ATTACHMENT 9
PART 2

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

MAP #42, Plate 1

GREATER PITTSBURGH REGION GEOLOGIC MAP

COMPILED BY W. R. Wagner, J. L. Craft, L. Heyman and J. A. Harper

1975

GROUP	FORMATION		DESCRIPTION	GROUND WATER CHARACTERISTICS	ENVIRONMENTAL ASPECTS
	Alluvium	Qa	Sand, gravel, clay.	refer to "Alluvium, Glacial Outwash, etc." under Geologic Notes section and to O'Neill's M67 listed below.	
	Terrace deposits	Qt	Sand, clay, gravel on terraces above present rivers; includes Carmichaels Formation.		
DUNKARD	Greene	Pg	Cyclic sequences of sandstone, shale, red beds, thin limestones and coals.	Generally a poor water-bearer because of small outcrop area and unfavorable topographic position with most outcrops on ridges. Where saturated, water occurs along joints and bedding plane openings. In the few occurrences of these rocks below stream level, the basal sandstone yields large quantities. Low because fractures are tight and scarce, well yields range from 0.4 to 22 gpm. Well depths range from 30 to 430 feet. Generally good quality water, moderately hard.	Landslides are common in zones where water seeps occur associated with limestone outcrops. These are especially bad where man-made or natural processes work on the base of a slope below a water seep area, and where the top of the slope is loaded by landfill activity. Surface drainage is variable. It is low in areas of shale, claystone, and siltstone and high in areas of sandstone and limestone. Shales and claystone erode easily with siltstone, sandstone, and limestone being much more resistant to erosion. However, these more resistant units form ledges and waterfalls with corresponding undercutting of less resistant materials, all of which collapse if the more resistant rock. There are possible deep mine subsidence problems related to abandoned mines in the Washington Coal and Waynesburg Coal.
	Washington	Pw	Cyclic sequences of sandstone, shale, limestone, and coal; contains Washington coal bed at base.		
	Waynesburg	PPw	Cyclic sequences of sandstone, shale, limestone and coal; contains Waynesburg coal bed at base.		
MONONGAHELA		Pm	Cyclic sequences of shale, limestone, sandstone and coal; contains Pittsburgh coal bed at base.	Most of the porosity and permeability in limestone is the result of enlargement of fractures through solution and removal of minerals by moving ground water. Permeability of sandstone varies greatly according to grain size, degree of sorting, and amount of cementing material. Secondary porosity may be developed by solution and removal of cementing material or by extensive fracturing. Shaly, a fine-grained rather impermeable rock, usually contains water in fracture or joint systems which developed during folding and faulting. Well yields are low because of tight, scarce fractures. Yields range from 0.2 to 15 gpm with the average yield about 3 gpm, adequate for domestic purpose only. Large-diameter wells will have greater yields than small ones for short periods because of greater storage capacity. Deepening wells does not significantly increase the yield. Low yields are partly the result of dewatering by coal mining. Well depths range from 23 to 265 feet with most wells between 100 and 200 feet. Water quality is largely affected by calcium bicarbonate content. Dissolved solids range from 272 to 610 mg/l. Iron ranges from 0.08 to 35 mg/l.	Landslides common in zones where water seeps occur associated with limestone outcrops. Especially bad where man-made or natural processes work on base of slope below the water seep area, and where the top of the slope is loaded by landfill activity. Surface drainage is variable; low in areas of shale, claystone, and siltstone and high in areas of sandstone and limestone. Erodibility of shales and claystone is high with limestone, sandstone, and limestone being much more resistant to erosion. Flowing these more resistant rocks form lips of water falls with corresponding undercutting of resistant materials allowing collapse of more resistant rock into cut channels. There is a high potential of deep mine subsidence in lower part of group related to old abandoned mines in the Redstone Coal in some areas, and in old and new mining in the Pittsburgh Coal.
CONEMAUGH	Casselman	Pcc	The best water-producers are the sandstones where water occupies the void spaces between the sand grains and in the fractures. In the shales and limestones water generally occupies bedding and joint planes, especially near axis of folds. A reliable source of small to moderate supplies of water. Well yields depend on local permeability of aquifers and whether or not the sandstones are drained. Some yields are more than 100 gpm with the median yield for wells in this group of 20 gpm. Sufficient water for domestic purposes can be obtained at most locations from wells drilled 100 to 150 feet below the water table. Yields large enough for industrial and municipal purposes are more difficult to obtain. Groundwater quality varies considerably. The range of dissolved solids is from 99 to 722 mg/l. Hardness ranges from 10 to 263 mg/l and iron content ranges from 0.08 to 25.2 mg/l. The upper limit for iron is 0.3 mg/l.	The rocks of the Conemaugh Group are the most landslide prone of the Greater Pittsburgh Region. Unstable slope conditions are especially common in the middle part of the group, from approximately 100 feet above the Ames limestone to the top of the Buffalo sandstone. Landslides are associated with red-clay shale units, known locally as the "Pittsburgh Red Beds." These red beds are found mainly below the Ames limestone member of the Glenshaw Formation. There is, however, a 10' to 20' thick red-bed unit in the Casselman Formation about 100' above the base. This upper red-bed unit has the greatest potential for urban-associated landslides, as it is associated with slopes suitable for modern development, is not oversteep and they have natural appeal because of aesthetic factors. Ancient landslides are especially common in this stratigraphic sequence. These old slides are extremely unstable when disturbed by construction activity. Possible deep mine subsidence problems related to old abandoned mines and new workings in the Upper Freeport Coal in all areas except Washington County.
	Ames				
	Glenshaw	PCg			
ALLEGHENY	Vanport	Pv	Cyclic sequences of shale, sandstone, limestone, and coal; contains Brookville coal at base and Upper Freeport coal at top; within group are the commercial Vanport limestone and Kittanning and Clarion coals.	Groundwater moves through fractures and pore spaces. In the shaly facies water is contained in joints and bedding plane openings. The best water-bearing units of the group are sandstones that are lenticular and discontinuous; thus, well yields may differ considerably from place to place. The yields will be small and drawdown will be rather large in wells that do not penetrate sandstone. A reliable source of small to moderate supplies of water, with an average yield of 5 gpm. Sufficient water for domestic purposes can be obtained at most locations from wells drilled 100 feet below the water table. Yields large enough for industrial or municipal purposes are very difficult to obtain.	Landslides common in zones of water seeps associated with clay, shale, and underclay. Especially bad where cuts are excavated into base of slope. Numerous minable coals and underclays exist throughout these formations. In some areas, such as Beaver, Butler, and Armstrong Counties, extensive underground mines have been developed for clay resources. Very little is known about the extent of these workings, and there is some possibility of mine subsidence occurring above the abandoned mines.
		Pa			
POTTSVILLE		Pp	Sandstone and shale; contains some conglomerate and locally mineable coal.	Water occurs in pore spaces between grains and in secondary openings (such as fractures) in the rock. The size of openings between grains differs with the degree of sorting of the original material and with the amount of cementation that binds grains together. The Pottsville Group in this area is coarse grained, well sorted, and lightly cemented, and yields moderate to large amounts of water. Well yield depends partly upon depth drilled. A well that completely penetrates the sandstone will yield more water than a partially penetrating well. Few data are available for wells in this aquifer, but the deepest has the highest yield (550 gpm) and the shallowest has the lowest yield (20 gpm).	Maintain a good quality slope at fairly steep angles if severe undercutting of resistant beds does not occur. Good quality foundation stability for heavy structures. Pocono Formation maintains a good quality slope at very steep angles. Excellent quality foundation for heavy structures.
MAUCH CHUNK		Mmc	Red and green shale with some sandstone; contains Wymps Gap and Loyalhanna lime-stones.	Available information is too sparse to make an accurate appraisal of water-bearing characteristics.	
POCONO		Mp	Sandstone and shale with Burgoon sandstone at top.		

SPECIFIC REFERENCES

Ref. No.		Estimated Reliability
1.	Poth, C. W. (1963), *Geology and hydrology of the Mercer quadrangle*, Pa. Geol. Survey, Water Resource Rept 16.	Fair
2.	Sherrill, E. E. Matteson, L. S. (1939), *Geology of the oil and gas fields of the Hillsdale quadrangle*, Pa. Geol. Survey, Prog. Rept. 122.	Fair
3.	Shaw, E. W. and others (1911), *Description of the Foxburg and Clarion quadrangles*, U.S. Geol. Survey, Folio 178.	Fair
4.	Groeber, C. K. and Foose, R. M. (1942), *Geology and mineral resources of the Brookville quadrangle*, Pa. Geol. Survey, Atlas 54.	Fair
5.	deWolf, F. W. (1929), *Geology and mineral resources of the New Castle quadrangle*, Pa. Geol. Survey, Atlas 5.	Fair to Good
6.	Richardson, G. B. (1936), *Geology and mineral resources of the Butler and Zelienople quadrangles*, U.S. Geol. Survey, Bull. 873	Poor
7.	Lytle, W. S. and Heeren, L. (1955), *Oil and gas field atlas of the Butler quadrangle*, Pa. Geol. Survey, Special Bull. 7.	Fair
8.	Butts, Charles (1904), *Description of the Kittanning quadrangle*, U.S. Geol. Survey, Folio 115.	Fair
9.	Butts, Charles (1905), *Description of the Rural Valley quadrangle*, U.S. Geol. Survey, Folio 125.	Fair
9A.	Butts, Charles (1906), *Economic geology of the Kittanning and Rural Valley quadrangles*, U.S. Geol. Survey, Bull. 279.	Good
10.	Shaffner, M. N. (1947), *Geology and mineral resources of the Smicksburg quadrangle*, Pa. Geol. Survey, Atlas 55.	Fair
11.	Edmunds, W. E. (1974), *Preliminary structure contour map of Allegheny, Armstrong, Beaver, Butler, Washington and Westmoreland Counties, Pa.*, U.S. Geol. Survey, Greater Pittsburgh Region Reports # 9, 10, 11, 12, 13, and 14, Pa. Geol. Survey, open file.	Good
12.	Grimsley, G. P. (1907), *Ohio, Brooke, and Hancock Counties*, W. Va. Geol. Survey, County Report.	Fair
13.	Woolsey, L. H. (1905), *Description of the Beaver quadrangle*, U.S. Geol. Survey, Folio 134.	Fair
14.	Munn, M. J. (1911), *Description of the Sewickley quadrangle*, U.S. Geol. Survey, Folio 176.	Fair
15.	Richardson, G. B. (1932), *Geology and coal, oil and gas resources of the New Kensington quadrangle*, U.S. Geol. Survey, Bull. 829.	Fair

REFERENCES TO PUBLISHED SOURCE MATERIAL

Ref. No.		Estimated Reliability
16.	Hughes, H. H. (1933), *Geology and mineral resources of the Freeport quadrangle*, Pa. Geol. Survey, Atlas 36.	Fair
17.	Stone, R. W. (1903), *Description of the Elders Ridge quadrangle*, U.S. Geol. Survey, Folio 123.	Fair
18.	Shaw, E. W. and Munn, M. J. (1911), *Description of the Burgettstown and Carnegie quadrangles*, U.S. Geol. Survey, Folio 177.	Good
19.	Johnson, M. E. (1928), *Geology and mineral resources of the Pittsburgh quadrangle*, Pa. Geol. Survey, Atlas 27.	Good
20.	Johnson, M. E. (1926), *Geology and mineral resources of the Greensburg quadrangle*, Pa. Geol. Survey, Atlas 37.	Fair
21.	Campbell, M. R. (1904), *Description of the Latrobe quadrangle*, U.S. Geol. Survey, Folio 110.	Good
22.	Shaffner, M. N. (1958), *Geology and mineral resources of the New Florence quadrangle*, Pa. Geol. Survey, Atlas 57.	Fair
23.	Phalen, W. C. (1910), *Description of the Johnstown quadrangle*, U.S. Geol. Survey, Folio 174.	Fair
24.	Schweinfurth, S. P. (unpublished), *Structure contour map of the Amelia and part of the Steubenville East quadrangles.*	Good
25.	Roen, J. B. (1971), *Preliminary geologic map of the Midway quadrangle*, U.S. Geol. Survey, Misc. Field Studies Map 319.	Good
26.	Schweinfurth, S. P. (unpublished), *Structure contour map of the West Middleton and part of the Bethany quadrangles.*	Good
27.	Berryhill, H. L and Swanson, V. E. (1954), *Geology of the Washington West quadrangle*, U.S. Geol. Survey, GQ 283.	Good
28.	Swanson, V. E. and Berryhill, H. L. (1964), *Geology of the Washington East quadrangle*, U.S. Geol. Survey, GQ 334.	Good
29.	Kent, B. H. (1967), *Geologic map of the Hackett quadrangle*, U.S. Geol. Survey, GQ 630.	Good
30.	Roen, J. B. (1968), *Geologic map of the Manongahela quadrangle*, U.S. Geol. Survey, GQ 743.	Good
31.	Campbell, M. R. (1903), *Description of the Brownsville and Connellsville quadrangles*, U.S. Geol. Survey, Folio 94.	Fair to Good
32.	Shaffner, M. N. (1963), *Geology and mineral resources of the Monongahela quadrangle*, Pa. Geol. Survey, Atlas 48.	Fair
33.	Richardson, G. B. (1934), *Description of the Somerset and Windber quadrangles*, U.S. Geol. Survey, Folio 224.	Fair
34.	Roen, J. B. and Ferrell, D. E. (unpublished), *Structure contour map of the Pittsburgh coal bed, southwest Pennsylvania, adapted from Munn, M. J.* (1912), *Description of the Claysville quadrangle*, U.S. Geol. Survey, Folio 180 and Clapp, F. G. (1907), *Description of the Rogersville quadrangle*, U.S. Geol. Survey, Folio 146.	Fair to Good
35.	Kent, B. H. (unpublished), *Structure on the Pittsburgh coal in the Prosperity quadrangle.*	Good
36.	Berryhill, H. L. (1964), *Geology of the Amity quadrangle*, U.S. Geol. Survey, GQ 296.	Good
37.	Berryhill, H. L. and Schweinfurth, S. P. (1964), *Geology of the Ellsworth quadrangle*, U.S. Geol. Survey, GQ 333.	Good
38.	Schweinfurth, S. P. (1967), *Geologic map of the California quadrangle*, U.S. Geol. Survey, GQ 648.	Good
39.	Roen, J. B. (1970), *Geologic map of the Waynesburg quadrangle*, U.S. Geol. Survey, GQ 838.	Good
40.	Kent, B. H. (1969), *Geologic map of the Mather quadrangle*, U.S. Geol. Survey, GQ 826.	Good
41.	Kent, B. H. (1969), *Geologic map of part of the Carmichaels quadrangle*, U.S. Geol. Survey, Misc. Geol. Inv. Map 588.	Good

GENERAL REFERENCES

Patterson, E. D. (1963), *Coal resources of Beaver County, Pennsylvania*, U.S. Geol. Survey, Bull. 1143-A.

Patterson, E. D. and Van Lieu, J. A. (1971), *Coal resources of Butler County, Pennsylvania*, U.S. Geol. Survey, Bull. 1143-C.

GEOLOGIC NOTES

STRATIGRAPHIC COLUMN

The rocks exposed at the surface of the six-county area of the Greater Pittsburgh Region have been subdivided into many map units on the basis of the characteristics of the rocks. Generally speaking, the rocks throughout this region are highly complex interlayers of shales, sandstones, siltstones, claystones, limestones, coals, and underclays, of varying thicknesses and areal extent. Unconsolidated glacial materials are found in the northwest part of the map area and in the major southward-flowing stream valleys. These deposits consist of clay, silt, sand, and gravel varying significantly in total thickness.

The boundaries between groups have been established on contrasts between readily identifiable thinner rock units. The base of the Pottsville Group is the most difficult boundary to recognize in the field, as it is based on a buried erosional surface. Marker beds separating the other groups are regionally significant coal beds: the bottom of the Brookville Coal is the base of the Allegheny Group; the top of the Upper Freeport Coal is the base of the Conemaugh Group; the base of the Pittsburgh Coal is the base of the Monongahela Group; and the base of the Waynesburg Coal is the bottom of the Dunkard Group.

Formations are established on recognizable rock units that can be traced over some distance. The thickness and rock-type of the different rock units are shown on the accompanying generalized stratigraphic column. The names to the right of the symbols on the column are local names used to designate this but recognizable rock units within a local area. The thickness shown is the range of thickness throughout the map area.

REPRESENTATIVE ROCK-TYPES

Sandstone

Description

A rough grainy rock composed of individual fragments ranging in size from 1/16 mm to 4 mm. Grains are bonded together by clay minerals, iron oxide, calcium carbonate or silica. The grains are accumulated together in layers from a fraction of an inch to many feet thick forming distinct consolidated beds. Sandstone can be identified by the presence of recognizable individual particles and a gritty feel.

Engineering Characteristics

Sandstones provide moderate to excellent foundation support, but are difficult to excavate and may require blasting. Bedded sandstone units between mined-out coal zones and the surface tend to provide a support structure preventing surface subsidence. Frequently a void zone occurs immediately below a thick sandstone unit where mine collapse has propagated toward the surface and has stopped at the base of the sandstone. Care should be taken not to overload such suspended sandstones. If failure of these sandstone roof rocks has occurred, it is usually expressed upward to the surface. Vertical jointing (cracks through the rock) plays an important role in support strength in sandstone units. The closer the jointing, the lower the support capacity of the rocks. High clay content in a sandstone makes a weaker, softer rock than other cementing materials. A sandstone cemented by calcium carbonate may be very weak structurally unless the zone of weathering where the calcium carbonate has been removed by weathering processes. However, it will be strong in the subsurface where the cement is present in the unweathered rocks.

Economic Uses

Sandstones, occurring at various intervals throughout the stratigraphic column are used as crushed rock, rough building stone, dimension block, and flagstone.

Shales, Claystones, Siltstone, Mudstones

Description

A wide variety of very-fine-grained rocks scattered throughout the area. "Mudstones" are a heterogeneous mixture of poorly bedded, shaley rock. "Claystone" is a soft plastic rock made up largely of clay-size particles of clay minerals. Shales are very-fine-grained rocks that have well developed bedding surfaces and siltstones are well bedded like shales but of coarser grain size. Mudstones are commonly associated with shale, siltstone and sandstone layers. Claystone is most commonly associated with coal beds, lying directly under the coal.

Engineering Characteristics

Mudstones, shales, and siltstones provide moderately durable foundation support. Generally will require blasting for deep excavation. Forms relatively stable cut-slopes but provides very little support of mine-subsidence prone areas. Clay, claystone and clay-shales generally provide weak foundation support but are easily excavated. They form unstable cuts because the material becomes plastic when wet and has a tendency to slump and provide no support over mined-out area. Most of this type of material can be excavated with light power equipment.

Economic Uses

Claystones and shales, very common in the area, are used for a variety of products: light-weight aggregate, face and building brick, medium-duty refractories, acid-resistant brick, sewer and drain tile, fire brick, and furnace linings.

Limestone

Description

A dense, hard rock composed mainly of the mineral calcite (calcium carbonate) and occurring as sharply-defined layers. Individual thicknesses vary from a fraction of an inch to more than three feet. Most limestone layers are separated from each other by thin claystone or mudstone layers. Throughout the area, limestones tend to have a high silt-clay content and have a tendency to break down rather rapidly in the zone of weathering. By scratching a fresh surface of the rock and dropping dilute hydrochloric acid on the resulting powder, one can confirm the presence of calcite if bubbles develop and conclude that the rock is limestone.

Engineering Characteristics

Limestones provide moderate to excellent foundation support. Excavation may require blasting. Most limestones throughout the area have a high frequency of jointing. Springs and water seeps are frequently encountered at the lower contact with shales. Individual fragments have high bearing capacity; however, jointing and the presence of interbedded clay and shale layers decrease the strength of the rock mass. A limestone roof rock over mined-out areas tends to collapse more readily than sandstone.

Economic Uses

The Vanport, Ames, and Greenbrier limestones maintain consistant physical characteristics and chemical compositions over wide areas. The Vanport Limestone, the most important, supplies stone for flux, cement, and constructional purposes.

Alluvium, Glacial Outwash, Etc.

Description

Unconsolidated deposits consisting of sand and gravel with varying amounts of silt and clay. Pebbles and gravel usually rounded to well rounded; sand grains commonly angular. Thicknesses of 1 to more than 150 feet present in deposits adjacent to many of the streams and rivers of the area.

Engineering Characteristics

These unconsolidated materials provide poor foundation support, but are easily excavated. Excellent drainage where situated above the water table. Forms unstable cuts and requires special design for foundations because of irregular distribution of materials and unconsolidated nature. Provides no support over mined-out area. When mine collapse fractures intersect with the ground water these unconsolidated materials, differential settling occurs and can cause structural damage to buildings.

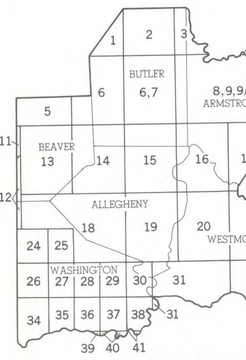
Economic Uses

Sand and gravel is available in large supply in parts of the region. In the northwest, thick glacial deposits contain large reserves of sand and gravel. Dredging is taking place in the Allegheny River near Tarentum and Natrona and in the Ohio River near East Liverpool. Operations are also underway in the high level river terraces at Harmarville.

COAL, OIL AND GAS

Large reserves of bituminous coal are present in the six-county area. The major coal seams are the Mercer of the Pottsville Group, Brookville, Middle Kittanning, and Upper Freeport of the Allegheny Group; Brush Creek and Bakerstown of the Conemaugh Group; Pittsburgh and Sewickley of the Monongahela Group; and the Waynesburg and Washington of the Dunkard Group.

The Greater Pittsburgh Region has produced large volumes of oil and gas in the past but current production is very low. Crude oil is produced in Allegheny, Beaver, Butler, and Washington Counties. During the last decade very few new oil wells have been drilled. The most active area of drilling is Westmoreland County. About 75 percent of the original oil in place is still present in the sandstones. The current trend is to use secondary and tertiary recovery methods to produce this remaining oil. Natural gas is produced in all of the six counties with most of the deep gas, 5,000 feet in depth or deeper, being produced in Westmoreland County. The gas is generally present on the flanks and along the axis of the anticlines while the oil is present in the synclines.



INDEX MAP TO SOURCE MATERIAL
(Numbers Refer to Source Reference List)

GEOLOGIC COLUMN

This map is a compilation and updating of geologic maps, some published at a scale of 1:62,500 (one inch equals approximately one mile) and others compiled at 1:24,000 (one inch equals 2000 feet). The geologic contacts have been adjusted to the topography of the 7½-minute topographic quadrangles (scale 1:24,000) and have been modified to agree with subsurface data. The maps, in many cases, represent major revisions of previous work at various scales. The position of the geologic contacts have not been field checked. After preparing the structural contours and geologic contacts on the 7½-minute topographic bases, the bases were reduced to 1:125,000 and assembled. The late W. R. Wagner developed this plan of construction and was senior compiler. The individual 7½-minute quadrangles showing structure and geologic contacts may be examined at the Pennsylvania Geological Survey in Pittsburgh.

