARRY

Date: 8/3/2015 Blast No. 2015-25 Time 11:14

Exact Blast Location: MIDDLE: N41°17.018', W075°48.013' / EAST END: N41°17.028', W075°47.998'

No. of Holes: 135 Diameter: 5" in. ~~Avg.~~ Depth: 22-29 ft. Subgrade: Ø ft.

Spacing: 9 ft. Burden: 9-13 ft. ~~Avg.~~ Stemming: 5-10 ft.

Make & Type of Explosives:

BULK ANFO	15,166 lbs
ORANGE CAP BOOSTERS	136 lbs
Hydromite 830 (4x20)	2,940 lbs
BROWN CAP BOOSTERS	68 lbs
	lbs
Total Explosives	18,310 lbs

Delay Make: AUSTIN - SHOCK STAR

Delay Type & Nos.: 25/500 - SURFACE 42 ms

Min. Delay Period: 8 ms

Max. lbs/delay period: 280 (2 holes/delay) lbs

Blaster: JOE CIOCCO, MAURER & SCOTT

Weather: SUNNY - 83°F

Wind Direction & Speed: NORTH 0-5 MPH.

Seismograph S/N (Cal Date) Operator	Seismograph Location	Distance & Direction from Shot (feet)	PPV (in/sec)	Dynamic Field Calibration Pre Blast	Dynamic Field Calibration Post Blast	Trigger Levels & Scaled Distance
8402-LCP (9-17-14) S. MUÑOZ	LOCATION # 1 ON GROUND, ON SOUTH SHOULDER OF HAULROAD, NEAR TOP OF HILL. N41°17.053', W075°47.993'	APPROX. 150' NE	T-2.120 V-1.188 L-2.158 Air (dB) 131	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	Ground: 0.05 in/sec Air: 128 dB SD: 8.96
8356-LCP (4-24-15) S. MUÑOZ	LOCATION # 2 ON GROUND, TOP OF BANK, APPROX. 50' WEST OF TOP OF ACTIVE DUMP BANK & BERM. N41° 17.079', W075° 47.976'	APPROX. 316 NE BRG. 031°	T-0.313 V-0.250 L-0.293 Air (dB) 126	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	Ground: 0.03 in/sec Air: 125 dB SD: 18.88
8288-LCP (5-26-15) S. MUÑOZ	LOCATION # 3 ON GROUND, APPROX. 100' EAST OF BASE OF BANK / SPOIL PILE. SHALLOW ROCK (SANDSTONE) BY SENSOR. N41°17.118', W075°47.957	APPROX. 580' NE BRG. 033°	T-0.065 V-0.035 L-0.060 Air (dB) 118	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	Ground: 0.02 in/sec Air: 125 dB SD: 34.66

Please use back of form for additional information

Remarks: GEOPHONES SPIKED & Weighted

Vibration Analysis by: Stephen Muñoz
Vibra-Tech Engineers, Inc.

Date: 8/3/2015

VIBRA-TECH ENGINEERS BLAST AND SEISMOGRAPHIC REPORT

BLAST DATA

Client: AECOM / WILKES BARRE MATERIALS

Job Location: LAFLIN, PA QUARRY

Date: 8/3/2015 | Blast No. 2015-25 | Time 11:14

Exact Blast Location: MIDDLE: N41°17.018', W075°48.013' / EAST END: N41°17.028', W075°47.998'

No. of Holes: 135 | Diameter: 5 in. | ~~Avg.~~ Depth: 22-29 ft. | Subgrade: ∅ ft.

Spacing: 9 ft. | Burden: 9-13 ft. | ~~Avg.~~ Stemming: 5-10 ft.

Make & Type of Explosives	lbs
BULK ANFO	15,166 lbs
ORANGE CAP BOOSTERS	136 lbs
Hydromite 830 (4x20)	2,940 lbs
BROWN CAP BOOSTERS	68 lbs
	lbs
Total Explosives	18,310 lbs

Delay Make: AUSTIN - Shock STAR

Delay Type & Nos.: 25/500 - SURFACE 42

Min. Delay Period: 8 ms

Max. lbs/delay period: 280 (2 holes/delay) lbs

Blaster: JOE CIOCCO - MAURER & SCOTT

Weather: SUNNY - 83°F

Wind Direction & Speed: NORTH 0-5 MPH

Seismograph S/N (Cal Date) Operator	Seismograph Location	Distance & Direction from Shot (feet)	PPV (in/sec)	Dynamic Field Calibration Pre Blast	Dynamic Field Calibration Post Blast	Trigger Levels & Scaled Distance
8298-LCP (5-26-15) S. MUÑOZ	LOCATION #4 ON GROUND, APPROX. 50' WEST OF STREAM, ON FLAT AREA ABOVE STREAM, NEAR CEMENT BLOCK STRUCTURE/TOILET, N41°17.897', W075°47.919'	APPROX. 1,108' NE; BRG. 32°	T-0.085 V-0.033 L-0.053 Air (dB): 112	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	Ground: 0.02 in/sec Air: 125 dB SD: 66.21
8299-LCP (5-26-15) S. MUÑOZ	LOCATION "X" (NOT PART OF LINEAR 1-4 ARRAY) ON GROUND, ON FLAT AREA NEAR HAULROAD. N41°17.033', W075°48.216'	APPROX. 950' West; BRG. 270°	T-0.190 V-0.093 L-0.130 Air (dB): 114	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	(PASS) FAIL (PASS) FAIL (PASS) FAIL (PASS) FAIL	Ground: 0.03 in/sec Air: 128 dB SD: 56.77
	/		T- V- L- Air (dB):	PASS FAIL PASS FAIL PASS FAIL PASS FAIL	PASS FAIL PASS FAIL PASS FAIL PASS FAIL	Ground: in/sec Air: dB SD:

Please use back of form for additional information

Remarks: GEOPHONES SPIKED & Weighted

Vibration Analysis by: Stephen Muñoz (signature), Vibra-Tech Engineers, Inc. | Date: 8/3/2015

Vibra-Tech, Inc. Seismic Analysis
Velocity Waveform Analysis

Serial No: 8402 v3.67
Date: 08/03/2015 11:14:02
Event No: 1
Record Time: 5.0 s
Client: WILKESBARRE MATERIAL
Operation: LAFLIN PA
Location: SEIS 1
Distance:
Operator: VIBRA TECH ENGINEERS
Comment:
Seismic Trigger: 0.050 in/s
Sound Trigger: 128 db

Summary Data

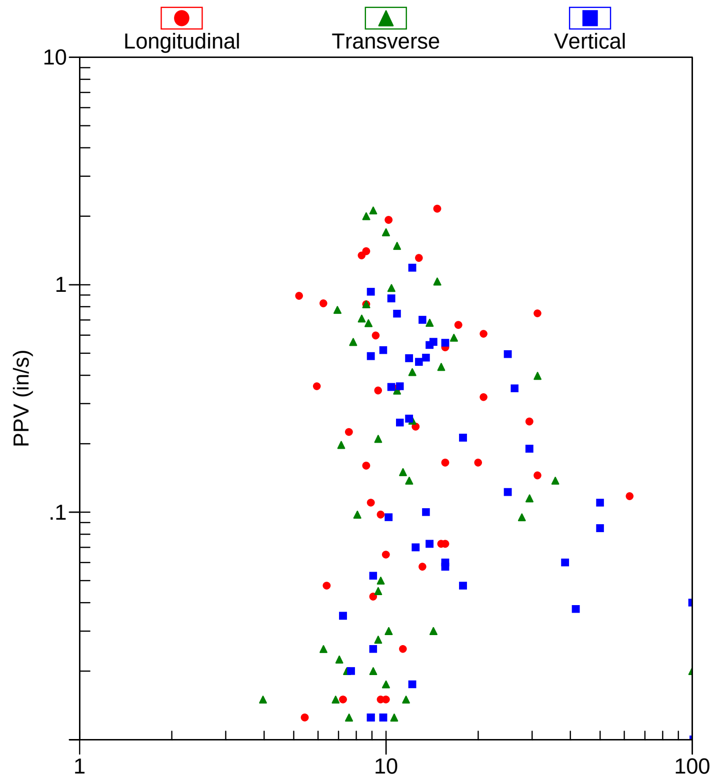
	L	T	V
PPV (in/s)	2.158	2.120	1.188
FREQ (Hz)	14.7	9.1	12.2
PD (.001")	29.60	37.45	15.06
PPA (g)	0.612	0.573	0.319
Peak Vector Sum :	2.245 in/s		
Peak Air Pressure:	131 db		
	0.01034 PSI @ 8.2 Hz		

Additional Info:

Shaketable Calibrated: 09/17/2014
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

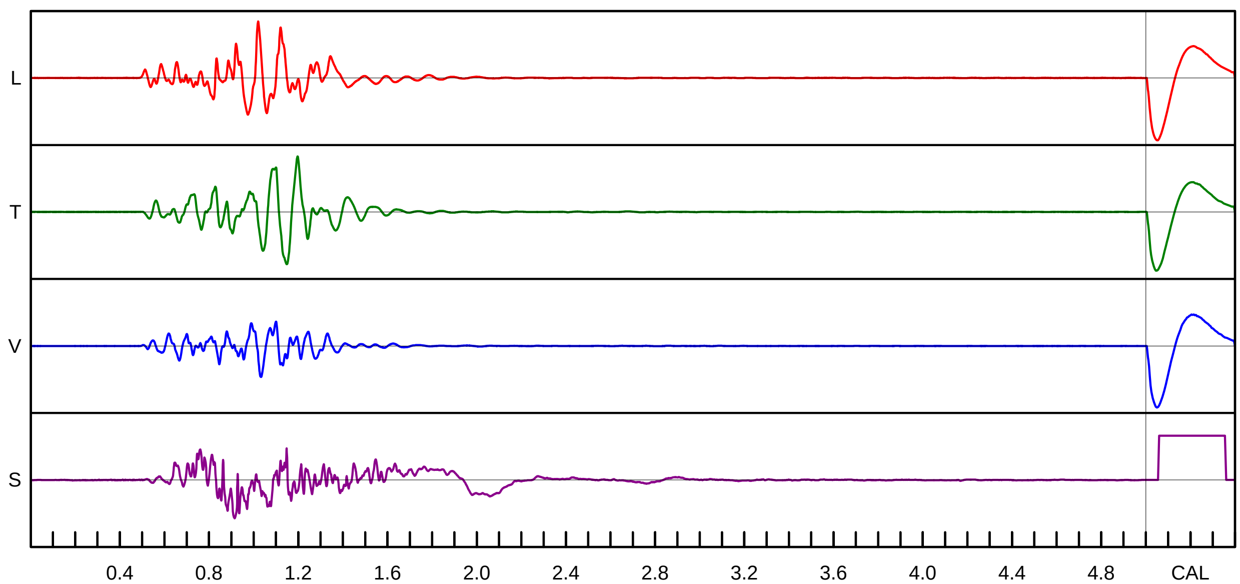
Velocity Waveform Graph Scale
Time Scale: 0.100 s
Seismic Scale: +/- 2.560 in/s
Sound Scale: +/- 0.0181 PSI

PPV vs Frequency
SN: 8402 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform
SN: 8402 Event: 1



Time (s)

Printed: September 01, 2015 **File:** EVEN1.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Vibra-Tech, Inc. Seismic Analysis

Velocity Waveform Analysis

Serial No:	8356 v3.67
Date:	08/03/2015 11:13:52
Event No:	1
Record Time:	5.0 s
Client:	WILKESBARRE MATERIAL
Operation:	LAFLIN PA
Location:	SEIS 2
Distance:	
Operator:	Vibra-Tech Engineers
Comment:	
Seismic Trigger:	0.030 in/s
Sound Trigger:	125 db

Summary Data

	L	T	V
PPV (in/s)	0.293	0.313	0.250
FREQ (Hz)	11.9	7.7	15.2
PD (.001")	4.90	4.81 2.71	
PPA (g)	0.078	0.065	0.065
Peak Vector Sum :	0.365 in/s		
Peak Air Pressure:	126 db		
	0.00560 PSI @ 3.5 Hz		

Additional Info:

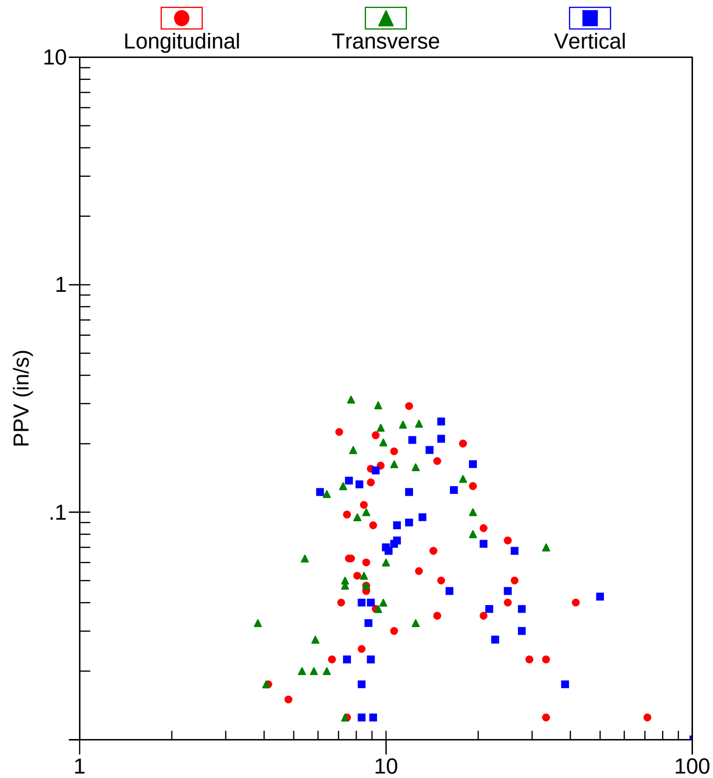
Shaketable Calibrated: 04/24/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

Velocity Waveform Graph Scale

Time Scale:	0.100 s
Seismic Scale:	+/- 0.320 in/s
Sound Scale:	+/- 0.0091 PSI

PPV vs Frequency

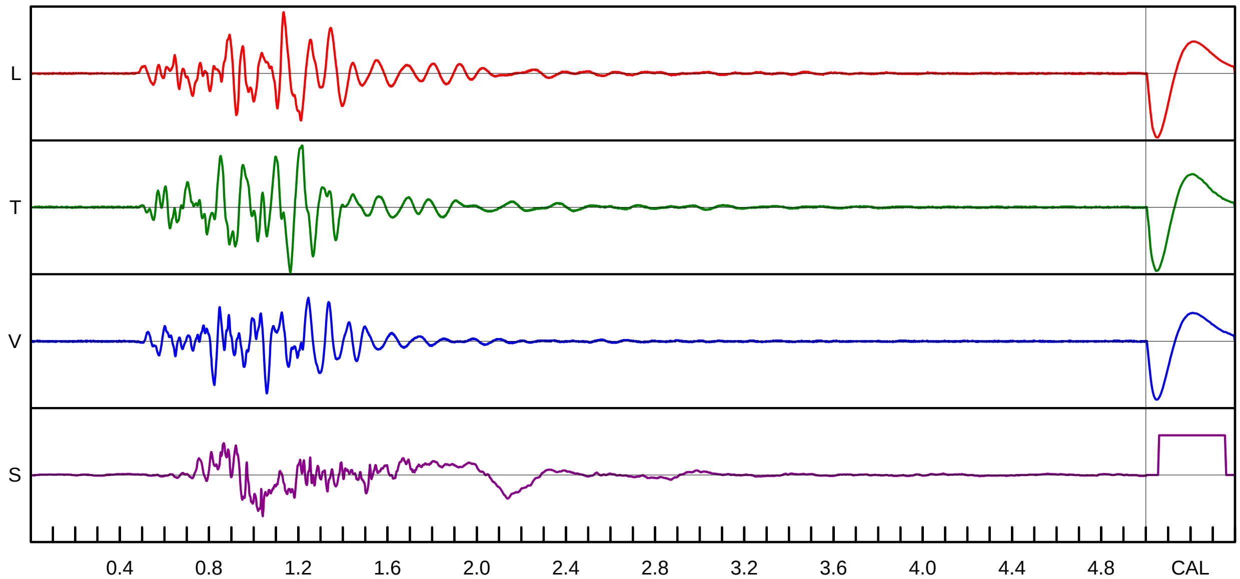
SN: 8356 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform

SN: 8356 Event: 1



Time (s)

Printed: September 01, 2015 **File:** EVEN2.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Vibra-Tech, Inc. Seismic Analysis

Velocity Waveform Analysis

Serial No: 8288 v3.67
Date: 08/03/2015 11:13:56
Event No: 1
Record Time: 5.0 s
Client: WILKESBARRE MATERIAL
Operation: LAFLIN PA
Location: SEIS 3
Distance:
Operator: VibraTech Engineers
Comment:
Seismic Trigger: 0.020 in/s
Sound Trigger: 125 db

Summary Data

	L	T	V
PPV (in/s)	0.060	0.065	0.035
FREQ (Hz)	21.7	21.7	38.5
PD (.001")	0.54	0.42	0.36
PPA (g)	0.026	0.026	0.026
Peak Vector Sum :	0.068 in/s		
Peak Air Pressure:	118 db		
	0.00214 PSI @ 3.7 Hz		

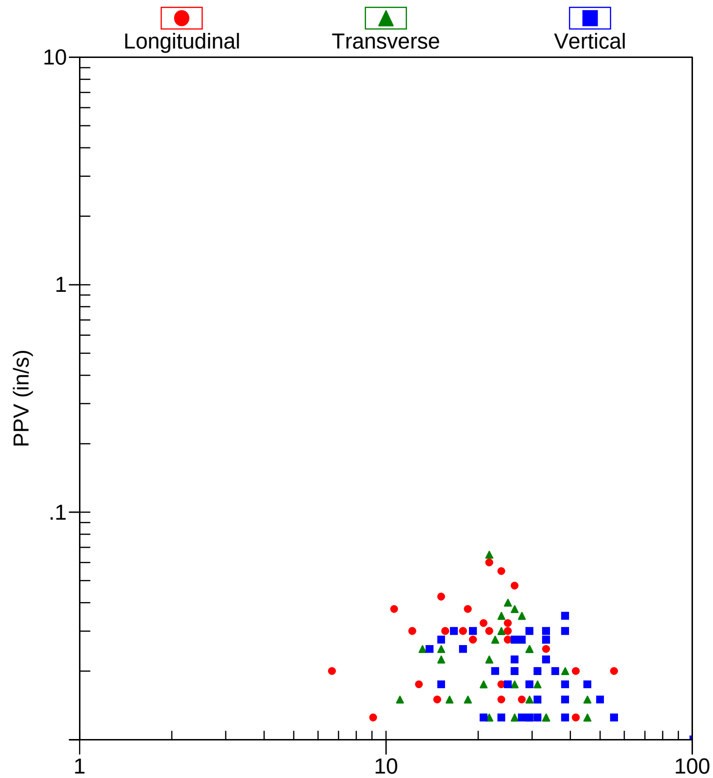
Additional Info:

Shaketable Calibrated: 05/26/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

Velocity Waveform Graph Scale
Time Scale: 0.100 s
Seismic Scale: +/- 0.160 in/s
Sound Scale: +/- 0.0023 PSI

PPV vs Frequency

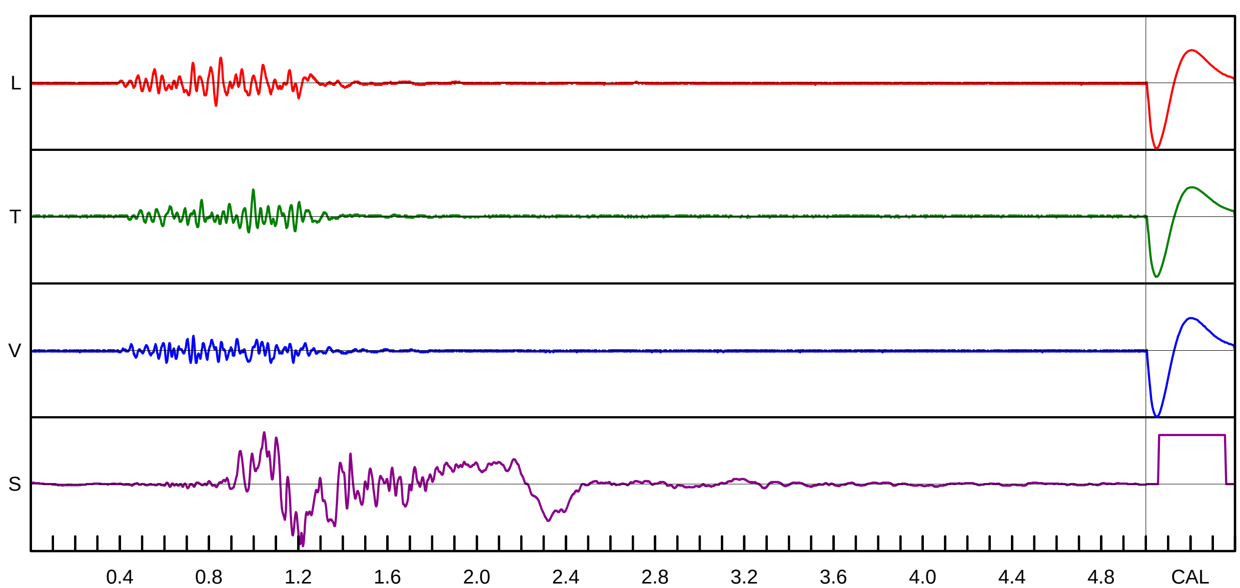
SN: 8288 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform

SN: 8288 Event: 1



Time (s)

Printed: September 01, 2015 **File:** EVEN3.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Vibra-Tech, Inc. Seismic Analysis
Velocity Waveform Analysis

Serial No:	8298 v3.66		
Date:	08/03/2015 11:13:59		
Event No:	1		
Record Time:	5.0 s		
Client:	WILKESBARRE MATERIAL		
Operation:	LAFLIN PA		
Location:	SEIS 4		
Distance:			
Operator:	VIBRA TECH ENGINEERS		
Comment:			
Seismic Trigger:	0.020 in/s		
Sound Trigger:	125 db		

Summary Data

	L	T	V
PPV (in/s)	0.053	0.085	0.033
FREQ (Hz)	33.3	19.2	23.8
PD (.001")	0.33	0.74	0.29
PPA (g)	0.033	0.033	0.020
Peak Vector Sum :	0.085 in/s		
Peak Air Pressure:	112 db		
	0.00119 PSI @ 2.3 Hz		

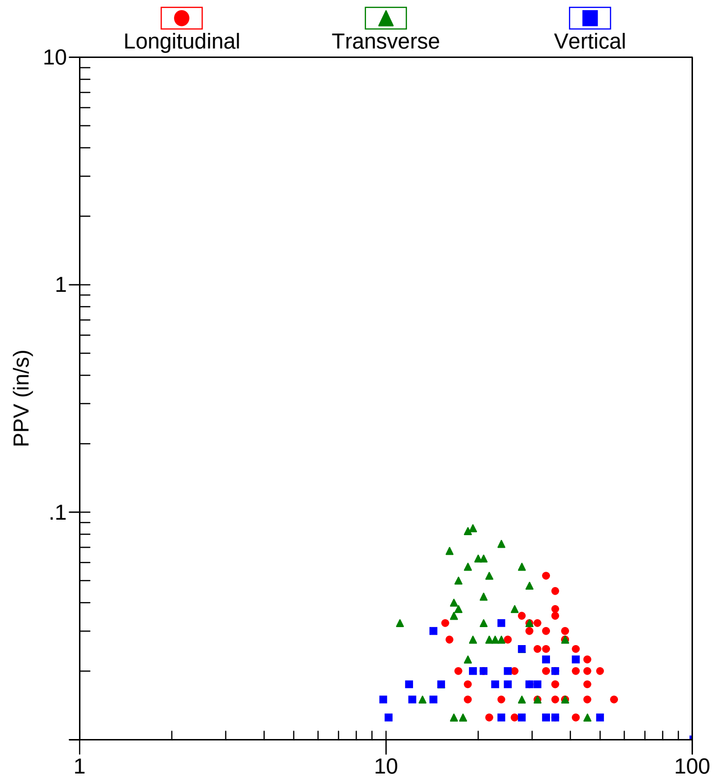
Additional Info:

Shaketable Calibrated: 05/26/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

Velocity Waveform Graph Scale

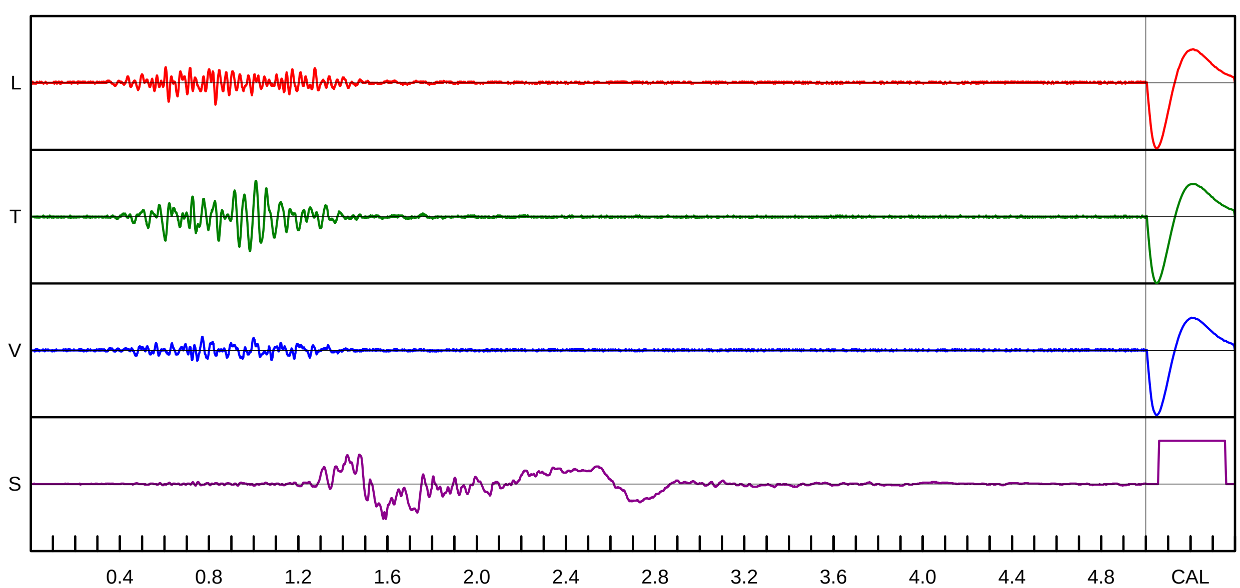
Time Scale:	0.100 s
Seismic Scale:	+/- 0.160 in/s
Sound Scale:	+/- 0.0023 PSI

PPV vs Frequency
SN: 8298 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform
SN: 8298 Event: 1



Time (s)

Printed: September 01, 2015 **File:** EVEN4.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Vibra-Tech, Inc. Seismic Analysis

Velocity Waveform Analysis

Serial No:	8299 v3.66		
Date:	08/03/2015 11:14:01		
Event No:	1		
Record Time:	5.0 s		
Client:	WILKESBARRE MATERIAL		
Operation:	LAFLIN PA		
Location:	SEIS X		
Distance:			
Operator:	Vibra Tech Engineers		
Comment:			
Seismic Trigger:	0.030 in/s		
Sound Trigger:	128 db		

Summary Data

	L	T	V
PPV (in/s)	0.130	0.190	0.093
FREQ (Hz)	13.9	14.7	20.0
PD (.001")	1.60	1.93	0.86
PPA (g)	0.039	0.065	0.033
Peak Vector Sum :	0.238 in/s		
Peak Air Pressure:	114 db		
	0.00160 PSI @ 4.0 Hz		

Additional Info:

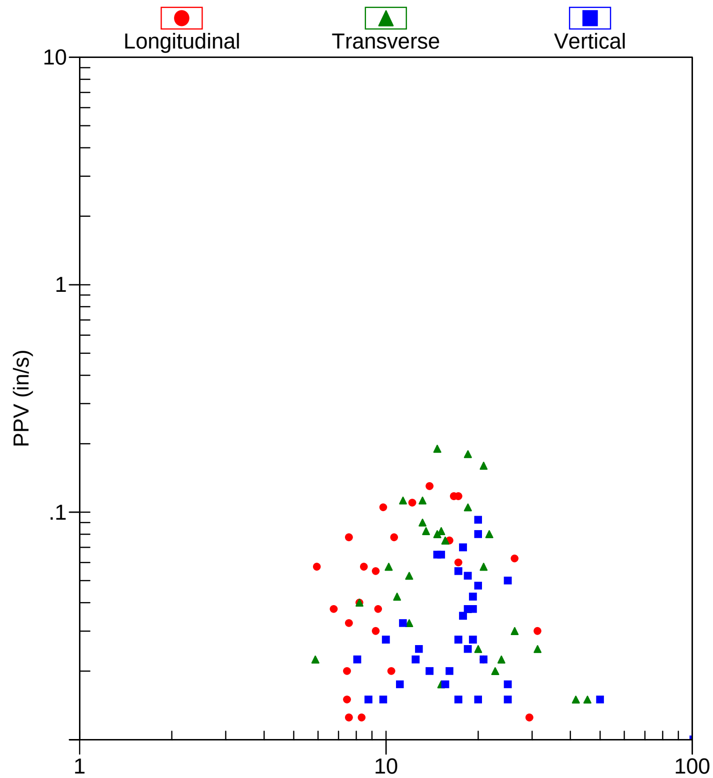
Shaketable Calibrated: 05/26/2015
By: Vibra-Tech, Inc.
2700 Holloway Road - Suite 113
Louisville, KY 40299 U.S.A.
TEL: 502.240.9900 FAX: 502.240.9902