Prepared by the
PENNSYLVANIA BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
in cooperation with the
UNITED STATES DEPARTMENT OF THE INTERIOR,
GEOLOGIC SURVEY
under U.S.G.S. Grant #14-08-0001-G-70

John G. Kuchinski, Cartographic Draftsman

UTM GRID AND 1972 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:125 000
1 inch equals approximately 2 miles
1 centimeter equals 1.25 kilometers

CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

LOCATION DIAGRAM

Greater Pittsburgh Regional Studies

1. O'Neill, B. J. (1974), *Greater Pittsburgh region construction aggregates*, Pa. Geol. Survey, 4th., ser., Min. Resource Rept. 67
2. Wagner, W. R., Heyman, Louis, Craft, J. L., Edmunds, W. E., and Harper, J. A. (1975) *Greater Pittsburgh region structure contour map of Allegheny, Armstrong, Beaver, Butler, Washington and Westmorland Counties*, Pa. Geol. Survey, 4th ser., Map #43.
3. Lytle, W. S. and Baloga, Lajos (1975), *Greater Pittsburgh region oil and gas fields map*, Pa. Geol. Survey, 4th ser., Map #44.
4. Curtis, S. E., Alexander, T. B., Edmunds, W. E., and Craft, J. L. (1975), *Greater Pittsburgh region maps of mined-out areas and thickness of rock over the Pittsburgh coal*, Pa. Geol. Survey, 4th ser., Map #45.

Mapped, edited, and published by the U. S. Geological Survey
Control by USGS, USC&GS, USCE, the city of Pittsburgh, and Pennsylvania Geodetic Survey
Compiled in 1971 from USGS quadrangles dated 1953–1969
Lambert Conformal Conic projection. 1927 North American datum
50,000-foot grids based on Pennsylvania coordinate system, south and north zones
10,000-meter Universal Transverse Mercator grid ticks, zone 17

Williams & Heinitz Map Corporation, Washington, D. C. 20007

ATTACHMENT “G”

Geological Data on the Injection and Confining Zones

Attachment G
Geological Data on Injection and Confining Zones
SEDAT #4A Injection Well

Geological Data for Sedat #4A Injection Well

The Sedat #4A injection well will be a repurposed depleted natural gas well located in the Renton Gas Field in Plum Borough, Allegheny County, Pennsylvania. The injection well will target the Murrysville Sand as the injection zone which is water saturated and located very near the axis of the Duquesne-Fairmount syncline, see the copy of a section of Pittsburgh Region Structure Contour Map (Map 1) included with this attachment. Also included is a Geologic Map of the western part of Allegheny County, PA (Map 2). The immediate area around the well has been striped mined for coal (Pittsburgh Seam) and mined by underground methods for coal (Upper Freeport Seam); see the Area of Review map in Attachment B.

There are 14 wells within the 1/2 mile Area of Review (ARO) that penetrate the Murrysville sand, the state permit numbers for the wells are:

Permit #	Permit #	Permit #	
003-21287	003-21210	003-22200	003-21223
003-21222	003-21644	003-21238	003-21438
003-21228	129-23348	129-23085	
003-21225	003-20903	003-21868	

All the wells were cased and cemented through the Murrysville. Well 003-00674 was plugged. The well records can be found in Attachment B. The Sedat #3A well (003-21223) has been issued an EPA UIC permit (PAS2D701BALL) and has been repurposed for injection. The Sedat #1A (003-21210) will be converted to an observation well for the Sedat #3A injection well. The Sedat #2A well (003-21222) will be converted to an observation well for the Sedat #4A injection well.

The Murrysville Sand is approximately 94’ thick, and lies at a depth of 1,706’ to 1,800’ in the Sedat #4A AOR. The well had an original TD of 3,886’ and will be plugged back to 1,850’ to just below the injection zone. See Attachment M Construction Details for well schematic and cement data. Fluid will be injected into a 60’ section of the Murrysville Sand through a 2⅞” injection string set on a packer at approximately 1,650’ in 4½” casing cemented to surface and into perforations in the 7” casing from 1,740’ to 1,800’. The confining zones are the Riddlesburg Shale (Sunbury Equivalent) which overlays the Murrysville with the Riceville-Oswayo Shale lying underneath as the lower confining zone.

The upper confining zone lying directly on top of the Murrysville is the Riddlesburg Shale. The Riddlesburg is a dark gray to greenish and grayish black laminated shale and siltstone with occasional sandstone and limestone beds. The Riddlesburg is

between 80 to 90 feet thick in the Sedat #4A AOR; see the Riddlesburg Isopach map, Map 3 at the end of Attachment G.

The Murrysville is a greenish-yellow to gray sandstone with occasional conglomeratic lenses, with high porosity and permeability. Because of the Murrysville's thickness, high porosity and permeability the formation serves as a gas storage reservoir to the south of the Sedat lease. All most all the wells in the AOR including the Sedat #4A were drilled and cased through the Murrysville without running a porosity logs, see the well records in Attachment B. There are two wells for which porosity logs are available that show the average density porosity through the Murrysville Sand to average around 24%, which agrees with published reports of porosity values in the Murrysville. Refer to the log sections and location map at the end of this attachment for wells permit # 129-24721, and well permit #129-25581. Both wells where saturated with brine and did not produce gas.

Penneco conducted several tests to determine the reservoir characteristics of the Murrysville on this lease with the results included at the end of Attachment H. The test provided a breakdown pressure, the pressure needed to initiate a fracture, as 3,115 psi, ISP is estimated as 1,114 psi, with a fracture gradient of 1.23 psi. The reservoir pressure is 232 psi, with an estimated closure pressure of 553 psi. See the supplement to the HFrac report labeled Item 5 for more detail on the methodology used to determine the fracture gradient.

Formation permeability for the Murrysville was reported by Melissa Sager (Petrologic Study of the Murrysville sandstone in SW PA, 2007) as generally high throughout the formation, with a range of 0.005 to 1,000 millidarcies and an average of around 100 millidarcies. The permeability of the Murrysville in the Sedat #4A is estimated to be 1.8 mD and was determined from a series of tests performed on the Sedat #3A well to determine the reservoir characteristics of the Murrysville sand on Penneco leases. The tests were conducted by HFrac Consulting Services, LLC (see the supplement to the HFrac report labeled Item 7 at the end of this attachment for additional detail). This value falls within the lower range of Sager's study.

The Riceville-Oswayo Shale lying directly beneath the Murrysville serves as the lower confining zone. The Riceville-Oswayo is about 30 feet thick in the AOR; see Map 4, Isopach map of the Oswayo Shale. The Riceville-Oswayo formation consists of dark gray to medium gray shale and siltstones.

Structurally the AOR has a series of northeast-southwest trending anticlines and synclines with the Sedat #4A well lying along the axis of the Duquesne-Fairmount syncline refer to Map 1. While there are some deep seated basement faults associated with the Rome Trough, review of Map 1, Map 2 and an additional structure map contoured on the top of the Murrysville Sand and additional cross sections across the AOR supports the idea that there are no apparent faults at shallower depths in the AOR. The Murrysville structure map along with additional cross sections across the AOR are

from McDaniel's Subsurface Stratigraphy and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA.

Review of Pennsylvania Geologic Publication, Atlas No. 36, Geology of the Freeport Quad (the Sedat #4A is in the SW corner of the quad) states on page 23 "displacement faults where not seen in any outcrop. Inquiry among mine operators indicate practically the same thing". Penneco Environmental Solutions, LLC had a related company that at one time mined in the AOR and a search of its records supports the statement found in Atlas No. 36.

The U.S.G.S rates the probability of seismic activity in SW Pennsylvania with sufficient intensity to cause damage as low. A series of four earthquake maps from the U.S.G.S earthquake hazards program website are found at the end of this attachment.

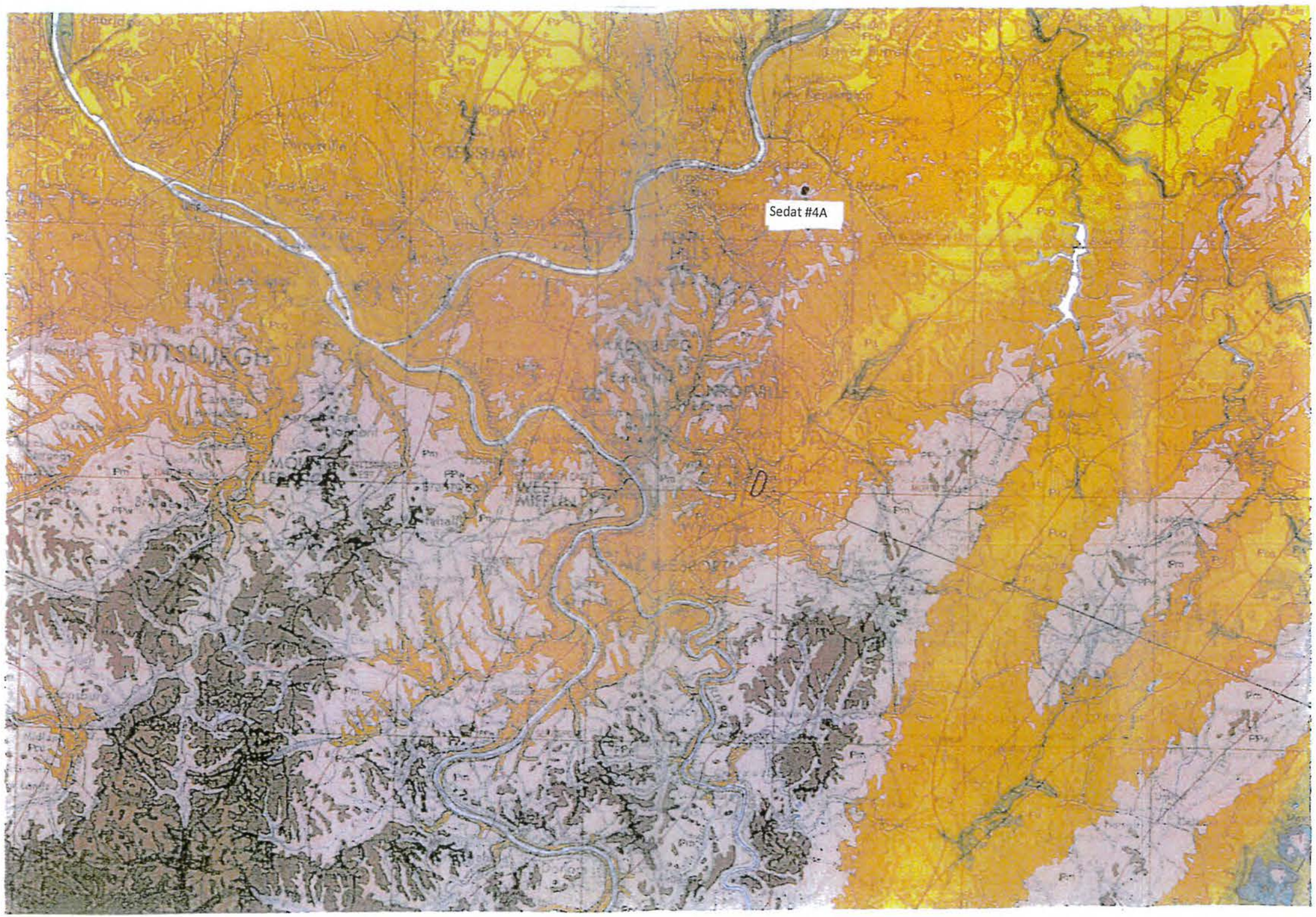
Earthquake Map 1 shows the historical locations of earthquakes in Pennsylvania and nearby areas. Earthquake Map 2 shows the entire US color code to show the chance of a seismic event occurring from lowest to highest. Map 1 shows no seismic events are shown to have occurred in SW PA, and Map 2 shows the AOR lies in an area with the second lowest hazard level.

Earthquake Maps 3 and 4 are from U.S.G.S. open file report 2016 One Year Seismic Hazard Forecast for the Central and Eastern United States from Induced and Natural Earthquakes OFR-2016-1035. Map 3 shows there is a small chance (one percent) that ground shaking greater then IV on the Modified Mercalli Scale will occur. Map 4 indicates the change of damage in the NE from natural or induced seismic activity to be 1% to 2%.

Penneco also contends that the maximum injection pressure is sufficiently below the pressure needed to initiate a fracture or reactive any unknown faults. The injection rate is also not of a sufficient volume to open or extend any fractures or reactive any unknown faults in the area, see the HFRAC report in Attachment I.

.

Map 2
From Pa Geologic Map
1980



SCALE 1:250,000

5 0 5 10 15 Miles

5 0 5 10 15 20 25 Kilometers

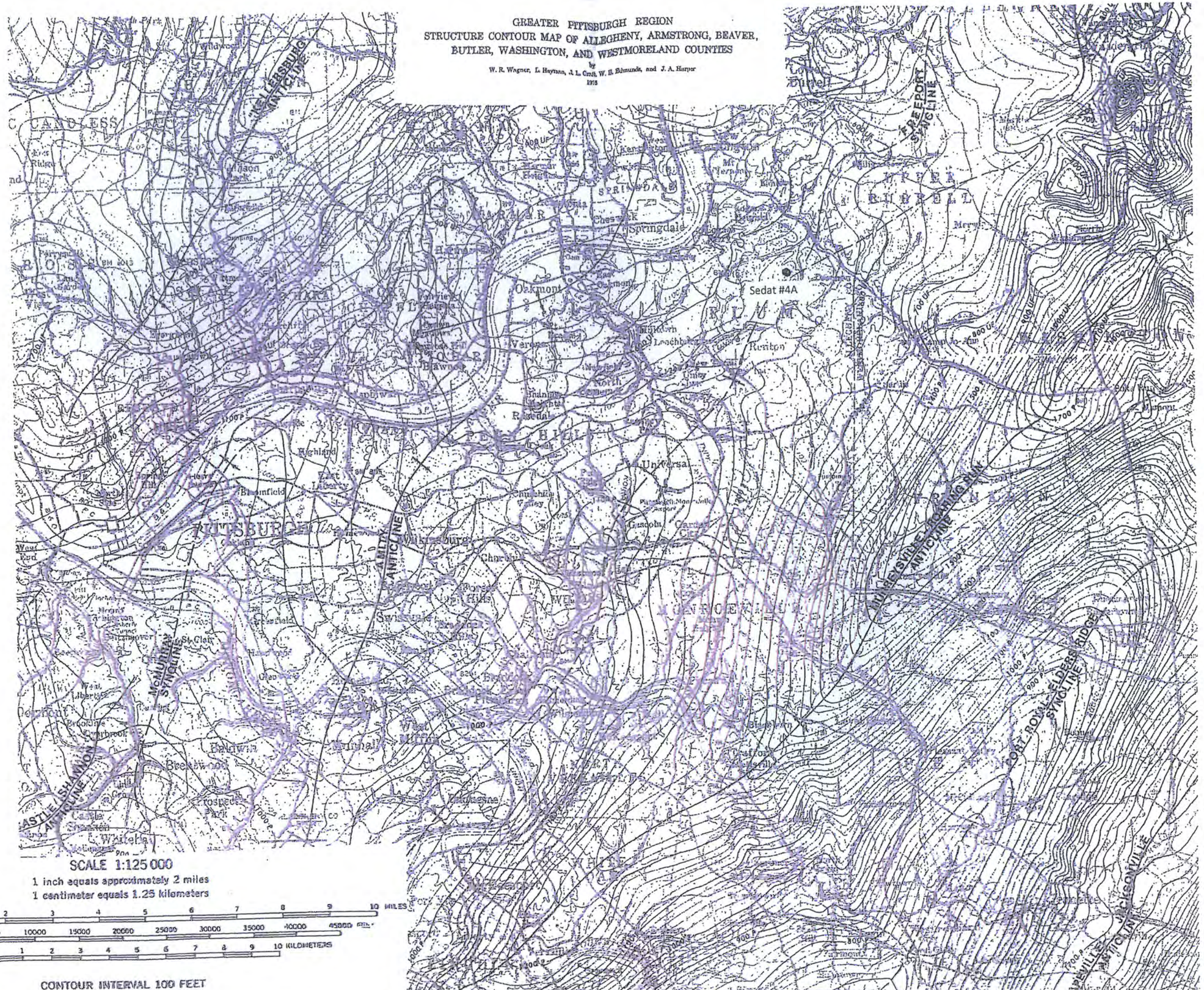
5000 0 5000 10000 15000 20000 25000 Yards

ONE INCH EQUALS APPROXIMATELY FOUR MILES

Map 1

GREATER PITTSBURGH REGION
STRUCTURE CONTOUR MAP OF ALLEGHENY, ARMSTRONG, BEAVER, BUTLER, WASHINGTON, AND WESTMORELAND COUNTIES

by
W. R. Wagner, L. Hayman, J. L. Craft, W. B. Edmunds, and J. A. Harper
1973



SCALE 1:125 000

1 inch equals approximately 2 miles
1 centimeter equals 1.25 kilometers

½ 0 1 2 3 4 5 6 7 8 9 10 MILES
5000 0 5000 10000 15000 20000 25000 30000 35000 40000 45000 FEET
1 ½ 0 1 2 3 4 5 6 7 8 9 10 KILOMETERS

CONTOUR INTERVAL 100 FEET
DATUM IS MEAN SEA LEVEL

MARC

SUPERIOR WELL SERVICES

SUPERIOR
Black Lick, Pa
Mercer, Pa
Wooster, Ohio
Charleston, W Va

GR / NEU
CDL / DIL
TEMPERATURE

CPNY PENNECO OIL COMPA Y , INC.
WELL SEDAT # 4A
FIELD NEW KENSINGTON EAST
CO. ALLEGHENY ST PA.

COMPANY PENNECO OIL COMPANY , INC.
WELL SEDAT # 4A PS-748
FIELD NEW KENSINGTON EAST
COUNTY ALLEGHENY STATE PA.

LOCATION
P/N - 37-003-21644-00
749' WEST 79-42-39.70
5366' SOUTH 40-31-36.90

SEC. ______ TWP. PLUM RGE. ______

OTHER SERVICES:
TIF FILE
2.0" SCALE
ANALYSIS

PERMANENT DATUM GL = 7.0" ELEV. 1068'
LOG MEASURED FROM TOP OF 7.0" ABOVE PERMANENT DATUM
DRILLING MEASURED FROM KB

ELEV.: K.B. 1079'
D.F. 1078'
G.L. 1068'

DATE	07-07-2004			
RUN NO.	ONE			
DEPTH-DRILLER	3925'			
DEPTH-LOGGER	3925'			
BTM. LOG INTER.	3925'			
TOP LOG INTER.	GR / SURFACE			
CASING-DRILLER	7.0" @ 1907'			
CASING-LOGGER	7.0" @ 1907'			
BIT SIZE	6.25"			
FLUID TYPE	AIR			
DENS. : VISC.	N/A			
PH : FLUID LOSS	N/A			
SOURCE OF SAMPLE				
RM @ MEAS. TEMP.				
RMF @ MEAS. TEMP.				
RMC @ MEAS. TEMP.				
SOURCE: RMF/RMC				
RM @ BHT				
TIME SINCE CIRC.				
MAX. REC. TEMP.				
EQUIP.: LOCATION	0041/BLACKLICK	PA		
RECORDED BY	KACHONIK			
WITNESSED BY	MR. HUMMEL	MR. HILL		

REMARKS:

MDEN - 2.68 CDL # 2473
FDEN - 1.0 DIL # 5272

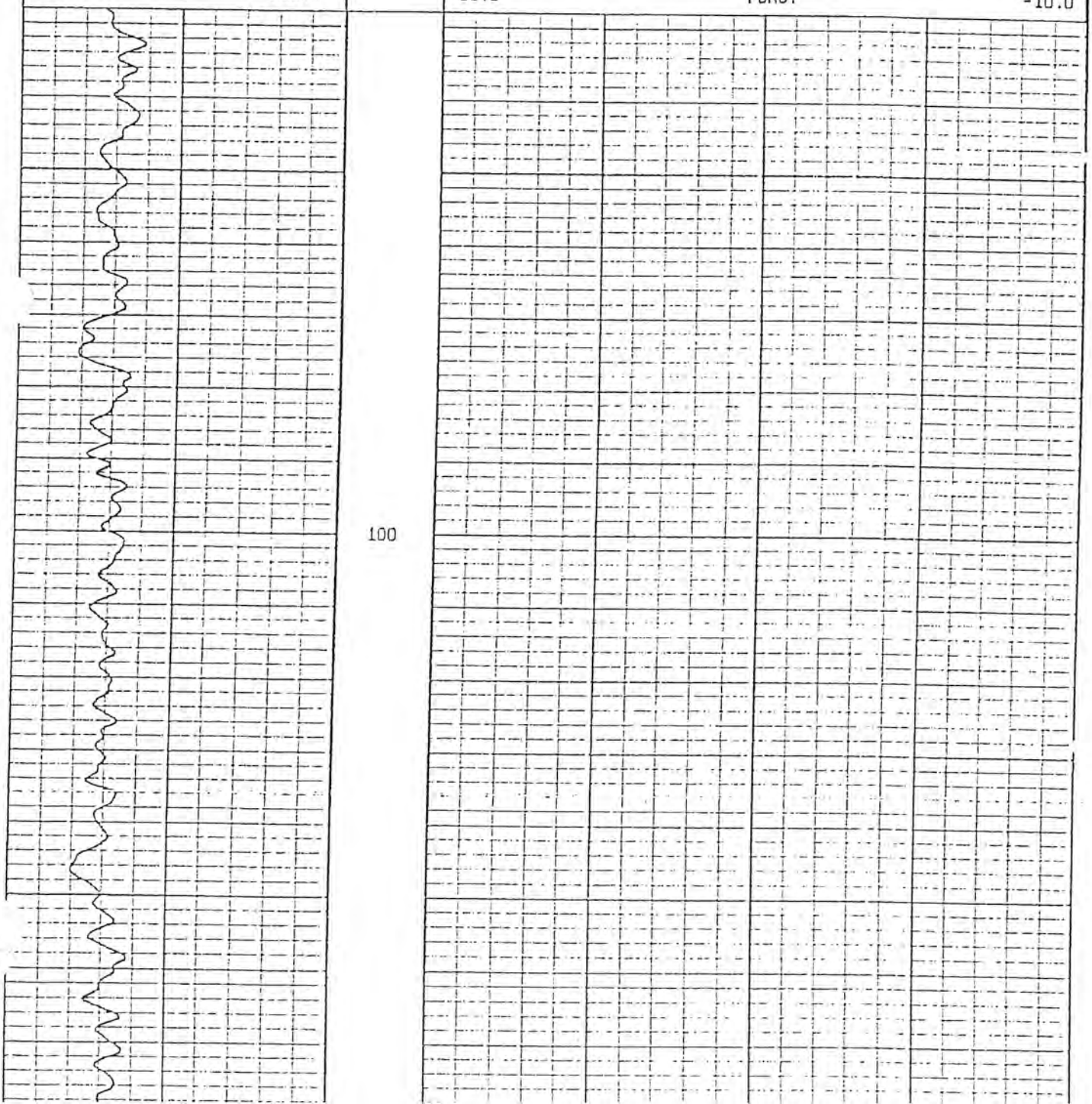
CREW : BREAKIRON , STUMPF
TEMPERATURE LOGGED UPHOLE
THANK YOU FOR CHOOSING SUPERIOR WELL SERVICES

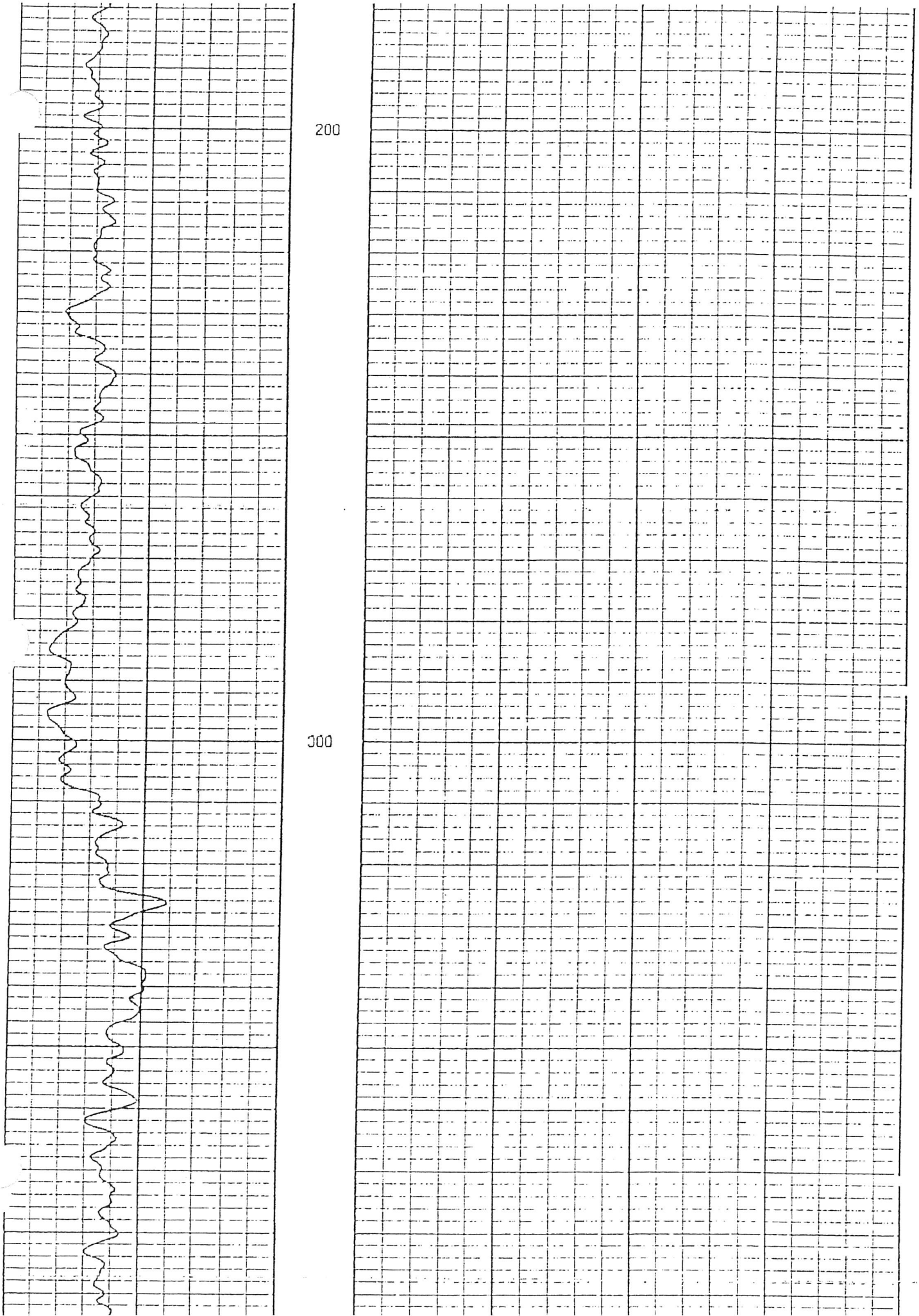
STOP DEPTH: 28.2 FEET
DIRECTION: UP 1:240

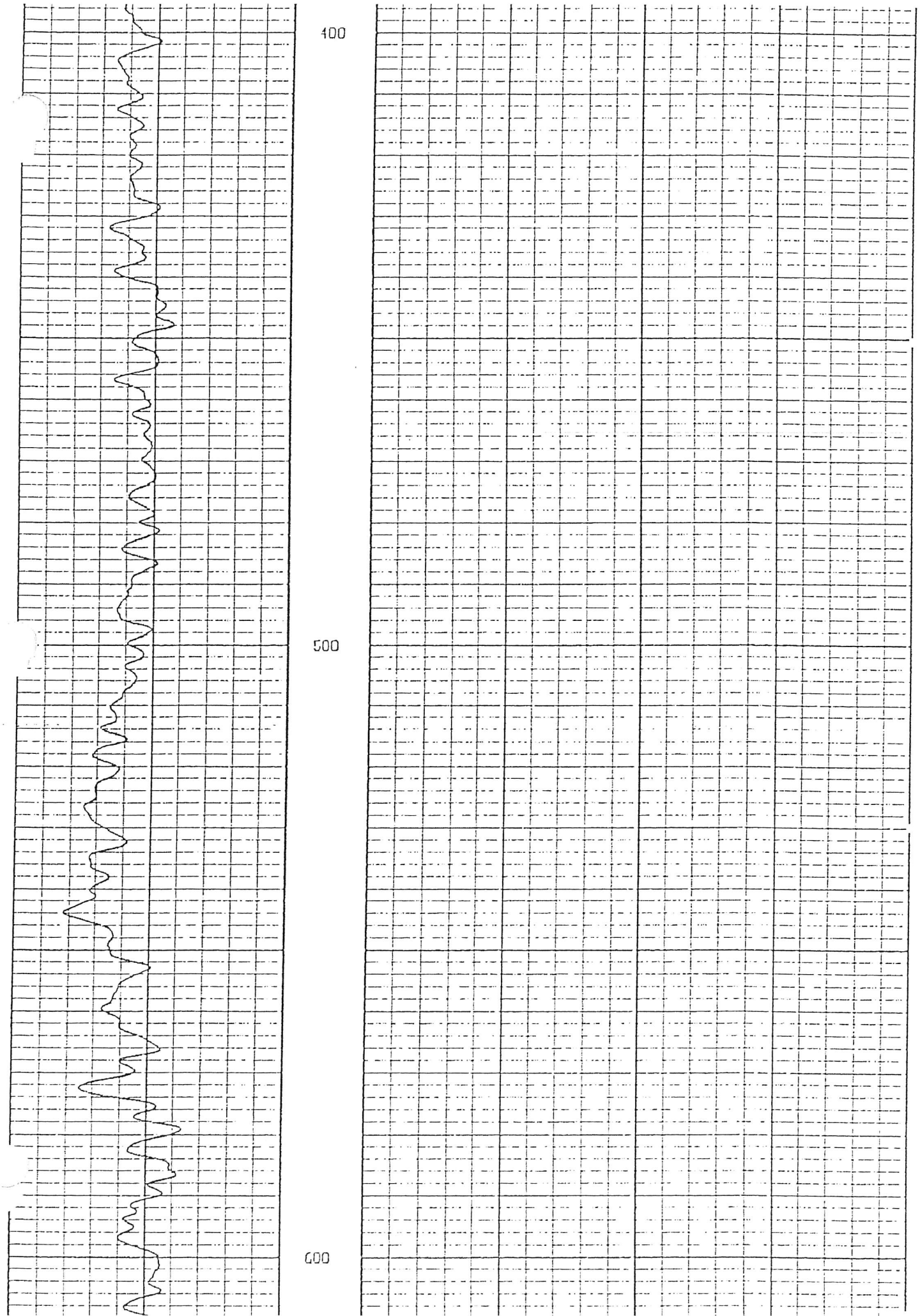
MAIN

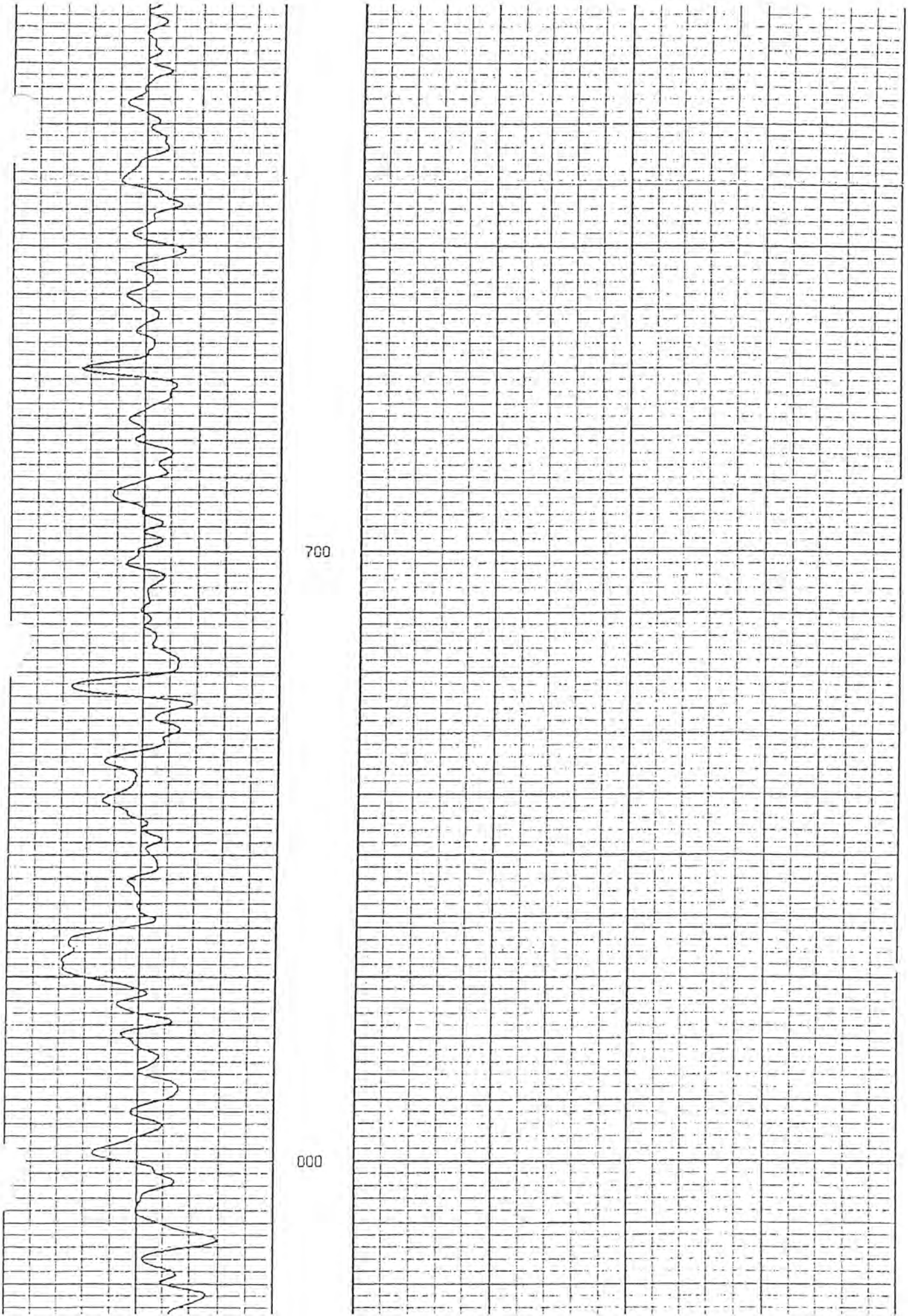
FILE DATE: 07-07-2004
TIME: 04:47

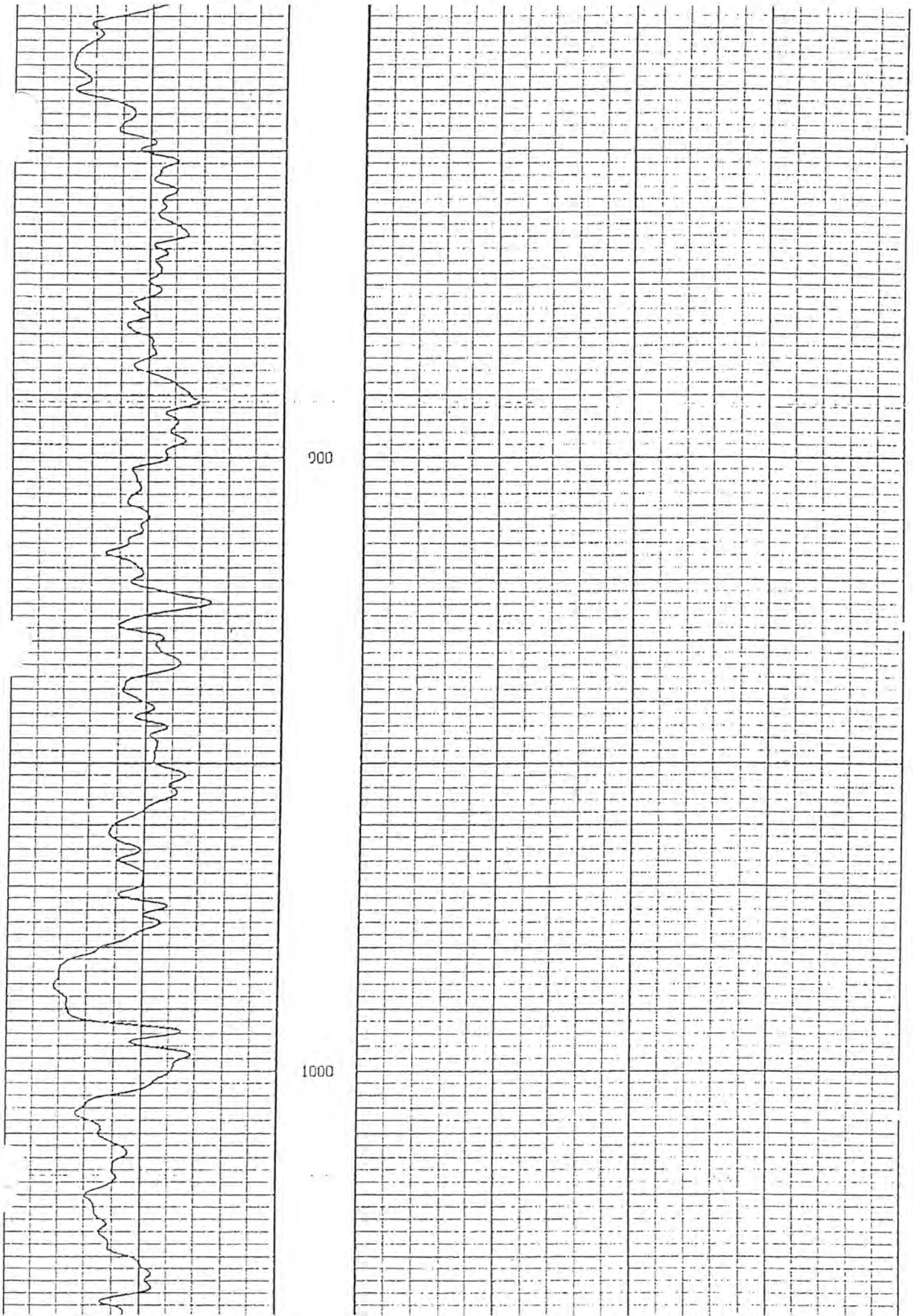
	MInR	
0.00	OHMM	100.00
	ILD	
0.00	OHMM	100.00
	CORR	
-0.25		0.25
	Temperature	
70.0	F	75.0
	DENSITY	
30.00	PORO.	-10.00
	CBD	
2.00	g/cc	3.00
	NEUTRON	
30.0	PORO.	-10.0
	DifTemp	
-10.0	Delta	10.0
	CALIPER	
5.0	inch	15.0
	GAMMA RAY	
0.0	API	200.0