Velocity Waveform Graph Scale

Time Scale:	0.100 s
Seismic Scale:	+/- 0.320 in/s
Sound Scale:	+/- 0.0023 PSI

PPV vs Frequency

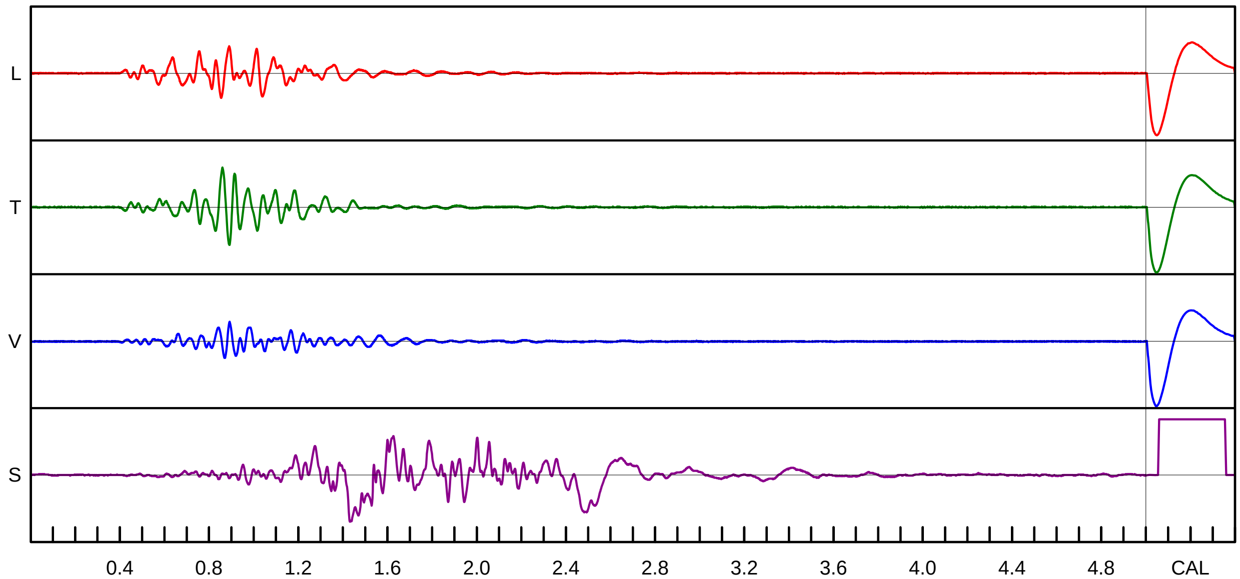
SN: 8299 Event: 1



Zero Crossing Half-Wave Frequency Analysis

Velocity Waveform

SN: 8299 Event: 1



Time (s)

Printed: September 01, 2015 **File:** EVENx.EV3 (GeoSonics Inc. AnalysisNET v8.1.52)

Market St
Seismograph 4
Seismograph 3
Seismograph 2
Seismograph 1
Seismograph X
Blast 2
587 ft
1992
© 2015 Google
Google earth
Imagery Date: 5/10/2014 41° 17.097' N 75° 48.004' W elev 900 ft eye alt 3330 ft

Appendix B
MASW Geophysical Testing

Geophysical Investigation
Multi-channel Analysis of Surface Waves (MASW)
American Asphalt
Wilkes-Barre Materials Quarry
Laflin, Pennsylvania

Prepared for:

AECOM
625 West Ridge Pike
Suite E-100
Conshohocken, Pennsylvania 19428

Prepared by:

Vibra-Tech Engineers, Inc.
109 East First Street
Hazleton, Pennsylvania 18201

September 8, 2015

Table of Contents

Geophysical Investigation
Multi-channel Analysis of Surface Waves (MASW)
American Asphalt
Wilkes-Barre Materials Quarry
Laflin, Pennsylvania

September 8, 2015

INTRODUCTION

A Multi-channel Analysis of Surface Waves (MASW) investigation was conducted by Vibra-Tech Engineers, Inc. at American Asphalt's Wilkes-Barre Materials Quarry, Laflin, Pennsylvania. The fieldwork for MASW Lines 1 through 3 was carried out on July 17 and 20, 2015. The fieldwork for MASW Lines 4 through 6 was carried out on August 5, 2015.

The purpose of the investigation was to measure the shear wave propagation velocity of the earth materials present at the study location. In order to achieve this objective, MASW methods were used to measure shear wave velocity profiles indicating encountered shear wave velocities and depths. This work was authorized by Mr. John C. Volk, P.E., of AECOM.

SCOPE AND CONDITIONS OF SURVEY

MASW measurements consisted of a total of six (6) acquisition lines or spreads located throughout the project area. MASW Lines 1 through 3 were located in association with the linear seismograph array for Blast 1 (July 17, 2015), while MASW Lines 4 through 6 were associated with the linear seismograph array for Blast 2 (August 3, 2015).

It must be stressed that the MASW lines run are in no way connected to Blast 1 and 2, aside from measuring the shear wave velocity of the same ground that propagated blast vibration energy. The MASW acquisition lines utilized a seismic source that was completely independent of the blasting.

Appendix-A presents a series of three (3) aerial photographs showing approximate MASW line locations. The first aerial photograph presents a view of the entire Wilkes-Barre Materials Quarry along with the location of all six (6) MASW acquisition lines. This is followed by an expanded view showing the location of MASW Lines 1 through 3, followed by an MASW Lines 4 through 6.

To serve as a cross-reference, the approximate seismograph locations are displayed as numbers 1 through 4 on the Appendix-A aerial photographs. These locations are referenced in detail in the Vibration Monitoring Reports for Blast 1 and Blast 2. In addition, the northern half of MASW Line 2 corresponds with the location of the apparent shear wave velocity acquisition line, referenced in the Apparent Shear Wave Velocity Measurements Report.

This site was inherently noisy because of an operating rock crusher and haul traffic from the nearby quarry. Periods of relative quiet within this busy environment were utilized for the collection of MASW data. This resulted in the collection of MASW data that ranged in clarity and quality from poor, near the vicinity of the rock crusher, to very good at more distant locations.

LIMITATION OF GEOPHYSICAL METHODS

Geophysical Methods are indirect methods of subsurface investigation subject to both natural limits and interpretational errors. Vibra-Tech Engineers, Inc. does not guarantee that the interpreted subsurface conditions will completely coincide with the geological conditions that actually exist. The methods and equipment described in this report represent standard accepted practices employed by the engineering geophysical industry. The interpretations made in this report are representative of the data on the day of the acquisition. Vibra-Tech Engineers, Inc. can not be held responsible for changes in subsurface conditions as a result of natural or man-made phenomena.

DATA ACQUISITION PROCEDURE

A twenty-four channel, Geometrics Strataview seismograph was used to record active-source MASW data collected at the site. Active-source denotes the active or intentional manner in which seismic energy is transmitted into the ground. The instrument was set to acquire seismic records of 2048 ms in length, with a sample interval of 1,000 µs. No pre-acquisition filters were used on the data.

On each of the investigation lines, spreads of twenty-four 4.5 Hz vertical geophones were placed along the ground surface. A five-foot spacing between geophones was utilized in the collection of MASW data, yielding 115 foot long spreads. Seismic energy was transmitted into the ground adjacent and in-line with the beginning and end of the geophone spread. Offset distances to this seismic source measured 20 feet away from the geophone spread. The seismic energy source consisted of a 14-Lb sledgehammer and a steel strike plate. The travel time of the seismic energy, from the source point to each geophone, was stored in the seismograph’s internal memory then transferred to disk for later analysis.

BACKGROUND

Multi-channel Analysis of Surface Waves (MASW) is a seismic method for near-surface characterization of the shear wave velocity of the sub-surface. It utilizes Rayleigh-type surface waves to determine the variation of shear wave velocity with depth. The Rayleigh Wave (R-Wave) is the dominant component of surface waves, and is often referred to as the “ground-roll”. Shear wave velocity (Vs) can be calculated by the mathematical inversion of the dispersive phase velocity of surface waves. The method uses 1.1 times the phase velocity for an estimate of Vs. Shear wave velocity is a direct indication of the stiffness of the material, where higher wave velocities is associated with higher stiffness.

When the ground surface is disturbed by an impact, two types of waves propagate in the system: body waves, and surface waves. Body waves travel in the body of the earth system and consist of shear waves and compressional waves. Surface waves propagate near the surface of the earth and are the focus of the MASW method. The ground motion associated with Rayleigh waves has been described as a motion that traces a retrograde-elliptical path throughout one complete cycle.

In an isotropic media, the velocity of surface waves does not vary with the frequency (wavelength) of the surface wave. However, if the stiffness of a site varies with depth, the velocity of the Rayleigh wave will vary with frequency. The variation of R-wave velocity with frequency is called dispersion, and a plot of surface wave velocity versus wavelength is called a dispersion curve.

Surface wave energy decays quite rapidly with depth. As a general rule of thumb, surface waves sample to an approximate depth of their wavelength divided by two. This means that the longer wavelength, lower-frequency surface waves travel deeper and thus contain more information about deeper velocity structure, while shorter wavelength, higher-frequency surface waves travel shallower and contain more information about shallower velocity structure. In surface wave surveying, it is assumed that the longest wavelength that can be sampled is as long as the spread length.

Many of the concepts utilized in the explanation of the MASW method are obtained from the publications of Soheil Nazarian and Kenneth Stokoe, whose work focuses largely on the spectral analysis of surface waves in the evaluation of roadways. In their work, In Situ Determination of Elastic Moduli of Pavement Systems By Spectral-Analysis-of-Surface-Wave Method: Practical Aspects1, Nazarian and Stokoe discuss many of the aspects of the SASW method, a precursor to MASW. In addition, the explanation of the MASW method used in this report also relied on the publication of Debra Underwood and Koichi Hayashi, Seismic Wave Surveying With Geometrics, Inc. Seismographs and SeisImager/SW, Geometrics Inc. Short Course Notes.2

[1] Nazarian, S. & Stokoe III, K.H. (1985). In Situ Determination of Elastic Moduli of Pavement Systems by Spectral-Analysis-of-Surface-Wave Method: Practical Aspects (Report No. FHWA/TX-86/13+368-1F). Austin, TX: Texas State Department of Highways and Public Transportation.

[2] Underwood, D.H. and Hayashi, K. (2005), Seismic Surface Wave Surveying With Geometrics, Inc. Seismographs and SeisImager/SW Software, Geometrics, Inc. Short Course Notes, San Jose, California and London, United Kingdom.

ANALYSIS PROCEDURE

Data files obtained in the field were imported into the SeisImager/SW software manufactured by Geometrics. SeisImager/SW is a Windows based software for the analysis of multi-channel surface wave data.

The first step in the processing of the MASW data deals with the extraction of the dispersion curve from the seismic data. The dipersion curves are imaged through a wavefield-transformation method that directly converts the multi-channel record into a dispersion pattern where phase velocity is plotted versus frequency. The fundamental mode of the Rayleigh wave is then extracted and separated from the remainder of the dispersion images. This stripping of the unwanted portions of the wave-train allows further analysis of the fundamental mode of the Rayleigh Wave.

Appendix-B of this report presents a set of four figures for each of the six (6) MASW investigation lines collected in the study area:

The first figure for each MASW line location presents the seismic data, or ***Multi-channel Waveform Record***. This record captures the character and magnitude of ground vibrations as they travel through the geophone spread. This seismic data is referred to as a shot gather in geophysical literature.

Following the multi-channel waveform record is the ***Dispersion Curve Image***. This image is obtained directly from the original waveform record through a process where surface waves on the shot gather are converted into images of multi-mode dispersion curves. In these color coded dispersion curve images, phase velocity in feet per second (ft/sec) is plotted vs. frequency, in Hertz (Hz). The maximum amplitude for each frequency was picked on the dispersion curve image, and is represented by a series of red dots.

Following the transformation from the waveform record into the dispersion curve image, The ***Initial S-Wave Velocity Model*** with depth was calculated. The initial S-wave velocity model is presented as a plot of S-wave velocity versus depth. The initial S-wave velocity model is calculated from the one-third wavelength approximation represented by the green circles pictured. Vs velocities determined up to this point are not actual velocities of the subsurface layers, but are apparent Vs velocities. The existence of a layer with high or low velocity at the ground surface affects measurement velocities of the underlying layers. A method for evaluating Vs from apparent Vs is provided by the inversion process.

Inversion consists of the determination of the depth of each layer and the actual shear wave velocity of each layer from the apparent R-Wave velocity versus wavelength information. The mathematical process is based on the Least-Squares Method and simply stated, iteratively modifies the initial model of Vs to minimize the difference from the observed data. The inversion process is an iterative one in which a shear wave velocity profile is assumed and a theoretical dispersion curve is constructed. The observed and calculated dispersion curves are compared and necessary changes are made in the assumed shear wave velocity profile until the two curves match within a reasonable tolerance. The ***Inverted S-Wave Velocity Model*** is generated in the inversion process. Results of this inversion follow the Initial S-Wave Velocity Model in Appendix-B.

DISCUSSION OF MASW RESULTS

The results of the MASW survey are presented in the Inverted S-Wave Velocity model in Appendix-B for each of the six (6) MASW spreads. These profile figures plot Shear Wave Velocity (ft/s) vs. Depth (ft). The shear wave velocity and corresponding depth interval values are also plotted alongside the right edge of the bar-graph plot.

The following discussion will address the results for each MASW Line location. The approximate location of each MASW line can be referenced in the Appendix-A aerial photographs.

MASW Line 1

MASW Line 1 was run adjacent the south side of an active haul road in the quarry floor. Shear wave velocities ranged from 1099 through 3023 ft/sec.

From a depth of 0 through 17.2 feet, shear wave velocities ranged from 1099 through 1683 ft/sec. This material is interpreted as a seam of softer bedrock and/or a broken and compacted bedrock associated with the haul road.

From a depth of 17.2 through 100 feet, shear wave velocities ranged from 2179 through 3023 ft/sec. This material is interpreted as bedrock. Sandstones, siltstones, shales, conglomerates, and anthracite coal seams were noted in the vicinity of MASW Line 1.

MASW Line 2

MASW Line 2 was located along the top of a prominent ridge that dominates the quarry's south-eastern edge, and spanned the broad and relatively flat top of the ridge. The north end of the spread was located approximately 50 feet away from the quarry's south high-wall.

The location of the northern half of MASW Line 2 corresponds with the location of the apparent shear wave velocity spread, detailed in the Apparent Shear Wave Velocity Measurements Report.

Shear wave velocities for MASW Line 2 ranged from 1646 through 3368 ft/sec. From a depth of 0 through 19.0 feet, shear wave velocities ranged from 1646 through 2003 ft/sec. This material is interpreted as softer, weathered bedrock.

From a depth of 19.0 through 100 feet, shear wave velocities ranged from 2092 through 3368 ft/sec. This material is interpreted as bedrock. A slightly weathered sandstone bedrock was exposed along the haul road slightly to the north of MASW Line 2.

MASW Line 3

MASW Line 3 was run in an open field located south of the quarry, and to the south of Ridgewood Road. The relatively flat topography at this location, and its association with a broad valley, suggest a region underlain by unconsolidated valley-fill material.

Shear wave velocities for MASW Line 3 ranged from 664 through 1615 ft/sec. From a depth of 0 through 34.5 feet, shear wave velocities ranged from 664 through 1031 ft/sec. This material is interpreted as a stiff soil.

From a depth of 34.5 through 100 feet, shear wave velocities ranged from 1202 through 1615 ft/sec. This material is interpreted as a weathered bedrock that transitions to un-weathered and harder bedrock with increasing depth.

MASW Line 4

MASW Line 4 was run adjacent the north side of an active haul road in the quarry. Shear wave velocities ranged from 1677 through 2791 ft/sec. This material is interpreted as bedrock. Sandstones, siltstones, shales, conglomerates, and anthracite coal seams were noted in the vicinity of MASW Line 4.

MASW Line 5

MASW Line 5 was run in a lightly wooded slope located east of the toe of the quarry's active dump face. A light cover of forest litter covered a shallow, tan to white, very hard sandstone. Shear wave velocities ranged from 3606 through 5791 ft/sec. This material is interpreted as bedrock.

MASW Line 6

MASW Line 6 was run in a relatively flat area that spanned a transition between heavily wooded evergreens and an open field. This flat area formed a shelf located slightly higher and adjacent to Gardner Creek. Bedrock outcrops (flaggy sandstones) were noted on the nearby hillside and slightly upstream along Gardner Creek.

Shear wave velocities for MASW Line 6 ranged from 1357 through 3284 ft/sec. This material is interpreted as a weathered bedrock that transitions to un-weathered and harder bedrock with increasing depth.

CONCLUSION

A Multi-channel Analysis of Surface Waves (MASW) investigation was conducted by Vibra-Tech Engineers, Inc. at American Asphalt's Wilkes-Barre Materials Quarry, Laflin, Pennsylvania. The shear wave propagation velocity of the earth materials present were measured at six (6) locations in the project area.

MASW survey results are summarized in the "Discussion of MASW Results" section of this report. A detailed view of survey results is provided in the Inverted S-Wave Velocity Model profile presented in Appendix-B of this report, for each line location.

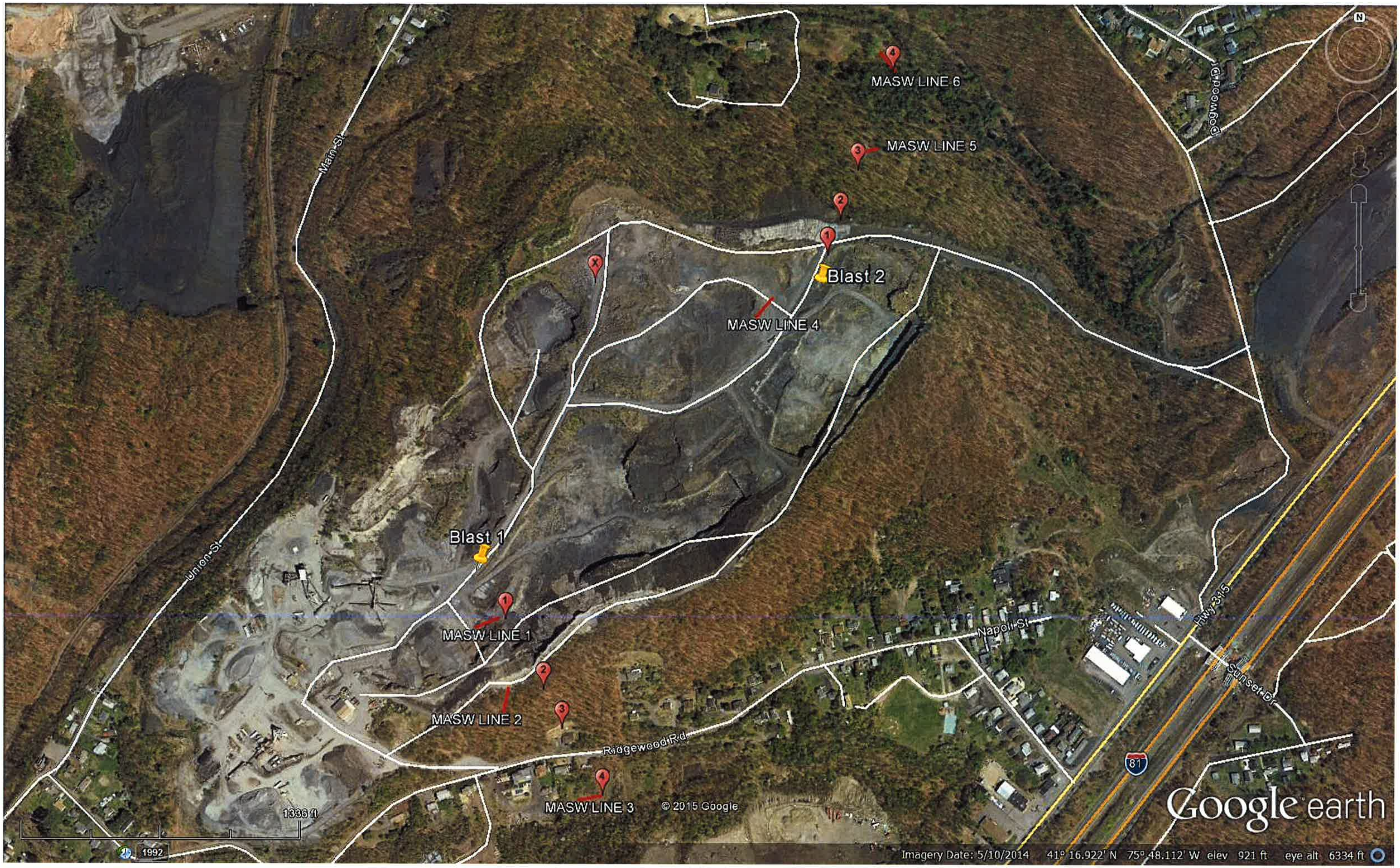
Respectfully submitted,
Vibra-Tech Engineers, Inc.

Ryan Jubran
Geological Technician

Stephen Munoz
Project Geologist

Douglas Rudenko, PG
Vice President

APPENDIX A – MASW LINE LOCATIONS



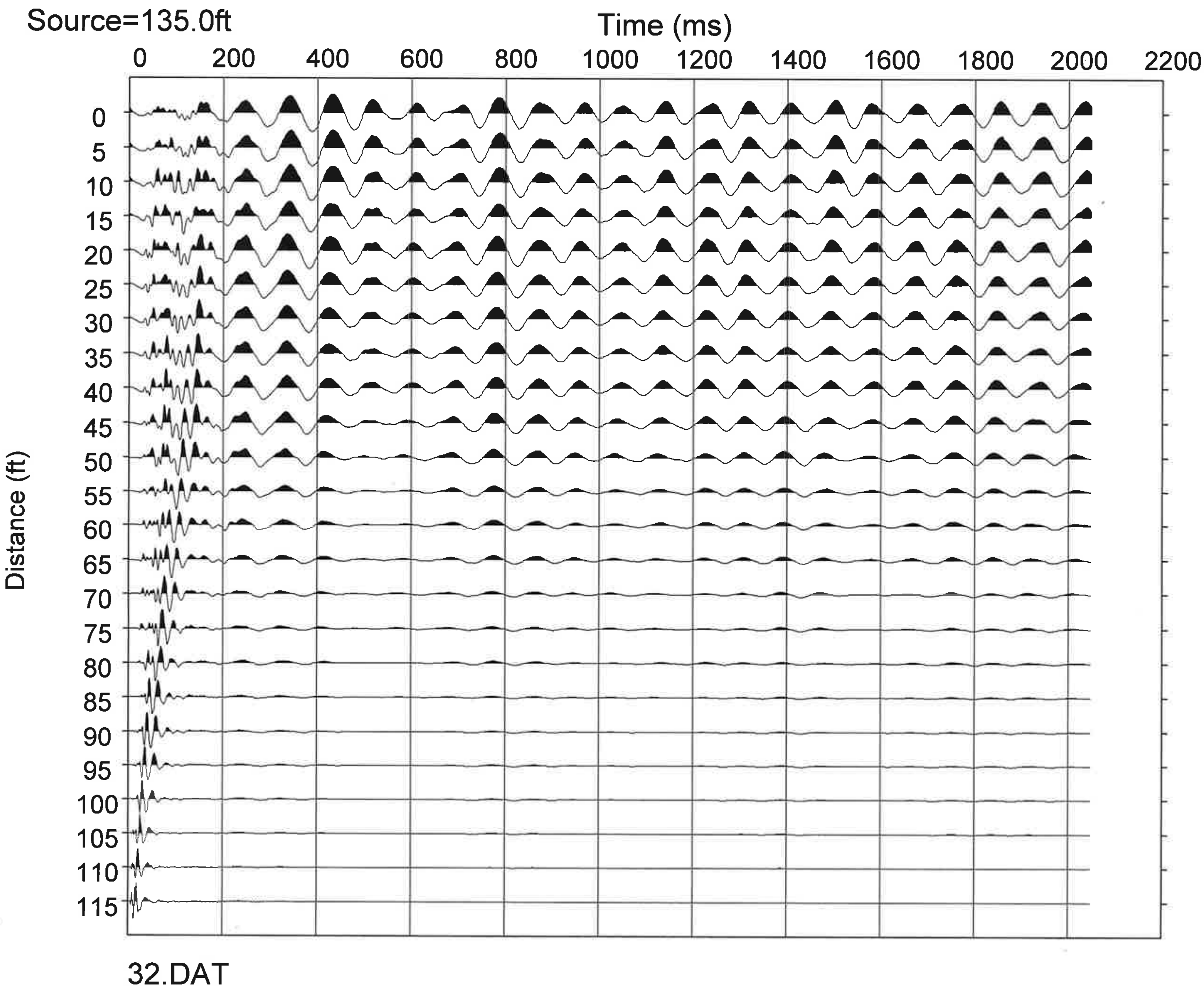
MASW LINE 6
MASW LINE 5
Blast 2
MASW LINE 4
Blast 1
MASW LINE 1
MASW LINE 2
MASW LINE 3
Main St
Union St
Dogwood Dr
Napoli St
Ridgewood Rd
Hwy 315
Sunset Dr
81
© 2015 Google
1336 ft
1992
Google earth
Imagery Date: 5/10/2014 41° 16.922' N 75° 48.112' W elev 921 ft eye alt 6334 ft

Union-St
Blast 1
1
MASW LINE 1
2
MASW LINE 2
3
Ridgewood Rd
4
MASW LINE 3
550 ft
1992
© 2015 Google
Google earth
Imagery Date: 5/10/2014 41° 16.728' N 75° 48.287' W elev 871 ft eye alt 3115 ft


Market St
MASW LINE 6
MASW LINE 5
MASW LINE 4
Blast 2
© 2015 Google
550 ft
1992
Google earth
Imagery Date: 5/10/2014 41° 17.106' N 75° 48.050' W elev 860 ft eye alt 3270 ft

APPENDIX B – MASW SURVEY RESULTS

MASW Line 1



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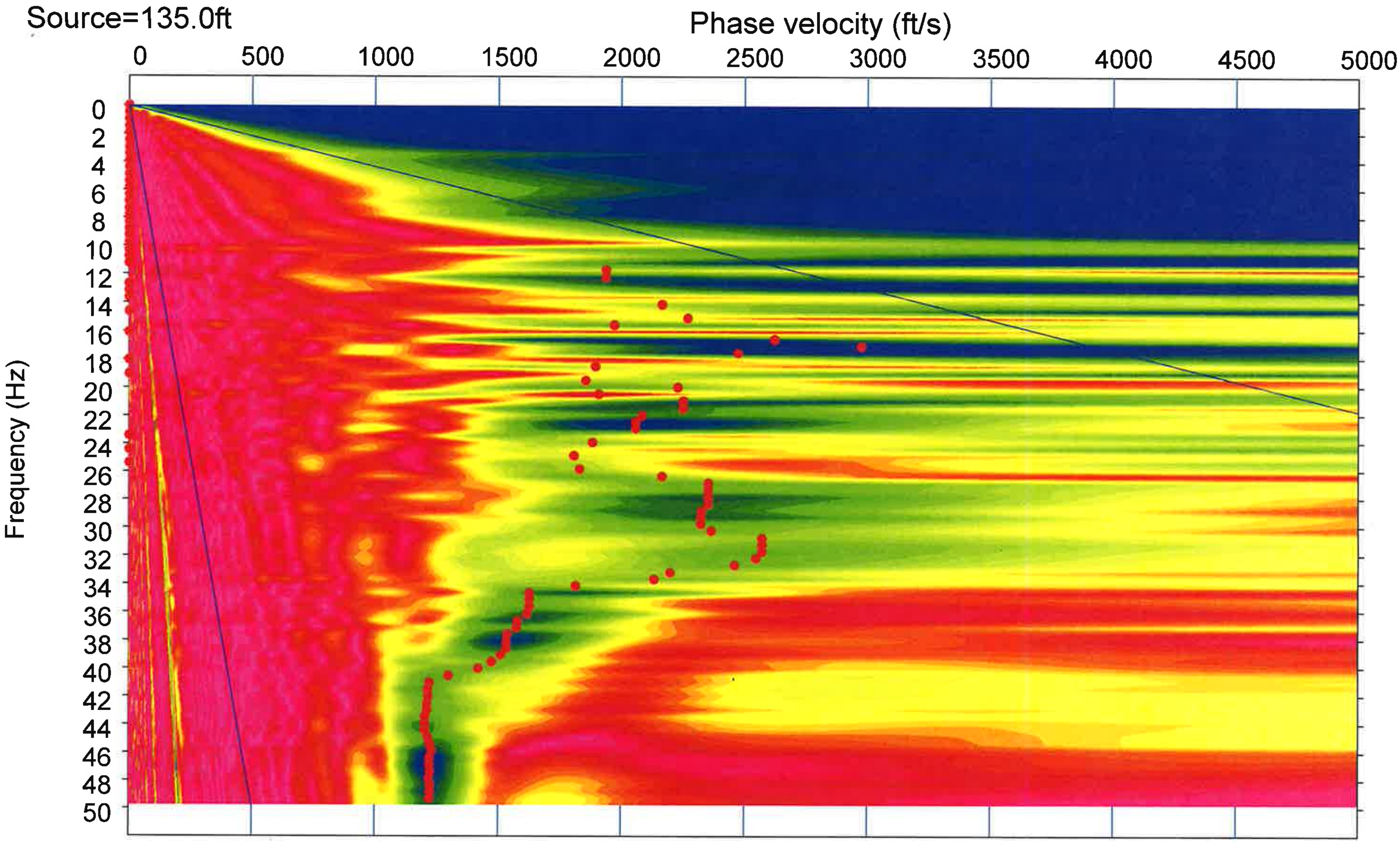