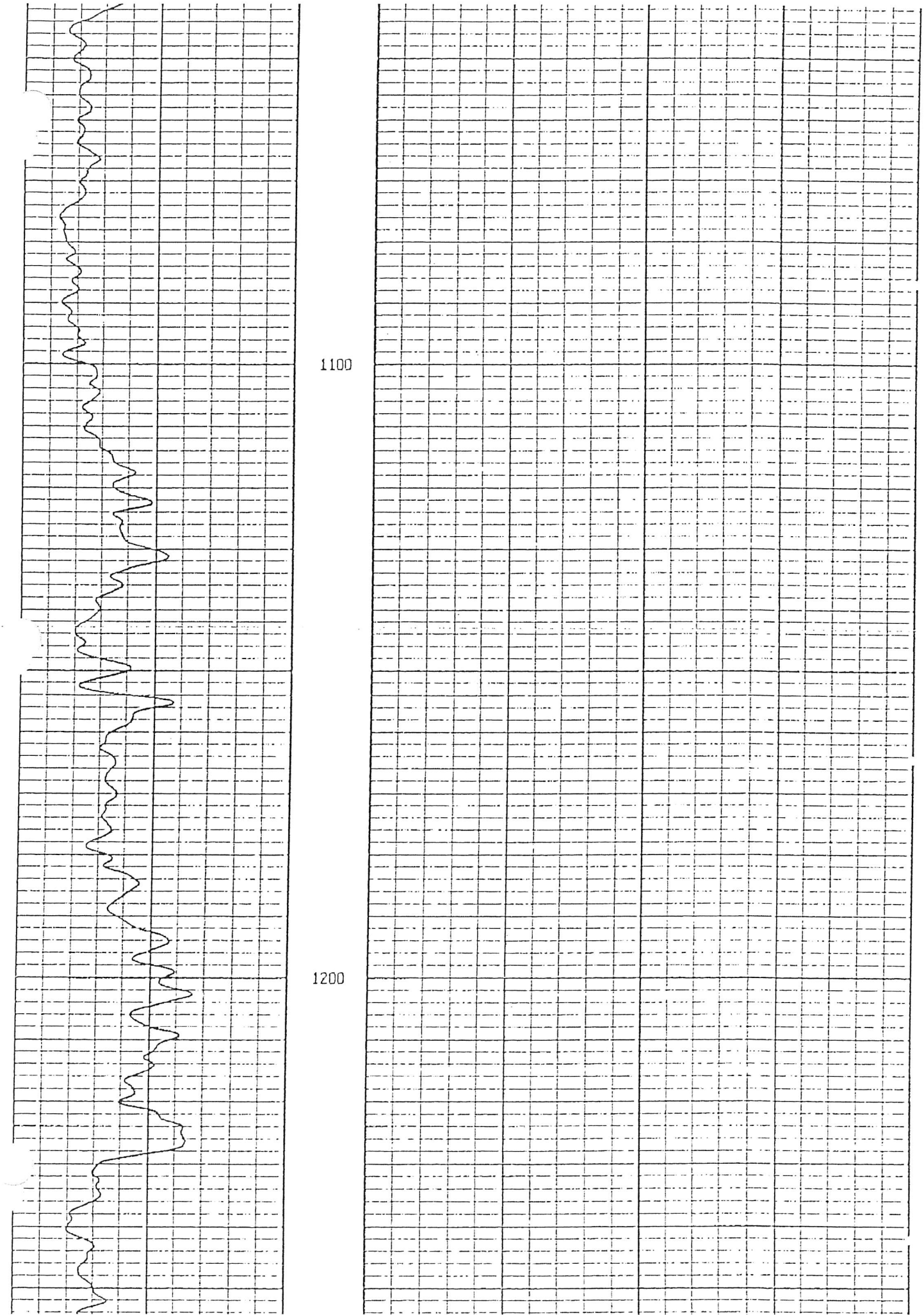


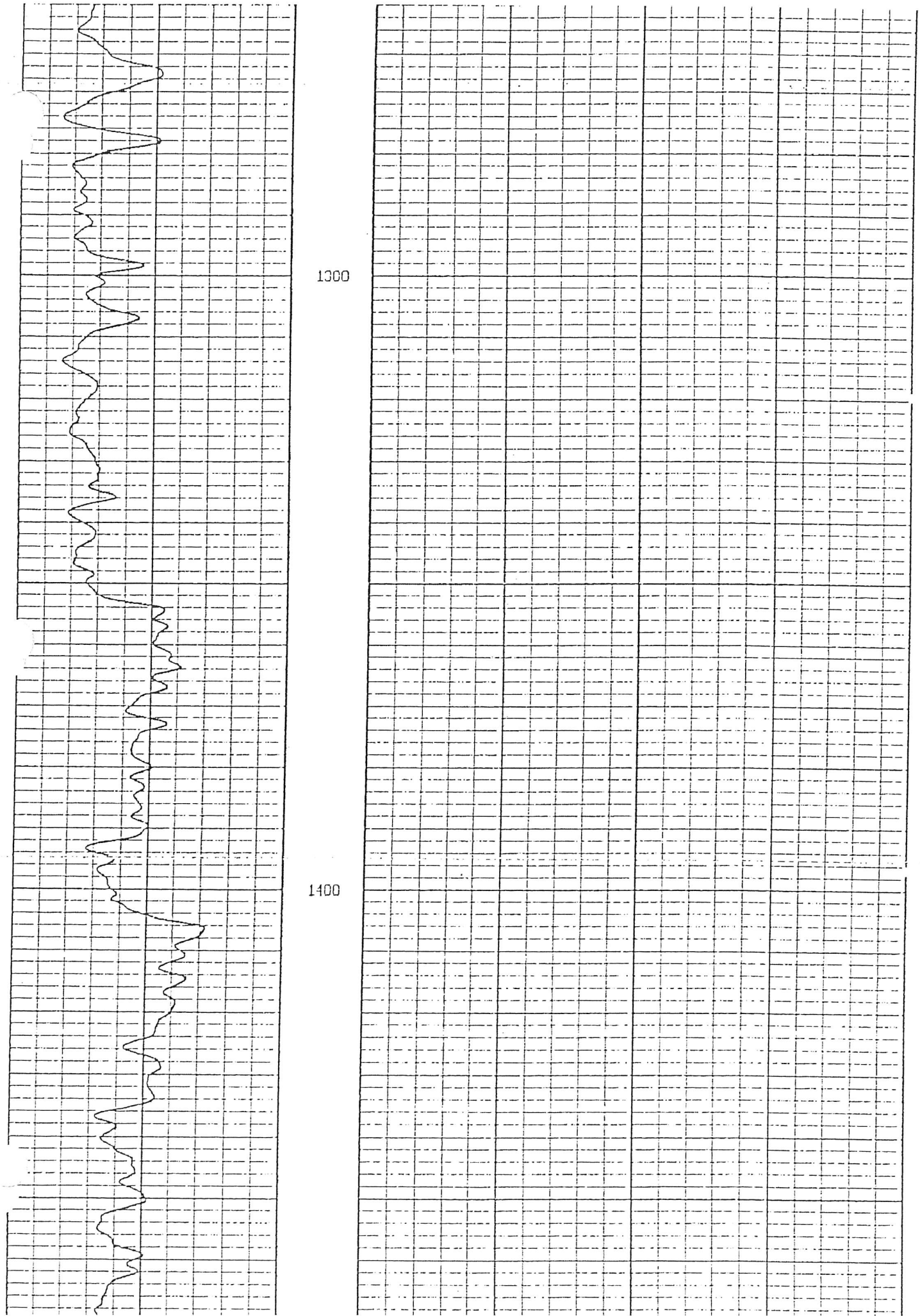

200
300

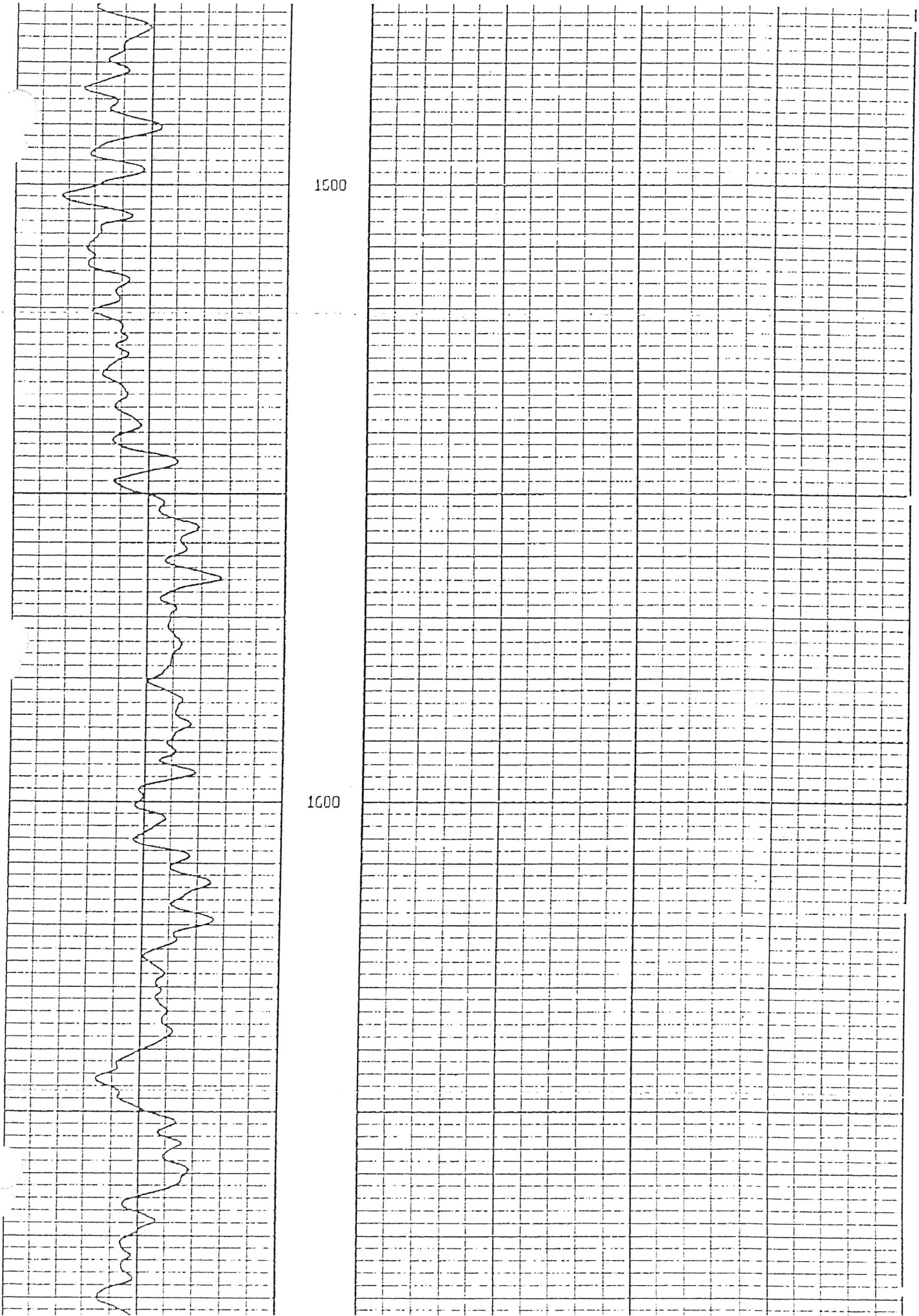

400
500
600


700
000

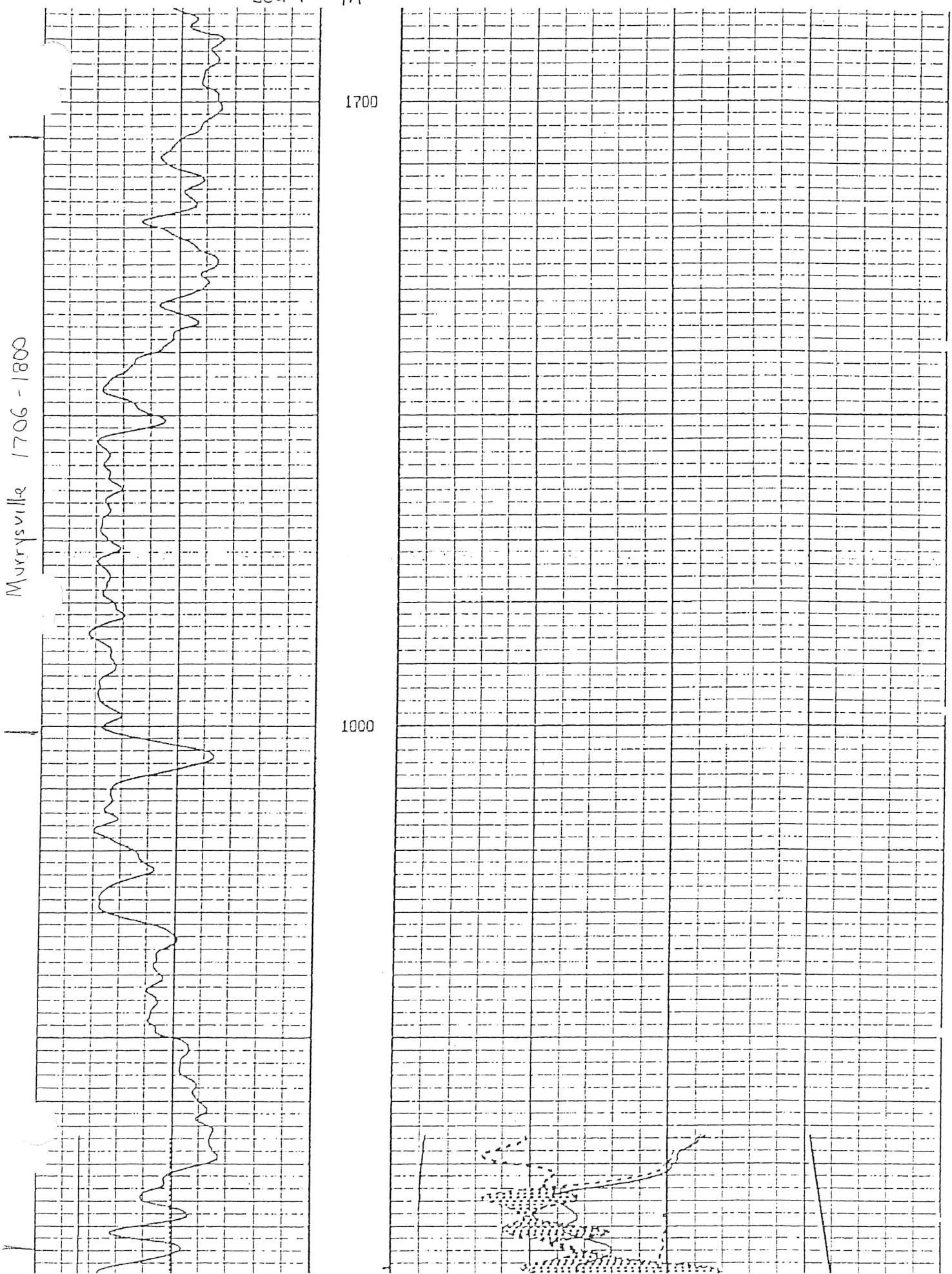

900
1000

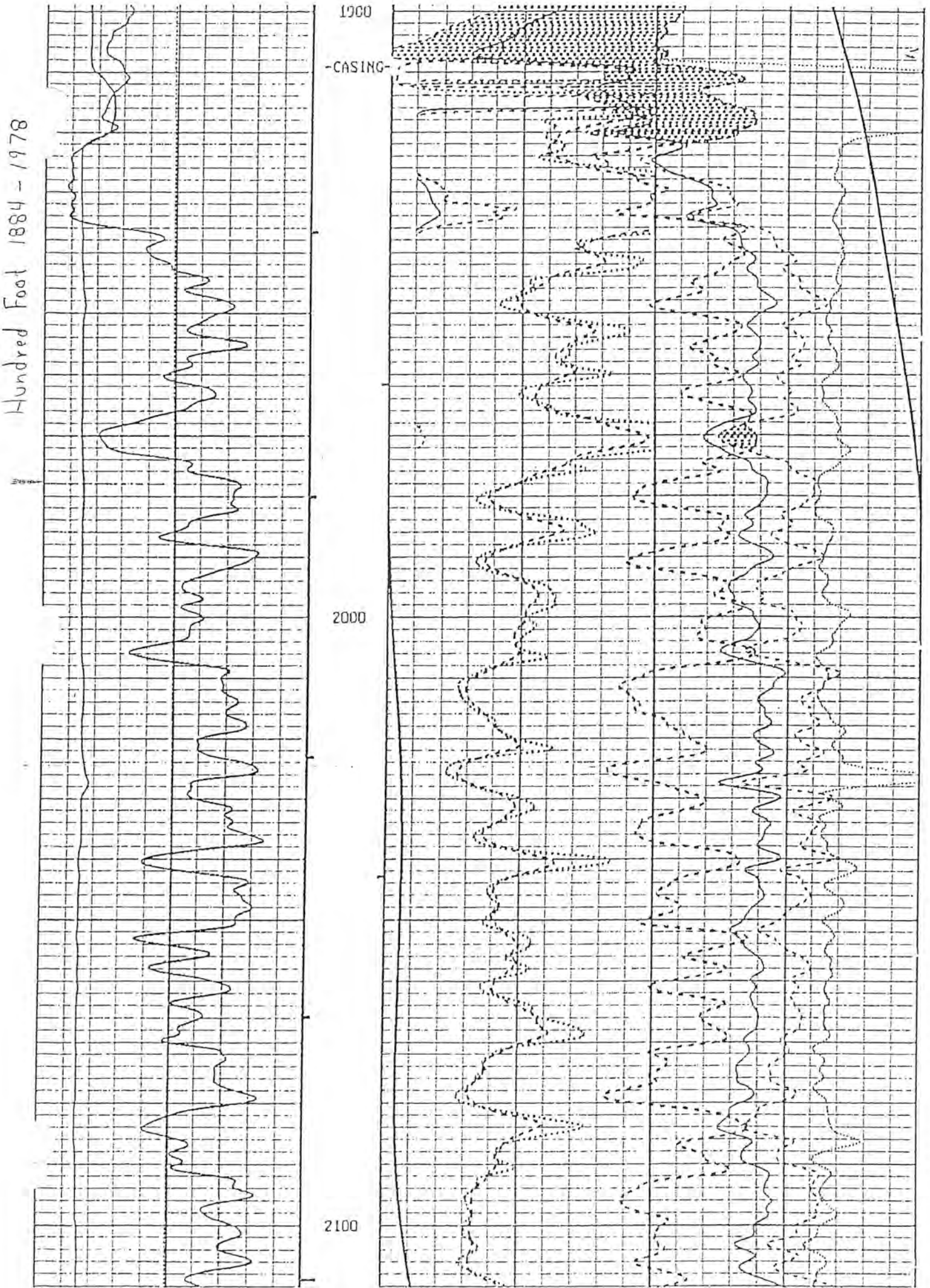

1100
1200


1300
1400


1500
1600

Sedet #4A




Hundred Foot 1884 - 1978
1900
-CASING-
2000
2100

MARC

SUPERIOR WELL SERVICES

SUPERIOR
Black Lick, Pa
Mercer, Pa
Wooster, Ohio
Charleston, W Va

GR / NEU
CDL / DIL
TEMPERATURE

CPNY PENNECO OIL COMPA Y , INC.
WELL SEDAT # 4A
FIELD NEW KENSINGTON EAST
CO. ALLEGHENY ST PA.

COMPANY PENNECO OIL COMPANY , INC.
WELL SEDAT # 4A PS-748
FIELD NEW KENSINGTON EAST
COUNTY ALLEGHENY STATE PA.

LOCATION
P/N - 37-003-21644-00
749' WEST 79-42-39.70
5366' SOUTH 40-31-36.90

SEC. ______ TWP. PLUM RGE. ______

OTHER SERVICES:
TIF FILE
2.0" SCALE
ANALYSIS

PERMANENT DATUM GL = 7.0" ELEV. 1068'
LOG MEASURED FROM TOP OF 7.0" ABOVE PERMANENT DATUM
DRILLING MEASURED FROM KB

ELEV.:K.B. 1079'
D.F. 1078'
G.L. 1068'

DATE	07-07-2004			
RUN NO.	ONE			
DEPTH-DRILLER	3925'			
DEPTH-LOGGER	3925'			
BTM. LOG INTER.	3925'			
TOP LOG INTER.	GR / SURFACE			
CASING-DRILLER	7.0" @ 1907'			
CASING-LOGGER	7.0" @ 1907'			
BIT SIZE	6.25"			
FLUID TYPE	AIR			
DENS. : VISC.	N/A			
PH : FLUID LOSS	N/A			
SOURCE OF SAMPLE				
RM @ MEAS. TEMP.				
RMF @ MEAS. TEMP.				
RMC @ MEAS. TEMP.				
SOURCE: RMF/RMC				
RM @ BHT				
TIME SINCE CIRC.				
MAX. REC. TEMP.				
EQUIP.: LOCATION	0041/BLACKLICK	PA		
RECORDED BY	KACHONIK			
WITNESSED BY	MR. HUMMEL	MR. HILL		

ALL INTERPRETATIONS ARE OPINIONS BASED ON INFERENCES FROM ELECTRICAL OR OTHER MEASUREMENT AND WE CANNOT AND DO NOT GUARANTEE THE ACCURACY OR CORRECTNESS OF ANY INTERPRETATION, AND WE SHALL NOT, EXCEPT IN THE CASE OF GROSS OR WILLFUL NEGLIGENCE ON OUR PART, BE LIABLE OR RESPONSIBLE FOR ANY LOSS, COSTS, DAMAGES, OR EXPENSES INCURRED OR SUSTAINED BY ANYONE RESULTING FROM ANY INTERPRETATION MADE BY ANY OF OUR OFFICERS, AGENTS OR EMPLOYEES. THESE INTERPRETATIONS ARE ALSO SUBJECT TO OUR GENERAL TERMS AND CONDITIONS SET OUT IN OUR CURRENT PRICE SCHEDULE.

REMARKS:

MDEN - 2.68 CDL # 2473
FDEN - 1.0 DIL # 5272

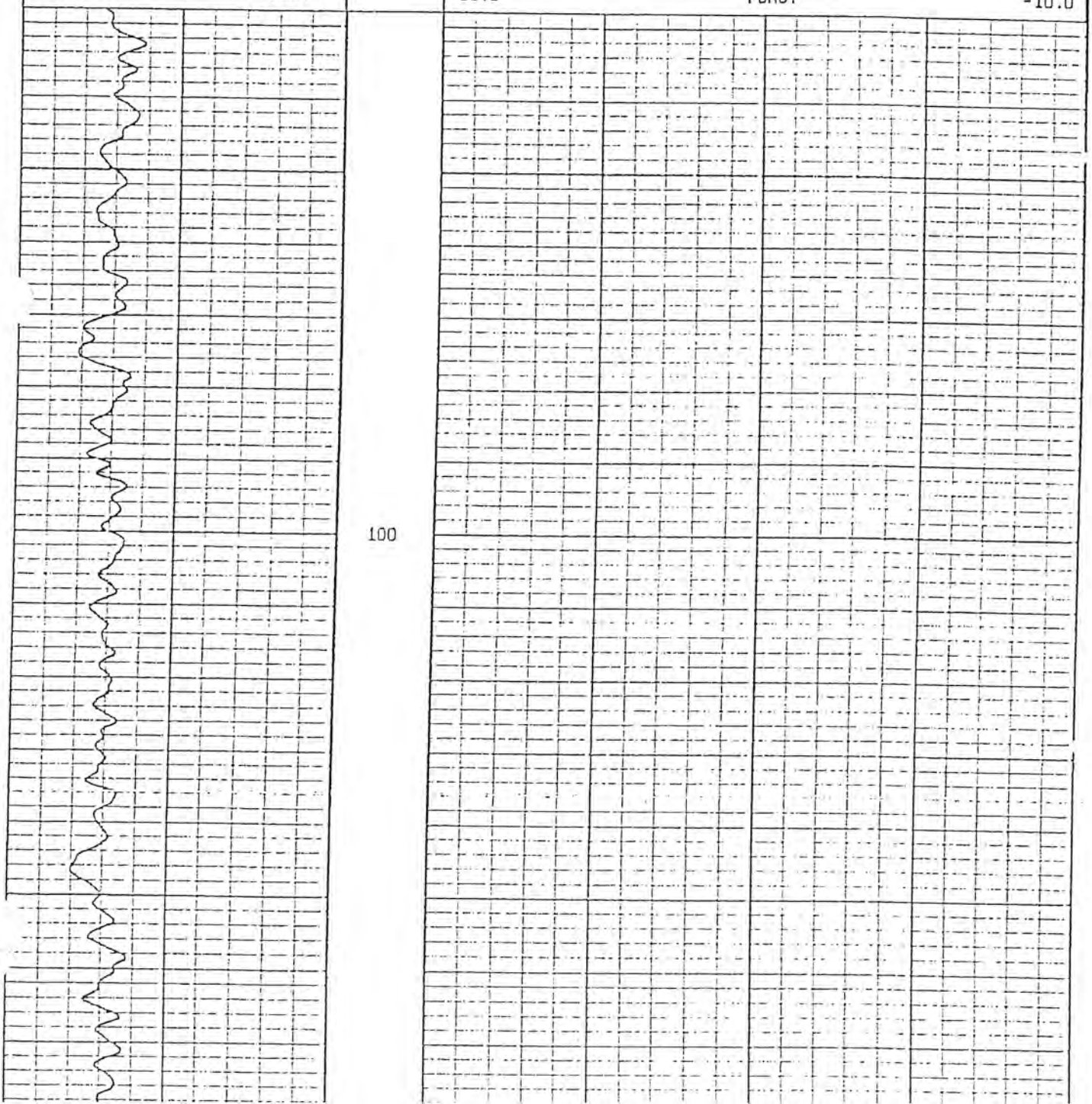
CREW : BREAKIRON , STUMPF
TEMPERATURE LOGGED UPHOLE
THANK YOU FOR CHOOSING SUPERIOR WELL SERVICES

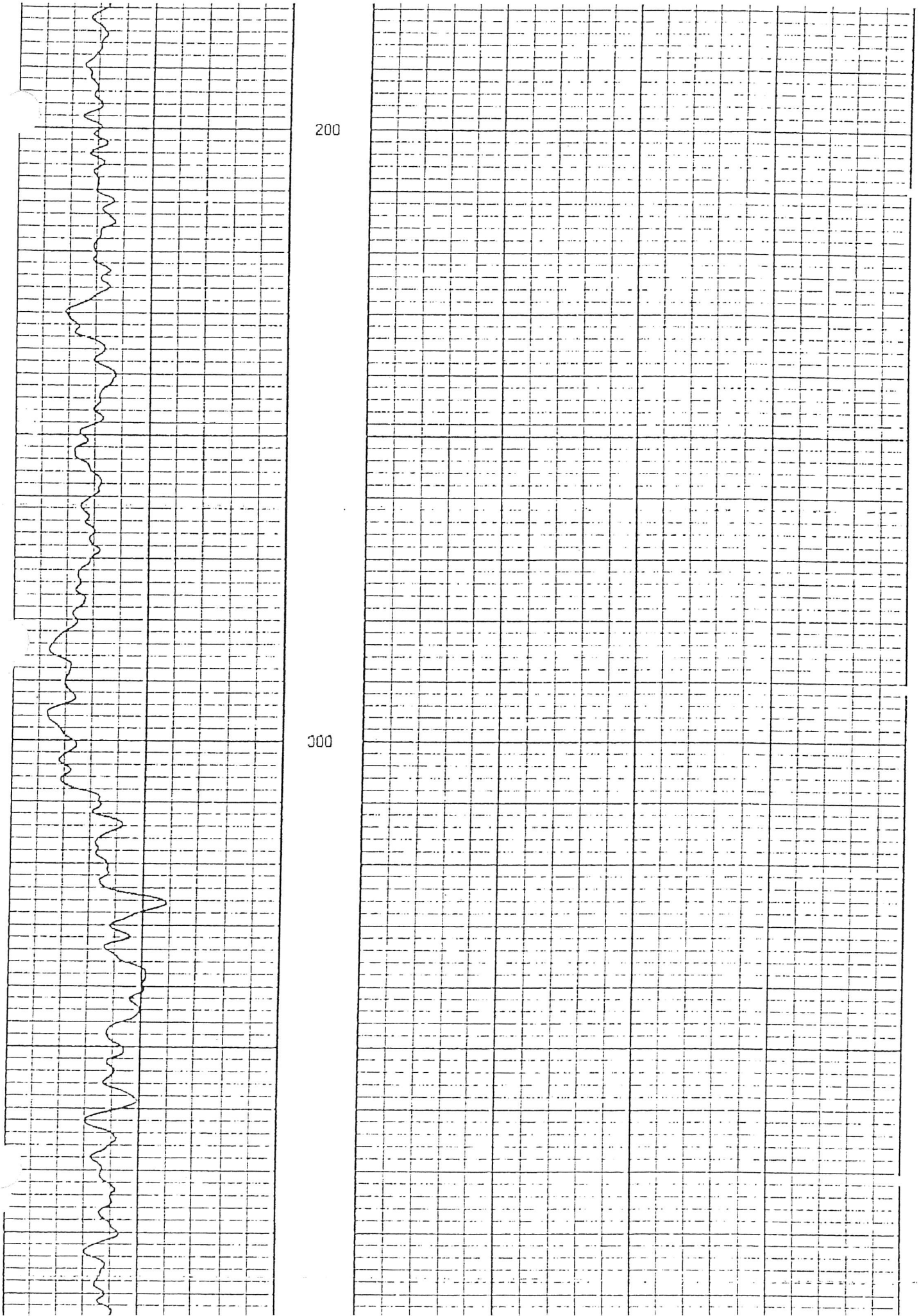
STOP DEPTH: 28.2 FEET
DIRECTION: UP 1:240

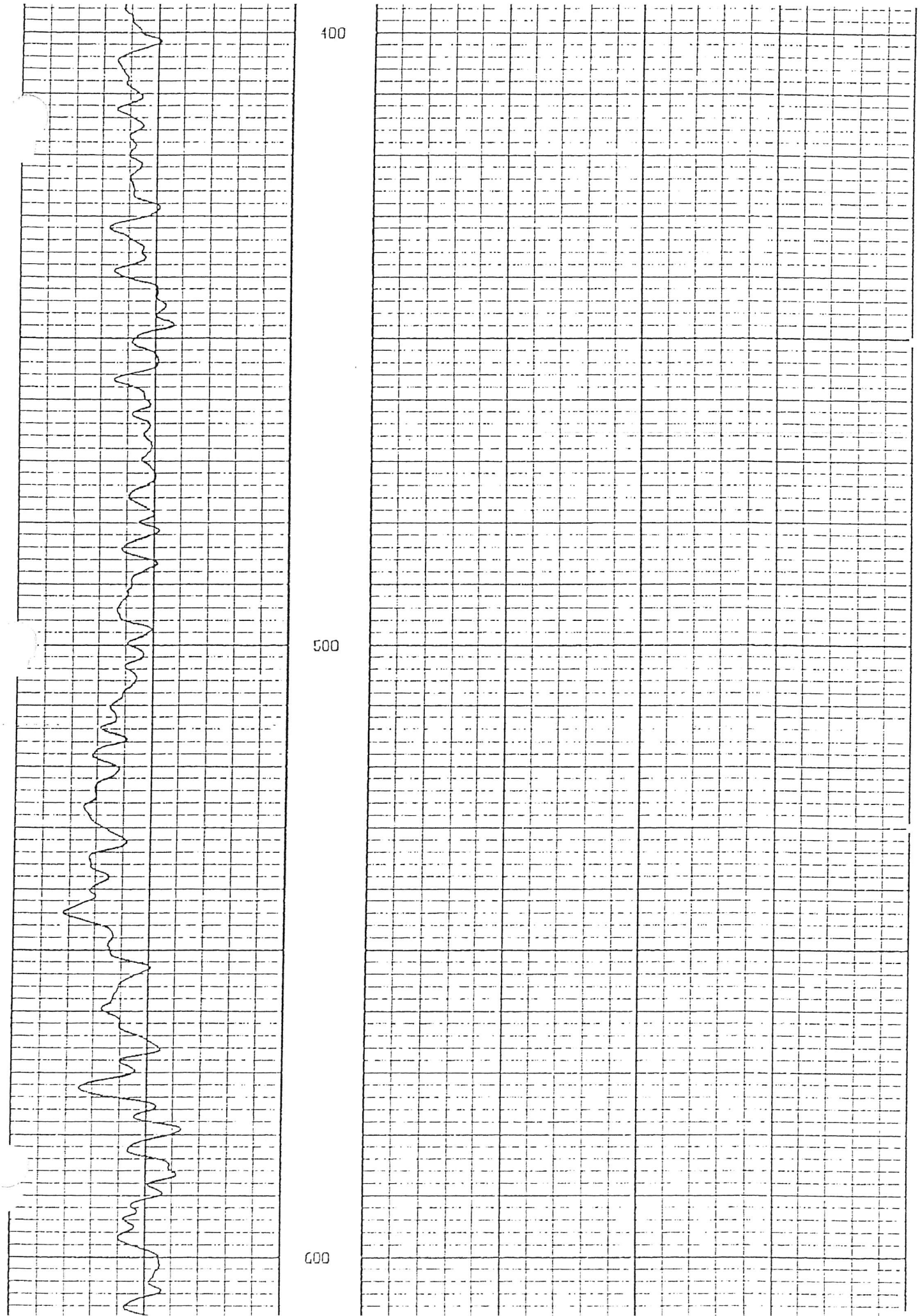
MAIN SECTION

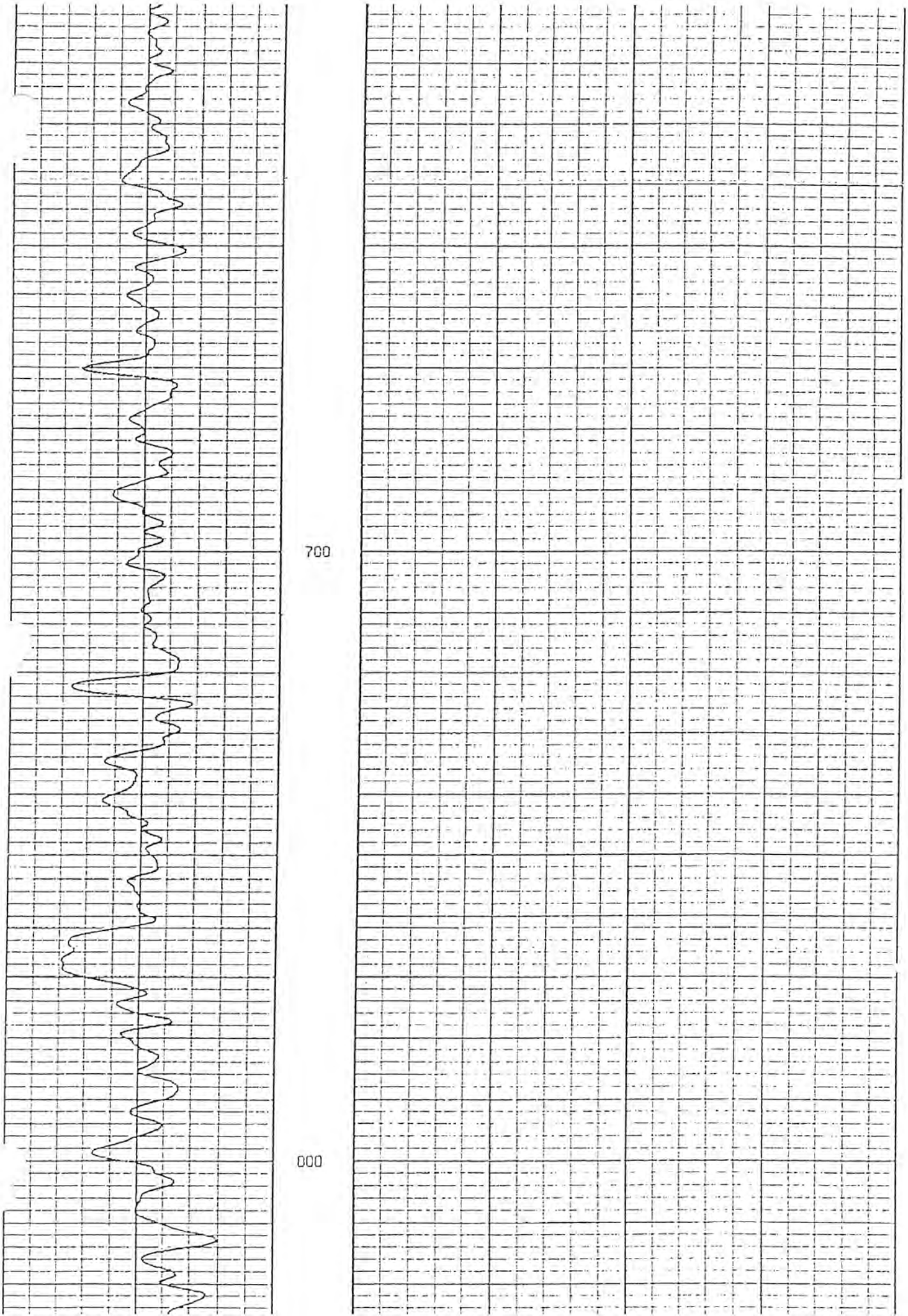
FILE DATE: 07-07-2004
TIME: 04:47

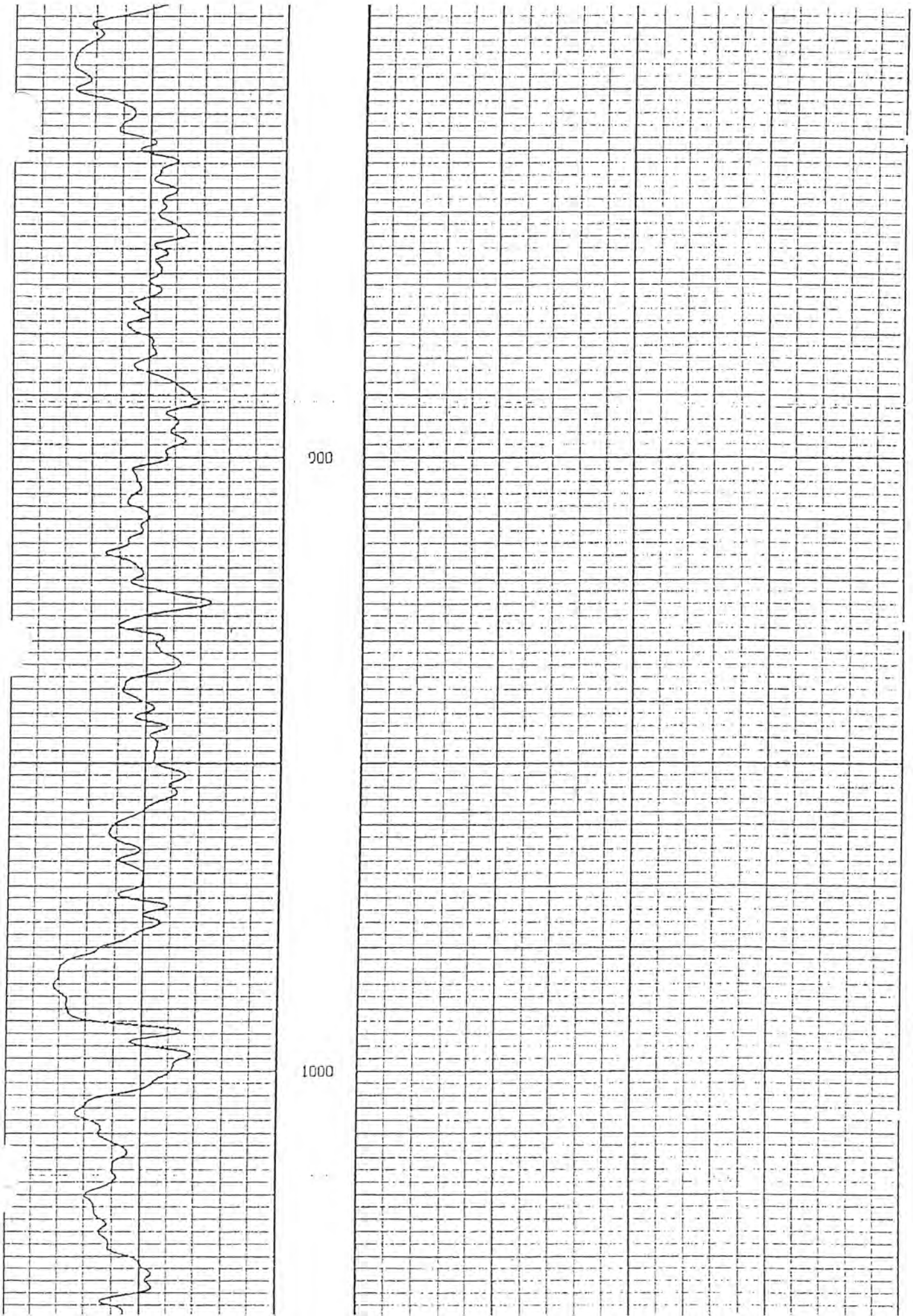
	MInR	
0.00	OHMM	100.00
	ILD	
0.00	OHMM	100.00
	CORR	
-0.25		0.25
	Temperature	
70.0	F	75.0
	DENSITY	
30.00	PORO.	-10.00
	CBD	
2.00	g/cc	3.00
	NEUTRON	
30.0	PORO.	-10.0
	DifTemp	
-10.0	Delta	10.0
	CALIPER	
5.0	inch	15.0
	GAMMA RAY	
0.0	API	200.0