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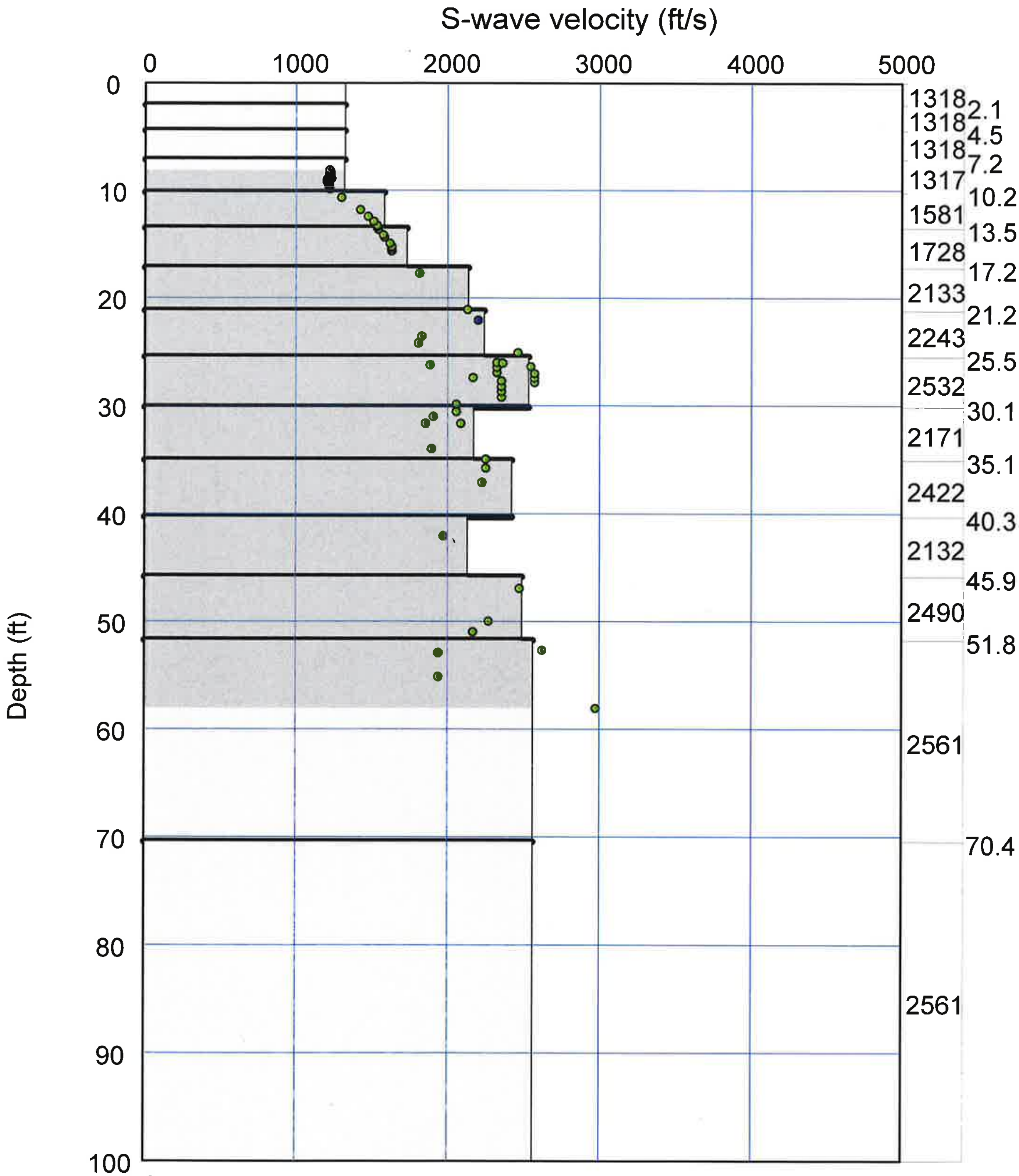

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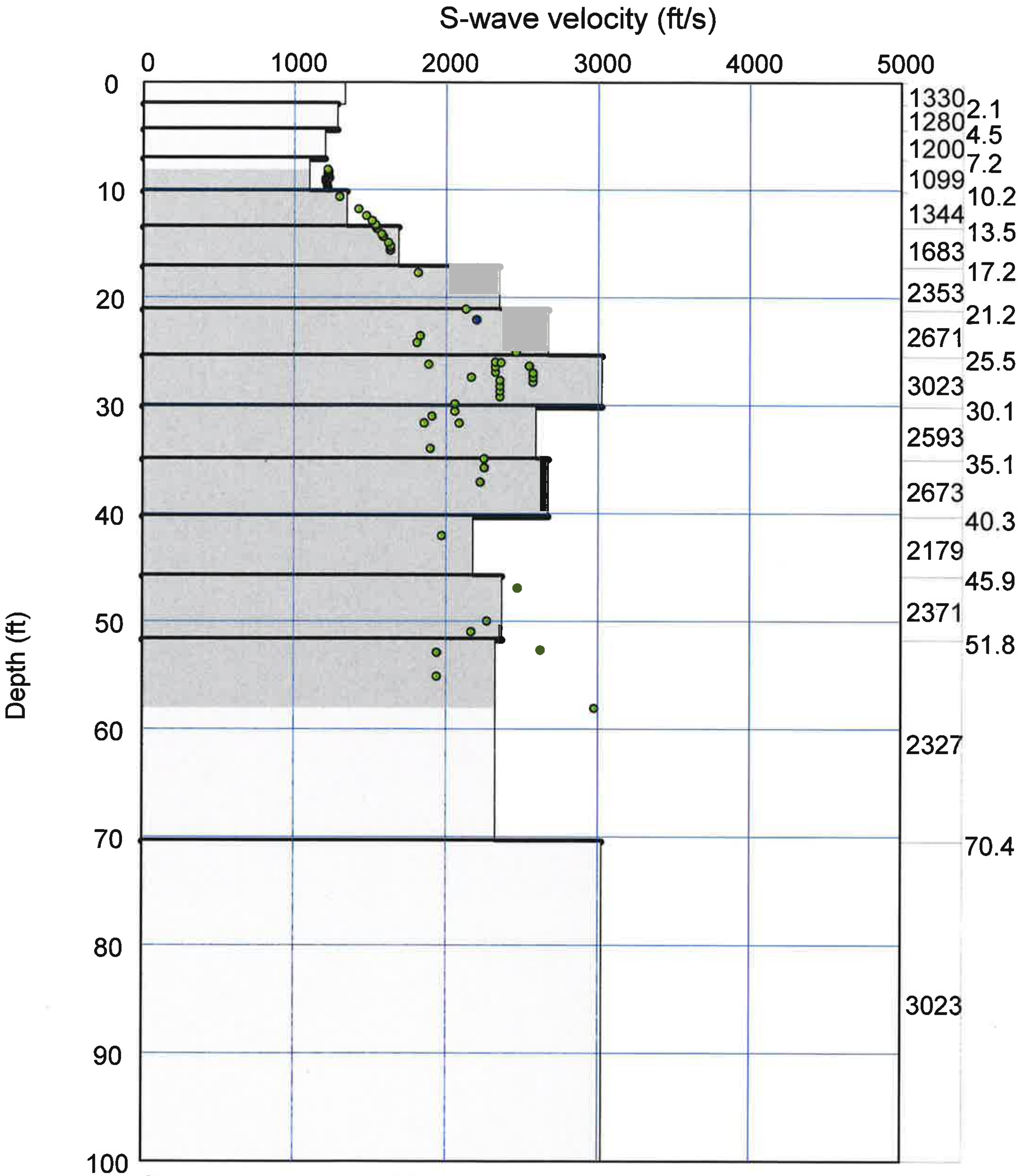
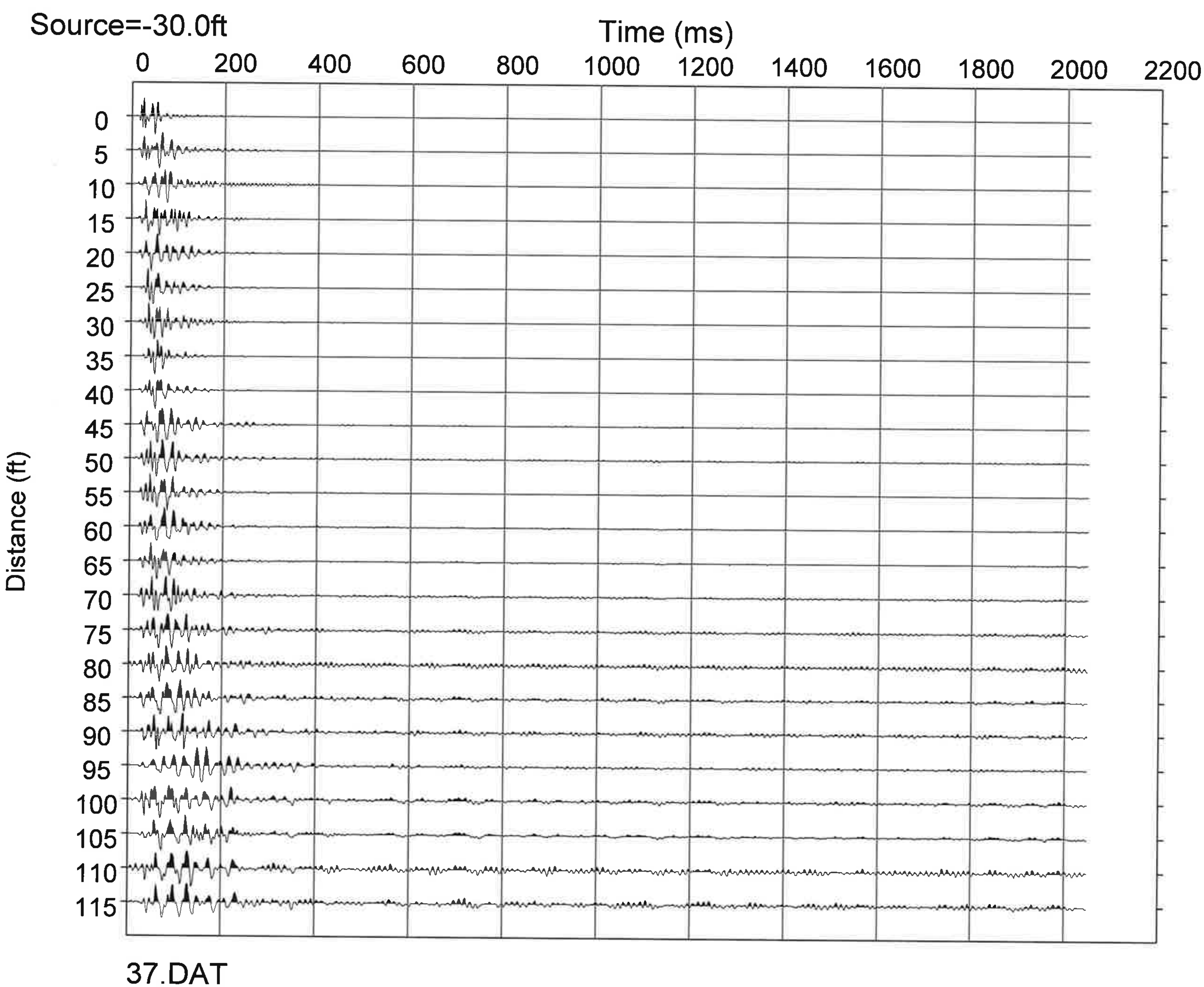


S-wave velocity model (inverted) : 32.DAT

MASW Line 2



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1000
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1800
2000
2200
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10
15
20
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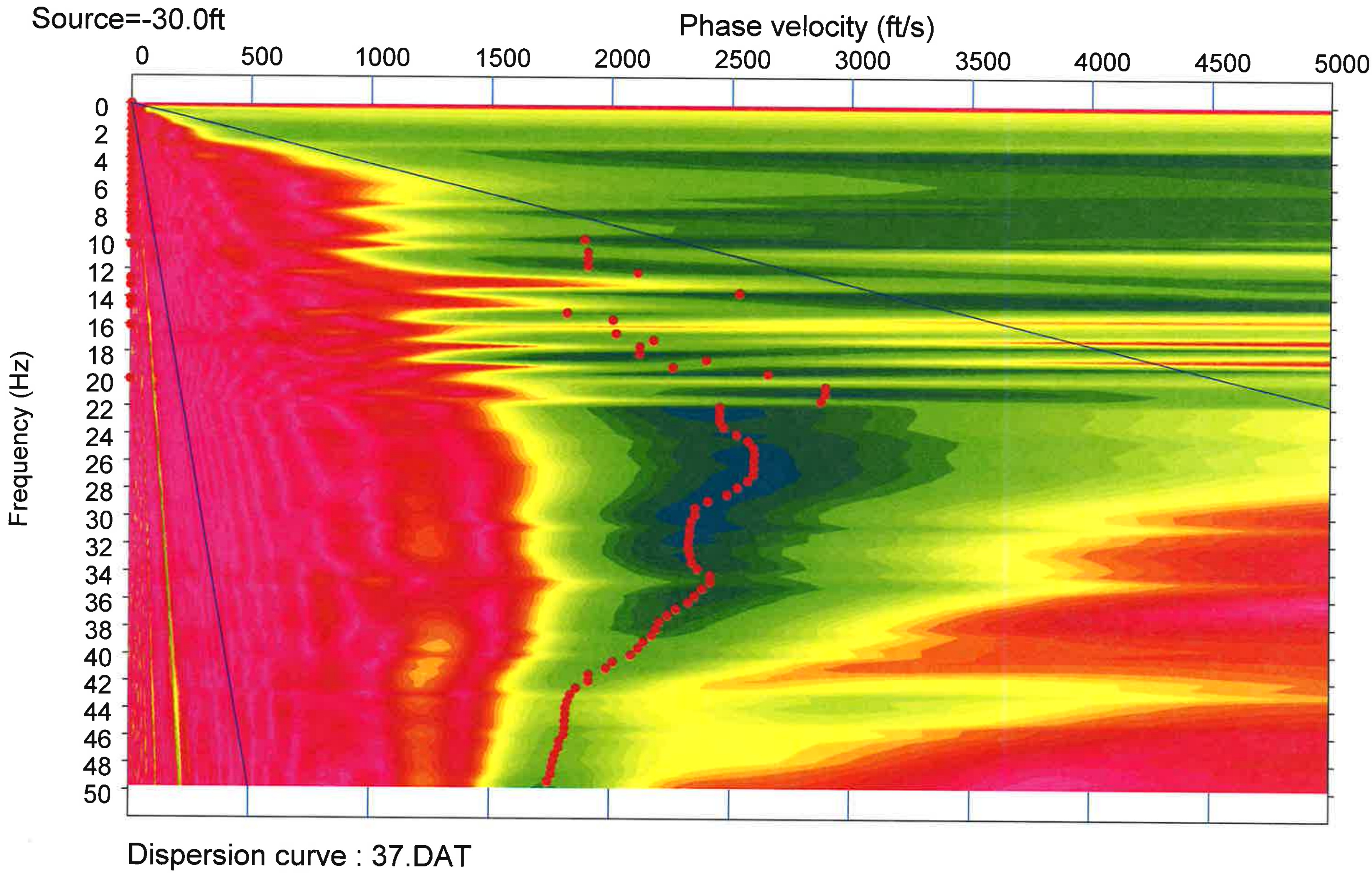
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4500
5000
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4
6
8
10
12
14
16
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44
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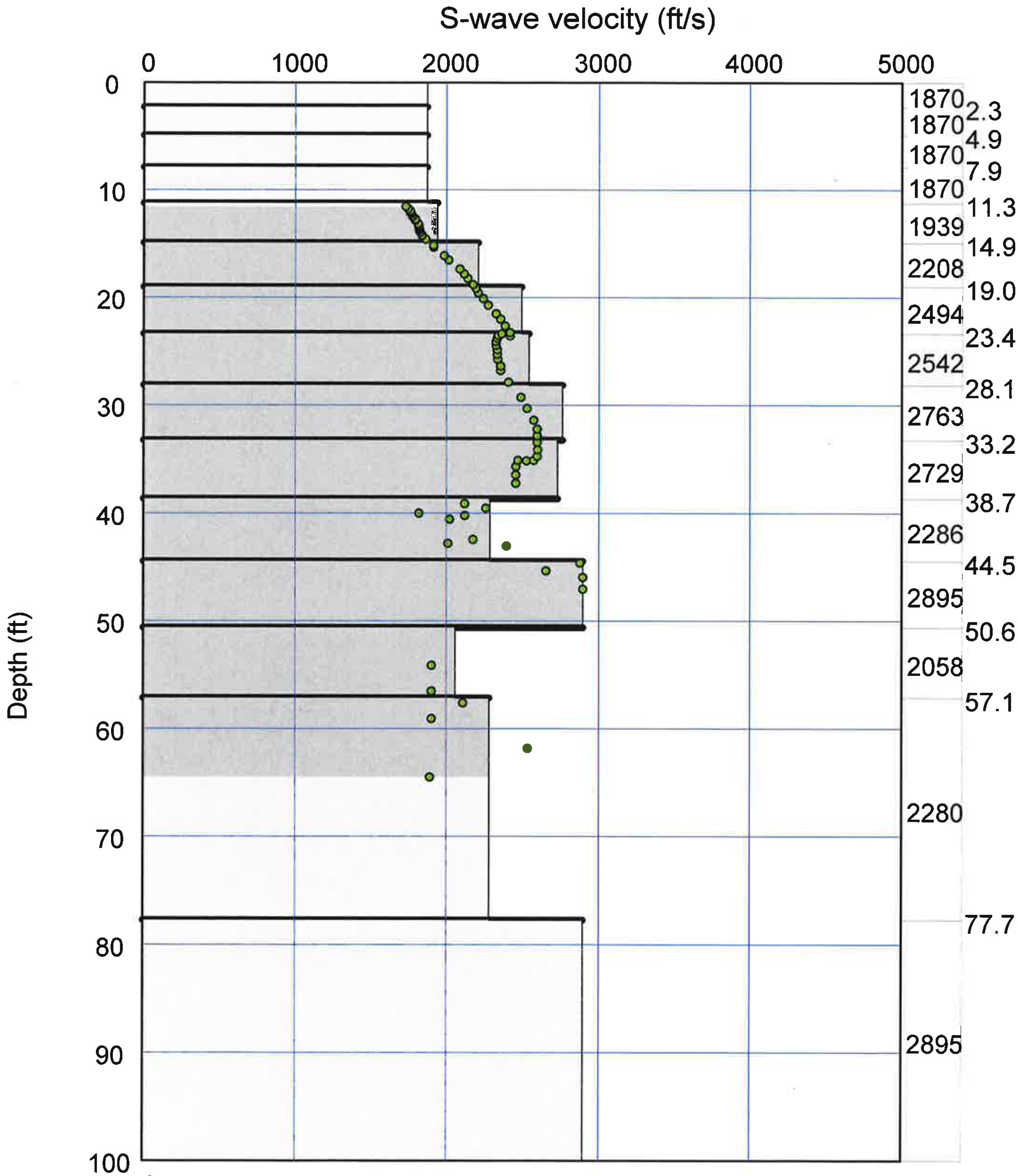
Dispersion curve : 37.DAT



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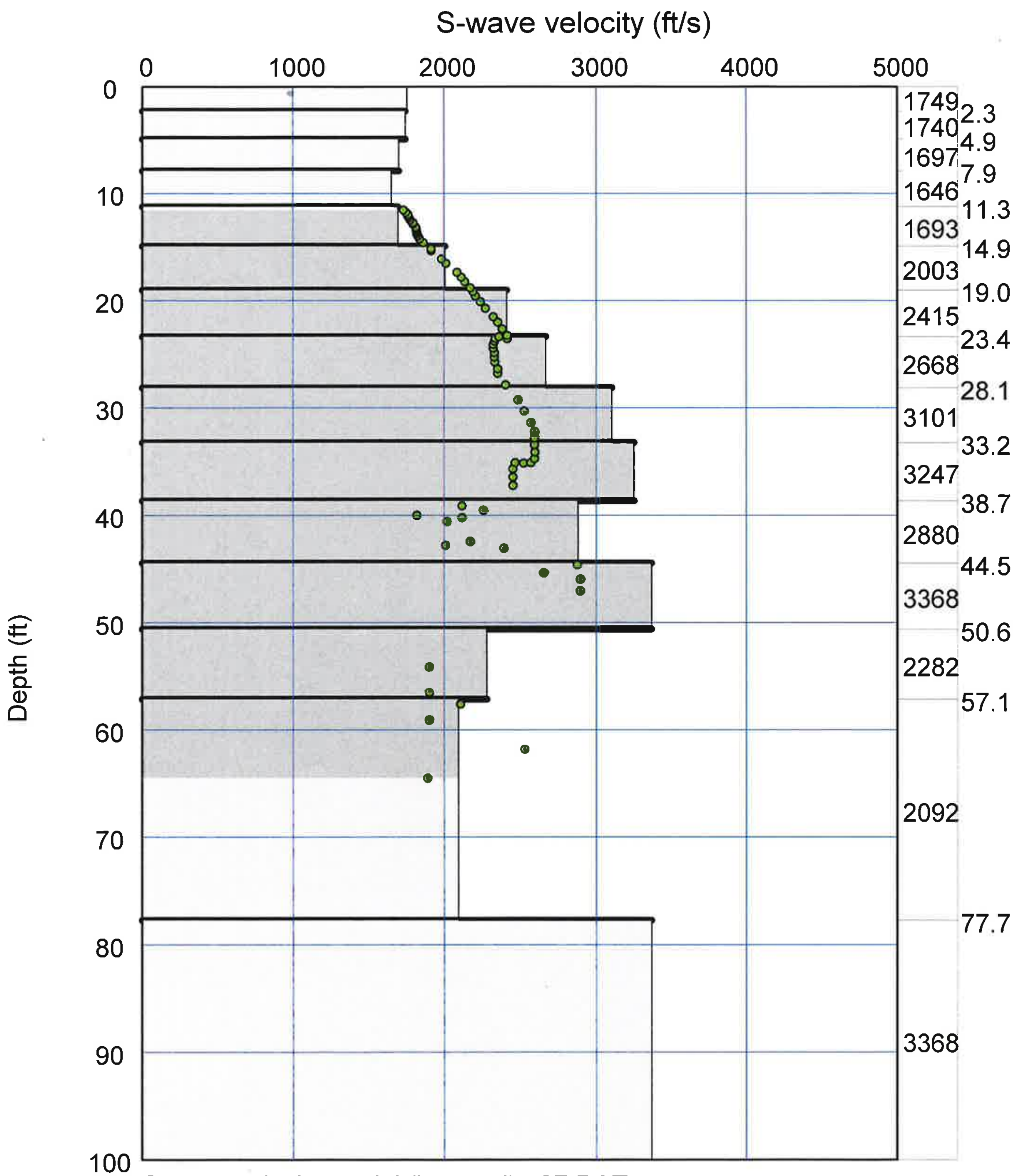
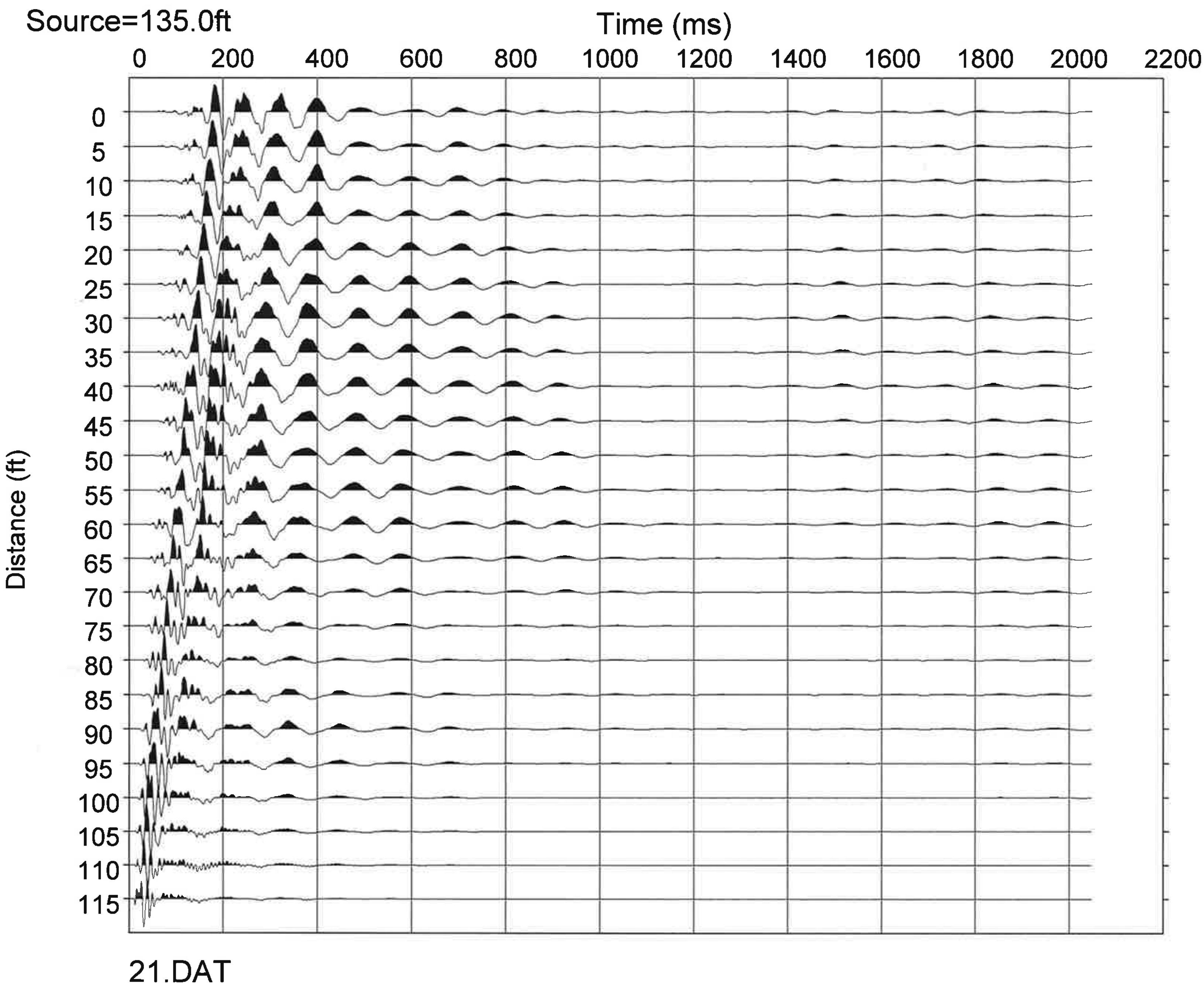


S-wave velocity model (inverted) : 37.DAT

MASW Line 3



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1800
2000
2200
Distance (ft)
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10
15
20
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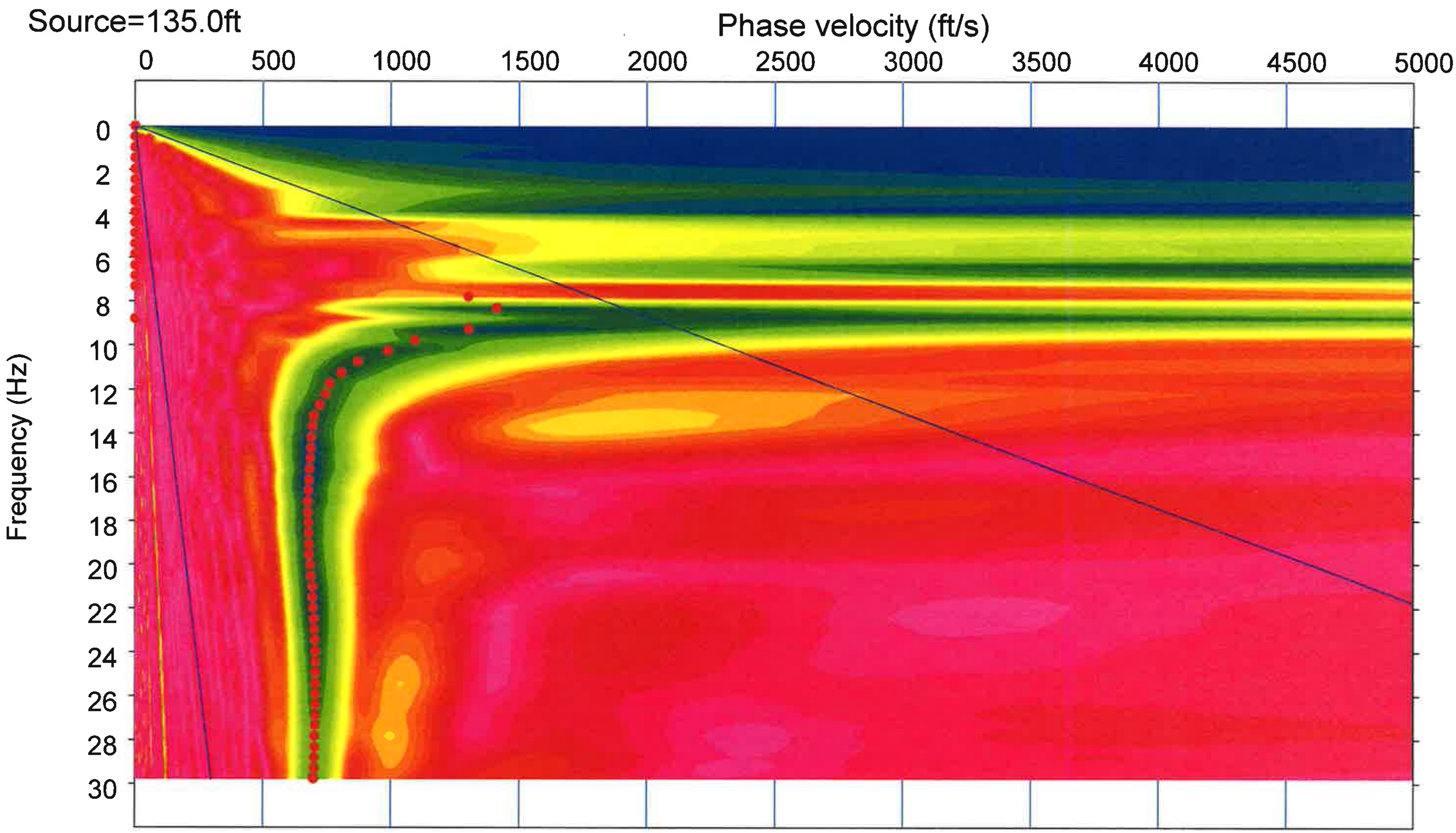
100
105
110
115
21.DAT