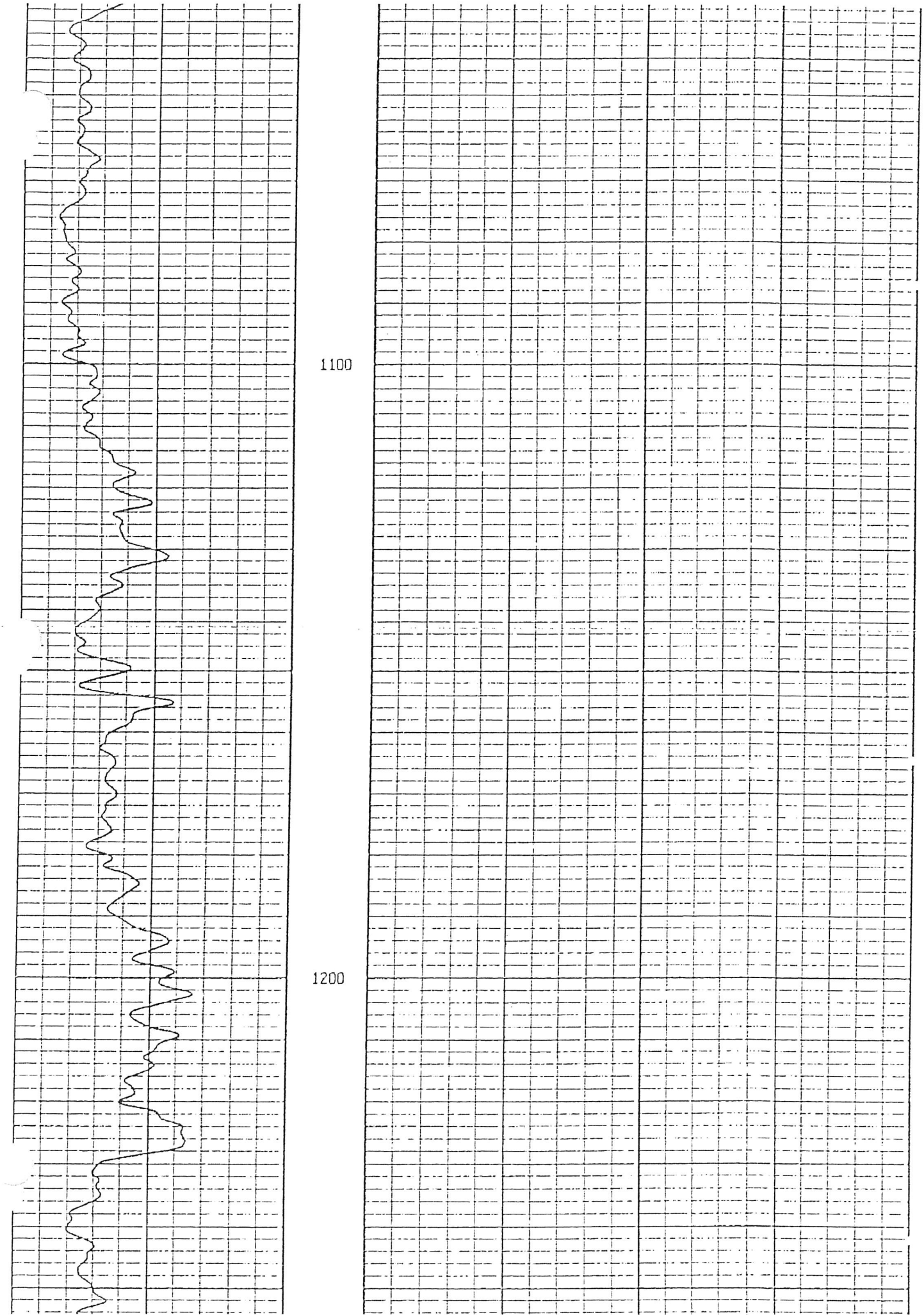


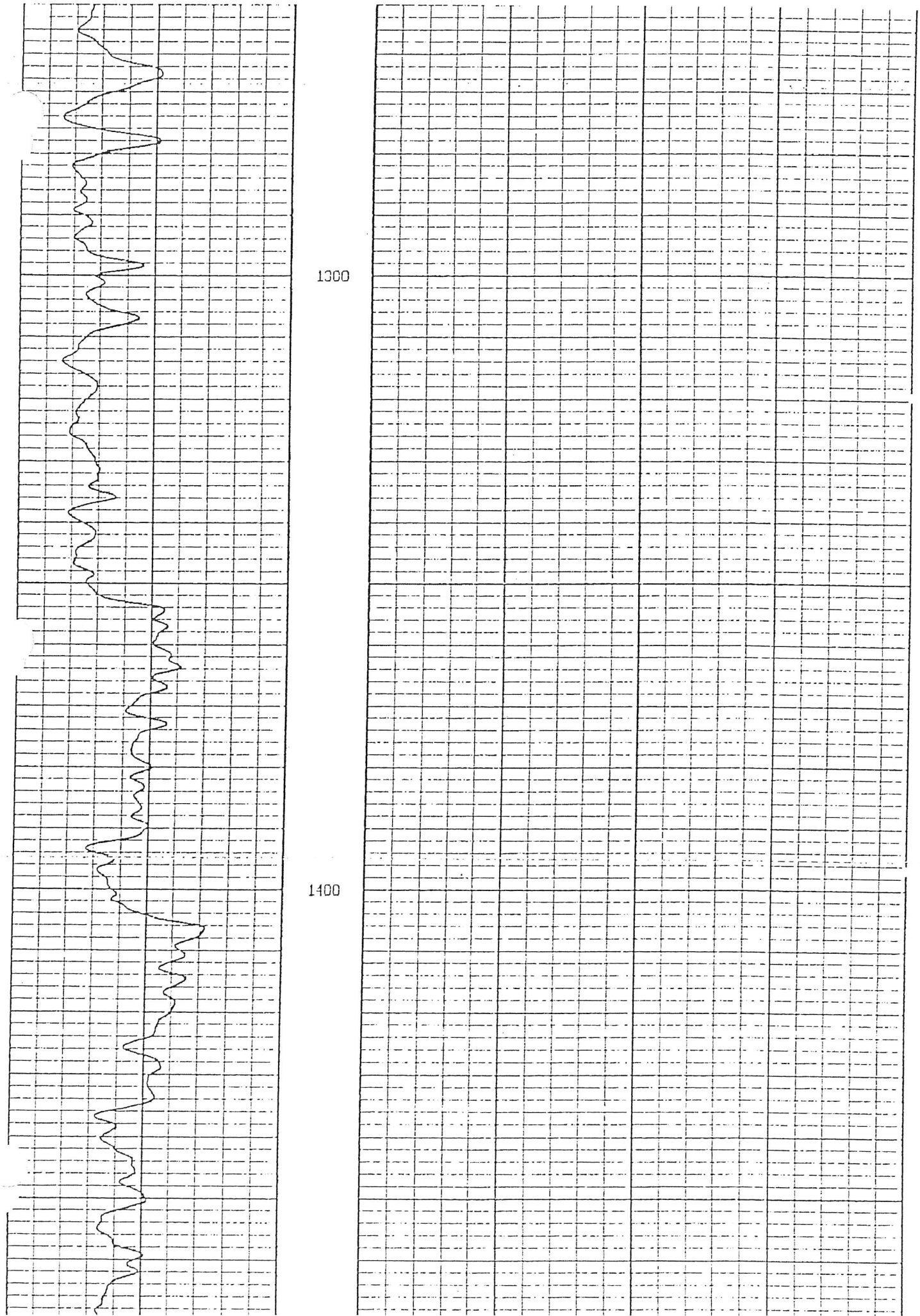

200
300

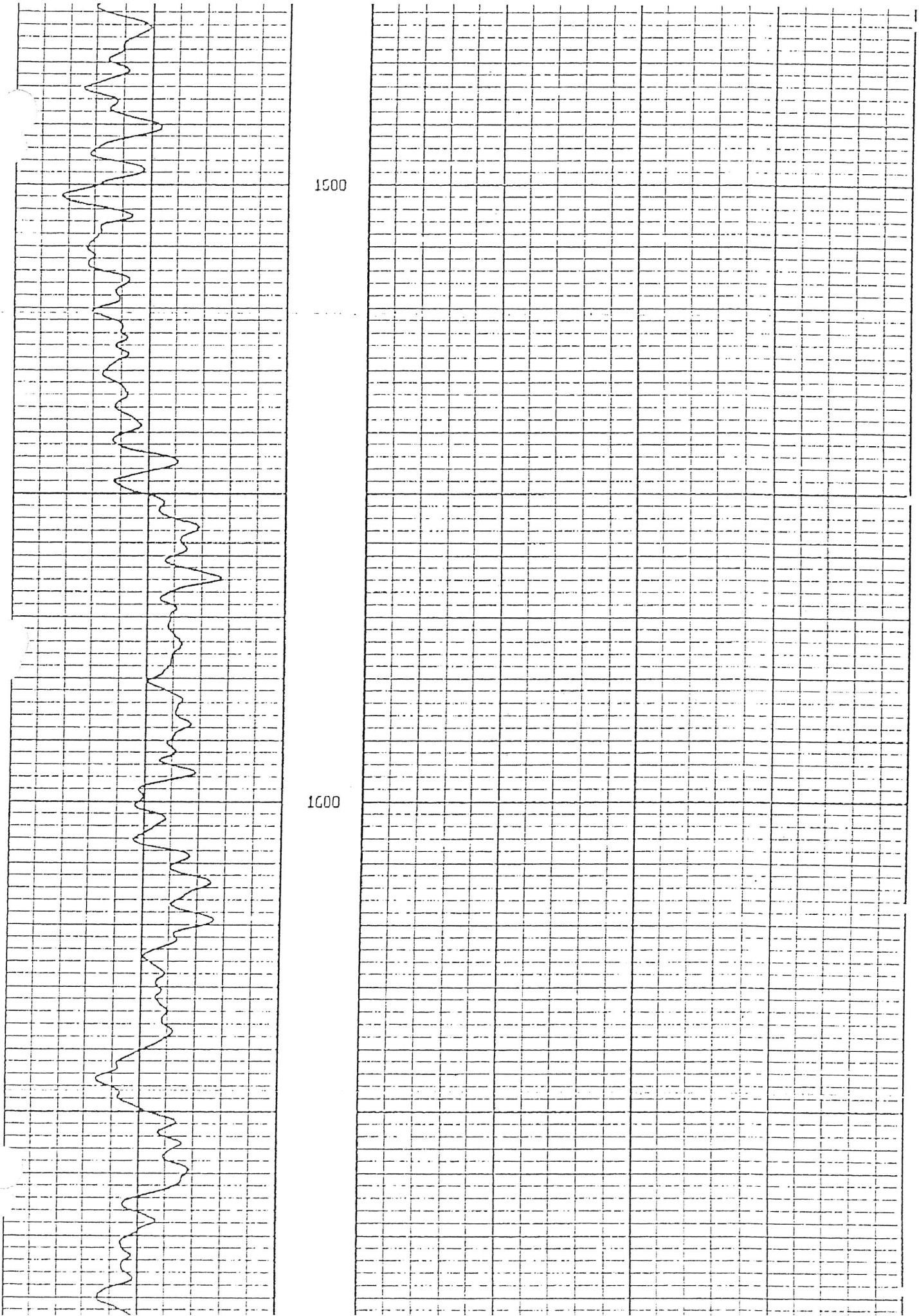

400
500
600


700
000

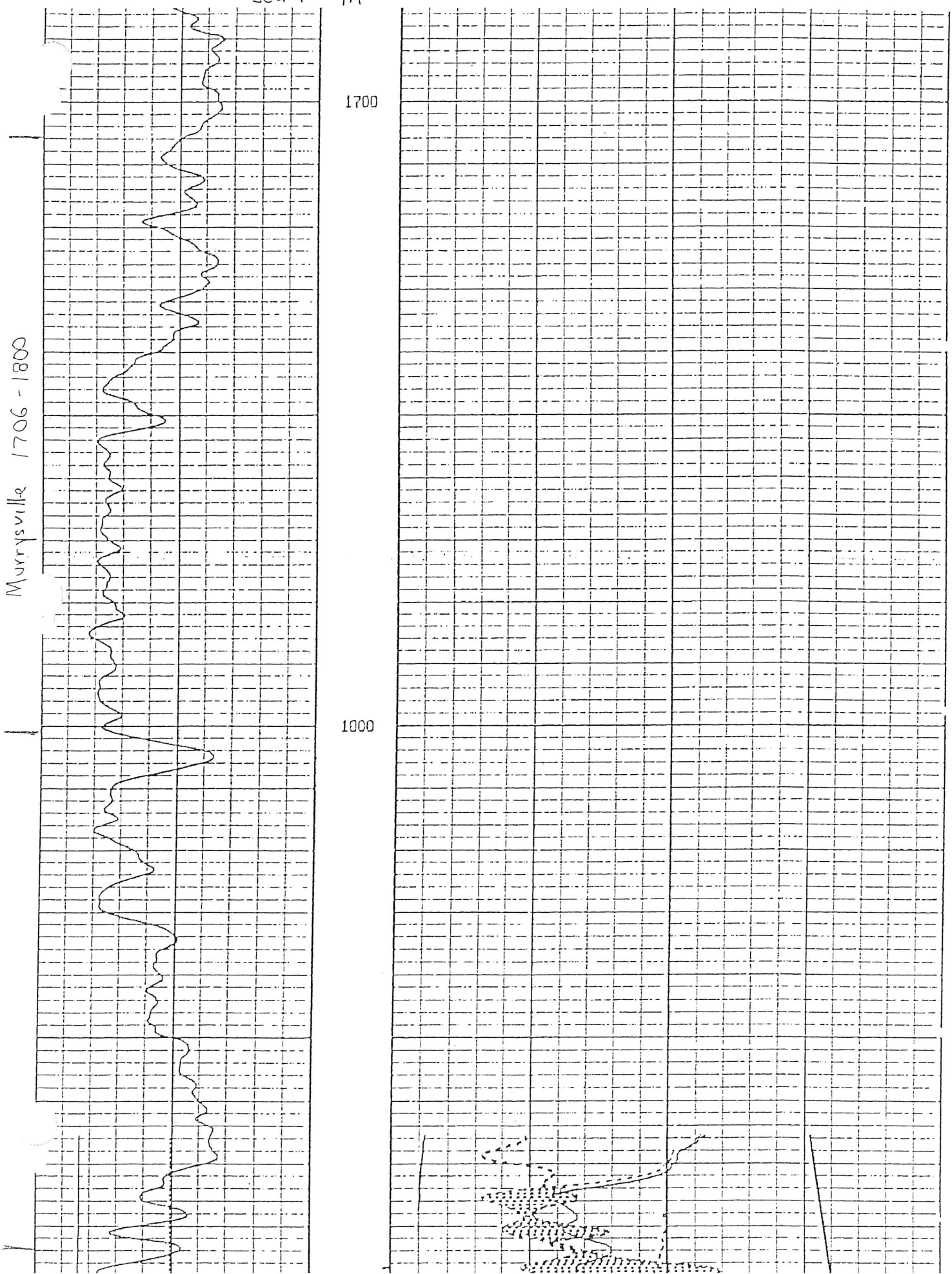

900
1000

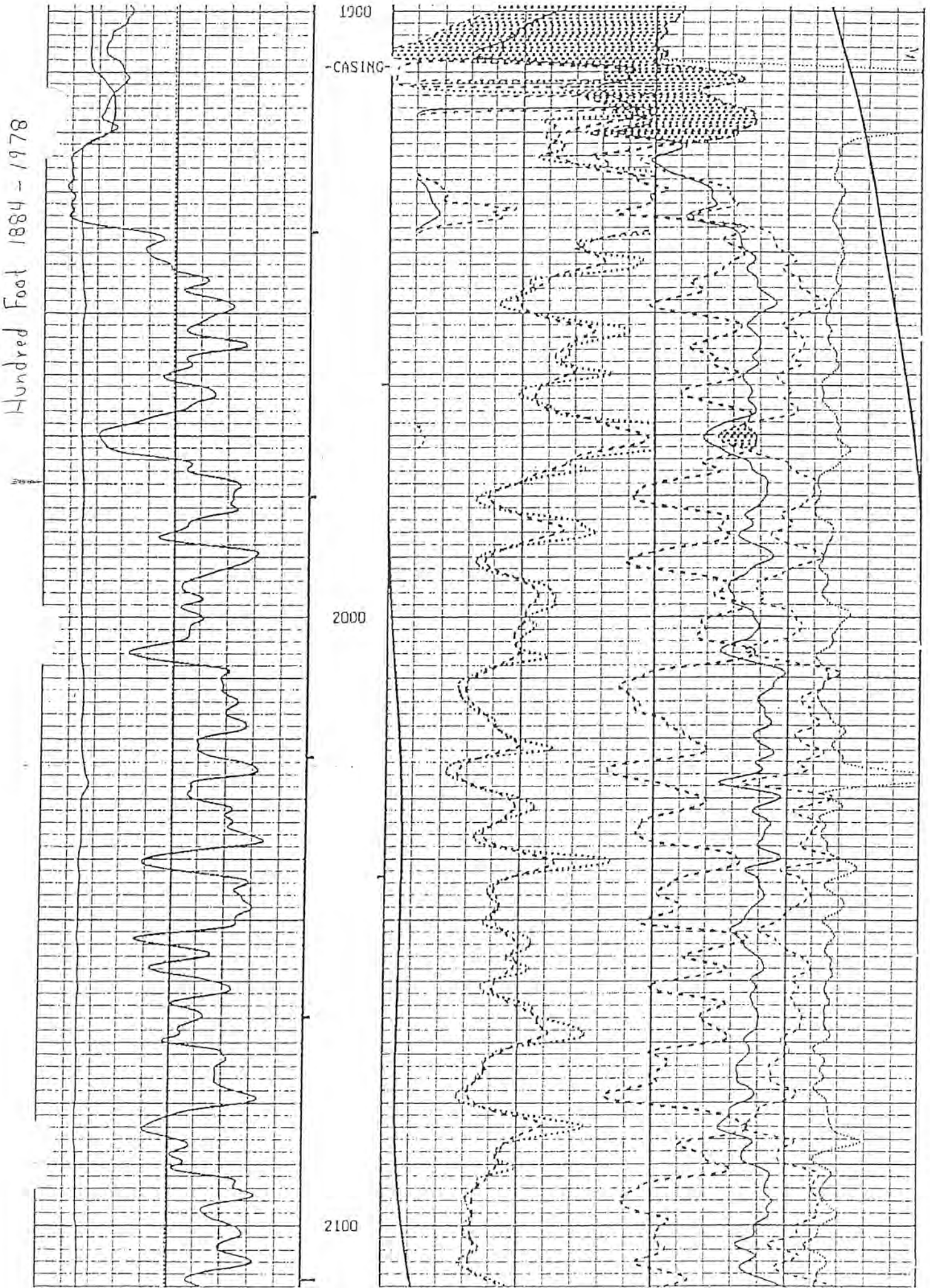

1100
1200


1300
1400


1500
1600

Sedet #4A




Hundred Foot 1884 - 1978
1900
-CASING-
2000
2100

SUPERIOR

Bluefield, Pa
Mercer, Pa
Wooster, Ohio
Charleston, W Va

GAMMA RAY
NEUTRON
DENSITY
DUAL INDUC

CPNY PENNECO OIL COMPANY
WELL MARONDA HOMES #1 (PM-
FIELD MURRYSVILLE QUADRANG
CO. WESTMORELAND STA

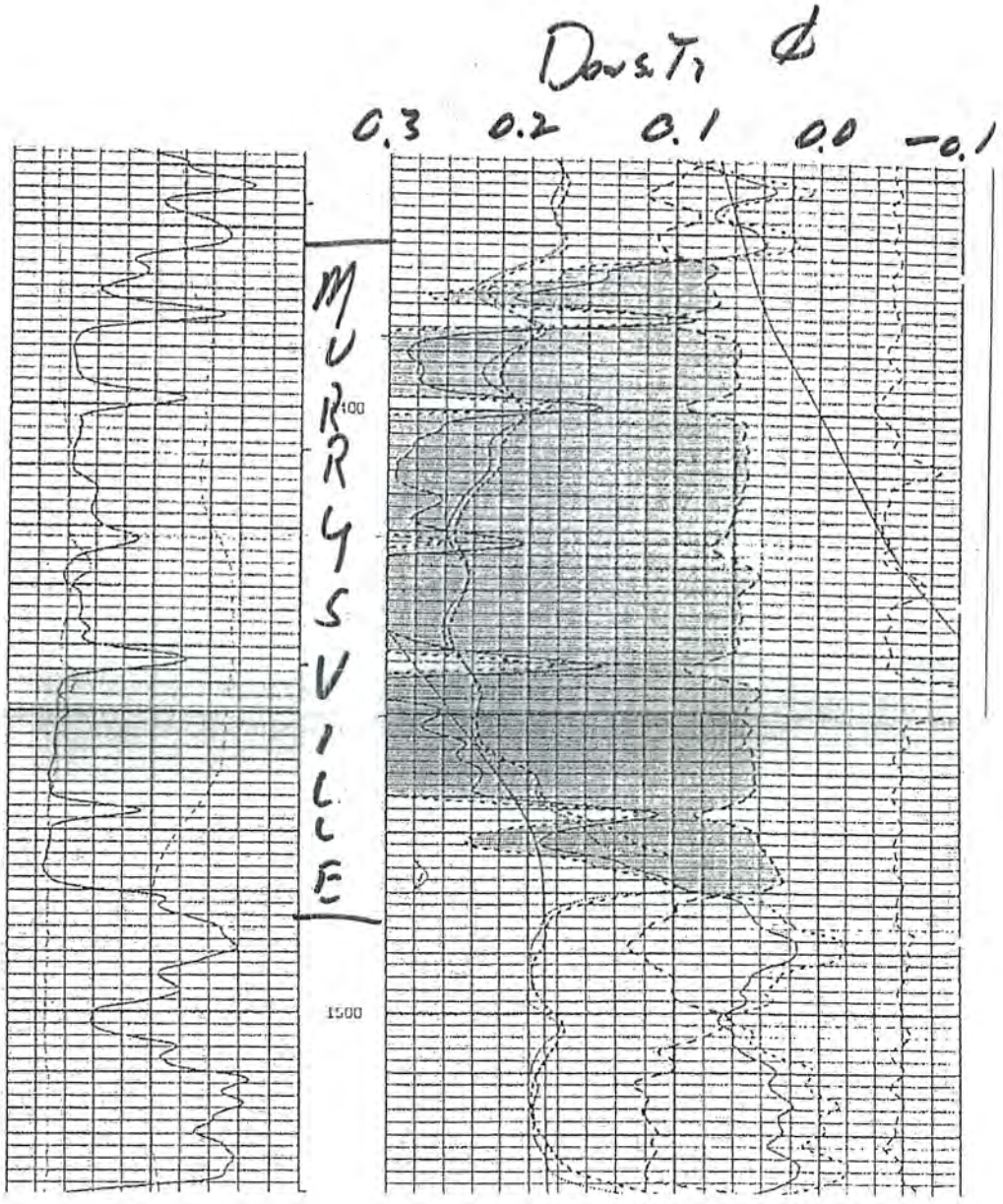
COMPANY PENNECO OIL COMPANY
WELL MARONDA HOMES #1 (PM-594)
FIELD MURRYSVILLE QUADRANGLE
COUNTY WESTMORELAND STAT

LOCATION
PERMIT#37-129-24721
0' WEST LONG:79°32'59.2"
0' SOUTH LAT:40°29'24.5"

SEC. _____ TWP. WASHINGTON

PERMANENT DATUM GROUND LEVEL ELEV. 1120 FT.
LOG MEASURED FROM TOP OF 7" ABOVE PERMANENT DATUM
DRILLING MEASURED FROM K.B.

DATE	06-14-02		
RUN NO.	ONE		
DEPTH-DRILLER	3550 FT.		
DEPTH-LOGGER	3537 FT.		
BTM. LOG INTER.			
TOP LOG INTER.	0 FT.		
CASING-DRILLER	1280 FT.		
CASING-LOGGER	1280 FT.		
BIT SIZE	6.25 IN.		
FLUID TYPE	AIR/GAS		
DENS. : VISC.	N/A		
PH : FLUID LOSS	N/A		
SOURCE OF SAMPLE	N/A		
RM @ MEAS. TEMP.	N/A		
RMF @ MEAS. TEMP.	N/A		
RMC @ MEAS. TEMP.	N/A		
SOURCE: RMF/RMC	N/A		
RM @ BHT	N/A		
TIME SINCE CIRC.	N/A		
MAX. REC. TEMP.	N/A		
EQUIP.: LOCATION	0058/BLKLCK		
RECORDED BY	JERRY MOORE		
WITNESSED BY	MR. JACOBS		


Dens. Ø
0.3
0.2
0.1
0.0
-0.1
MURRYSVILLE
1400
1500

LDT

Schlumberger

DOMINION EXPLORATION & PRODUCTION, INC.

JACOB SNYDER UNIT #3 (WPA06512)
HEMPFIELD TWP
WESTMORELAND PENNSYLVANIA

COUNTY: WESTMORELAND
Field: HEMPFIELD TWP.
Location: LATITUDE: 40-15-34.2700
Well: JACOB SNYDER UNIT #3 (WP
Company: DOMINION EXPLORATION & PR

LITHO DENSITY
COMPENSATED NEUTRON / GR
ARRAY INDUCTION / TEMPERATURE

LOCATION

LATITUDE: 40-15-34.2700
LONGITUDE: 79-40-1.3800
11711' S & 106' W OF NE CORNER

Elev.: K.B.
G.L. 1080 ft
D.F.

Permanent Datum: GROUND LEVEL — Elev.: 1080 ft
Log Measured From: KB — 8.0 ft above Perm. Datum
Drilling Measured From: KB

API Serial No	MAP SECTION:	TOWNSHIP:	QUAD:
37-129-25581-00	8	HEMPFIELD	IRWIN

		Run 1	Run 2	Run 3	Run 4
Logging Date		31-Aug-2005			
Run Number		1			
Depth Driller		2130 ft			
Schlumberger Depth		2135 ft			
Bottom Log Interval		2127 ft			
Top Log Interval		0 ft			
Casing Driller Size @ Depth		9.625 in @ 354 ft	@	@	
Casing Schlumberger		366 ft			
Bit Size		6.875 in			
Type Fluid In Hole		AIR / GAS / PRODUCED FLUIDS			
MUD	Density / Viscosity	0 lbm/gal			
MUD	Fluid Loss / PH				
MUD	Source Of Sample				
RM @ Measured Temperature		@	@	@	
RMF @ Measured Temperature		@	@	@	
RMC @ Measured Temperature		@	@	@	
Source RMF / RMC					
RM @ MRT / RMF @ MRT		@ 70 / @ 70	@ / @	@ / @	
Maximum Recorded Temperatures		70 degF			
Circulation Stopped / Time					
Logger On Bottom / Time		31-Aug-2005 / 18:40			
Unit Number / Location		3069 / BRADFORD			
Recorded By		TIM LYON, MIKE KORNACKI			
Witnessed By		NATE ZIMMERMAN, MELISSA THARP			

DISCLAIMER

Jacob Snyder Unit #3

129-25581

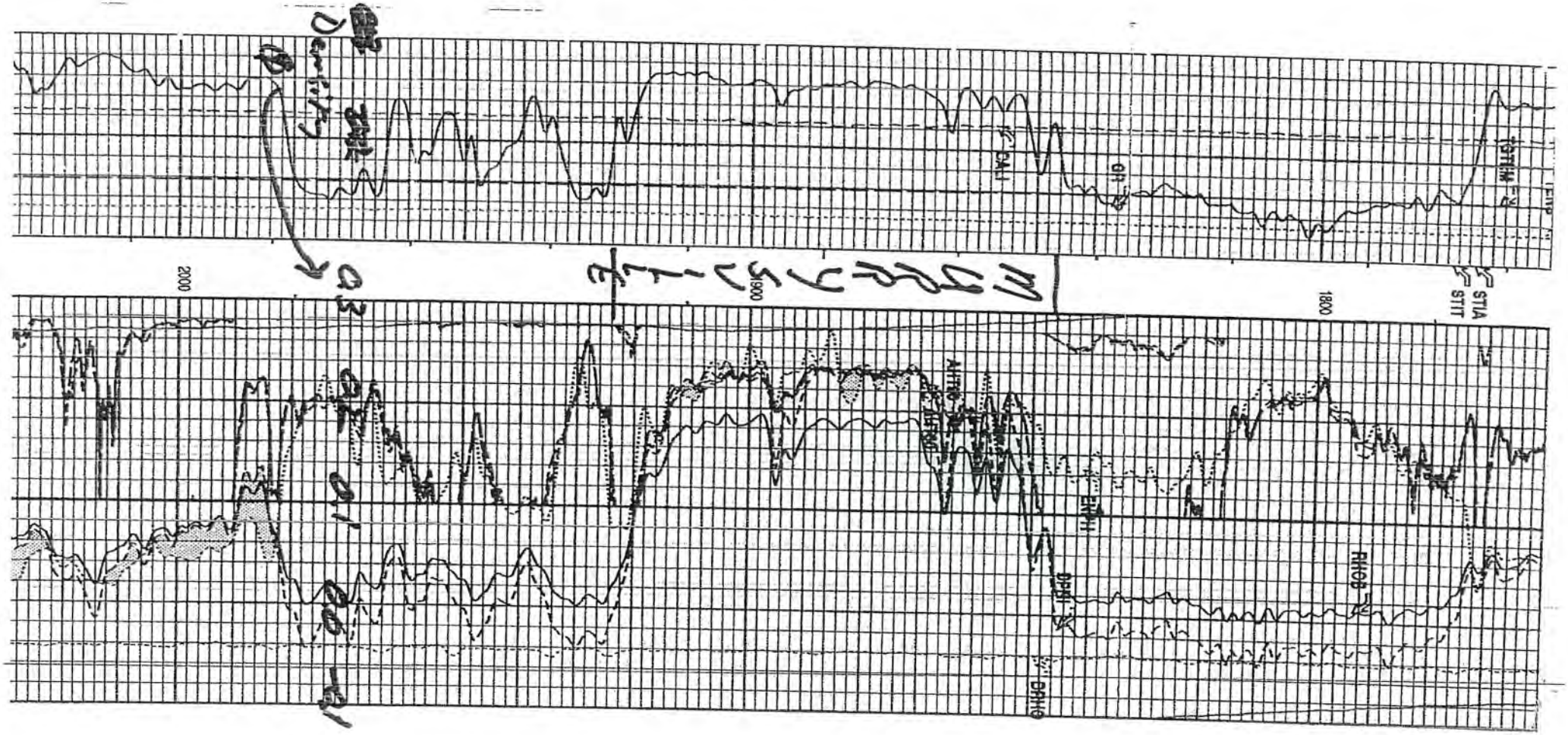


Figure 52 -- Permeability vs Depth

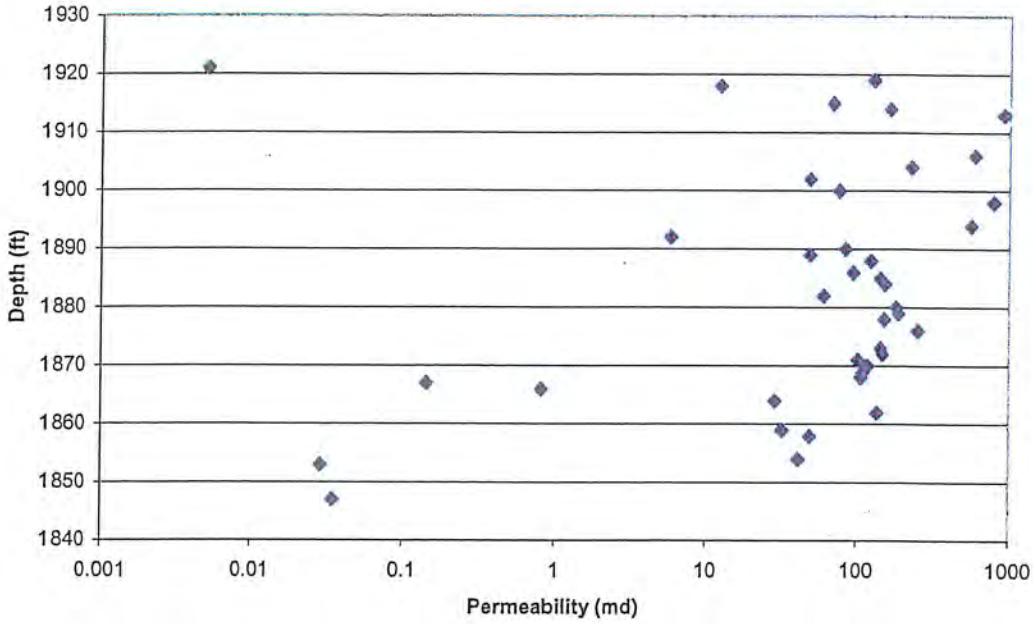
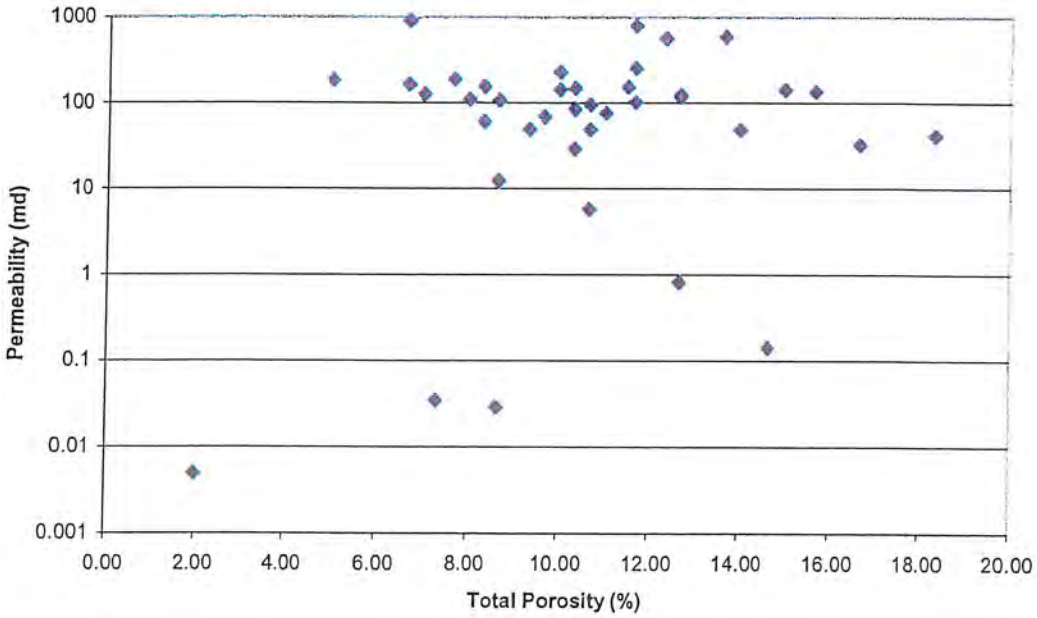
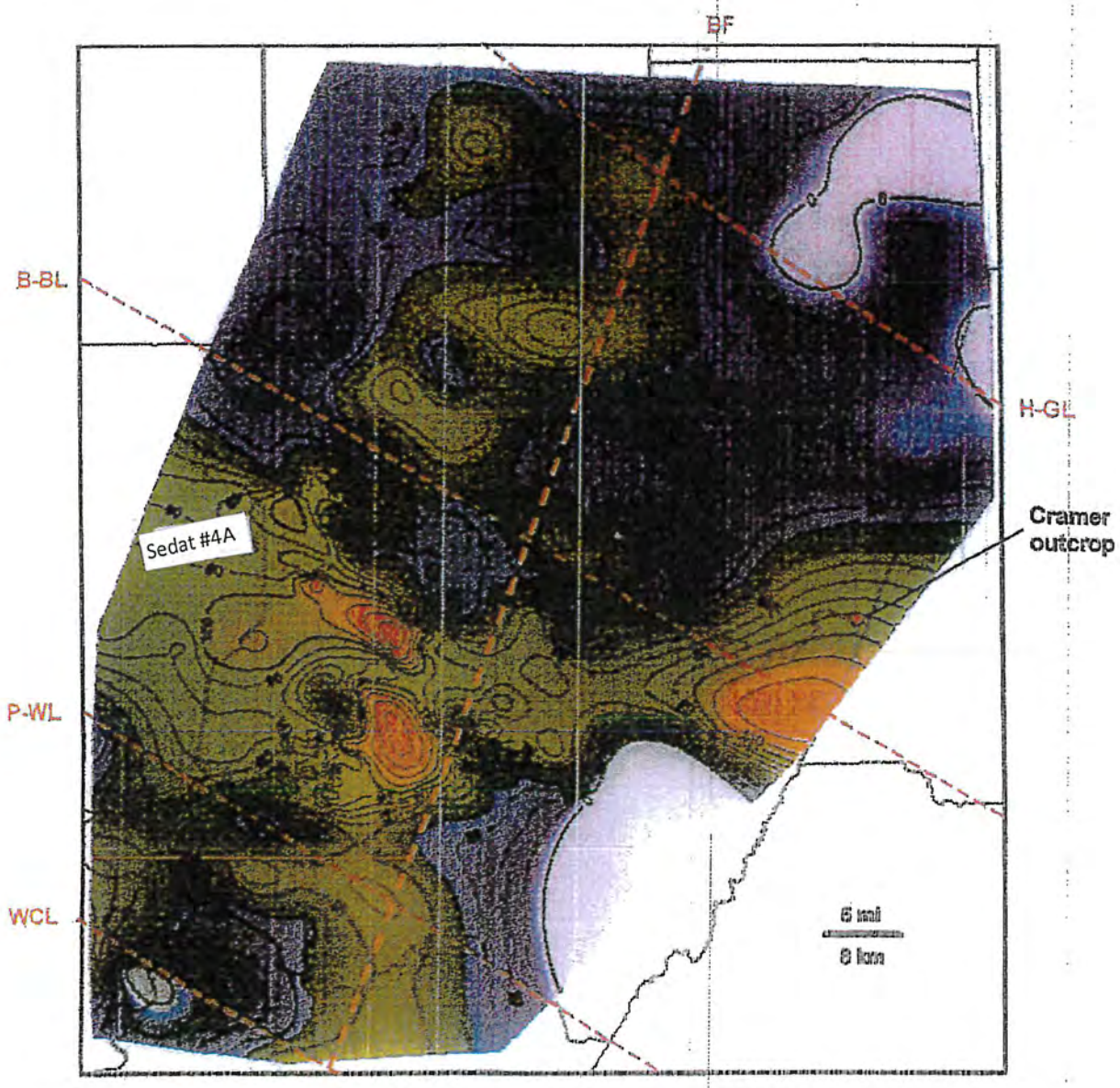


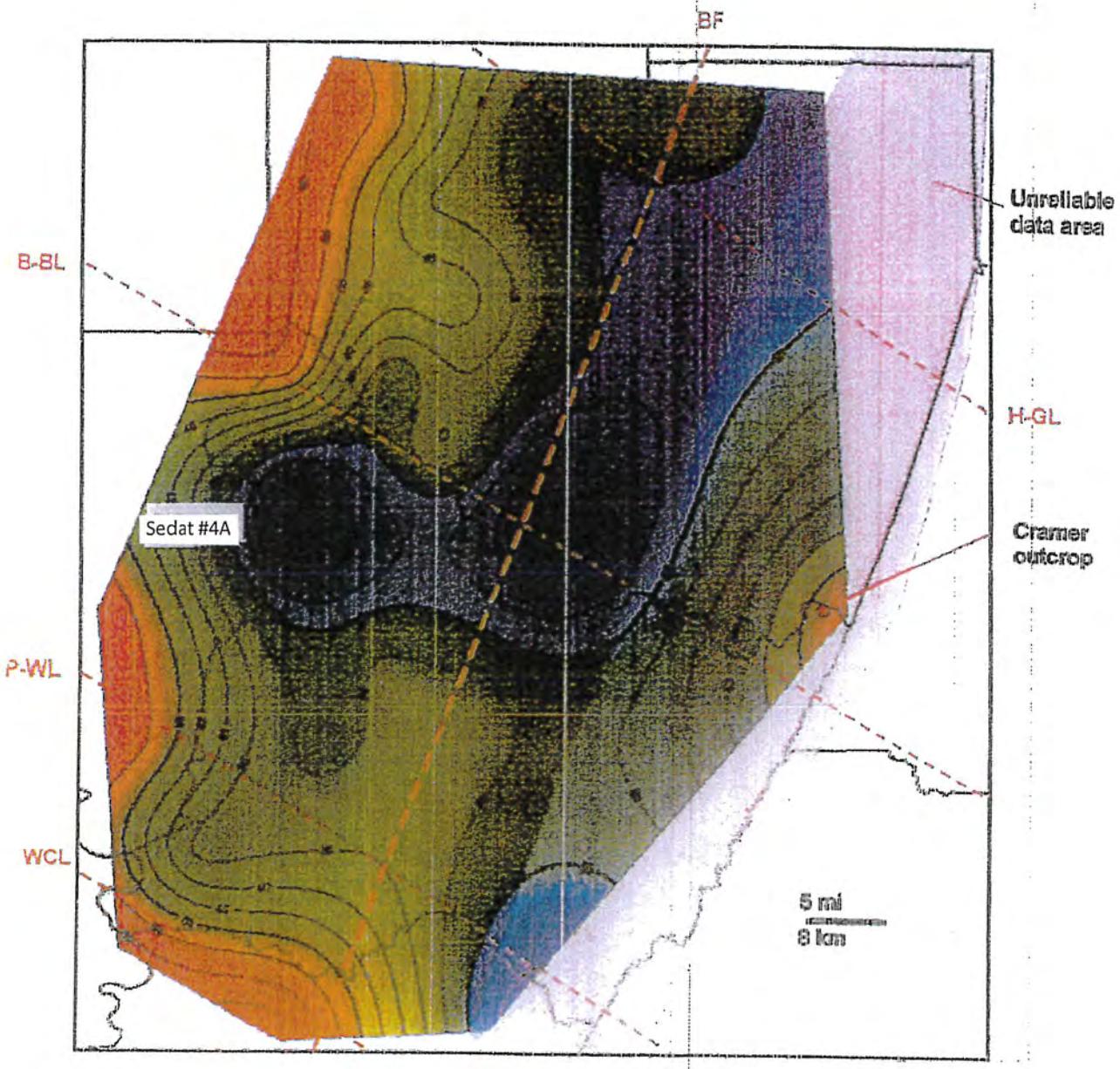
Figure 53 -- Total Porosity vs Permeability





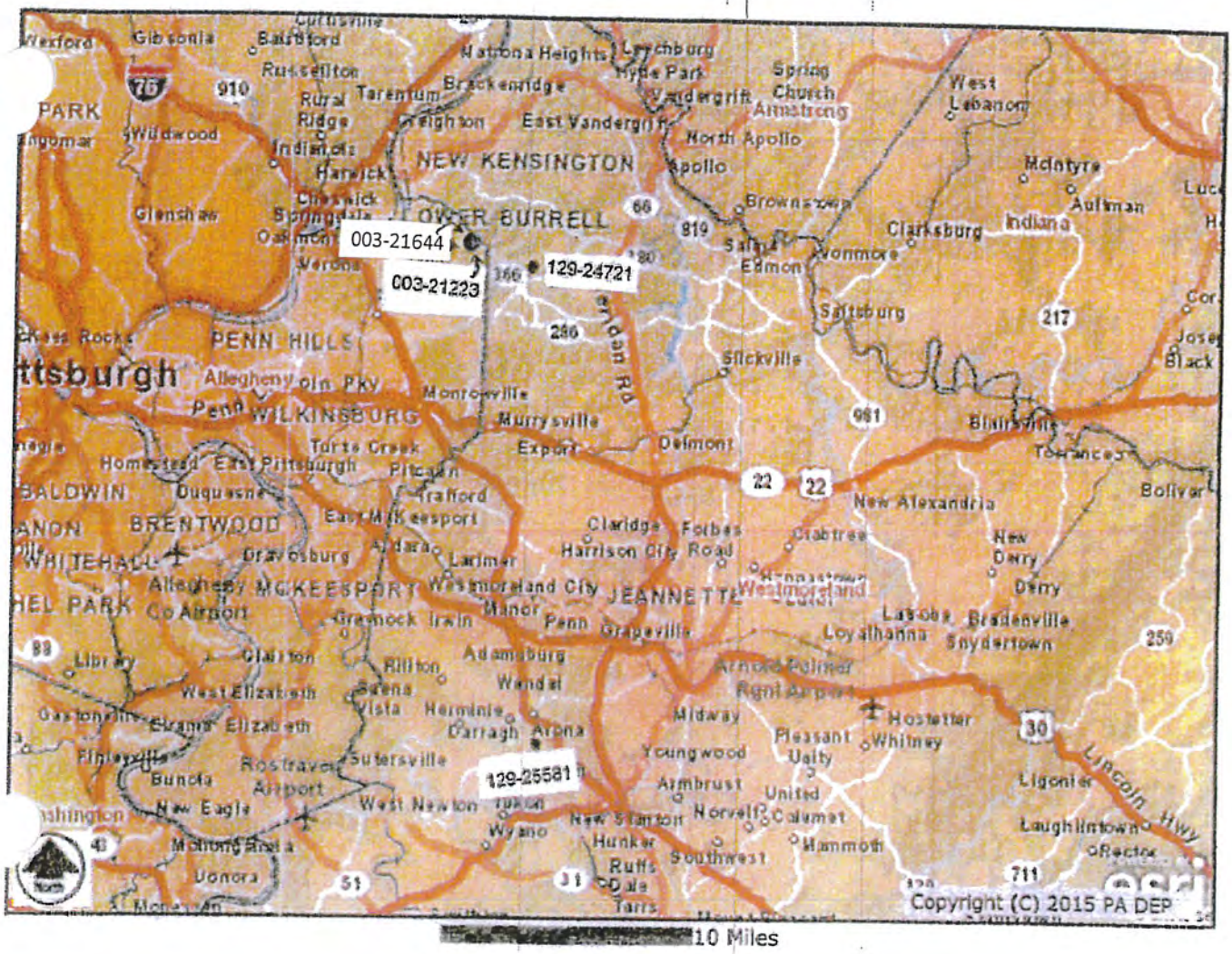
Map 3. Riddlesburg Shale Isopach Map

McDaniel, Bret, 2006. Subsurface Stratigraphy and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA



Map 4. Riceville-Oswayo Shale Isopach Map

McDaniel, Bret, 2006. Subsurface Stratigraphy and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA.

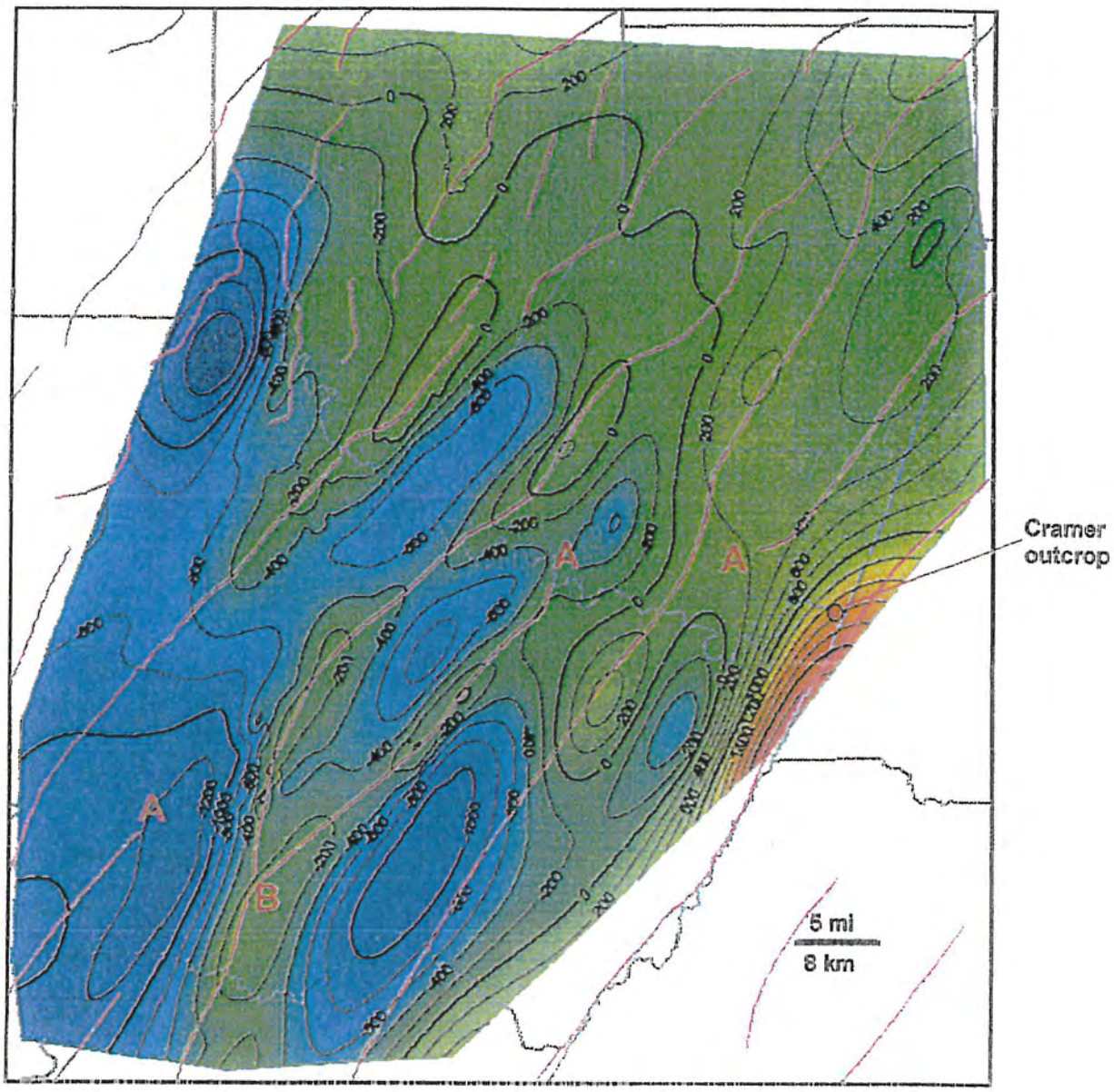


Legend

Unconventional Wells

Conventional Wells

County Boundaries



Map 5. Structure Map on Top of Murrysville Sand

McDaniel, Bret, 2006, Subsurface Stratigraphic and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA

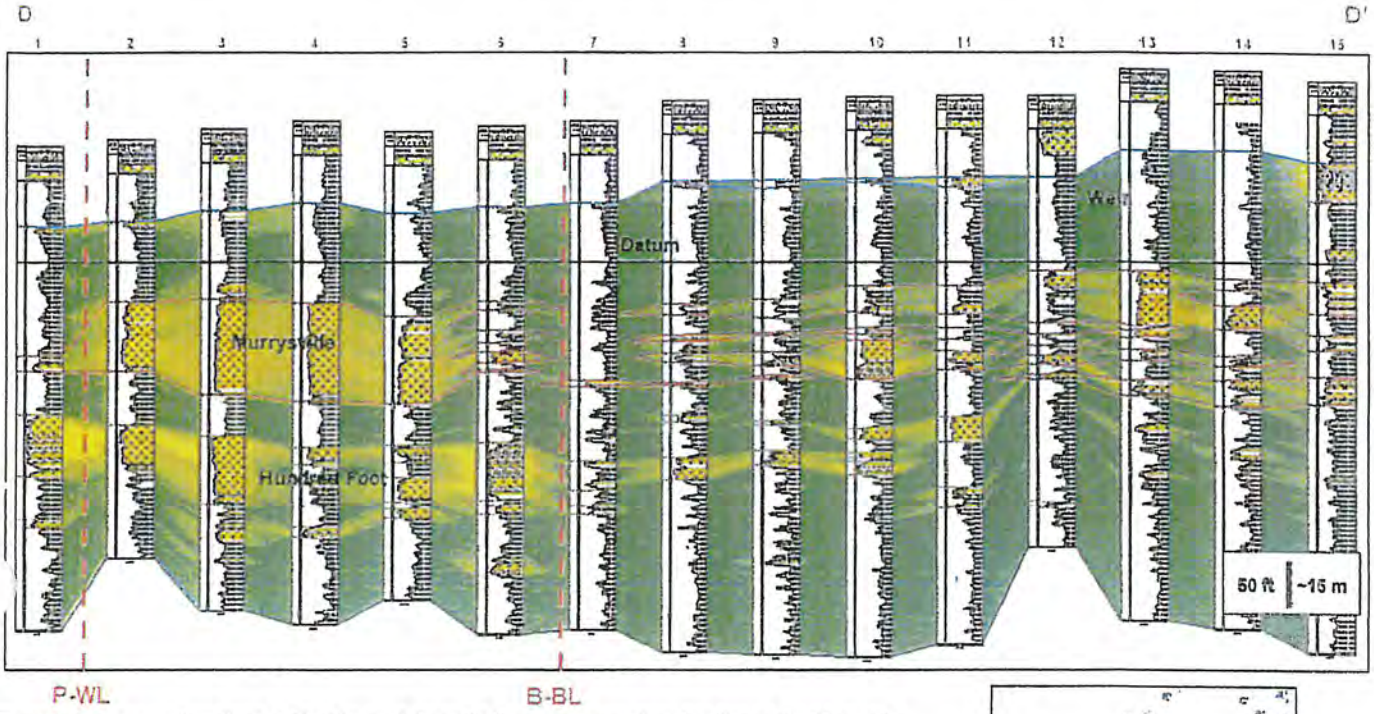
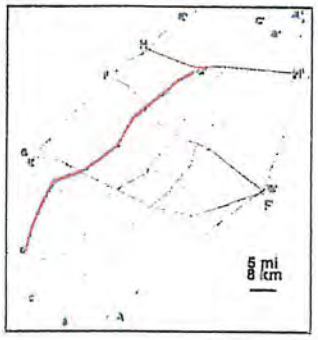
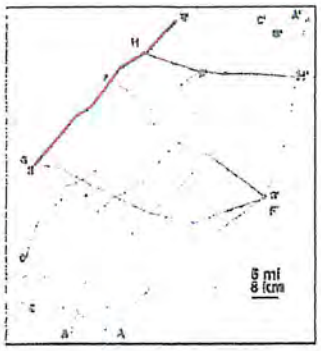


Figure 34. Cross section along D-D'. The most dramatic thinning occurs along this line as the Murrysville crosses the Blairsville-Broadtop Lineament (B-BL). Also evident is that there are two thick sequences of Murrysville, one thick and blocky in the southwest and another that lies to the northeast. It is unclear how this northeastern Murrysville relates to the blocky section to the south. One hypothesis may be that the north Murrysville may be nearshore deposits deposited north and south of the main channel the or perhaps these sandstones are abandoned delta lobes. The Weir is thin since it is far to the west of its depositional trend. The Hundred Foot becomes thick to the south, and it is here where the barrier bar sequence is best developed. See Figure 19 for the location of each numbered well.



Cross Section D-D'

McDaniel, Bret, 2006, Subsurface Stratigraphic and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA



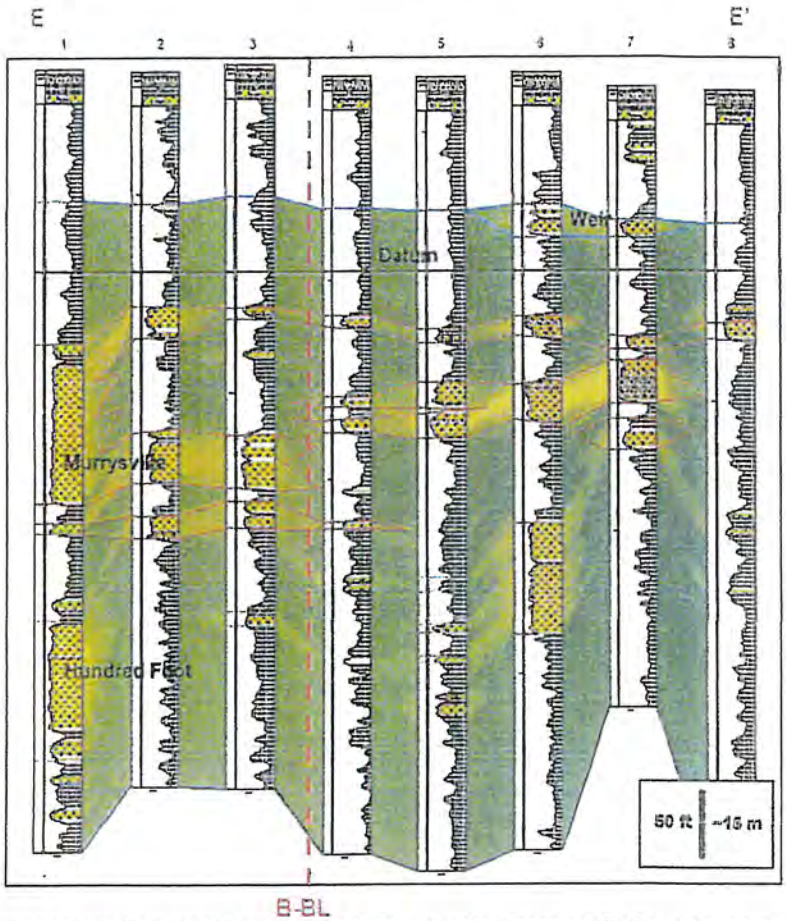


Figure 35. Cross-section along E-E'. This is the most erratic section in terms of correlative sand units. The data becomes difficult to interpret within this section, but there is still some evidence that the Blairsville-Broadtop Lineament (B-BL) may have had some influence on deposition of the Murrysville. The Weir sandstone is nearly gone this far west, with only a few intermittent sandstones. See Figure 19 for the location of each numbered well.