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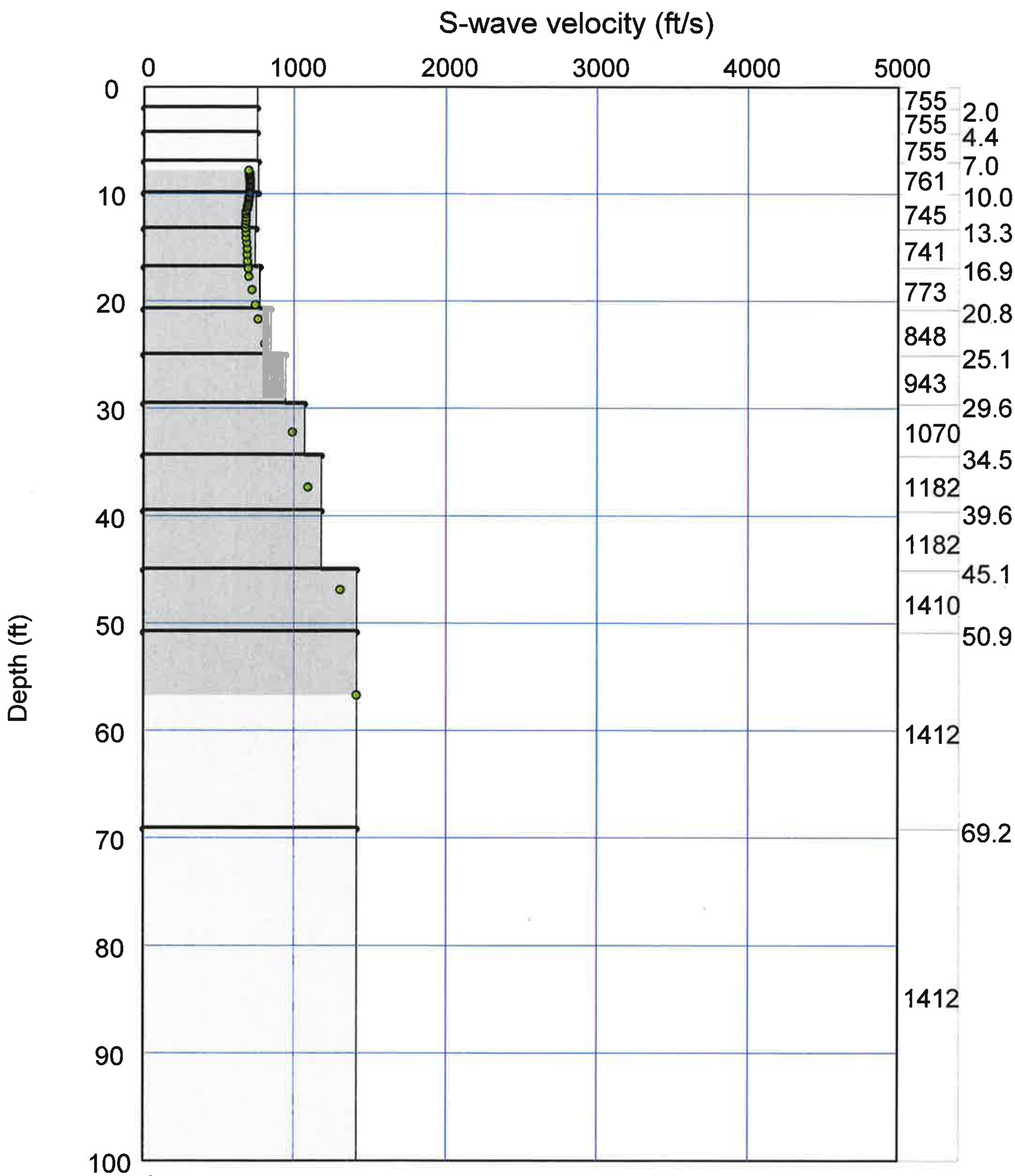

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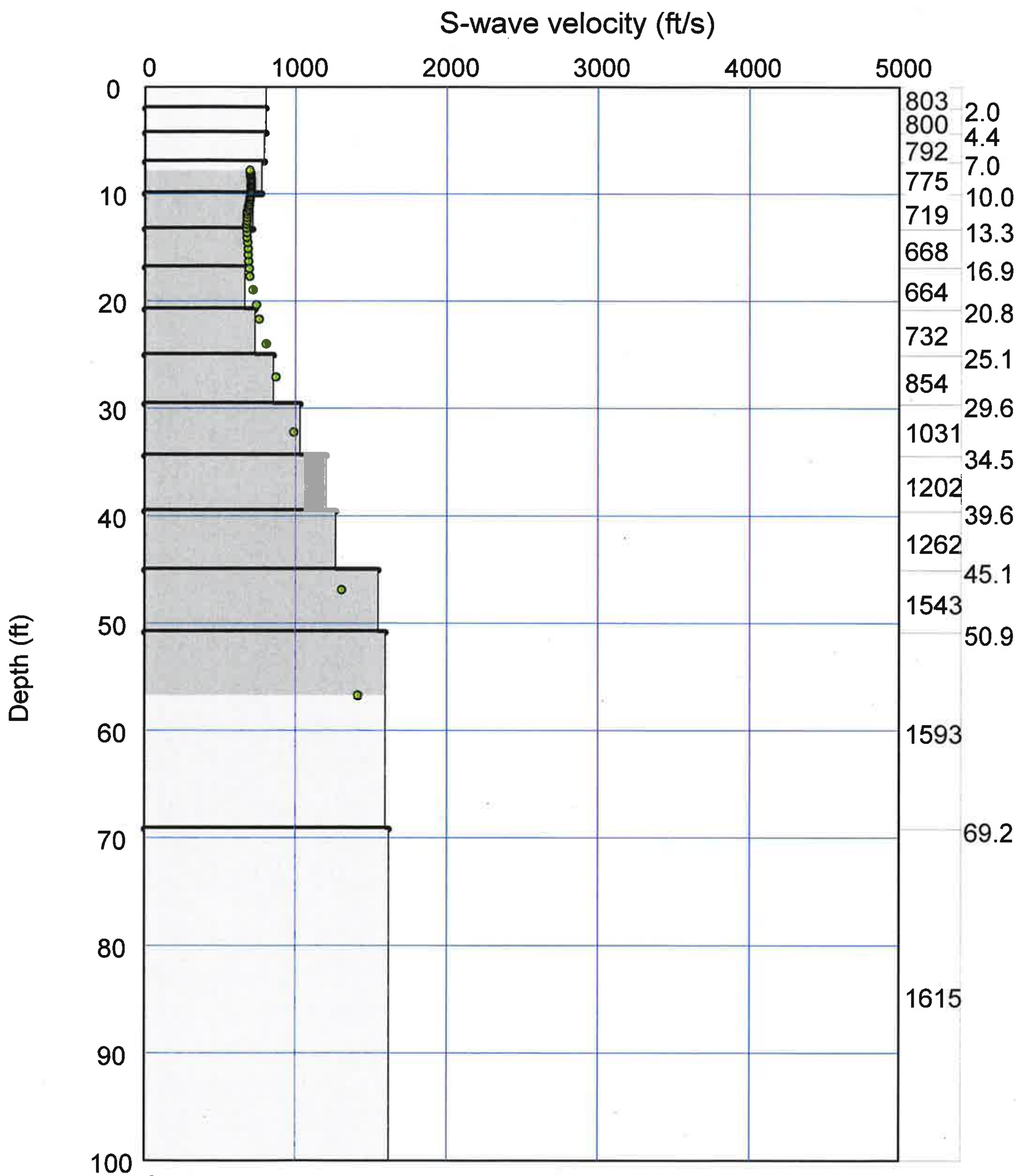
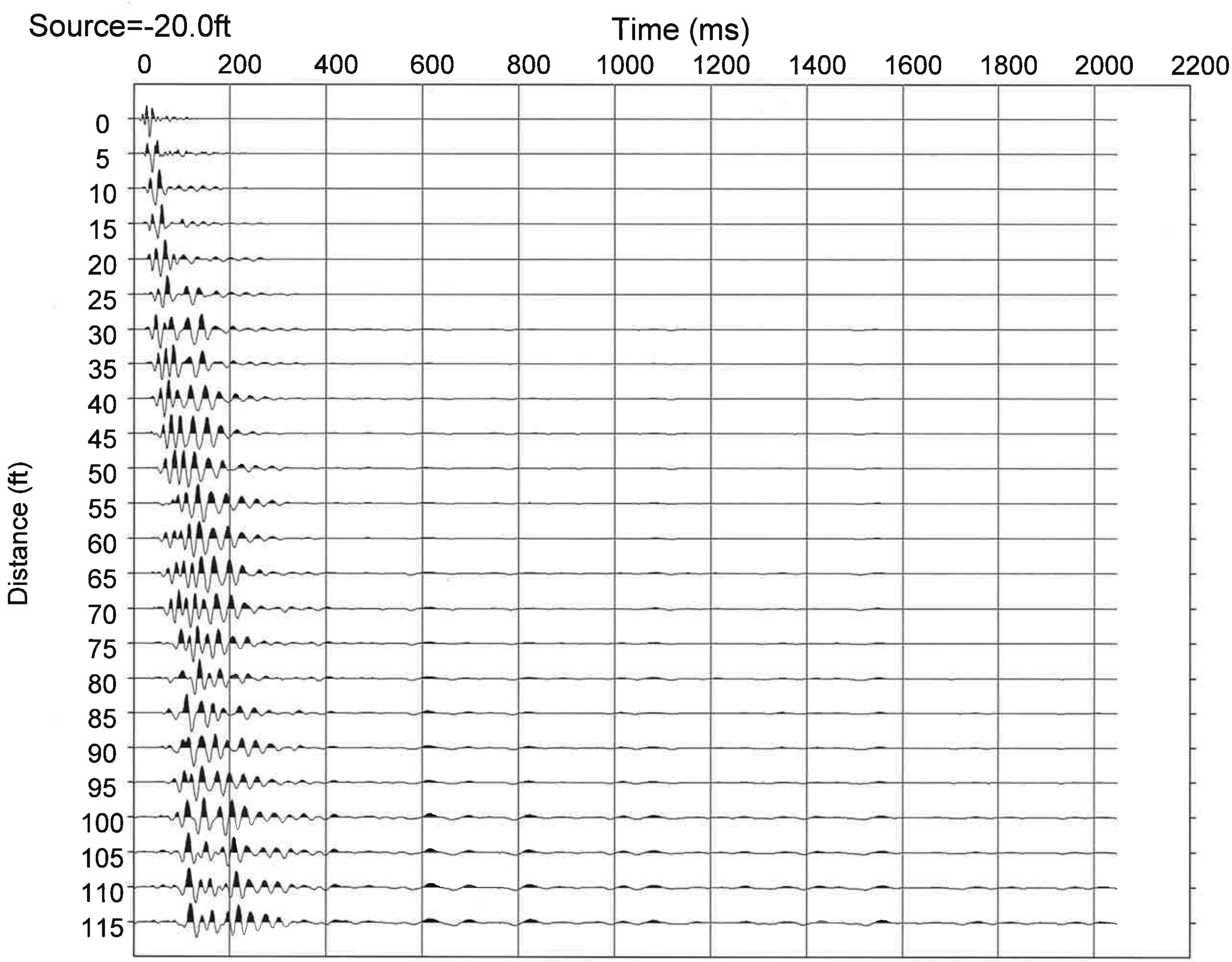


S-wave velocity model (inverted) : 21.DAT

MASW Line 4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20
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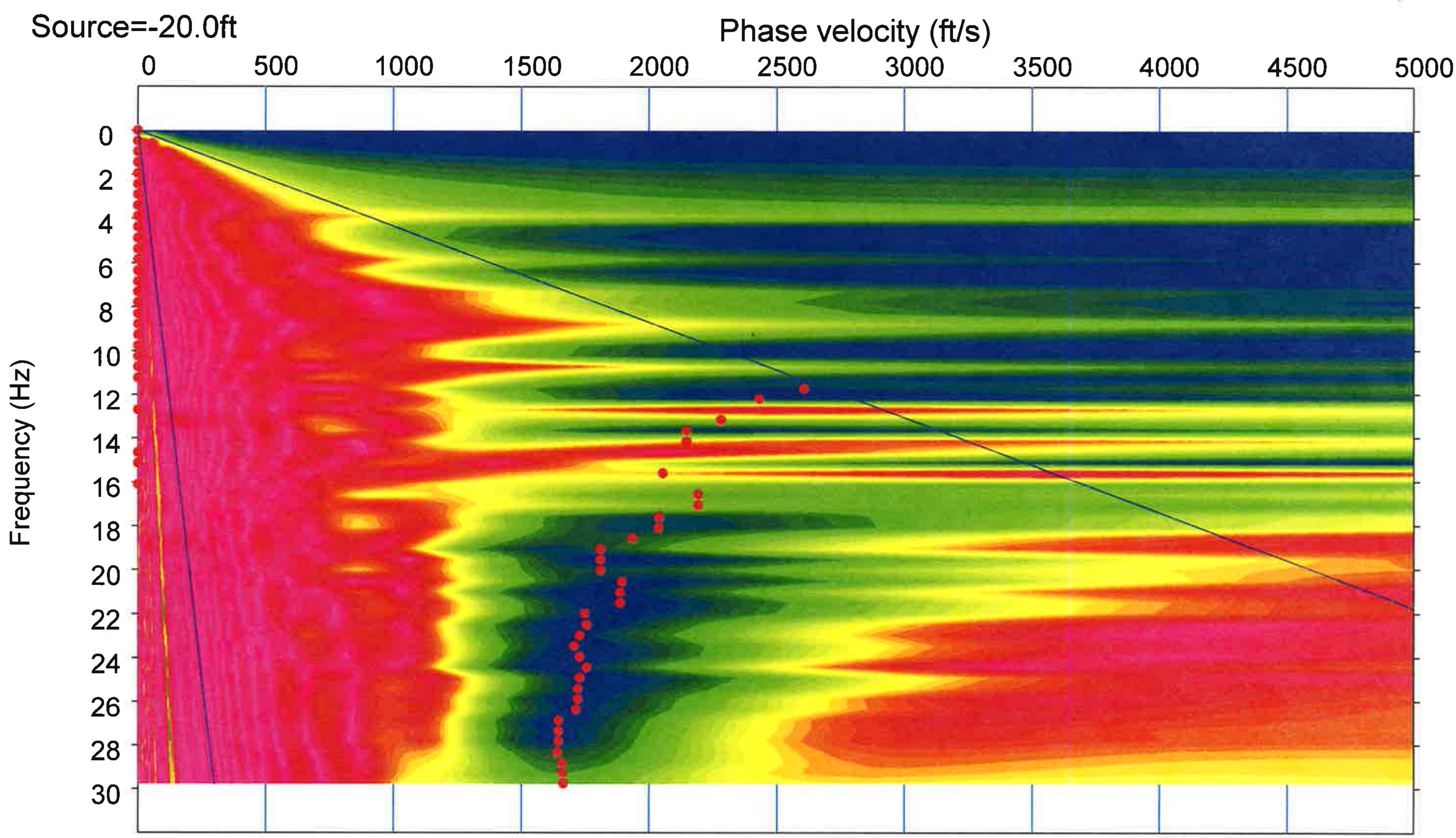
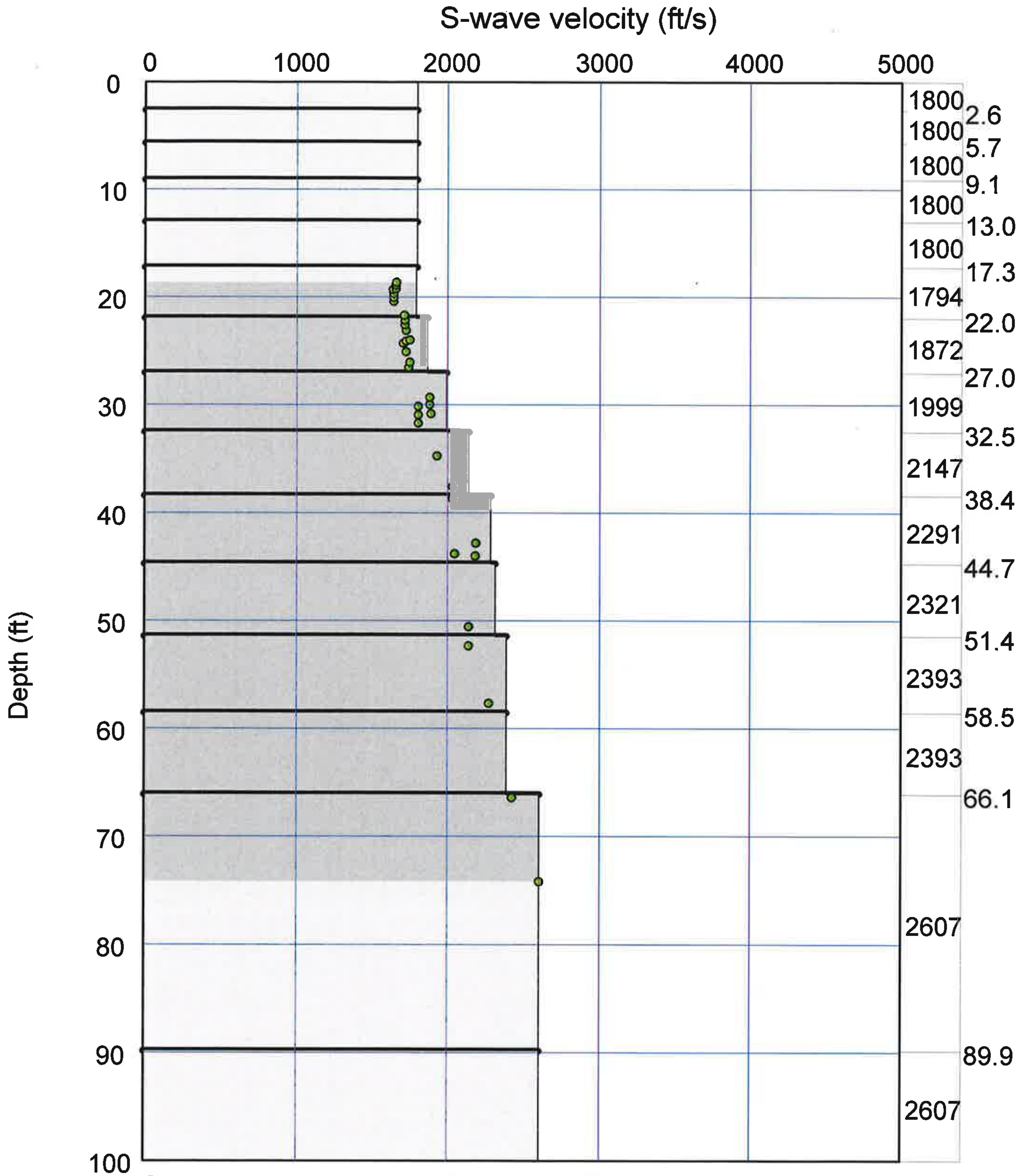
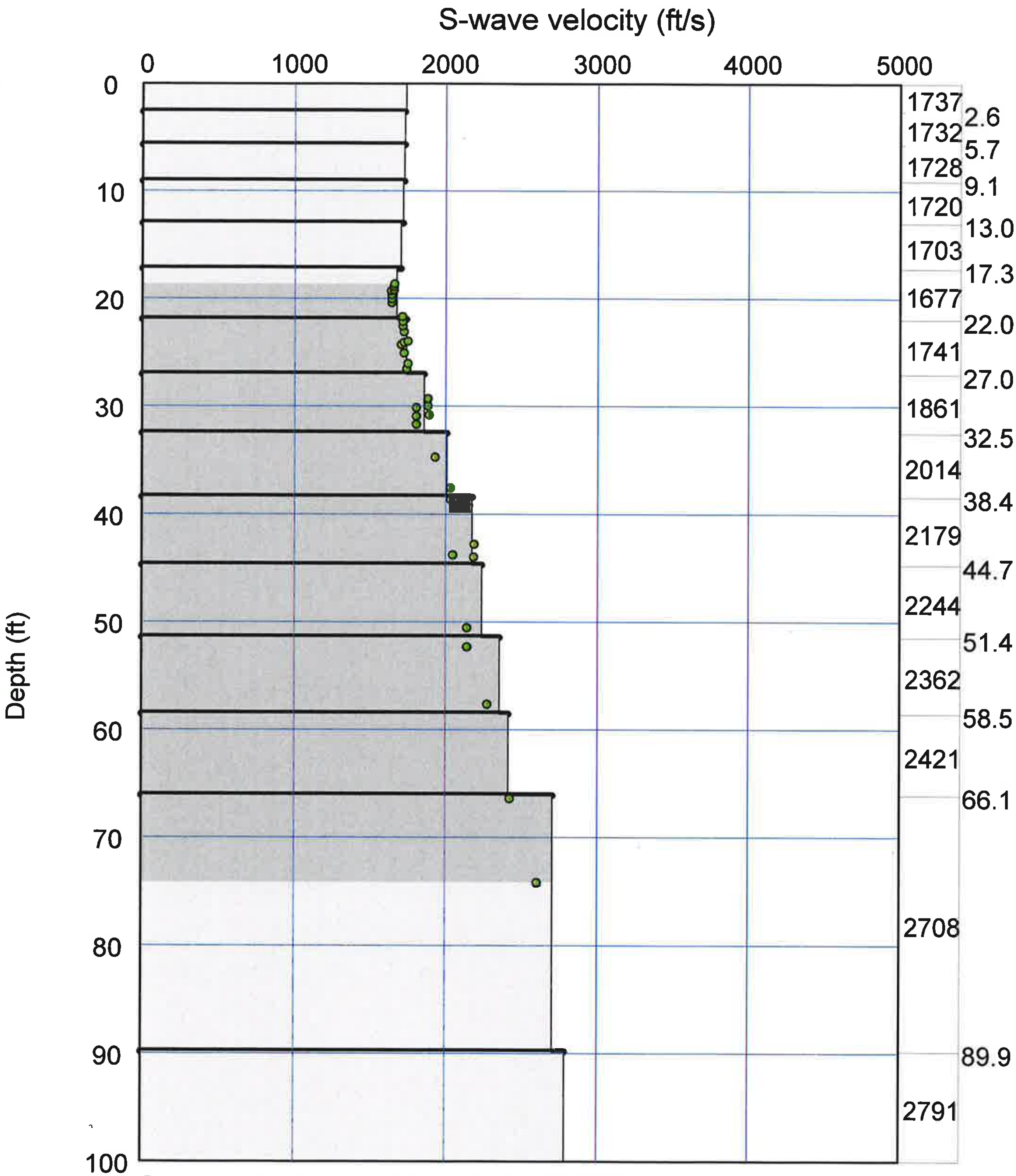
28.DAT



Dispersion curve : 28.DAT



S-wave velocity model (initial) : 28.DAT



S-wave velocity model (inverted) : 28.DAT

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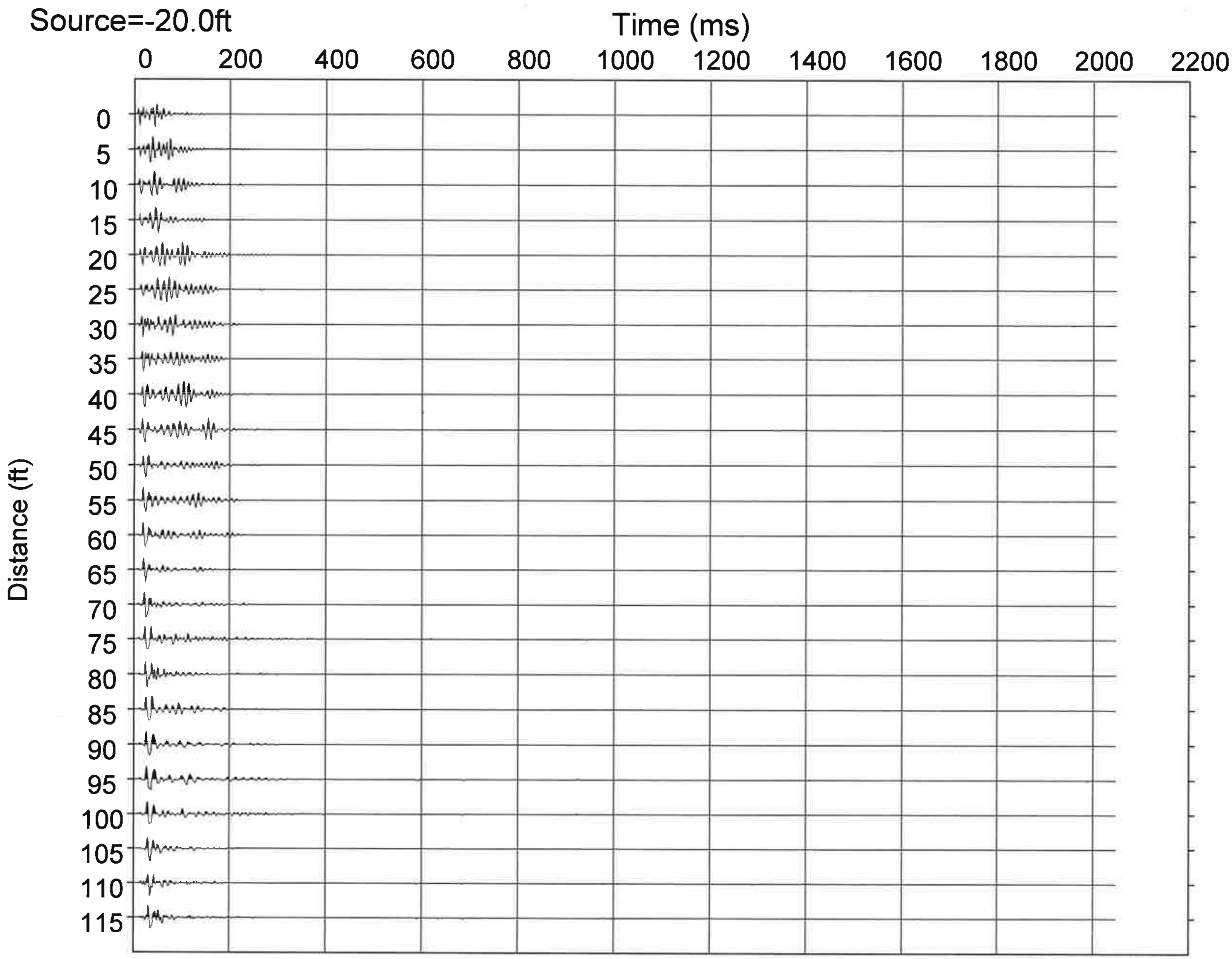
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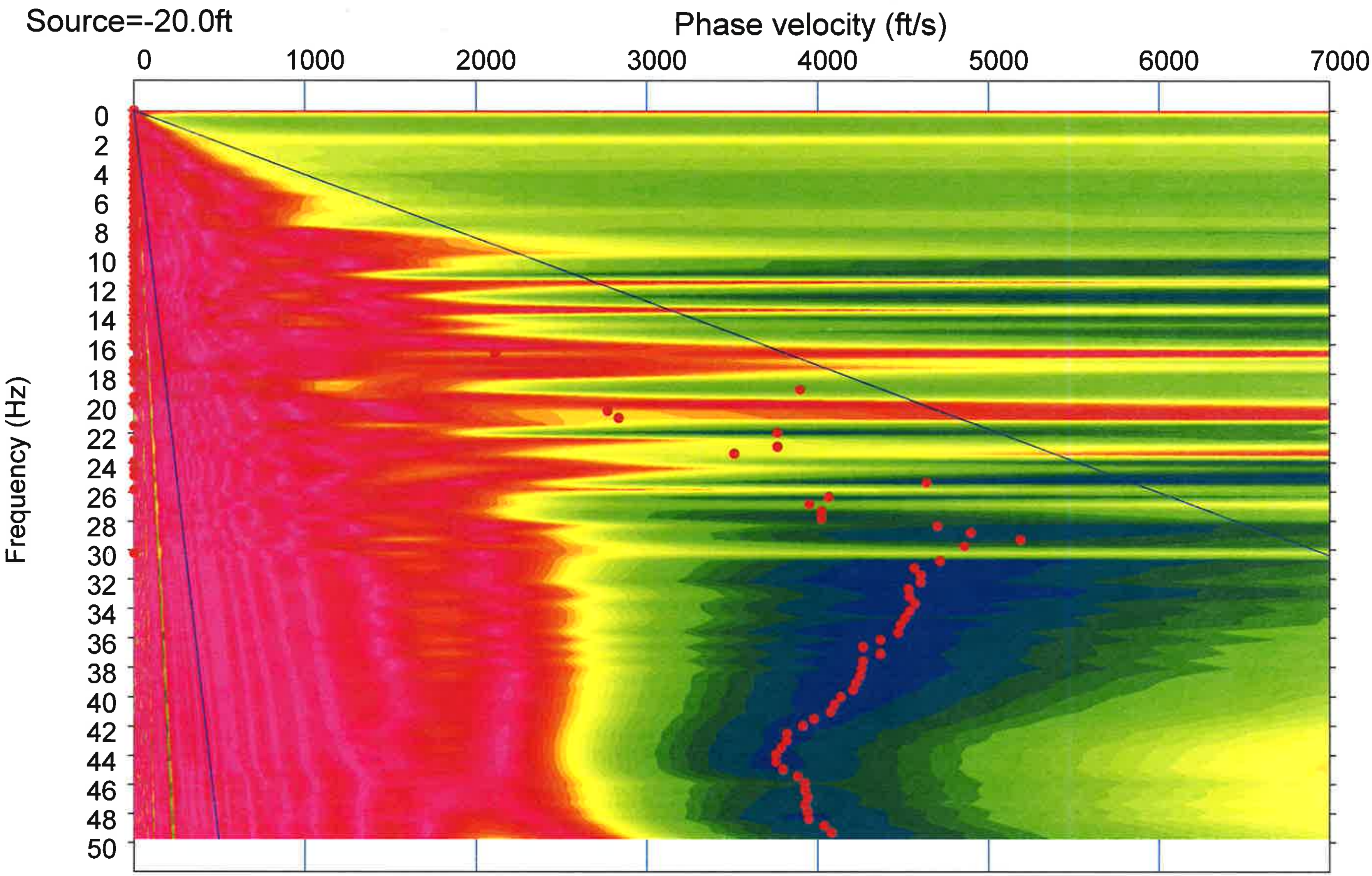
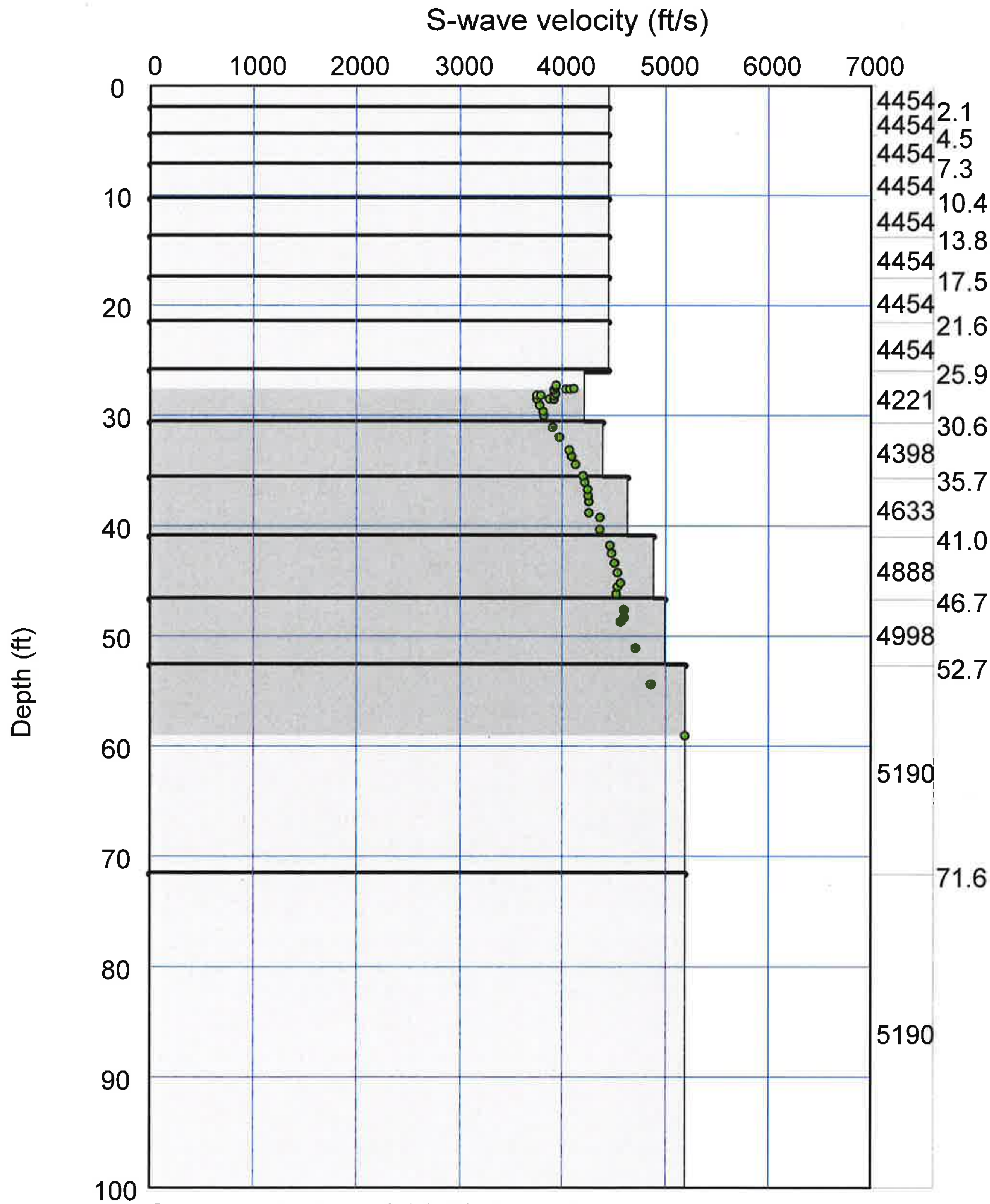
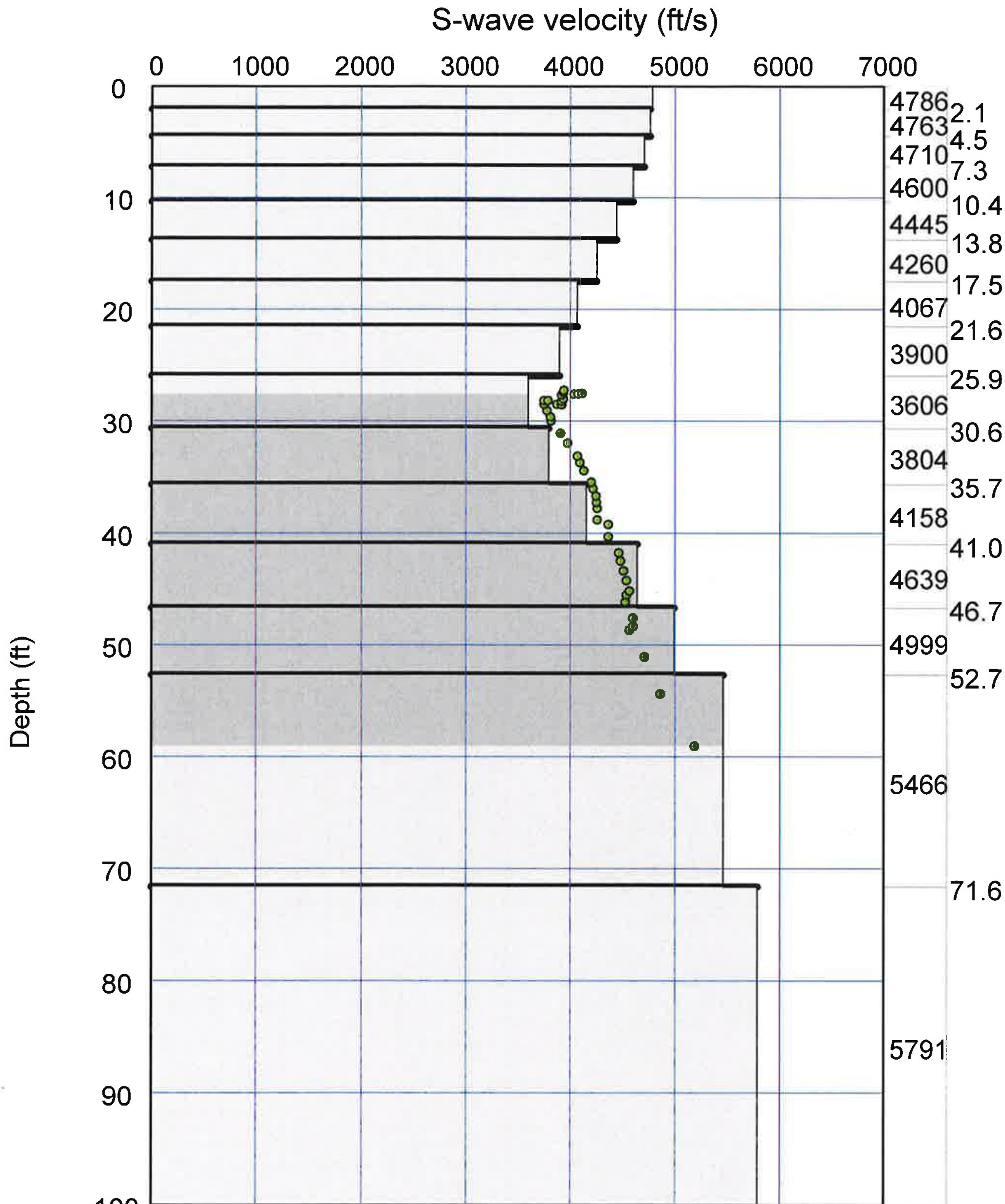
17.DAT



Dispersion curve : 17.DAT



S-wave velocity model (initial) : 17.DAT



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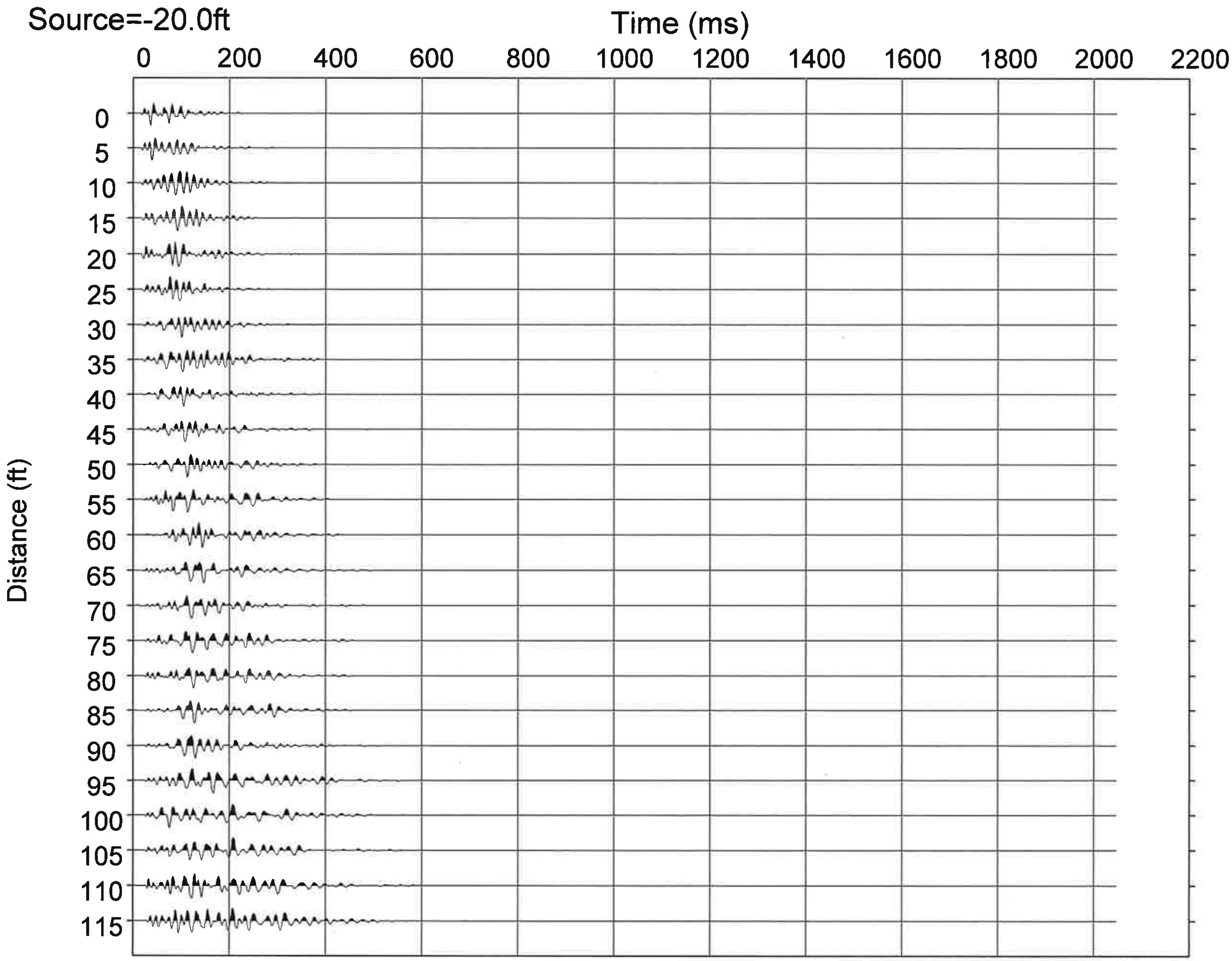
MASW Line 6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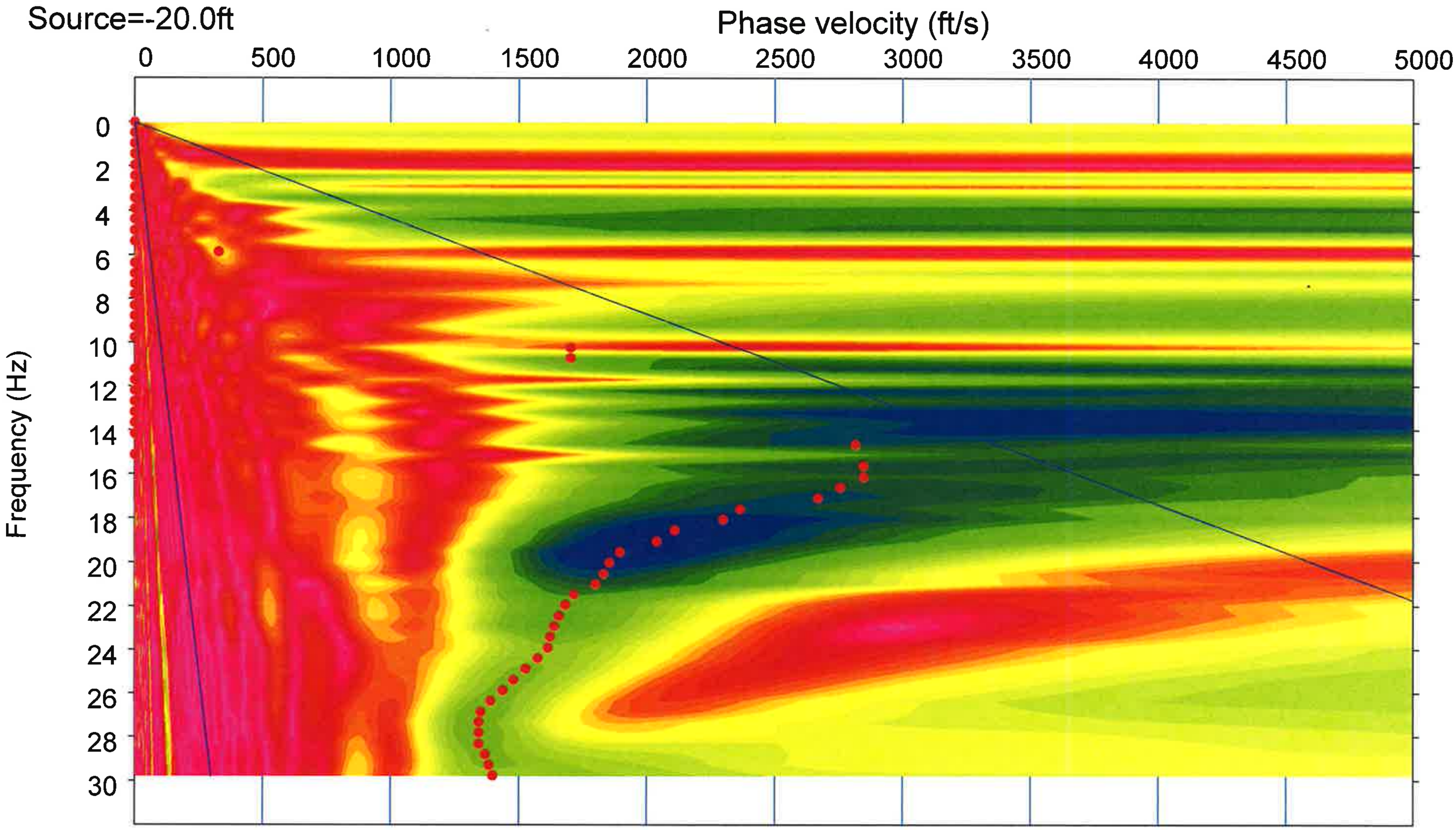

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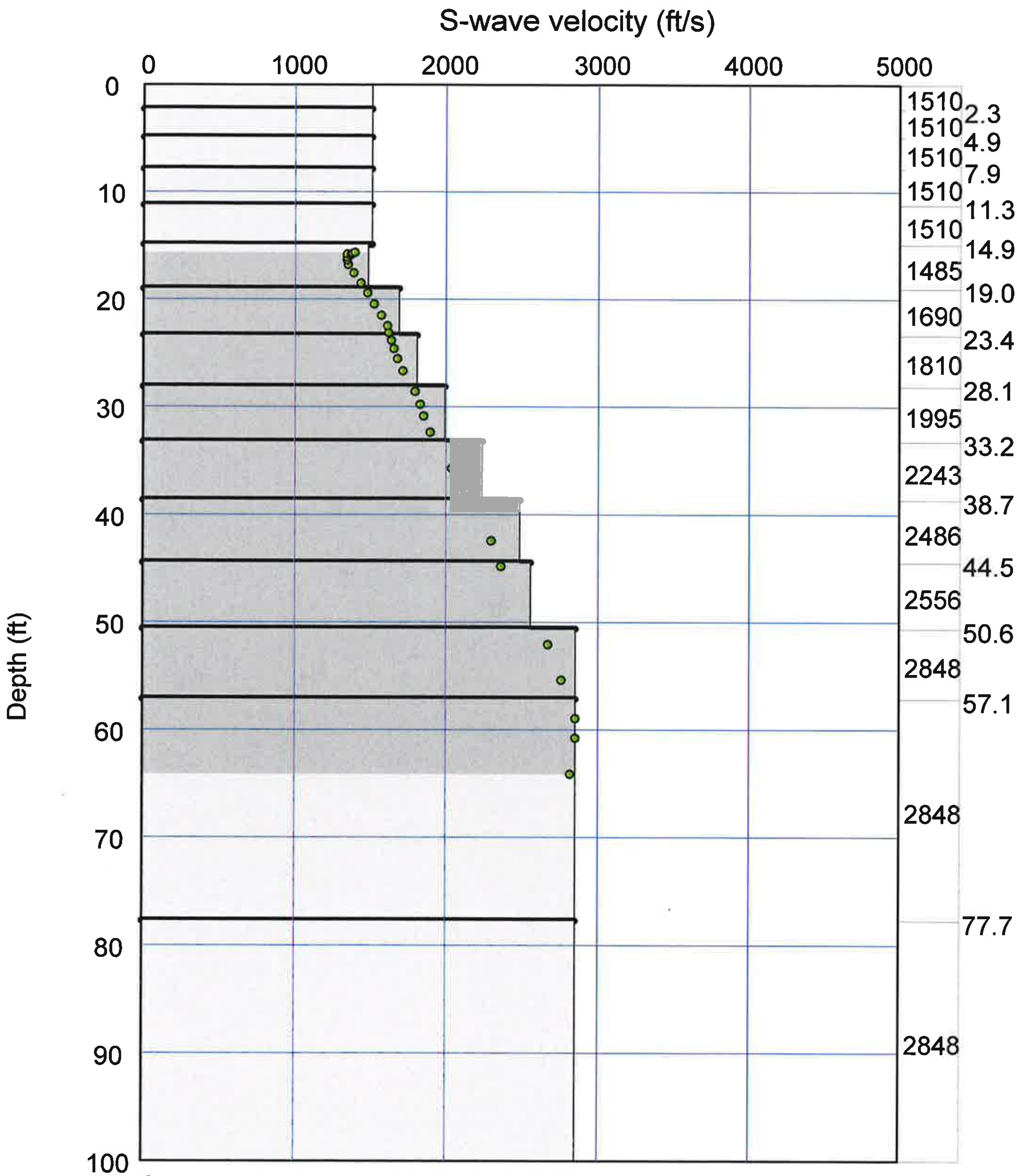

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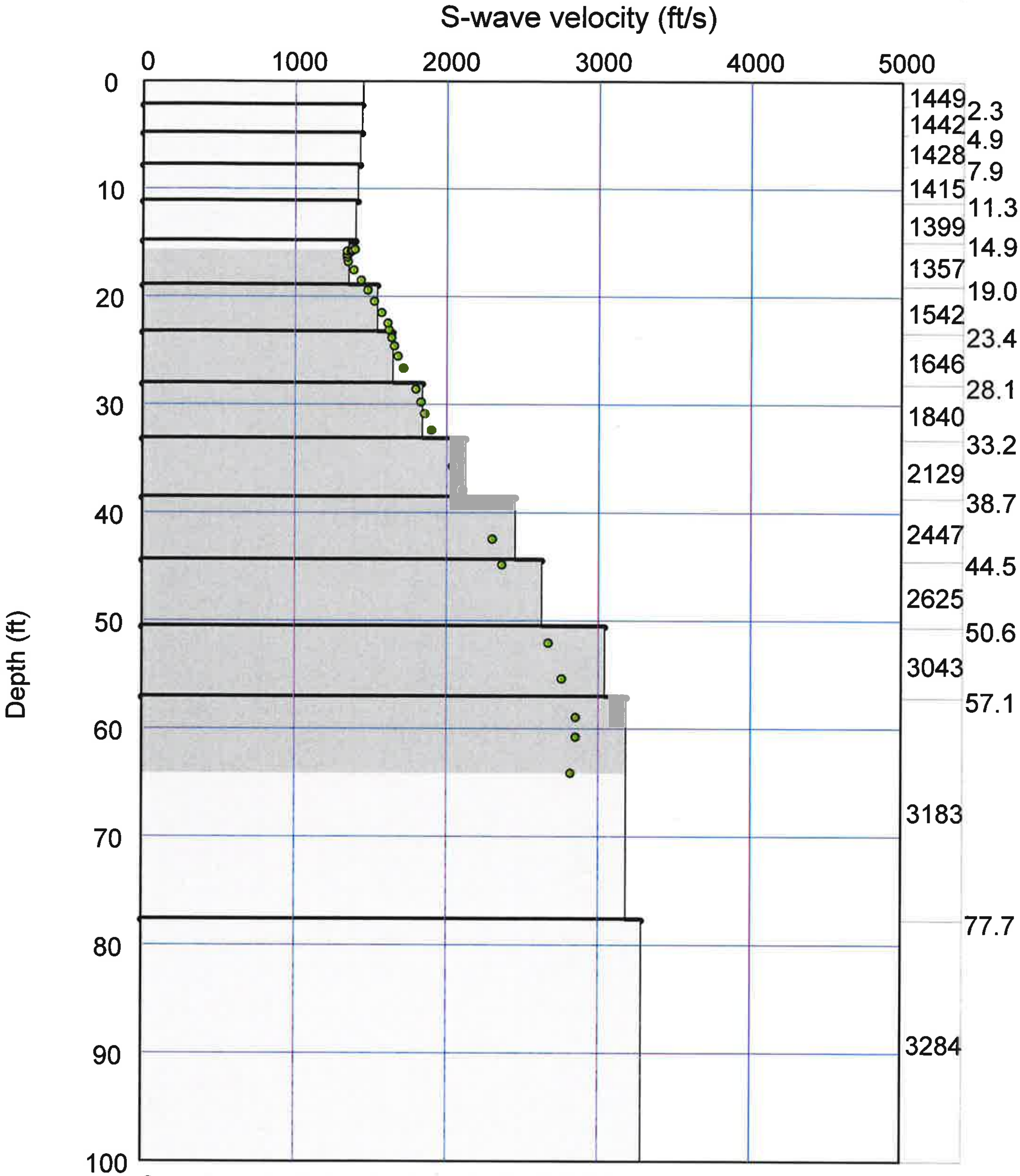

S-wave velocity model (inverted) : 6.DAT

Appendix C

Apparent Shear-Wave Velocity Geophysical Testing

Geophysical Investigation
Apparent Shear Wave Velocity Measurements
American Asphalt
Wilkes-Barre Materials Quarry
Laflin, Pennsylvania

Prepared for:

AECOM
625 West Ridge Pike
Suite E-100
Conshohocken, Pennsylvania 19428

Prepared by:

Vibra-Tech Engineers, Inc.
109 E. First Street
Hazleton, Pennsylvania 18201

August 27, 2015

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Geophysical Investigation
Apparent Shear Wave Velocity Measurements
American Asphalt
Wilkes-Barre Materials Quarry
Laflin, Pennsylvania

August 27, 2015

INTRODUCTION

Apparent Shear Wave Velocity Measurements were conducted by Vibra-Tech Engineers, Inc. at American Asphalt's Wilkes-Barre Materials Quarry, Laflin, Pennsylvania. The fieldwork was carried out on July 20, 2015.

The purpose of the investigation was to measure the apparent shear wave propagation velocity of the earth materials present at the study location. This work was authorized by Mr. John C. Volk, P.E., of AECOM.

SCOPE AND CONDITIONS OF SURVEY

The apparent shear wave velocity measurements consisted of one (1) twelve-channel acquisition array or spread located along the top of a prominent ridge that dominates the quarry's south-eastern edge. The acquisition array measured 55 feet from end to end, and spanned the broad and relatively flat top of the ridge. The north end of the spread was located approximately 50 feet away from the quarry's south highwall.

The approximate location of the apparent shear wave velocity spread is shown in the Appendix-A aerial photograph. The location of the apparent shear wave velocity spread corresponds with the location of the northern half of MASW Line 2, detailed in the MASW Study Report.

The north edge of the spread terminated at the boundary between a steep haul road to the north and woods to the south. The entire apparent shear wave velocity spread was run on a loose and unconsolidated forest cover consisting of leaves, soil, and sand. A slightly weathered bedrock was observed along the haul road shortly to the north. The bedrock consisted of a relatively hard and well-consolidated course sandstone.

This site was inherently noisy because of an operating rock crusher and haul traffic from the nearby quarry. Periods of relative quiet within this busy environment were utilized for the collection of apparent shear wave velocity measurements. This resulted in the collection of shear data of good clarity and quality.

LIMITATIONS OF GEOPHYSICAL METHODS

Geophysical methods are indirect methods of subsurface investigation subject to both natural limits and interpretational errors. Vibra-Tech Engineers, Inc. does not guarantee that the interpreted subsurface conditions will completely coincide with the geological conditions that actually exist. The methods and equipment described in this report represent standard accepted practices employed by the engineering geophysical industry. The interpretations made in this report are representative of the data on the day of the acquisition. Vibra-Tech Engineers, Inc. can not be held responsible for changes in subsurface conditions as a result of natural or man-made phenomena.

DATA ACQUISITION PROCEDURE

A twenty-four channel, Geometrics Strataview seismograph was used to record the apparent shear wave velocity measurements. The instrument was set to acquire seismic records of 256 ms in length, with a sample interval of 250 µs. No pre-acquisition filters were used on the data.

The apparent shear wave velocity investigation line consisted of a string of twelve (12) 4.5 Hz horizontal geophones positioned along the ground surface in a line radiating away and perpendicular to the alignment of the shear source. Each of the twelve (12) geophones were oriented with their axis parallel to the wooden plank and direction of shear.

The shear source consisted of an 8-foot long, 6 X 6 inch wooden plank that was coupled to the ground by loading with the front wheels of a vehicle. Horizontal waves of opposite polarity are generated by impacting the plank on opposite ends with a 14-lb sledge hammer. The offset distance from the shear source to the first geophone was five (5) feet. The travel time of the seismic energy, from the source point to each geophone, was stored in the seismograph's internal memory then transferred to disk for later analysis.

ANALYSIS AND INTERPRETATION PROCEDURE

The first step in analyzing the apparent shear wave velocity data was to pick the onset of the shear wave arrival for each shot point-geophone pair. The onset of the shear wave arrivals for the recorded data on this project was picked using Interpex Firstpix software that enabled the enhancement of each individual seismic trace. Seismograms 1 and 2 in Appendix-B present a seismogram of the apparent shear wave velocity data. The onset of the shear wave arrival is marked with a computer generated tick mark.

The criteria utilized in the identification of the onset of the arrival of the shear wave involved a sudden increase in amplitude and period change, coupled with a 180 degree polarity change of the waveform in response to the reversal in the polarity of the seismic source.

The following table lists the shear wave arrival times picked, for each shot point-geophone pair. Channels 1 - 12 represent a right impact of the shear source, while Channels 13-24 represent a left impact.

Geophone #	Shot Point - Geophone Pair	Distance from Source (feet)	Arrival Time of Shear Wave (milliseconds)
1	1 & 24	5	6.32
2	2 & 23	10	10.70
3	3 & 22	15	11.22
4	4 & 21	20	13.20
5	5 & 20	25	13.26
6	6 & 19	30	14.54
7	7 & 18	35	15.56
8	8 & 17	40	17.45
9	9 & 16	45	18.21
10	10 & 15	50	19.43
11	11 & 14	55	19.84
12	12 & 13	60	20.72

The above information was used to construct a graph plotting Arrival Time (milliseconds) vs. Traverse Distance (feet). The Time/Distance plot is presented in Appendix-B of this report, following the seismograms. A best fit line was generated through the plotted points. The slope of this best fit line represents the measured apparent shear wave velocity of the earth materials sampled. The presence of two (2) layers were interpreted on the Time/Distance plot:

LAYER 1

Layer 1 represents direct arrivals of the shear wave, captured by geophones # 1 & 2. The best fit line through these points, including the shear source at Time 0 (T0), measured at 935 feet/second. Layer 1 is interpreted as unconsolidated overburden material and highly weathered bedrock.

LAYER 2

Layer 2 represents refracted arrivals of the shear wave, captured by geophones # 2 through 12. The best fit line through these points yielded an apparent shear wave velocity of 4,737 feet/second. Layer 2 is interpreted as unweathered bedrock.

CONCLUSION

Apparent Shear Wave Velocity Measurements were conducted by Vibra-Tech Engineers, Inc. at American Asphalt's Wilkes-Barre Materials Quarry, Laflin, Pennsylvania. Survey results indicate the presence of two velocity layers at the sampled location:

Layer 1 yielded an apparent shear wave velocity of 935 ft/sec. This material is interpreted as a thin cover (estimated at 5 ft. thick) of unconsolidated overburden material and highly weathered bedrock.

Layer 2 yielded an apparent shear wave velocity of 4,737 ft/sec. This material is interpreted as unweathered bedrock.

Respectfully submitted,
Vibra-Tech Engineers, Inc.

Ryan Jubran
Geological Technician

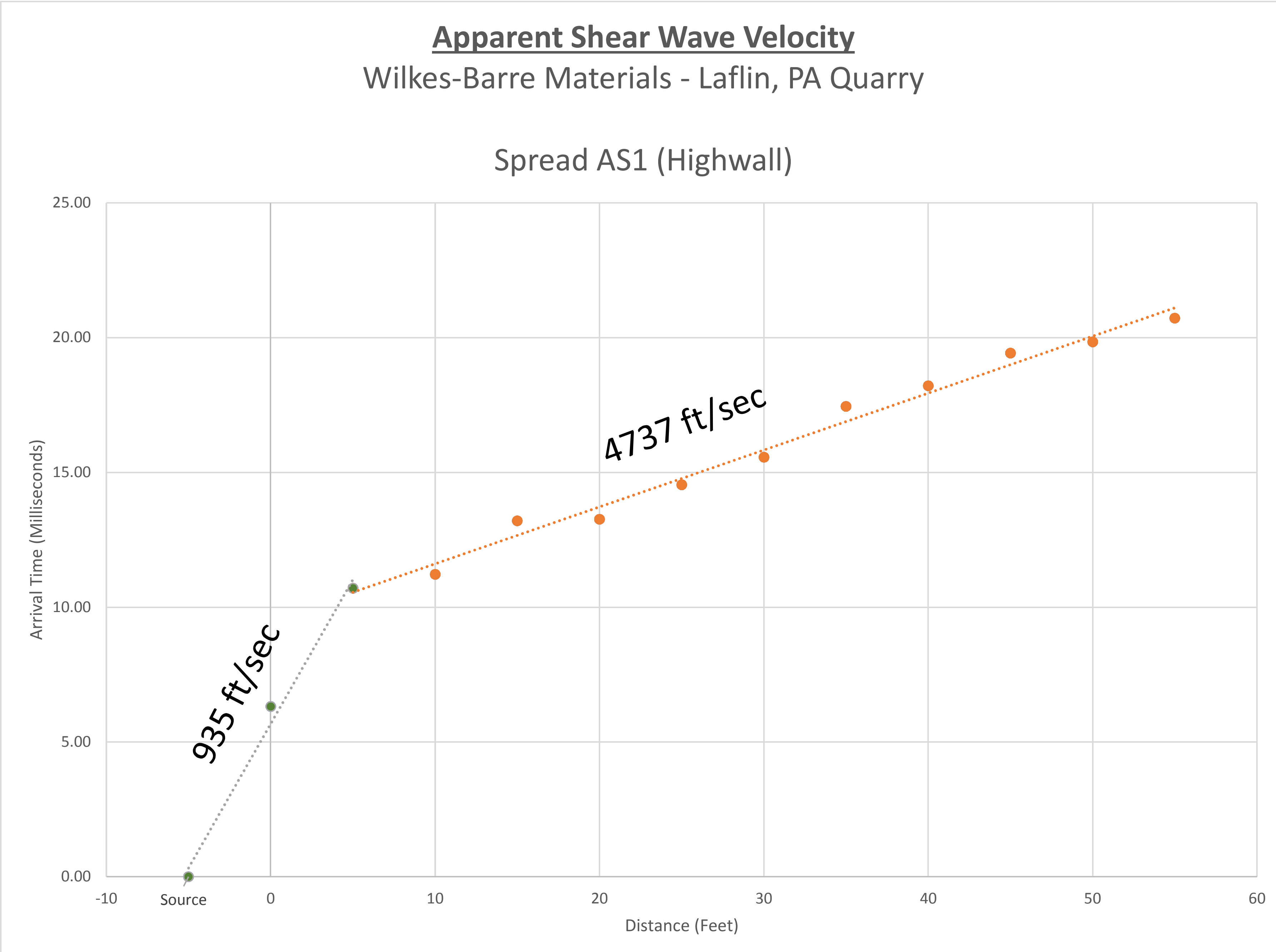
Stephen Muñoz, PG
Project Geologist

Douglas Rudenko, PG
Vice President

APPENDIX A


APPARENT SHEAR WAVE VELOCITY
Ridgewood Rd
406 ft
1992
© 2015 Google
Google earth
Imagery Date: 5/10/2014 41° 16.737' N 75° 48.335' W elev 815 ft eye alt 2575 ft

APPENDIX B


Apparent Shear Wave Velocity
Wilkes-Barre Materials - Laflin, PA Quarry
Spread AS1 (Highwall)
Arrival Time (Milliseconds)
Distance (Feet)
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15.00
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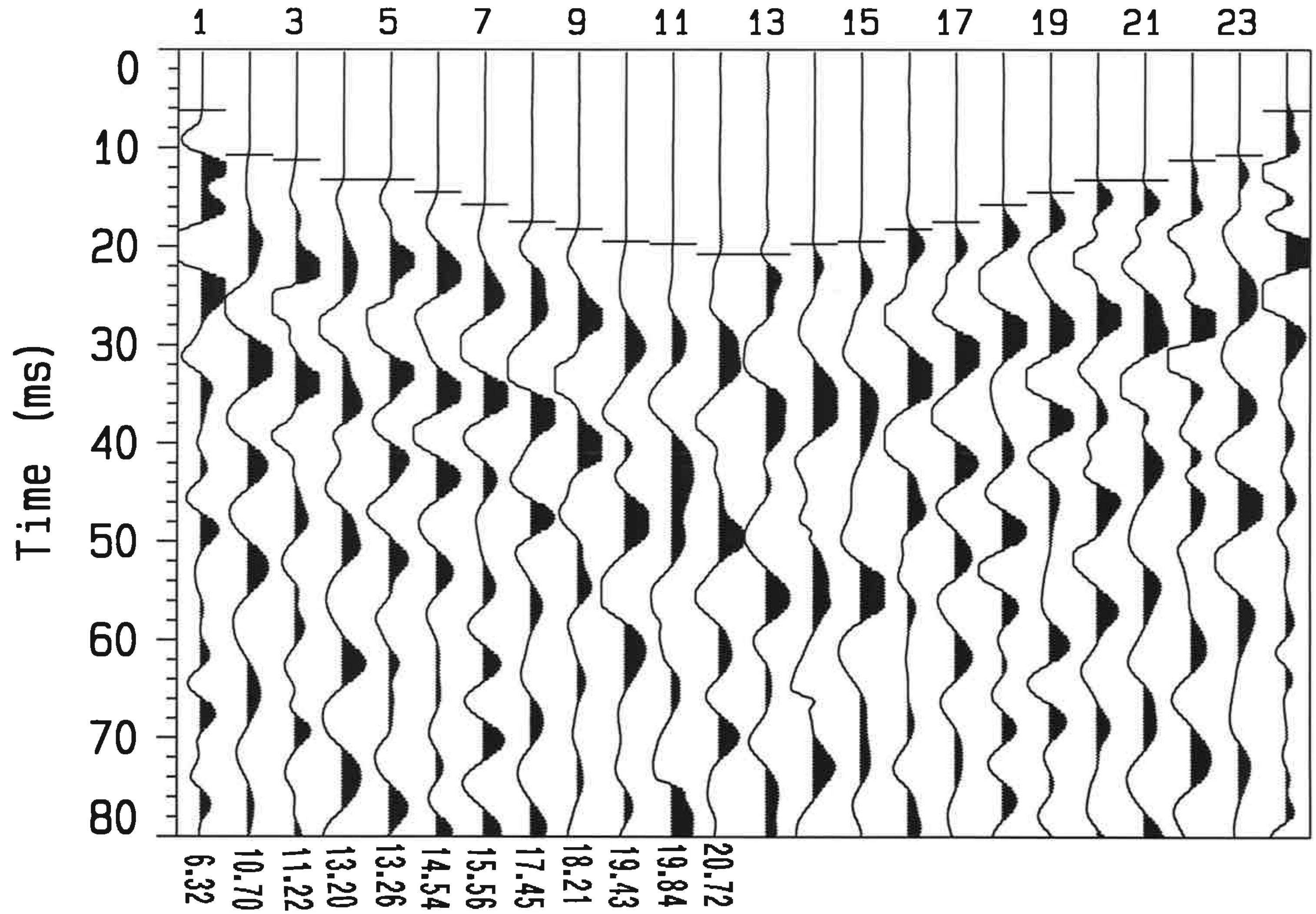
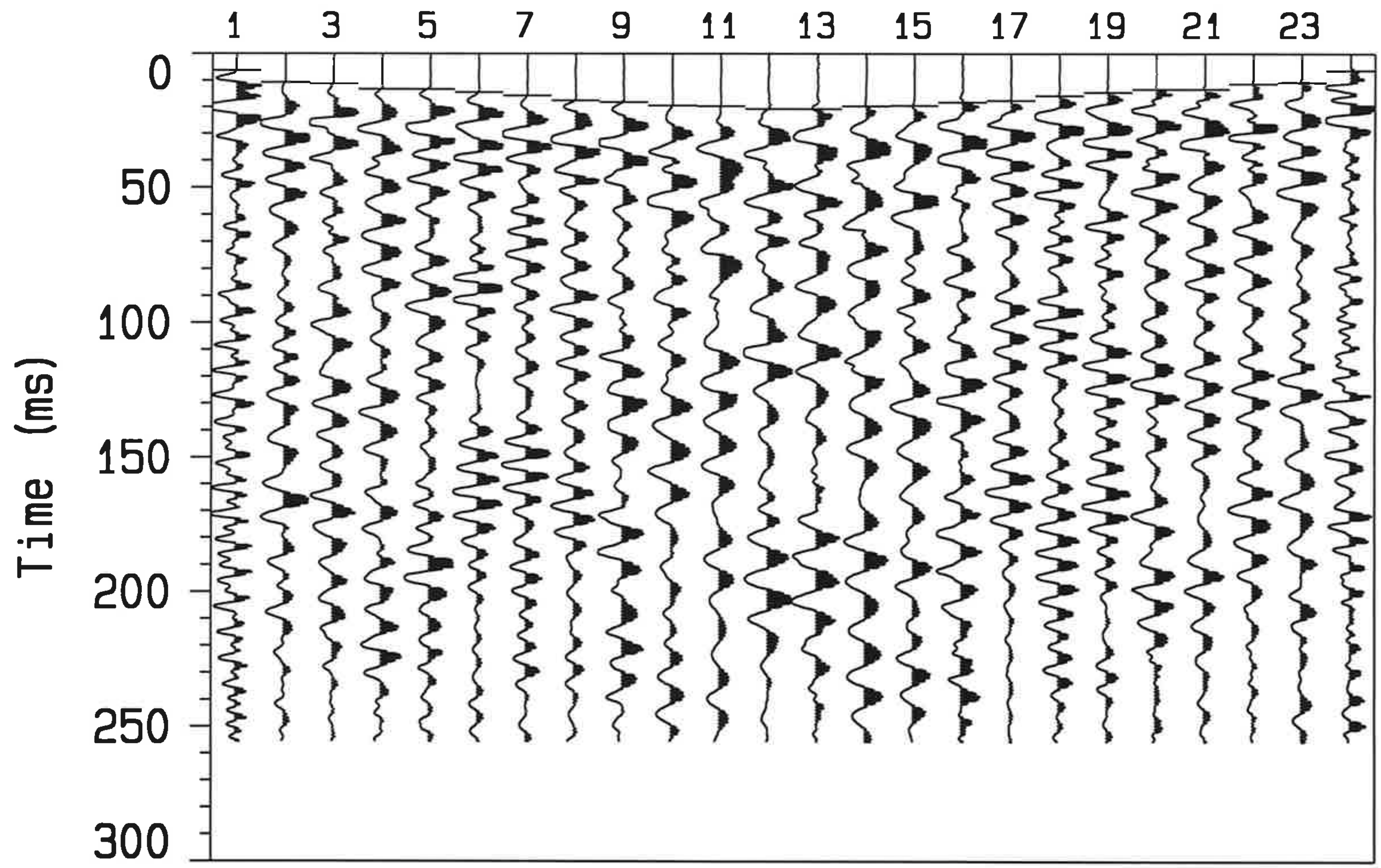


AECOM		WILKES BARRE MATERIALS
VIBRA-TECH ENGINEERS INC.		HIGHWALL LUZERNE COUNTY, PA
Spread: AS1	Date: 7-17-2015	
Equip: Strataview	Location: -5	Record ID: 0 / Azimuth:



AECOM		WILKES BARRE MATERIALS	
VIBRA-TECH ENGINEERS INC.		HIGHWALL LUZERNE COUNTY, PA	
Spread: AS1	Date: 7-17-2015		
Equip: Strataview	Location: -5	Record ID: 0	Azimuth:

Attachment 14

Requirements for Construction near the PennEast Pipeline

PennEast Pipeline Project
Requirements for Construction Near the PennEast Pipeline

Issue and Revision Record

Rev	Date	Originator	Checker	Approver	Description
A	12-10-2015	D. Hartman	A. Young	M. Wilcox	Issued for Information
B					
C					
0					

Table of Contents

1 Purpose

1.1 This guideline presents the requirements for construction in the vicinity of PennEast's Natural gas system. These requirements are general in nature whereby specific circumstances may necessitate special considerations. Refer to OSHA's excavation standards outlined in 29 CFR 1926, and MSHA requirements outlined in 30 CFR 1-199 for additional provisions. The following areas are addressed in this document:

a. Purpose

b. PennEast Notifications

c. General Requirements

d. Excavation and Blasting

e. Foreign Line Crossings

1.2 If any of the conditions stated in this document cannot be satisfied, the Superintendent of Special Projects - Process Division shall be advised immediately.

2 PennEast Notifications

2.1 PennEast considers it essential that contractors know the location and depth of their pipeline and requires that all underground facilities be shown on the contractor's construction plans.

2.2 Copies of any proposed plans or drawings for road crossings within 25 feet of pipeline facilities shall be submitted to PennEast for review at least 30 days prior to the commencement of work.

2.3 PennEast shall be given at least three (3) working days advance notice prior to the actual commencement of any work or excavation over or near its pipeline so that they may locate the pipeline and have a PennEast representative present during excavation or construction activities. Mechanized equipment shall NOT be authorized within 50 feet of any pipeline facility until the pipeline section has been located and marked out by a PennEast representative.

2.4 PennEast will field locate and stake its pipeline. A Superintendent of Special Projects - Process Division must be present during the excavation to expose the pipeline.

2.5 The PennEast representative shall check the nearby permanent line markers at the site of the proposed construction, to ensure that they are properly maintained and that the identification sign is correct and clearly visible. The cost to replace and reinstall any markers disturbed or damaged during the excavation activities shall be the responsibility of the contractor.

2.6 Any PennEast or Contractor personnel engaged in trenching activities are required to undergo training in all sections of the PennEast Safety Procedure SPP# 1926.650 Excavation, Trenching, and Shoring. Training of contractors in all sections of the procedure is the sole responsibility of the contractor. The contractor must provide proof of training of all employees to the respective PennEast Representative engaged in these activities during the planning stage of the project.

2.7 In addition to complying with the above requirements, contractors shall comply with the provisions of all state and/or local regulations relating to excavation and demolition work in the vicinity of underground facilities.

3 General Requirements

3.1 At no time are Contractors allowed to move or alter PennEast's pipe or fittings, or in any other way interfere with the pipe without the written consent of PennEast, and then only if the work is done under direct supervision of the PennEast Superintendent of Special Projects - Process Division.

3.2 PennEast has the authority to stop work at any time if it is suspected that the work is unsafe. If, in the judgment of PennEast, the excavator's activities threaten the safety and integrity of the pipeline, PennEast shall take whatever reasonable actions are necessary to protect the pipeline.Excavations and trenches will be inspected by the PennEast Superintendent of Special Projects - Process Division, PennEast Safety and Health Representative, and Contractor Representative, prior to the start of work and may be monitored while employees are working within the excavations and trenches. The PennEast Superintendent of Special Projects - Process Division, and/or a PennEast Safety and Health Representative will conduct an inspection whenever a hazard-increasing event (such as a rainstorm) occurs.

3.3 Superintendent of Special Projects - Process Division shall give prior approval for heavy equipment to cross PennEast's pipeline at any location. Minimum cover and other requirements will be determined by PennEast on an individual basis.

3.4 A warning system such as barricades, hand or mechanical signals or stop logs will be used when mobile equipment is operated near the edge of an excavation and the operator does not have a clear and direct view of the edge.

3.5 Air quality tests will be performed before employees enter any excavation where a hazardous atmosphere exists or could reasonably be expected to exist.

3.6 No buildings, structures or other obstructions may be erected above or below the pipeline, or within 25 feet of the centerline.

3.7 Wire type, stockade, decorative and similar type fencing that can be easily removed and replaced may cross the pipeline alignment at or near right angles.

3.8 Planting of trees is not permitted within 25 feet of the pipe centerline.

3.9 Planting of shrubs, bushes or other plants associated with landscaping within 25 feet of the pipe centerline is subject to PennEast approval and shall not exceed 4 feet in height.

3.10 No drainage swales and no reductions in grade are permitted within 25 feet of the pipeline. Limited additional fill may be deposited with prior written approval from PennEast. Parking areas should be planned so as to avoid covering the pipeline if possible.

3.11 No roads, foreign lines, or utilities may be installed parallel to the pipeline within 25 feet of the centerline.

3.12 All foreign lines, roads, electrical cables and other utilities that are located within 25 feet of the pipeline shall cross the pipeline at or near right angles, if practical.

3.13 All surface encumbrances, such as trees, boulders, adjacent structures, utility poles, large equipment, etc. that are located so as to create a hazard to employees will be removed or supported as necessary to safeguard employees and or contractors against cave-ins. As a minimum, excavations must be flagged and barricaded to prevent mobile equipment or personnel from falling into the excavation. If left unattended overnight, barricades with amber flashing lights must be placed around the perimeter.

4 Excavation and Blasting

4.1 Excavation operations shall be performed in accordance with the guidelines set forth below.

4.1.1 Excavation shall mean any operation for the purpose of movement or removal of earth, rock, pavement, or other materials in or on the ground, or otherwise disturbing the subsurface of the earth, by use of powered or mechanized equipment or by blasting, including but not limited to digging, auguring, backfilling, boring, drilling, grading, plowing in, pulling in, fencepost or pile driving, tree root removal, saw cutting, jack hammering, trenching, and tunneling, excluding vacuum excavation and saw cutting and jack hammering in connection with pavement restoration of a previous excavation where only the pavement is involved.

4.1.2 When a contractor excavates near PennEast pipelines, the Superintendent of Special Projects - Process Division shall be on site at all times to locate the pipeline(s), to determine the depth of cover before and during the excavation (see Sections 2.3 and 2.4) and to witness the excavation and backfilling operations. The contractor shall not perform any excavation, crossing, backfilling or construction operations unless the Superintendent of Special Projects - Process Division is on site.

4.1.3 The location of utility and other mining installations that may be encountered during excavation work will be determined prior to opening an excavation. If underground installations are uncovered, they will be properly supported to protect employees.

4.2 Excavation by a backhoe or other mechanical equipment shall not be permitted within 25 feet of the pipe centerline until an excavation plan has been reviewed and approved by the Superintendent of Special Projects - Process Division. The excavation plan may be a written document produced by the contractor or a verbal discussion between the contractor and the Superintendent of Special Projects - Process Division. At a minimum, the excavation plan shall include but not be limited to the following:

- Backhoe set-up position in relationship to the pipeline
- Need for benching to level backhoe
- Required excavation depth and length
- Sloping and shoring requirements
- Ingress/egress ramp locations
- Minimum clearance requirements for mechanical equipment
- Verify bar has been welded onto backhoe bucket teeth and side cutters have been removed
- Pipeline location and depth
- Spoil pile location
- Compliance with OSHA and MSHA regulations

4.2.1 **All operating excavation equipment shall be directed by a qualified competent person who is positioned to see the relative location of the pipeline facilities and placement of the digging component (e.g., backhoe bucket).**

4.2.2 For excavations adjacent to existing live pipeline facilities, the backhoe bucket teeth shall be barred and the side cutters removed. In the event that conditions require the removal of the bar or the use of the side cutters, approval from the Superintendent of Special Projects - Process Division is required.

4.2.3 Excavation by machine shall be limited to no closer than 3 feet (in any direction) to the pipeline facility. The facility shall then be exposed and the location verified by hand excavation. After the facility is exposed, and only while the Superintendent of Special Projects - Process Division is on-site, excavation by machine is permitted to within 1 foot (in any direction) of the facility. The remaining excavation must be hand dug.

4.2.4 Wherever possible, mechanical excavating equipment shall be operated parallel to the direction of the pipeline when excavation is within 3 feet of the pipeline.

4.2.5 In the sole judgment of the Superintendent of Special Projects - Process Division, excavation by machine may be limited to distances greater than those described above due to soil conditions or other extenuating factors.

4.3 *With prior agreement from the Superintendent of Special Projects - Process Division, hydrovac may be used as an alternative to hand digging.*Federal regulations require that PennEast's pipe be inspected whenever it is exposed. OSHA and MSHA regulations pertaining to excavations must therefore be met to ensure the safety of the PennEast representative who must enter the excavation.

4.4 Blasting operations shall be performed in accordance with the minimum guidelines set forth below.

4.4.1 PennEast shall be advised of any blasting proposed within 200 feet (500 feet for large scale quarry-type blasting) of its pipeline facilities. No blasting is permitted within 25 feet of the pipeline.

4.4.2 PennEast reserves the right to require that the party responsible for blasting furnish a detailed blasting plan at least three (3) working days prior to blasting to allow for evaluation and to make arrangements for witnessing the blasting operation. Blasting codes shall be followed in all cases.

5 Foreign Line Crossing

5.1 All buried foreign lines shall be installed as noted below and as stated in Sections 3.13 and 3.14, as appropriate.

5.1.1 Foreign lines shall be installed below PennEast's pipeline with a minimum of 12" of clearance except as noted in Section 5.1.2. Additional separation may be required in marshy areas or other areas where the 12" of clearance would have a potential to cause future problems.

5.1.2 If the normal crossing requirements present undue difficulties, foreign lines may be installed above PennEast's pipeline with prior approval from the Superintendent of Special Projects - Process Division. All such lines shall be installed with a minimum of 12" of clearance. PennEast will not be responsible for any damage or required repairs which are caused by PennEast's operating and maintenance activities when foreign lines are installed above the pipeline. Protective measures such as a concrete encasement, ditch marking tape, and/or above ground markers may be required as deemed necessary by the Superintendent of Special Projects - Process Division.

5.1.3 Suitable backfill shall be placed between the foreign line and PennEast's pipeline. Suitable backfill is backfill free of rocks, refuse and any foreign material including, but not limited to, skids, welding rods, pipe rings, trash, tree and shrubbery limbs.

5.1.4 The installation of test leads (two No. 12 THW black insulated solid copper wires) attached at the point of crossing for corrosion control monitoring may be required for metallic foreign lines as directed by the Superintendent of Special Projects - Process Division. Test wires shall be routed underground and terminated at a point specified by PennEast.

5.1.5 A stairway, ladder, ramp or other means of egress will be located in any trench that is 4 feet or more in depth so as to require no more than 25 feet of lateral travel for employees. Structural ramps may be designed by a competent person unless they are used by equipment. If this is the case, the design will be developed by a competent person qualified in structural design.

5.2 The following requirements shall be met for fiber optic cables which encroach upon all PennEast pipeline facilities within 25 feet from the centerline of pipe on either side.

5.2.1 High capacity fiber optic cable shall be installed in a rigid non-metallic conduit or covered in 6-8" of concrete which has been colored with an orange dye extending across 25’ of the pipeline on both sides of the centerline.

5.2.2 The fiber optic cable shall be installed a minimum of 12” below the PennEast’s pipeline, unless approved by the Superintendent of Special Projects - Process Division.

5.2.3 Orange warning tape shall be buried a minimum of 18” directly above the fiber optic cable, where practical.

5.2.4 The fiber optic cable crossing shall be clearly and permanently marked with identification signs on both sides of the pipeline within 25’.

5.3 The information listed below shall be furnished to PennEast for all proposed electrical cables which will encroach upon the pipeline within 25’ of the centerline.

- Number, spacing and voltage of cables
- Line loading and phase relationship of cables
- Grounding system
- Position of cables and load facilities relative to pipeline

5.4 Specific installation requirements for cables carrying less than 600 volts shall be determined by PennEast on a case by case basis.

5.5 The following installation requirements shall be met for electrical cables carrying over 600 volts but less than 7,600 volts. PennEast will determine the installation procedures for electrical lines carrying voltages over 7,600 volts on a case by case basis.

5.5.1 The electrical cable shall be installed in a rigid non-metallic conduit covered in a minimum thickness of 2” of concrete which has been colored with a red dye extending across 25’ of both sides of the pipeline centerline.

5.5.2 The electrical cable shall be installed a minimum of 12” below PennEast’s pipeline across 25’ of either side of the pipeline centerline, unless approved by the Superintendent of Special Projects - Process Division.

5.5.3 Each phase conductor should be surrounded with a spirally wound, concentric neutral conductor. The neutral may be within the outer cable jacket.

5.5.4 Red warning tape shall be buried a minimum of 18” directly above the electric cable extending across 25’ of both sides of the pipeline centerline, where practical.

5.5.5 The electric cable crossing shall be clearly and permanently marked with identification signs within 25’ on the pipe centerline on both sides of the pipeline.

5.6 Overhead power line and telephone line installations shall be reviewed by PennEast on an individual basis. As a minimum requirement, overhead lines shall be installed with a minimum clearance of 25 feet above the grade of the pipeline. The installation of poles will not be permitted within 25’ of the pipe centerline on either side of the pipeline**.**

6 Special Provisions for Near-by Mining Activity

6.1 As a critical resource, it is imperative that precautions during planning, design, construction, and operation be taken to prevent unanticipated impacts to the pipeline during its service life. As an initial method of precaution, PennEast has attempted to minimize the potential for impacts of nearby mine, quarry, and heavy earthmoving activities by inventorying these activities and avoiding them in the preferred alignment, where possible. While active mining is not as significant as it was in the region during the first half of the 19th century, remnant mines do exist at locations across Pennsylvania and New Jersey. To address this concern PennEast has reviewed multiple local data sources, including mine and subsidence mapping prepared by the New Jersey Department of Environmental Protection (NJDEP) and Pennsylvania Department of Conservation and Natural Resources (PADCNR) while selecting a preferred alignment route. For example, PennEast reviewed such maps as NJDEP Open File Map “DGS03-2 Abandoned Mines of New Jersey”, Open File Map “DGS06-3 Landslides in New Jersey”, 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”, PA Department of Environmental Protection “Abandoned Mine Land Inventory” mapping, and other relevant geologic mapping while performing siting and planning for pipeline and facilities.

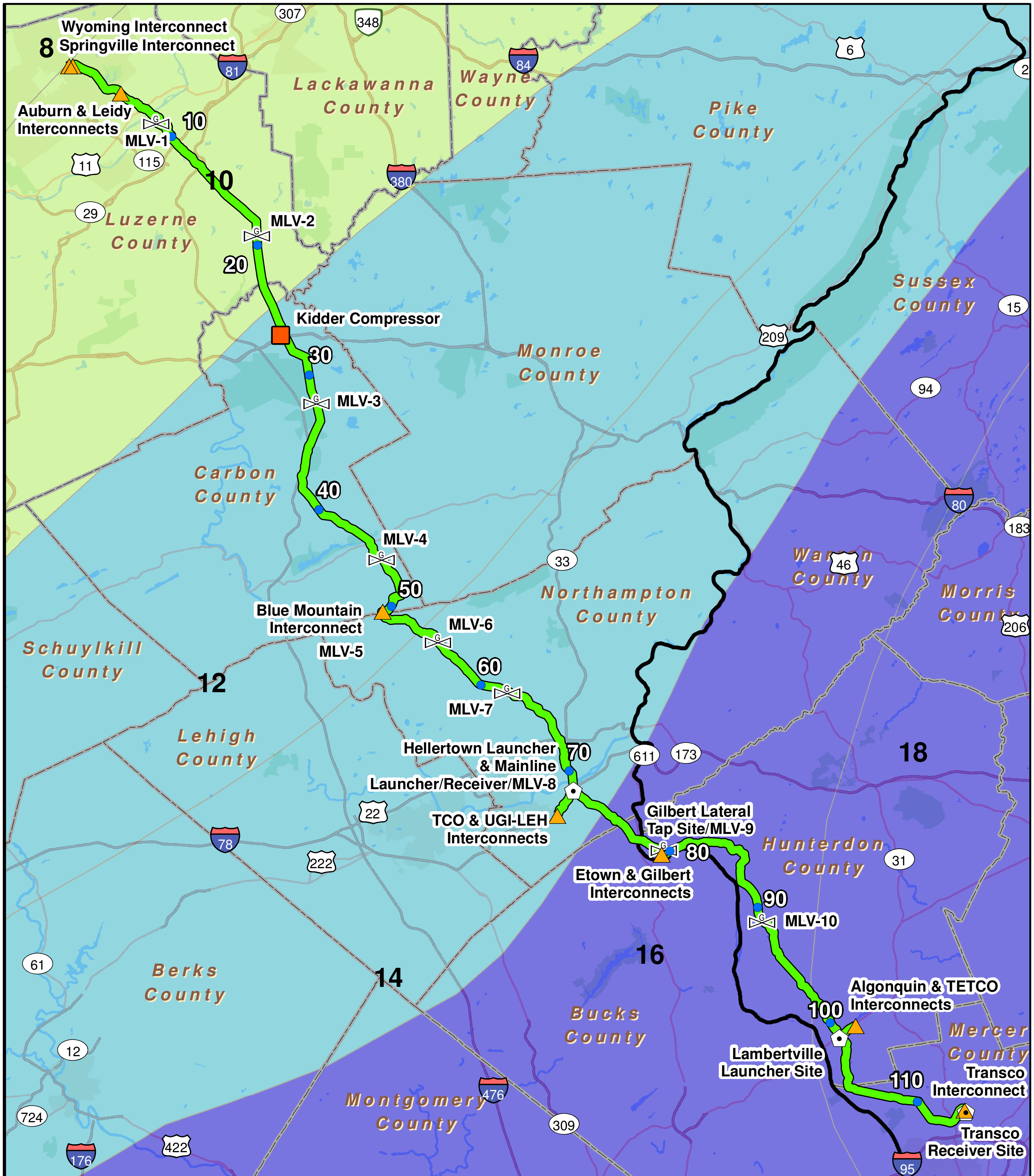
6.2 Should land sliding or slumping occur due to earthmoving and extraction activities by others which have potential to affect the pipeline, this method of failure would be slow-moving and would not cause an immediate rupture or damage to the pipeline. Such slumping failure may be directly visible during routine inspection of the right-of-way, which will be documented and addressed by implementing necessary engineered safeguards. Should sudden land sliding occur, an observer may be able to immediately contact local fire, police, or public works department as well as a toll-free reporting line for which will be established by PennEast. As typical of natural gas pipelines, the contact information will be displayed prominently on pipeline marker signs for ease of access. PennEast will dispatch incident response personnel and employ National Incident Management System (NIMS) best practice guidelines, as developed by the United States Department of Homeland Security, as necessary for each specific incident.

6.3 For notification and protection with regards to blasting, State regulations such as provisions contained within blasting codes of the New Jersey Administrative Code (N.J.A.C.) provide minimum notification and protection guidelines which will be followed by PennEast for work conducted in vicinity of the pipeline and facilities. For blasting conducted within 500 feet of any pipe distributing liquefied petroleum, manufactured, mixed or natural gas, in accordance with N.J.A.C. 12:190-7.7, the blaster shall notify the gas utility company having control of such gas at least three full working days (excluding Sundays or holidays) prior to blasting. As required by code such notice shall be in writing and served personally or by registered mail. In addition, safeguards such as State One-Call and Call Before You Dig programs will trigger notification to PennEast operational staff which will prompt additional work-specific safeguards as required.

Attachment 15

Supplemental Information to Appendix O

Seismic Hazard Map



N
W E
S
0 2 4 8 Miles

- Mile Post
- Launcher/Receiver Site
- Interconnect
- Mainline Block Valve
- Compressor Station
- Proposed Route

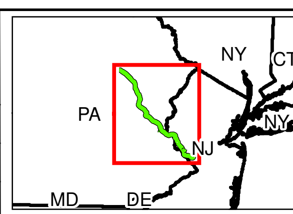
Acceleration Value (% Gravity)
- 6 - 10
- 11 - 15
- 16 - 200

- County Boundary
- State Boundary

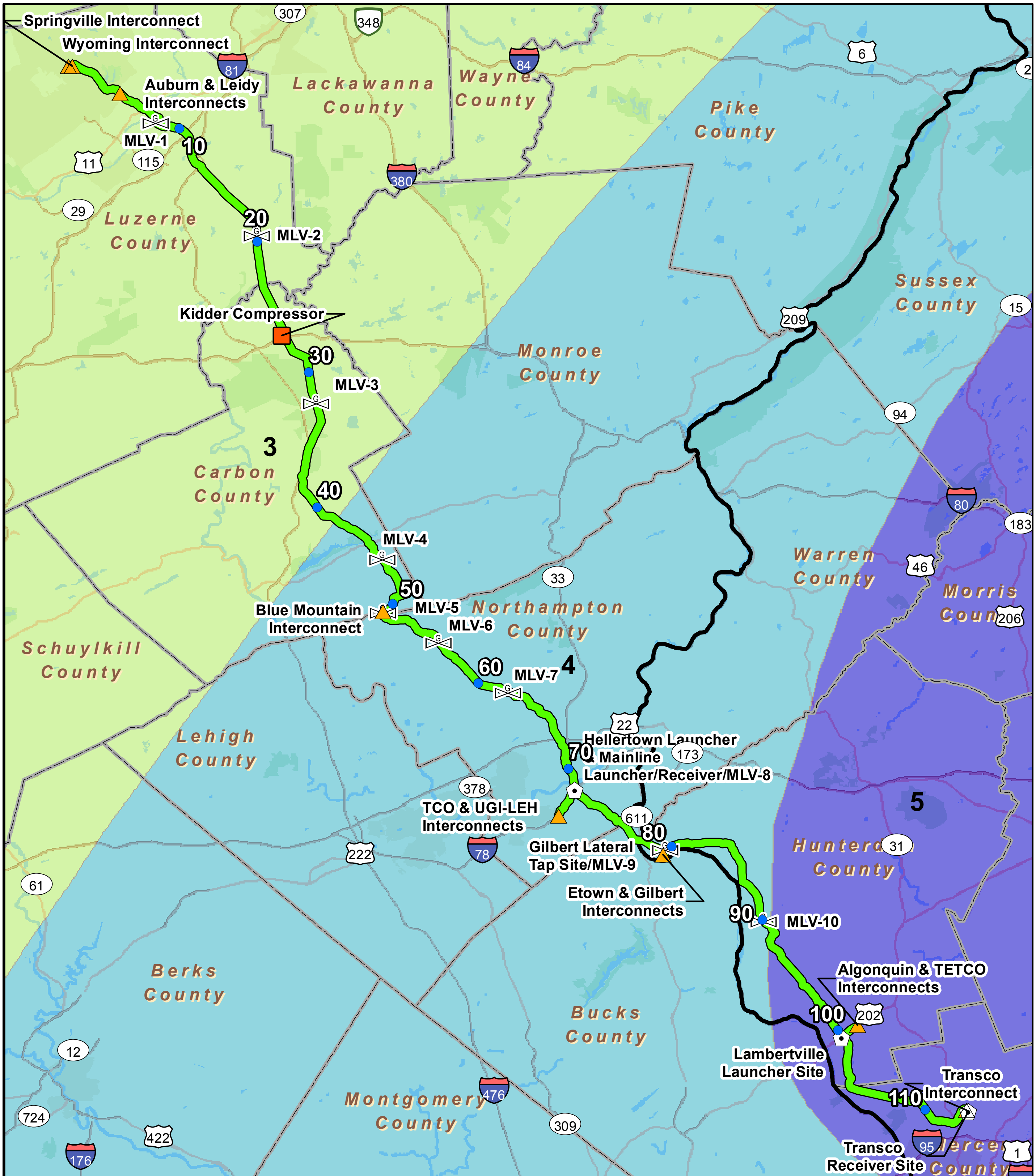
Reference:
USGS Seismic Hazards Map
OFR 97-130 and 97-131

TITLE:
PennEast Pipeline Project - Peak Acceleration (Percent of Gravity)
With 2 Percent Probability of Exceedance in 50 Years

LOC: Luzerne County, PA to Mercer County, NJ			REV.:
CKD. BY: JB	ENG.:	Date: 12/3/2015	W.O.:
DRN. BY: LB	SCALE: SEE GRAPHIC SCALE	DWG. NO.:	SHEET:1



PennEast PIPELINE
PennEast Pipeline Company, LLC



N E S W

0 2 4 8 Miles

- Mile Post
- PennEast Proposed Route
- Interconnect
- Launcher/Receiver
- Mainline Valve Site
- Compressor Station Option

Acceleration Value (% Gravity)
- 3
- 4
- 5

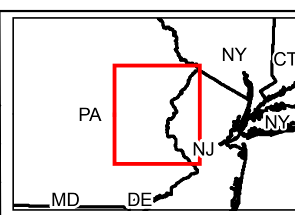
- County Boundary
- State Boundary

Reference:
USGS Seismic Hazards Map
OFR 97-130 and 97-131

TITLE:

PennEast Pipeline Project - Peak Acceleration (Percent of Gravity)
With 10 Percent Probability of Exceedance in 50 Years

LOC: Luzerne County, PA to Mercer County, NJ			REV.:
CKD. BY: JB	ENG.:	Date: 9/23/2015	W.O.:
DRN. BY: LB	SCALE: SEE GRAPHIC SCALE	DWG. NO.:	SHEET:1



PennEast PIPELINE

PennEast Pipeline Company, LLC

Attachment 16

Maximum Pipe Span Lengths

for PennEast Pipeline

QPS ENGINEERING, LLC
A QUANTA SERVICES COMPANY

MAXIMUM PIPE SPAN LENGTHS

FOR

PENNEAST PIPELINE PROJECT

Document No. 80111-RP-002

Prepared for

PennEast PIPELINE

Prepared by

QPS Engineering, LLC

Revision	Date Issued	QPSE Review/Approvals: Prepared By:	Reviewed By:	Approved By:	Description
A	12/29/2014	Luke Lenard		Randy Bostick	Initial Issue/Issued for Review

QPS Engineering, LLC
4500 S. Garnett Rd., Suite 700
Tulsa, OK 74146
PH: 918-858-7620
www.qpsepc.com

The allowable bending stresses and maximum span lengths for a 36-in diameter steel pipe were calculated, and the results may be found in the attached reports. The span lengths and bending radii for natural gas and liquid pipelines are limited by the allowable bending stress for the pipe. The deflection limitation, L/360, is normally considered for beams in structures such as buildings or bridges. It is ignored in this situation. The pipe will not fail until it deflects beyond the allowable bending stress. Deflection further than the bending stress threshold could result in plastic deformation and possibly failure due to buckling or rupture. ASME B31.8 notes that stresses from spanning or differential settlement are difficult to evaluate accurately and can be disregarded in most cases (ASME B31.8 Paragraph 833.3c). Table 1 lists the pipe data and Table 2 gives the maximum span length for Class Locations 2 and 3.

Table 1: Pipe Data and Allowable Bending Stress

Class Location	MAOP	OD	SMYS	Design Factor	Wall Thickness	Maximum Allowable Bending Stress
2	1,480 psi	36 in	70,000 psi	0.60	0.635 in	21,936 psi
3	1,480 psi	36 in	70,000 psi	0.50	0.762 in	35,091 psi

Table 2: Maximum Pipe Span Lengths Due To Bending

Class Location	Maximum Pipe Span 400 lb/ft Soil Load	Maximum Pipe Span 200 lb/ft Soil Load	Maximum Pipe Span 0 lb/ft Soil Load
2	92.35 ft	102.63 ft	117.35 ft
3	124.86 ft	138.15 ft	156.86 ft

The ASME Class 600 rating for the valves and flanges limits the maximum allowable operating pressure (MAOP) of the pipeline to 1,480-psi. An additional uniform load of 400 pounds per foot was added to the top of the pipe to account for a soil load if the soil remains on the pipe in the event of erosion causing a cavity in the ground beneath the pipe (sinkhole). The uniform load of 400 pounds per foot represents soil with a density of 130 pounds per cubic foot, such as wet sand. The maximum test pressure is 1.5 times the MAOP which is the recommended test pressure (ASME B16.5 Paragraph 2.6). ASME B31.8 requires a minimum test pressure of 1.4 times the maximum operating pressure for Class Locations 3 and 4 (ASME B31.8 Paragraph 841.322d).

Project		
PennEast		
Location	Date	
PA	12/29/2014	

Maximum Allowable Pipe Span Length

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1480	Young's Modulus for Steel [ksi]	29,000
Pipe Outside Diameter [in]	36.00	Poisson's Ratio for Steel	0.30
Pipe Wall Thickness [in]	.635	Average Unit Weight of Steel	490
Specified Minimum Yield Stress [psi]	70,000		
Design Factor	0.60	Pipe Hydrotesting Applied:	Yes
Longitudinal Joint Factor	1.0		
Temperature Derating Factor	1.000		
Additional Uniform Load on Pipe [lb/ft]	400		
Deflection Limited to	L/360		
Maximum Test Pressure [psi]	2220		
Maximum Allowable % of SMYS for Testing [%]	109.0		

RESULTS OF CALCULATION:

MAOP - Maximum Allowable Operating Pressure [psig]	1,480
Hoop/Barlow Stress [psi]	62,929
Maximum Allowable Bending Stress	21,936
Moment of Inertia [in^4]	11,027.43
Section Modulus [in³]	612.64
Bending Moment [lb-ft]	1,119,902.9

Maximum Pipe Span Length due to Bending [ft]	92.35	Deflection [in]	5.38
Maximum Pipe Span Length due to Deflection [ft]	76.69	Deflection [in]	2.56

MAXIMUM ALLOWABLE PIPE SPAN LENGTH [ft] 76.69

Notes:

Reference: CFR Part 192, ASME B31.8 and Roark's Formulas for Stress and Strain

Prepared By Luke Lenard	Approved By	Revision: 10.0.0

Project		
PennEast		
Location: PA	Date: 12/29/2014	

Maximum Allowable Pipe Span Length

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1480	Young's Modulus for Steel [ksi]	29,000
Pipe Outside Diameter [in]	36.00	Poisson's Ratio for Steel	0.30
Pipe Wall Thickness [in]	.635	Average Unit Weight of Steel	490
Specified Minimum Yield Stress [psi]	70,000		
Design Factor	0.60	Pipe Hydrotesting Applied:	Yes
Longitudinal Joint Factor	1.0		
Temperature Derating Factor	1.000		
Additional Uniform Load on Pipe [lb/ft]	200		
Deflection Limited to	L/360		
Maximum Test Pressure [psi]	2220		
Maximum Allowable % of SMYS for Testing [%]	109.0		

RESULTS OF CALCULATION:

MAOP - Maximum Allowable Operating Pressure [psig]	1,480
Hoop/Barlow Stress [psi]	62,929
Maximum Allowable Bending Stress	21,936
Moment of Inertia [in^4]	11,027.43
Section Modulus [in³]	612.64
Bending Moment [lb-ft]	1,119,902.9

Maximum Pipe Span Length due to Bending [ft]	102.63	Deflection [in]	6.64
Maximum Pipe Span Length due to Deflection [ft]	82.28	Deflection [in]	2.74

MAXIMUM ALLOWABLE PIPE SPAN LENGTH [ft] 82.28

Notes:

Reference: CFR Part 192, ASME B31.8 and Roark's Formulas for Stress and Strain

Prepared By: Luke Lenard	Approved By	Revision: 10.0.0

Project		
PennEast		
Location: PA	Date: 12/29/2014	

Maximum Allowable Pipe Span Length

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1480	Young's Modulus for Steel [ksi]	29,000
Pipe Outside Diameter [in]	36.00	Poisson's Ratio for Steel	0.30
Pipe Wall Thickness [in]	.635	Average Unit Weight of Steel	490
Specified Minimum Yield Stress [psi]	70,000		
Design Factor	0.60	Pipe Hydrotesting Applied:	Yes
Longitudinal Joint Factor	1.0		
Temperature Derating Factor	1.000		
Additional Uniform Load on Pipe [lb/ft]	0		
Deflection Limited to	L/360		
Maximum Test Pressure [psi]	2220		
Maximum Allowable % of SMYS for Testing [%]	109.0		

RESULTS OF CALCULATION:

MAOP - Maximum Allowable Operating Pressure [psig]	1,480
Hoop/Barlow Stress [psi]	62,929
Maximum Allowable Bending Stress	21,936
Moment of Inertia [in^4]	11,027.43
Section Modulus [in³]	612.64
Bending Moment [lb-ft]	1,119,902.9

Maximum Pipe Span Length due to Bending [ft]	117.35	Deflection [in]	8.68
Maximum Pipe Span Length due to Deflection [ft]	89.97	Deflection [in]	3.00

MAXIMUM ALLOWABLE PIPE SPAN LENGTH [ft] 89.97

Notes:

Reference: CFR Part 192, ASME B31.8 and Roark's Formulas for Stress and Strain

Prepared By: Luke Lenard	Approved By	Revision: 10.0.0

Project		
PennEast		
Location: PA	Date: 12/29/2014	

Maximum Allowable Pipe Span Length

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1480	Young's Modulus for Steel [ksi]	29,000
Pipe Outside Diameter [in]	36.00	Poisson's Ratio for Steel	0.30
Pipe Wall Thickness [in]	.762	Average Unit Weight of Steel	490
Specified Minimum Yield Stress [psi]	70,000		
Design Factor	0.50	Pipe Hydrotesting Applied:	Yes
Longitudinal Joint Factor	1.0		
Temperature Derating Factor	1.000		
Additional Uniform Load on Pipe [lb/ft]	400		
Deflection Limited to	L/360		
Maximum Test Pressure [psi]	2220		
Maximum Allowable % of SMYS for Testing [%]	109.0		

RESULTS OF CALCULATION:

MAOP - Maximum Allowable Operating Pressure [psig]	1,482
Hoop/Barlow Stress [psi]	52,441
Maximum Allowable Bending Stress	35,091
Moment of Inertia [in^4]	13,092.77
Section Modulus [in³]	727.38
Bending Moment [lb-ft]	2,127,055.6

Maximum Pipe Span Length due to Bending [ft]	124.86	Deflection [in]	15.72
Maximum Pipe Span Length due to Deflection [ft]	80.17	Deflection [in]	2.67

MAXIMUM ALLOWABLE PIPE SPAN LENGTH [ft] 80.17

Notes:

Reference: CFR Part 192, ASME B31.8 and Roark's Formulas for Stress and Strain

Prepared By: Luke Lenard	Approved By	Revision: 10.0.0

Project PennEast		
Location PA	Date 12/29/2014	

Maximum Allowable Pipe Span Length

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1480	Young's Modulus for Steel [ksi]	29,000
Pipe Outside Diameter [in]	36.00	Poisson's Ratio for Steel	0.30
Pipe Wall Thickness [in]	.762	Average Unit Weight of Steel	490
Specified Minimum Yield Stress [psi]	70,000		
Design Factor	0.50	Pipe Hydrotesting Applied:	Yes
Longitudinal Joint Factor	1.0		
Temperature Derating Factor	1.000		
Additional Uniform Load on Pipe [lb/ft]	200		
Deflection Limited to	L/360		
Maximum Test Pressure [psi]	2220		
Maximum Allowable % of SMYS for Testing [%]	109.0		

RESULTS OF CALCULATION:

MAOP - Maximum Allowable Operating Pressure [psig]	1,482
Hoop/Barlow Stress [psi]	52,441
Maximum Allowable Bending Stress	35,091
Moment of Inertia [in^4]	13,092.77
Section Modulus [in³]	727.38
Bending Moment [lb-ft]	2,127,055.6

Maximum Pipe Span Length due to Bending [ft]	138.15	Deflection [in]	19.25
Maximum Pipe Span Length due to Deflection [ft]	85.77	Deflection [in]	2.86

MAXIMUM ALLOWABLE PIPE SPAN LENGTH [ft] 85.77

Notes:

Reference: CFR Part 192, ASME B31.8 and Roark's Formulas for Stress and Strain

Prepared By Luke Lenard	Approved By	Revision: 10.0.0

Project		
PennEast		
Location: PA	Date: 12/29/2014	

Maximum Allowable Pipe Span Length

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1480	Young's Modulus for Steel [ksi]	29,000
Pipe Outside Diameter [in]	36.00	Poisson's Ratio for Steel	0.30
Pipe Wall Thickness [in]	.762	Average Unit Weight of Steel	490
Specified Minimum Yield Stress [psi]	70,000		
Design Factor	0.50	Pipe Hydrotesting Applied:	Yes
Longitudinal Joint Factor	1.0		
Temperature Derating Factor	1.000		
Additional Uniform Load on Pipe [lb/ft]	0		
Deflection Limited to	L/360		
Maximum Test Pressure [psi]	2220		
Maximum Allowable % of SMYS for Testing [%]	109.0		

RESULTS OF CALCULATION:

MAOP - Maximum Allowable Operating Pressure [psig]	1,480
Hoop/Barlow Stress [psi]	52,441
Maximum Allowable Bending Stress	35,091
Moment of Inertia [in^4]	13,092.77
Section Modulus [in³]	727.38
Bending Moment [lb-ft]	2,127,055.6

Maximum Pipe Span Length due to Bending [ft]	156.86	Deflection [in]	24.81
Maximum Pipe Span Length due to Deflection [ft]	93.35	Deflection [in]	3.11

MAXIMUM ALLOWABLE PIPE SPAN LENGTH [ft] 93.35

Notes:

Reference: CFR Part 192, ASME B31.8 and Roark's Formulas for Stress and Strain

Prepared By: Luke Lenard	Approved By	Revision: 10.0.0

Attachment 17

Supplemental Information to Resource Report 7

Revised Figure 7.1-1

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- PROPOSED PENNEAST PIPELINE CENTERLINE
- PROPOSED GILBERT LATERAL
- PROPOSED LAMBERTVILLE LATERAL
- PROPOSED HELLERTOWN LATERAL
- INTERSTATE
- HIGHWAY
- RAILROAD
- WATER BODY
- PARKS
- CITY AREA
- PAGE INDEX
- COUNTY BOUNDARY
- STATE BOUNDARY

PENNEAST PIPELINE PROJECT
SOIL MAP
MAP INDEX
FIGURE 7.1-1
PENNSYLVANIA & NEW JERSEY

10 5 0 10 MILES

N E S W

ABSOLUTE SCALE: 1:633,600

REFERENCE SCALE: 1 IN = 10 MILES

PennEast PIPELINE

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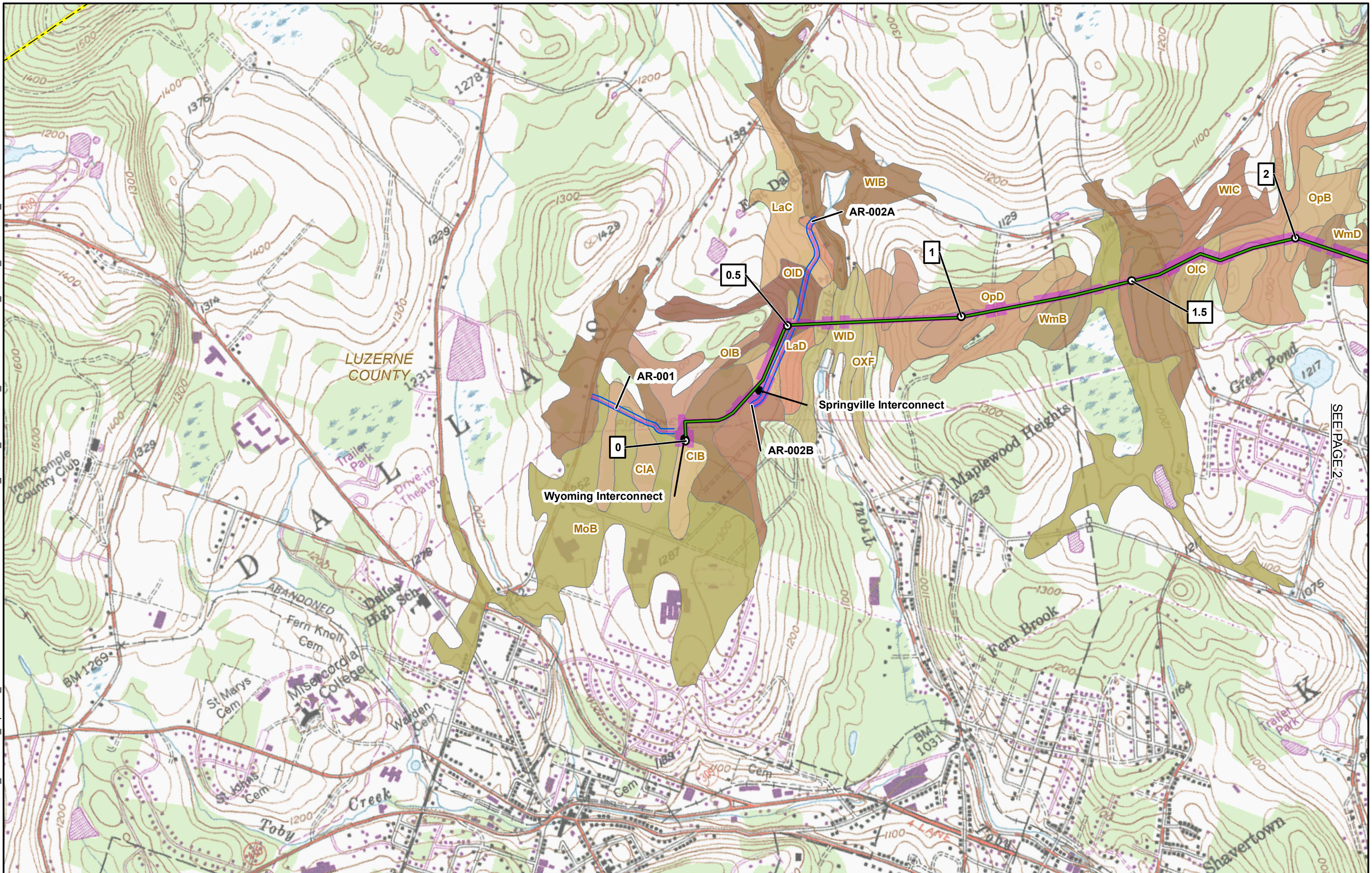

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1 MILE POST
● PROPOSED PERMANENT ABOVE GROUND FACILITY
PROPOSED ROUTE
PROPOSED PERMANENT ACCESS ROAD
PROPOSED TEMPORARY ACCESS ROAD
PROPOSED CONSTRUCTION LIMIT
PROPOSED WAREYARD
PROPOSED STAGING AREA
AbA SOILS CROSSED BY PROJECT
COUNTY BOUNDARY
STATE BOUNDARY
USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT
SOIL MAP
FIGURE 7.1-1

LUZERNE COUNTY
PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000

REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE

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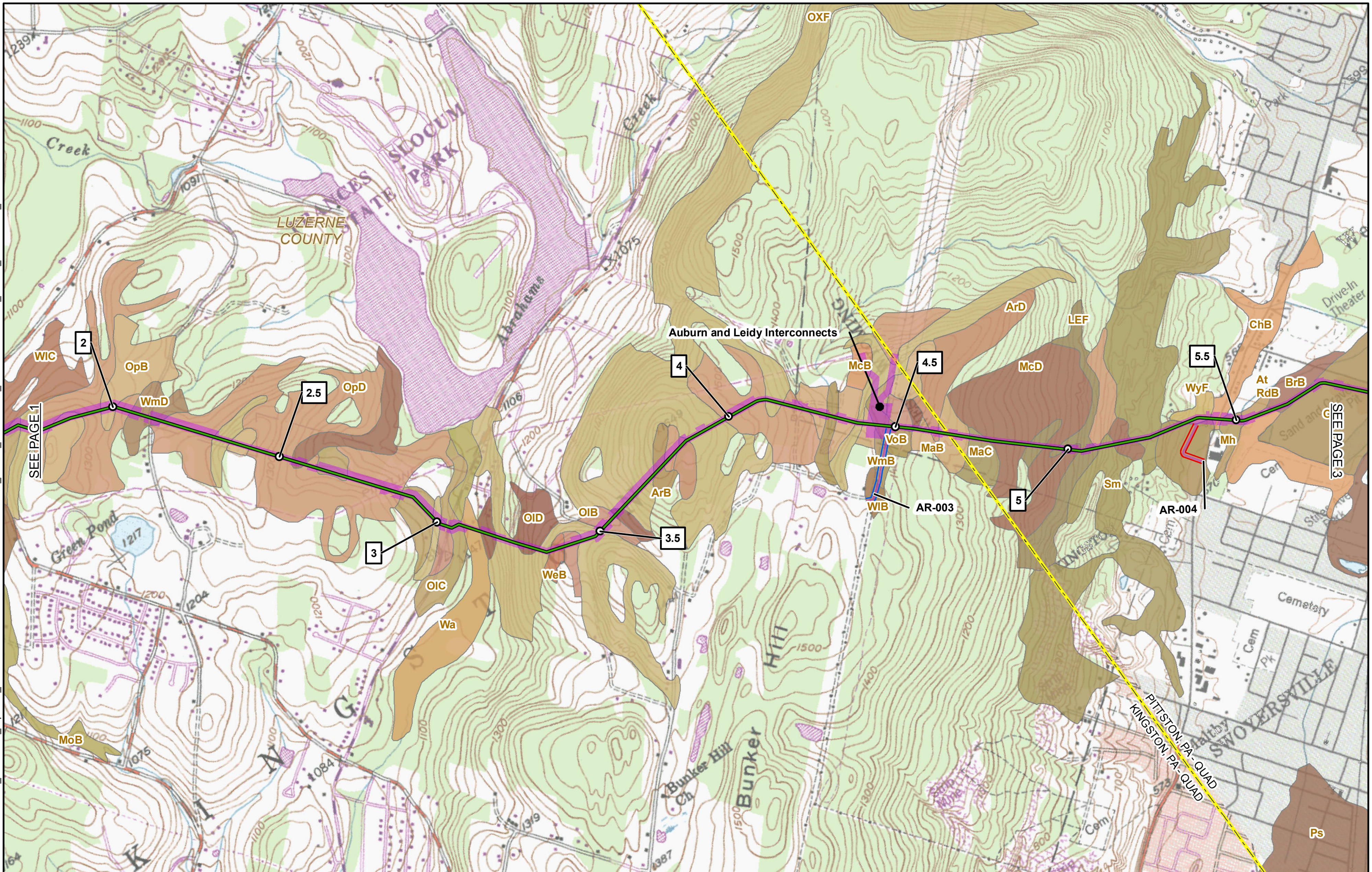

1 MILE POST

PROPOSED PERMANENT ABOVE GROUND FACILITY

PROPOSED ROUTE

PROPOSED PERMANENT ACCESS ROAD

PROPOSED TEMPORARY ACCESS ROAD

PROPOSED CONSTRUCTION LIMIT

PROPOSED WAREYARD

PROPOSED STAGING AREA

AbA SOILS CROSSED BY PROJECT

COUNTY BOUNDARY

STATE BOUNDARY

USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT

SOIL MAP

FIGURE 7.1-1

LUZERNE COUNTY

PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000

REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE

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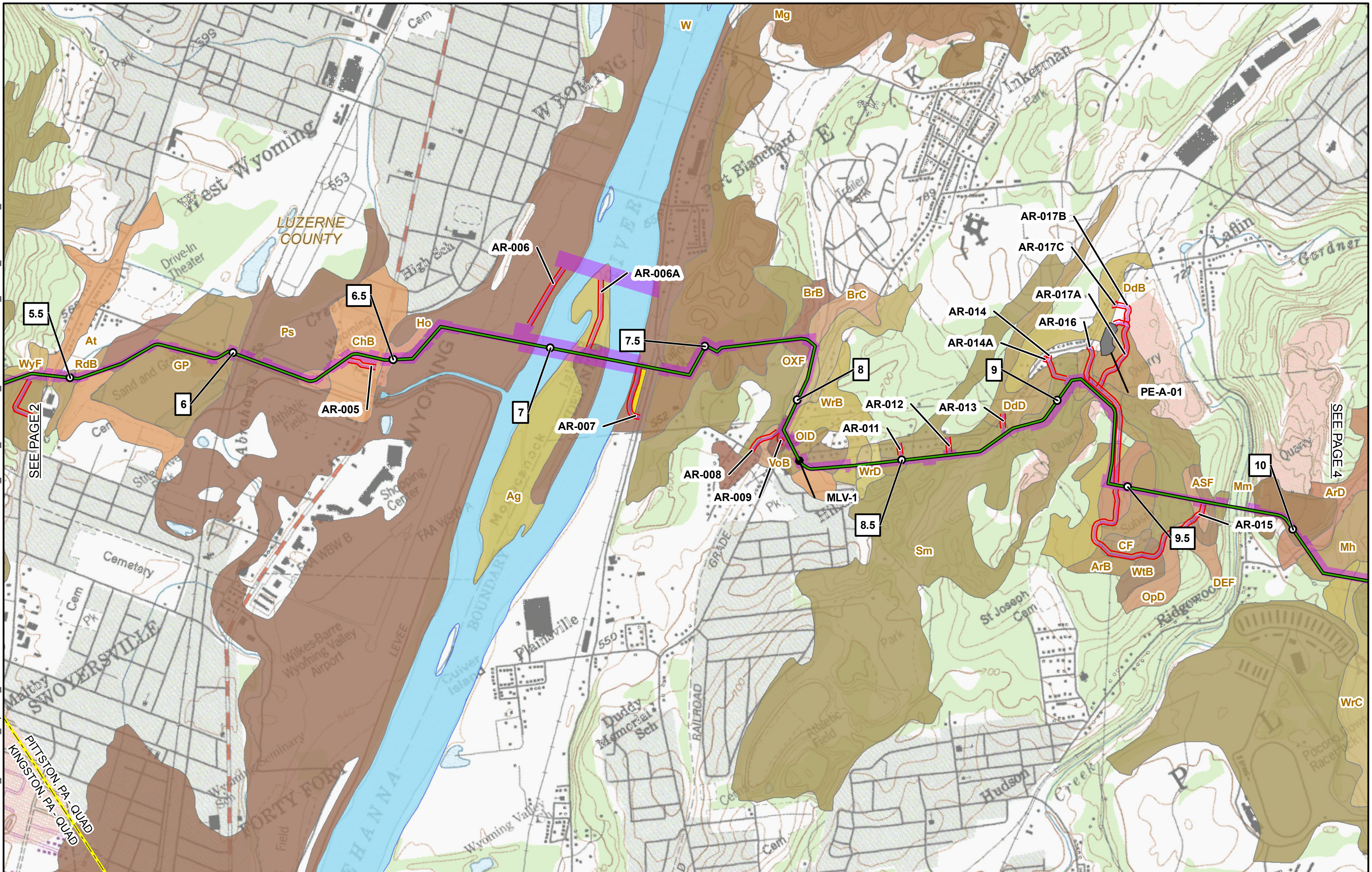

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PROPOSED PERMANENT ABOVE GROUND FACILITY

PROPOSED ROUTE

PROPOSED PERMANENT ACCESS ROAD

PROPOSED TEMPORARY ACCESS ROAD

PROPOSED CONSTRUCTION LIMIT

PROPOSED WAREYARD

PROPOSED STAGING AREA

SOILS CROSSED BY PROJECT

COUNTY BOUNDARY

STATE BOUNDARY

USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT

SOIL MAP

FIGURE 7.1-1

LUZERNE COUNTY

PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000

REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE

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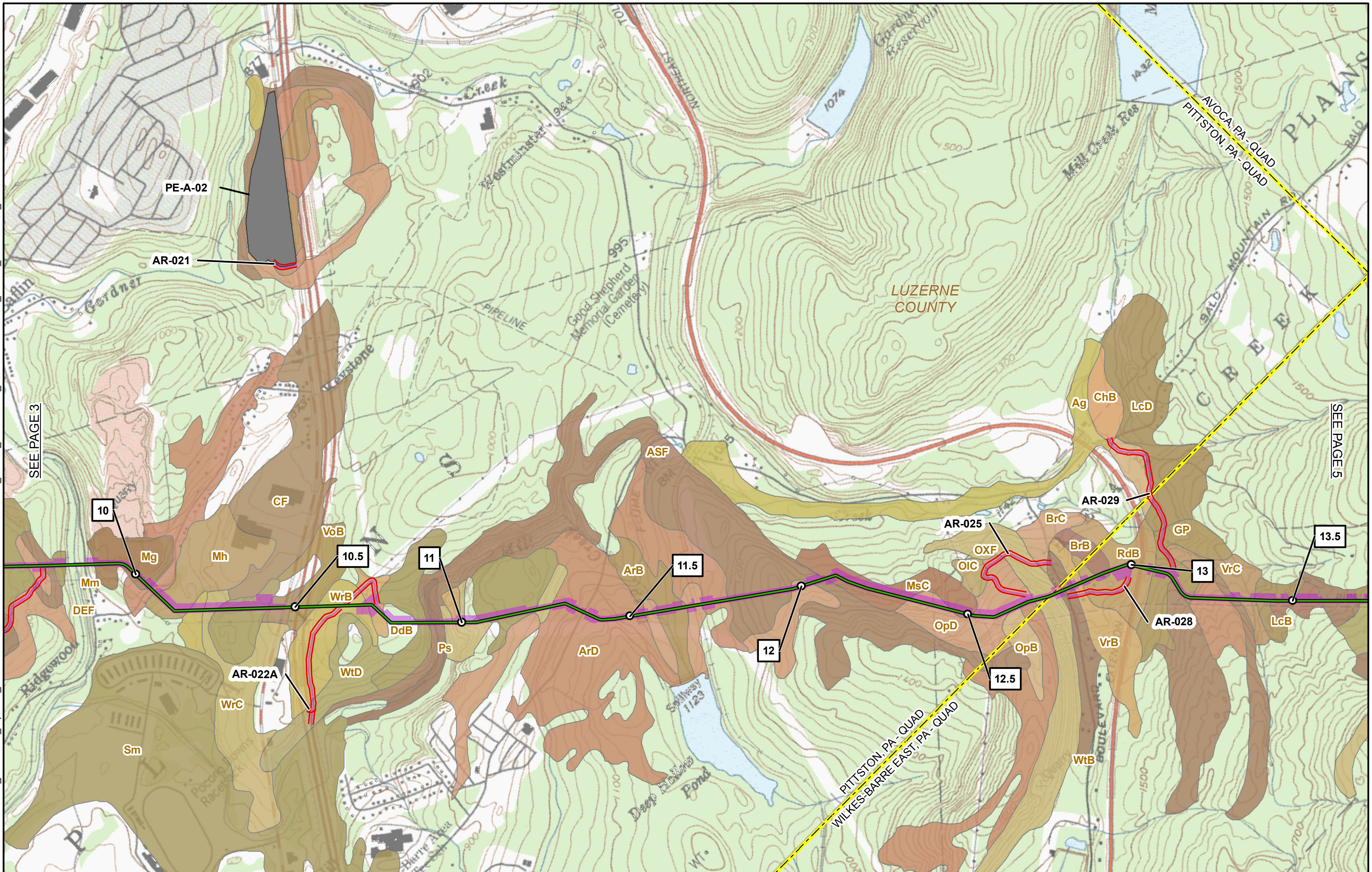

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PROPOSED PERMANENT ACCESS ROAD
PROPOSED TEMPORARY ACCESS ROAD
PROPOSED CONSTRUCTION LIMIT
PROPOSED WAREYARD
PROPOSED STAGING AREA
AbA SOILS CROSSED BY PROJECT
COUNTY BOUNDARY
STATE BOUNDARY
USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT
SOIL MAP
FIGURE 7.1-1

LUZERNE COUNTY
PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000
REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE
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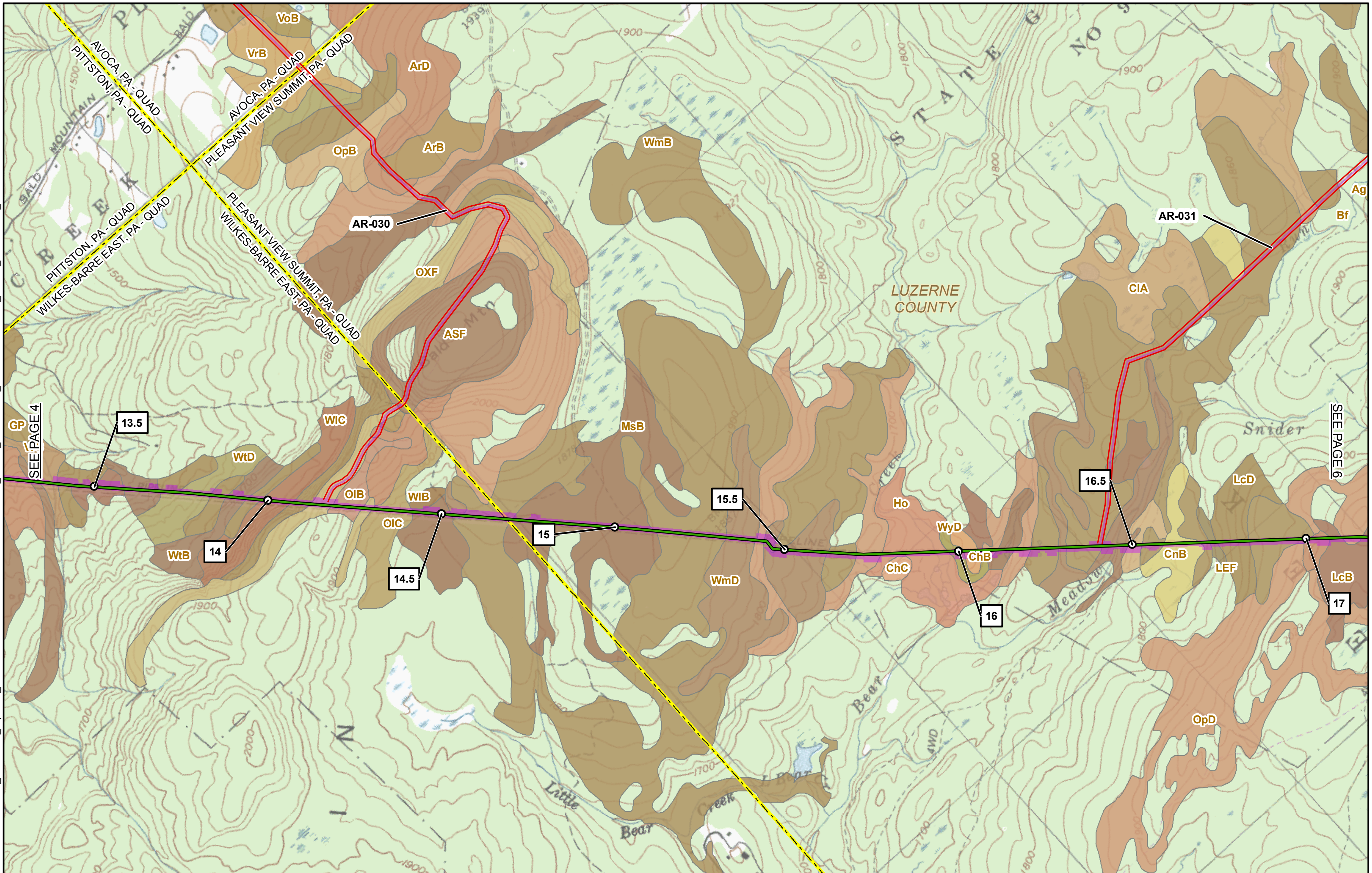

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PROPOSED TEMPORARY ACCESS ROAD
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PROPOSED WAREYARD
PROPOSED STAGING AREA
AbA SOILS CROSSED BY PROJECT
COUNTY BOUNDARY
STATE BOUNDARY
USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT
SOIL MAP
FIGURE 7.1-1

LUZERNE COUNTY
PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000

REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE

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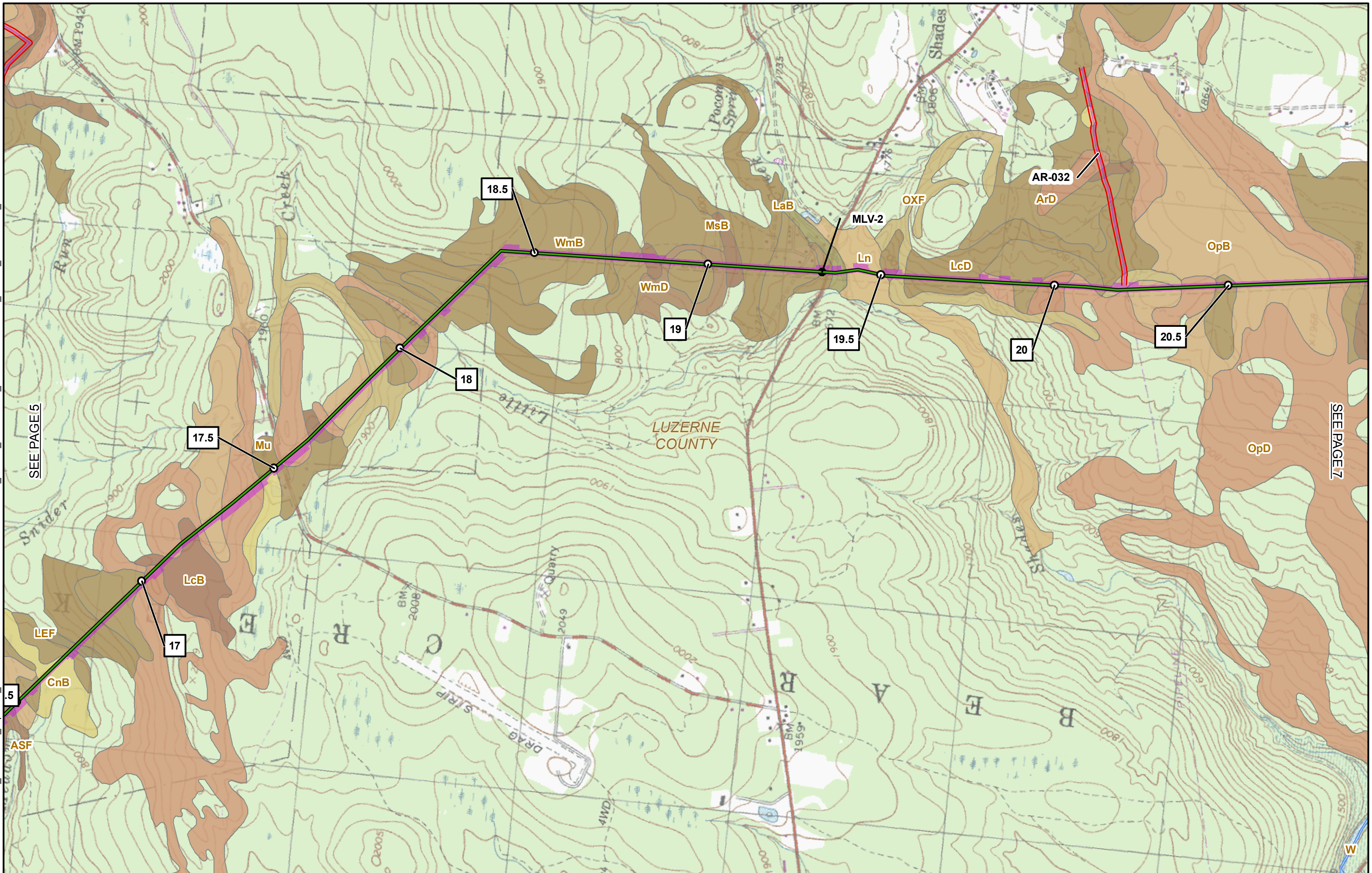

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PROPOSED WAREYARD
PROPOSED STAGING AREA
AbA SOILS CROSSED BY PROJECT
COUNTY BOUNDARY
STATE BOUNDARY
USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT

SOIL MAP

FIGURE 7.1-1

LUZERNE COUNTY
PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000

REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE

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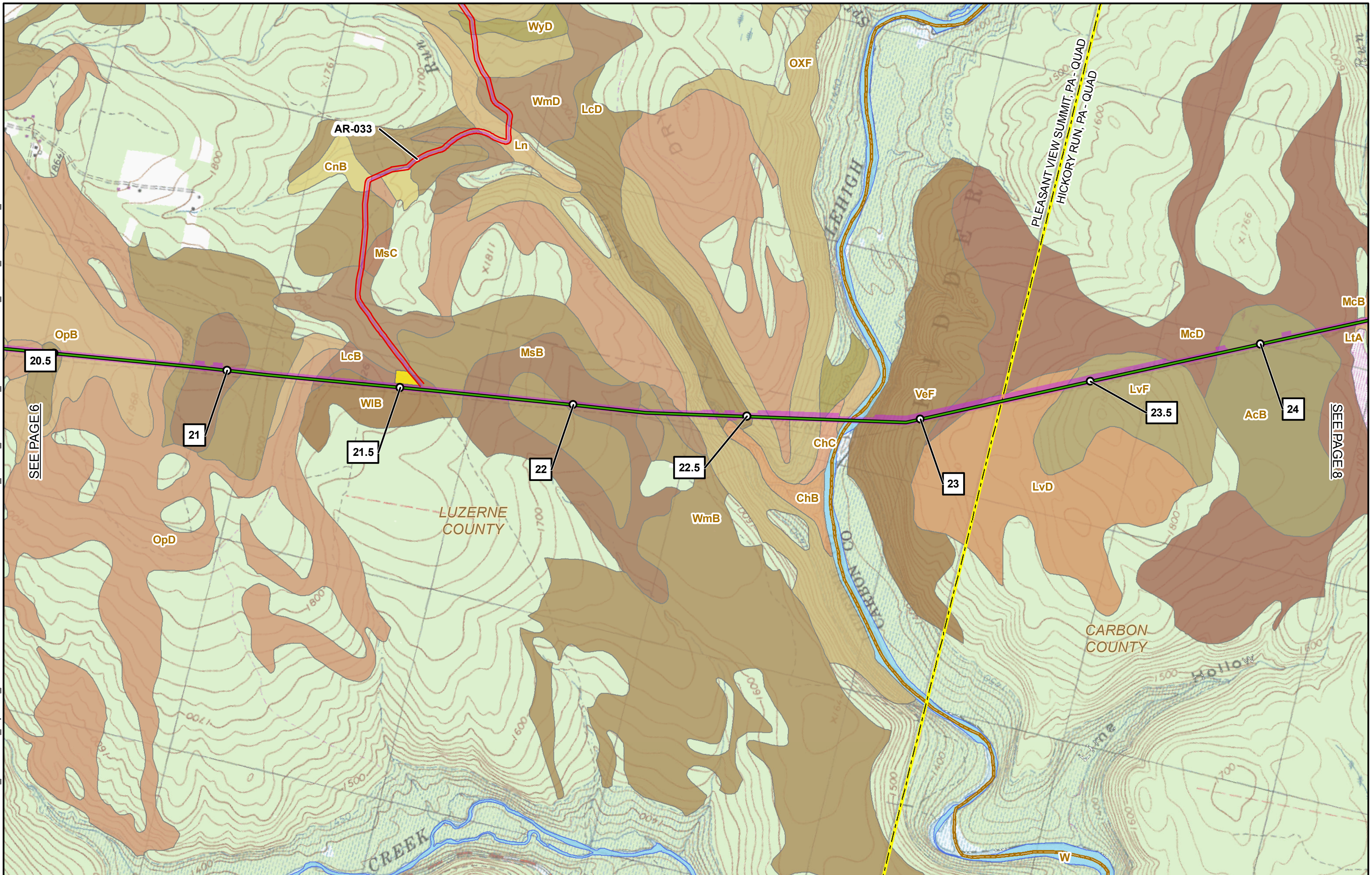

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PROPOSED TEMPORARY ACCESS ROAD
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PROPOSED STAGING AREA
AbA SOILS CROSSED BY PROJECT
COUNTY BOUNDARY
STATE BOUNDARY
USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT
SOIL MAP
FIGURE 7.1-1

LUZERNE & CARBON COUNTIES
PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

ABSOLUTE SCALE: 1:24,000
REFERENCE SCALE: 1 IN = 2,000 FT

PennEast PIPELINE

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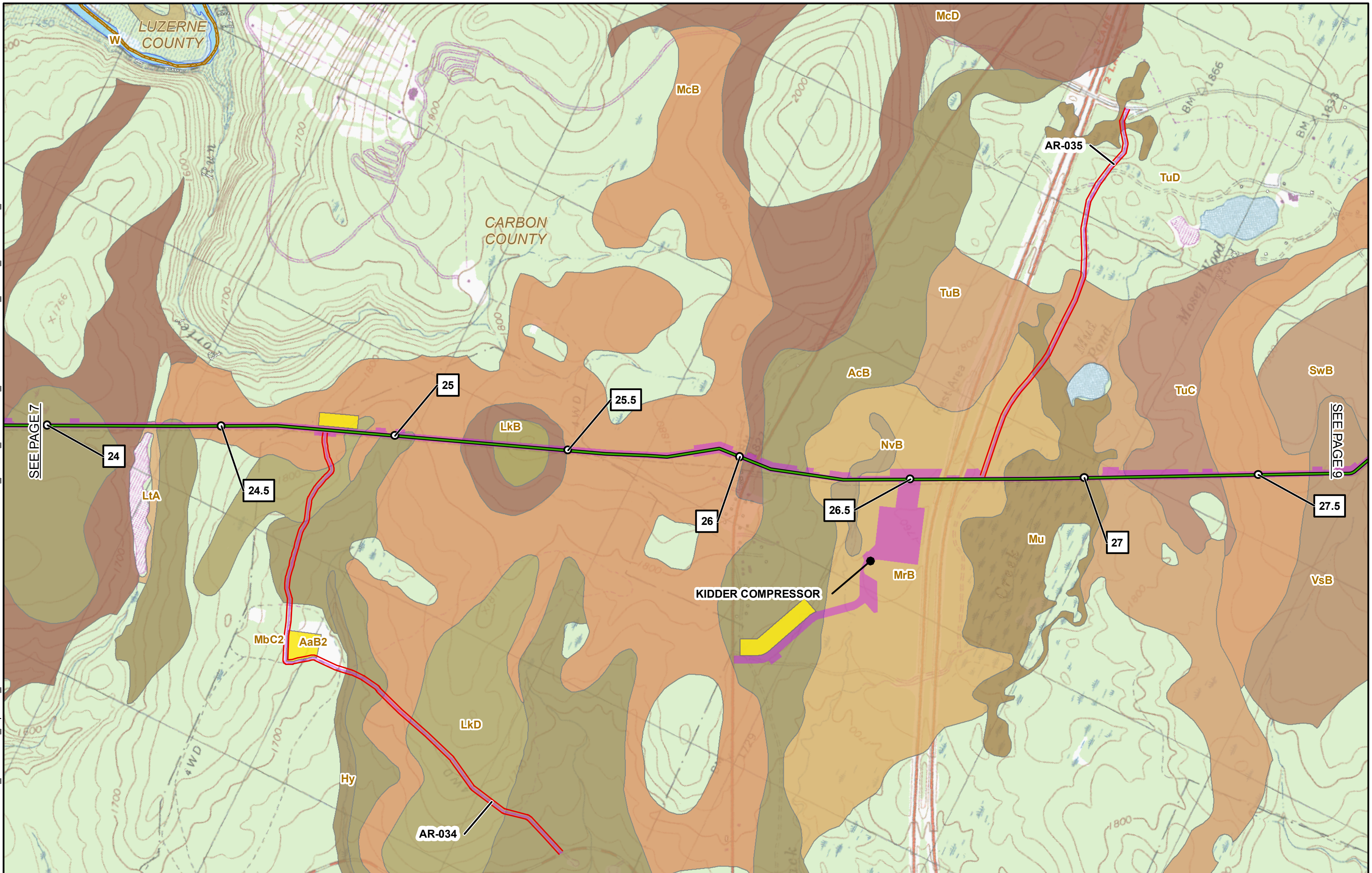

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- PROPOSED TEMPORARY ACCESS ROAD
- PROPOSED CONSTRUCTION LIMIT
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- AbA SOILS CROSSED BY PROJECT
- COUNTY BOUNDARY
- STATE BOUNDARY
- USGS QUADRANGLE BOUNDARY

PENNEAST PIPELINE PROJECT

SOIL MAP

FIGURE 7.1-1

CARBON COUNTY
PENNSYLVANIA

2,000 1,000 0 2,000 4,000 FEET

N E S W

ABSOLUTE SCALE: 1:24,000

REFERENCE SCALE: 1 IN = 2,000 FT

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