Cross Section E-E''

McDaniel, Bret, 2006, Subsurface Stratigraphic and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA

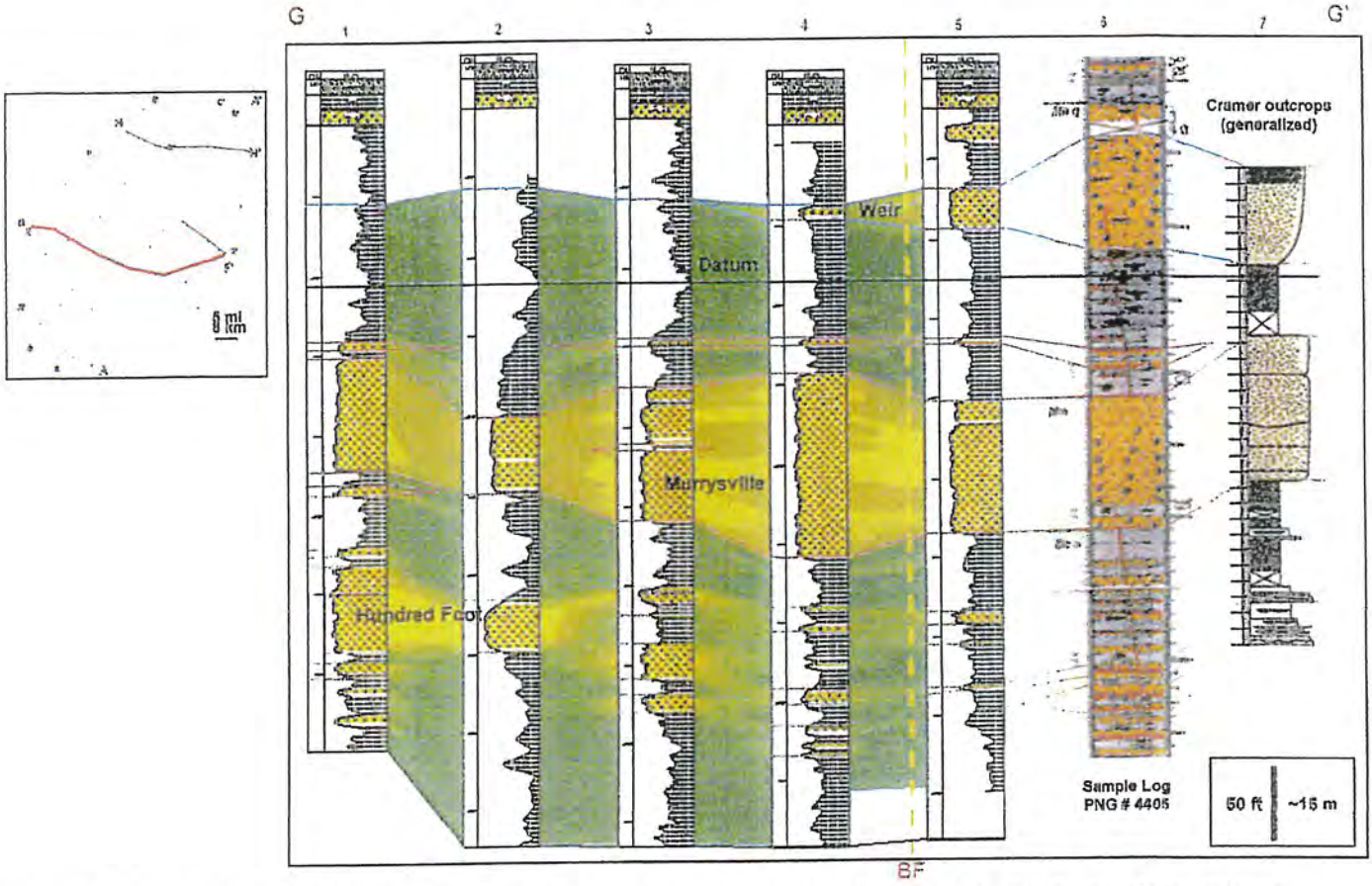


Figure 37. Cross section along G-G' section. This section attempts to tie the well log section to the outcrop data along the major Murrysville trend. Three things are evident from the section. (1)The Weir dramatically thins to the west across the proposed basement fault. (2)The Murrysville displays a thickened section to the west of the basement fault. (3)The Hundred Foot thins eastward as it reaches the basement fault. See Figure 19 for the location of each numbered well.

Cross Section G-G'

McDaniel, Bret, 2006, Subsurface Stratigraphic and Depositional Controls on Late Devonian-Early Mississippian Sediments in SW PA

PennState Extension

Natural Gas

Seismicity in Pennsylvania and the Pennsylvania State Seismic Network

Dr. Andrew Nyblade, Dept. of Geosciences, Penn State, discusses the research on seismic activity as part of a DCNR and DEP monitoring program

Time Log:

00:00 Introduction

03:41 Earthquake primer and review of seismicity in PA

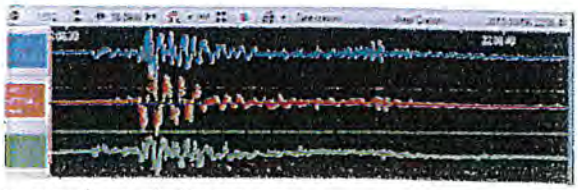
14:29 Review of building the PA Seismic network

20:56 Seismicity in PA 2013-2014

35:01 More on building PASEIS

42:54 Lawrence County Earthquakes

47:30 Q & A



www.dcnr.state.pa.us

Seismicity in Pennsylvania and the Pennsylvania State Seismic Network powerpoint
PDF, 5.5 MB

Recorded Webinar - Seismicity in Pennsylvania and the Pennsylvania State Seismic Network

Seismicity in Pennsylvania and the Pennsylvania State Seismic Network (PASEIS)

Andy Nyblade
Department of Geosciences, Penn State University
May 19, 2016

PennState

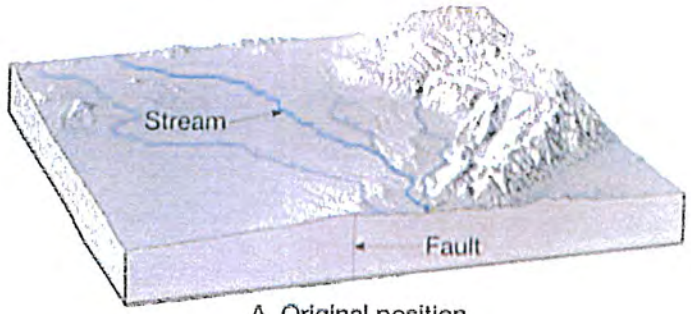
pennsylvania
DEPARTMENT OF CONSERVATION
AND NATURAL RESOURCES

pennsylvania
DEPARTMENT OF ENVIRONMENTAL
PROTECTION

Introduction

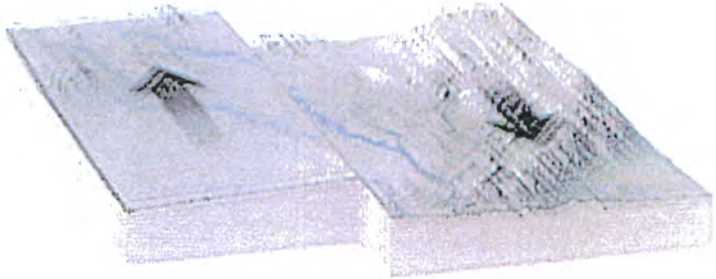
- Earthquake primer
- Review of seismicity in PA
- Review of seismic networks in PA
- Building the Pennsylvania State Network (PASEIS)
- Seismicity in Pennsylvania 2013-2014
- More on building PASEIS
- April 25, 2016 Lawrence County earthquakes

Deformation of rocks

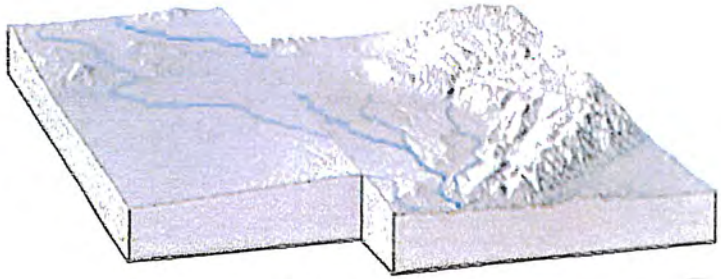


A. Original position

B. Buildup of strain



C. Slippage (earthquake)



D. Strain released

Deformation of a limber stick

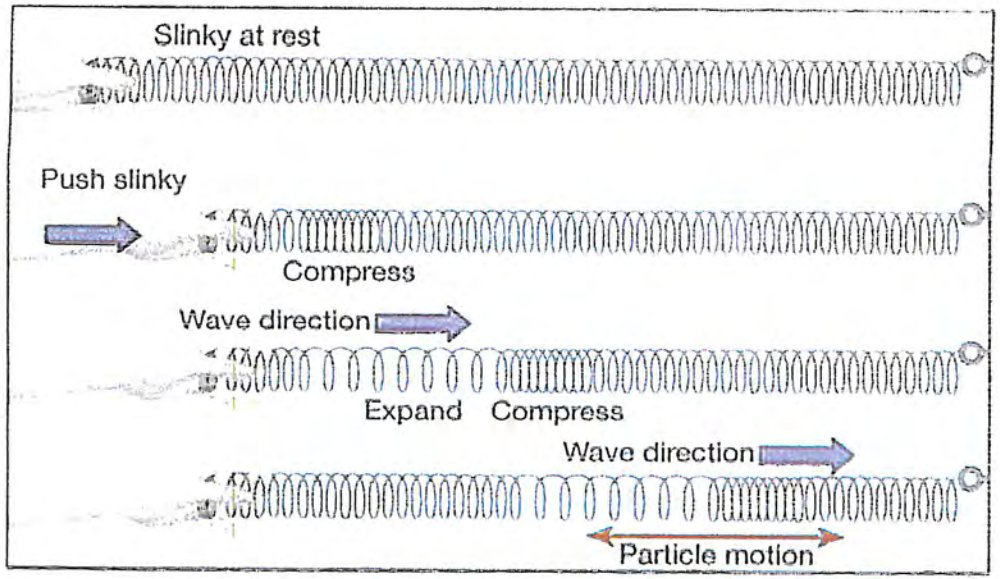
A. Original position

B. Buildup of strain

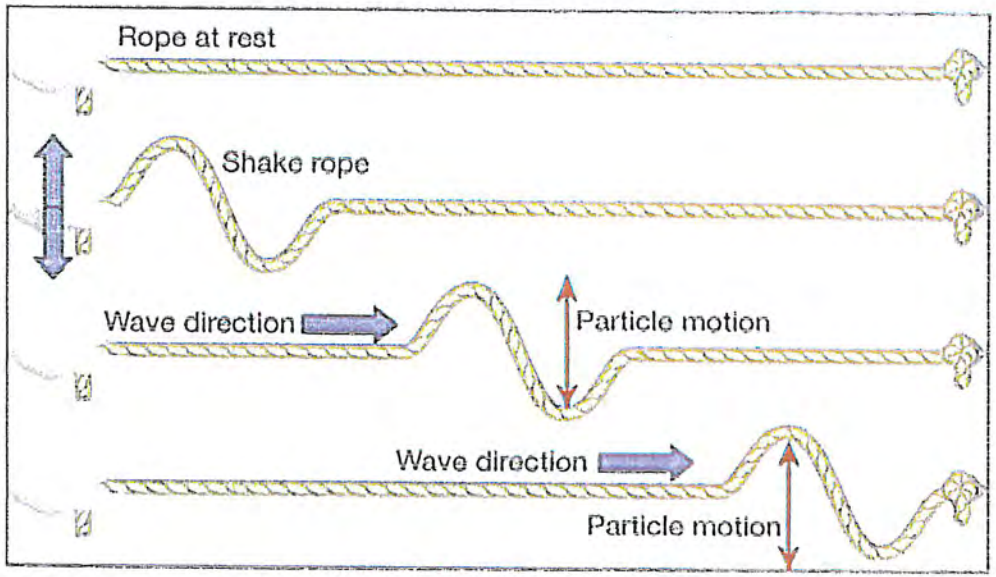
C. Rupture

D. Strain released

Body Waves:

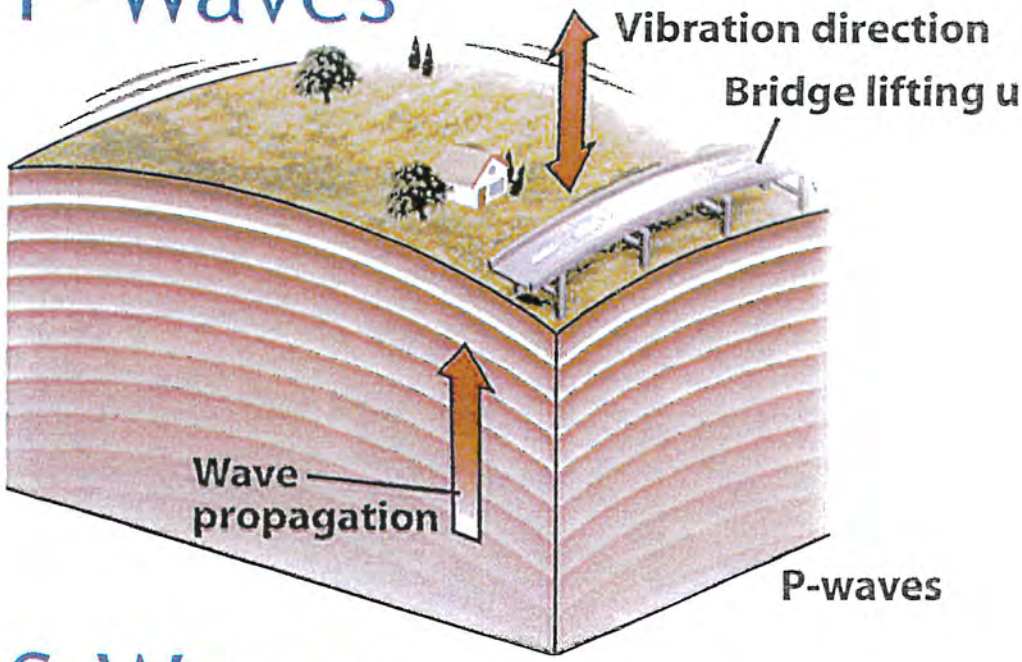


A. P waves generated using a slinky

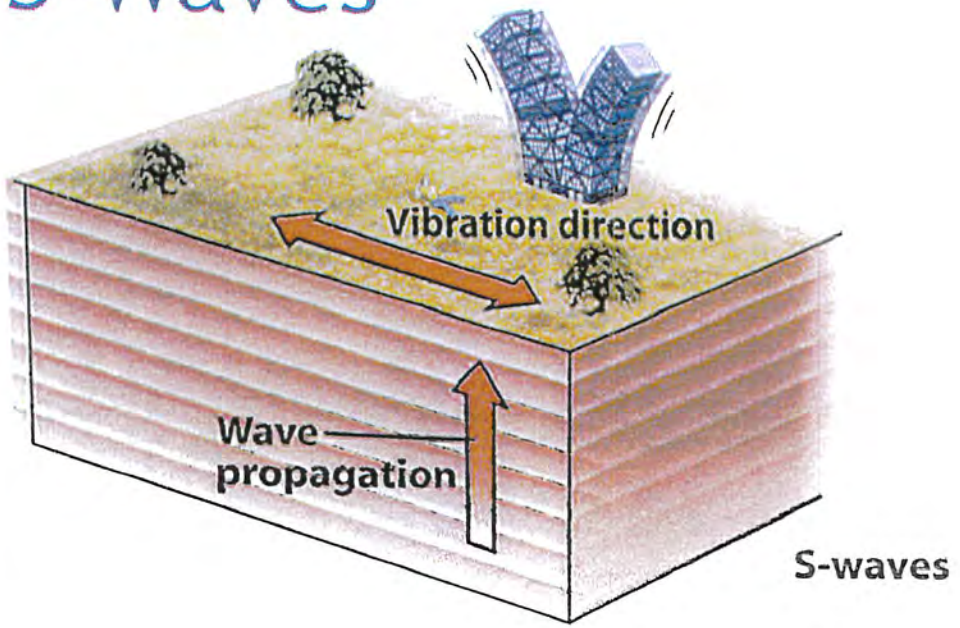


C. S wav[illegible]nerated using a rope

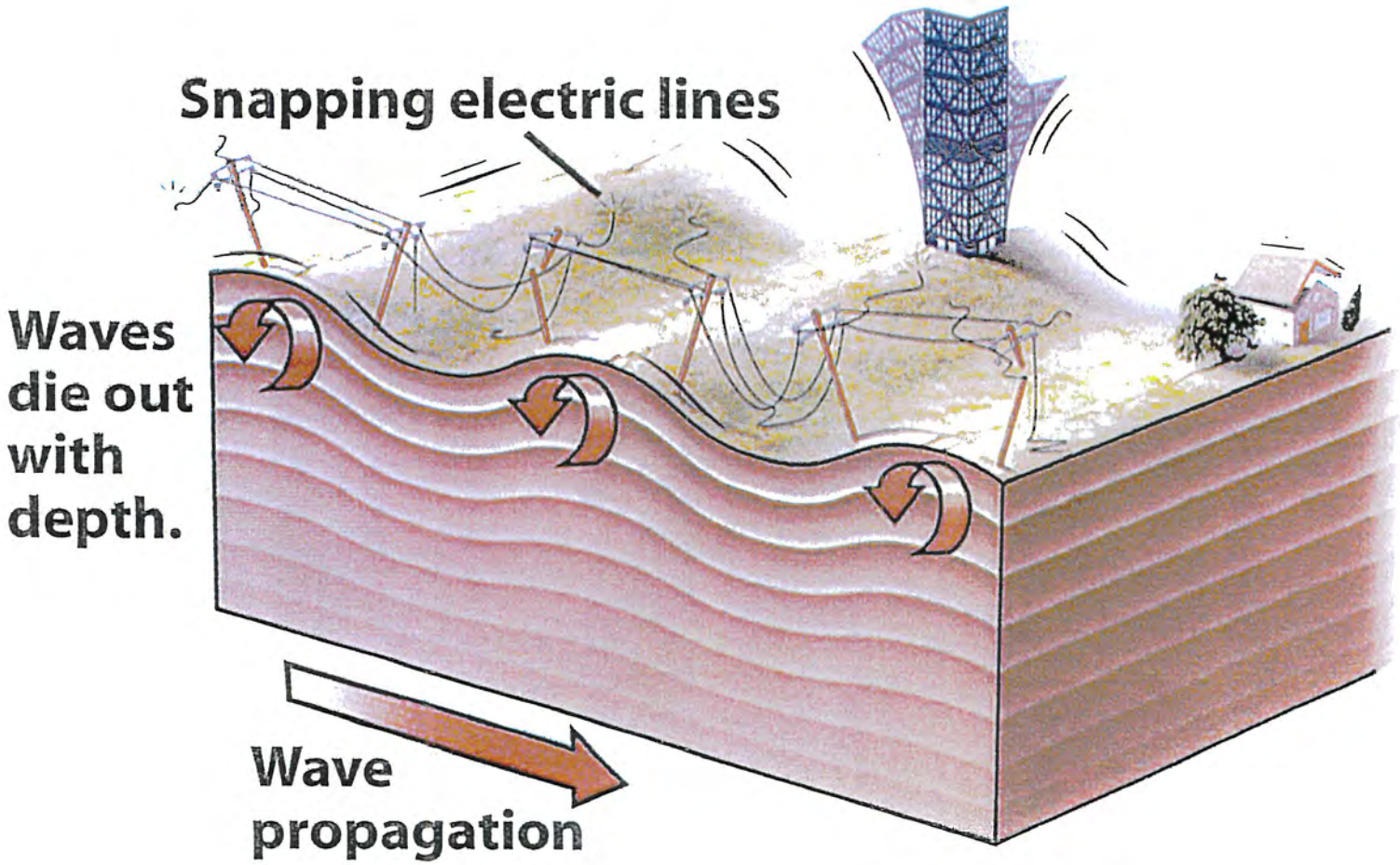
P-Waves



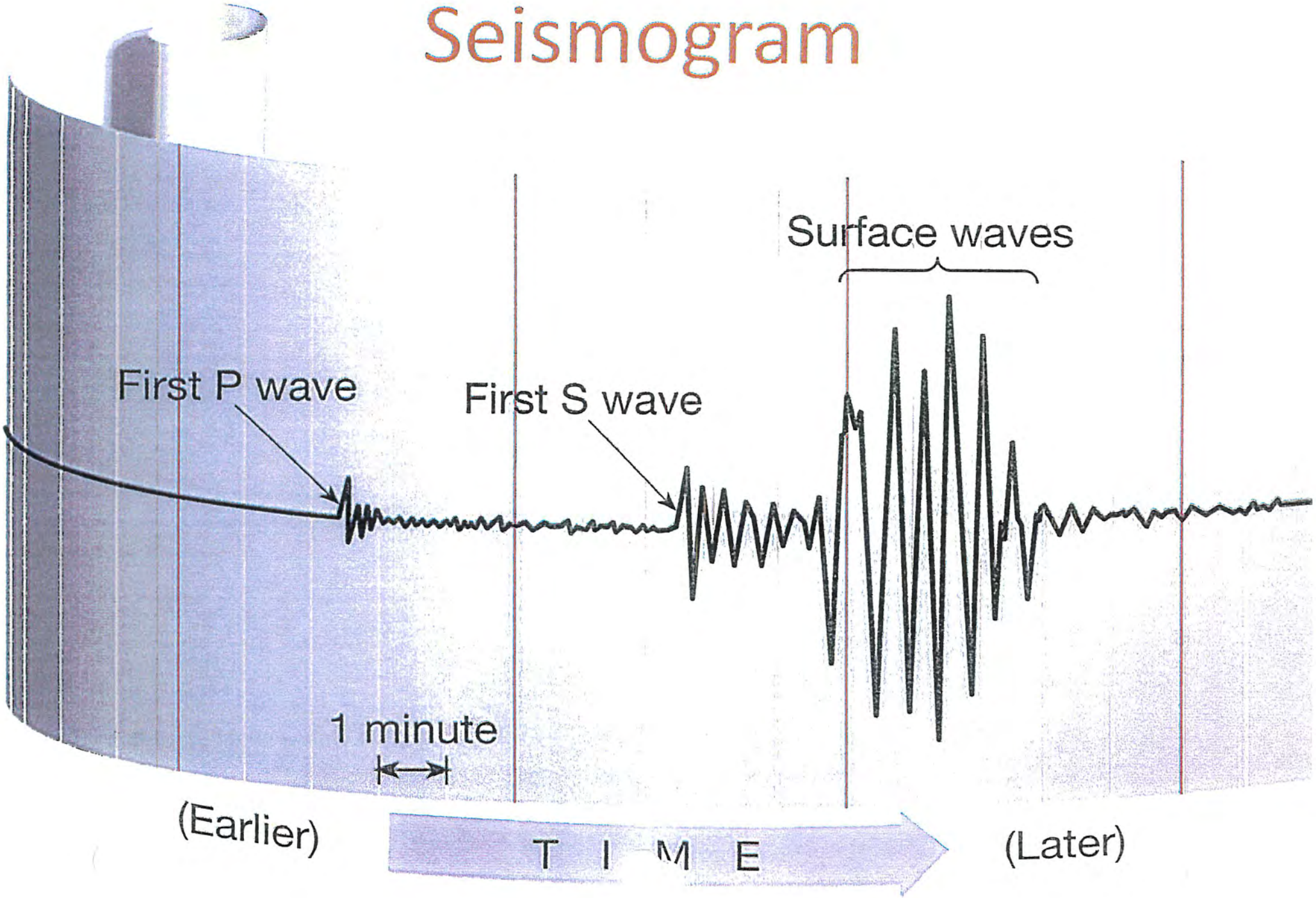
S-Waves



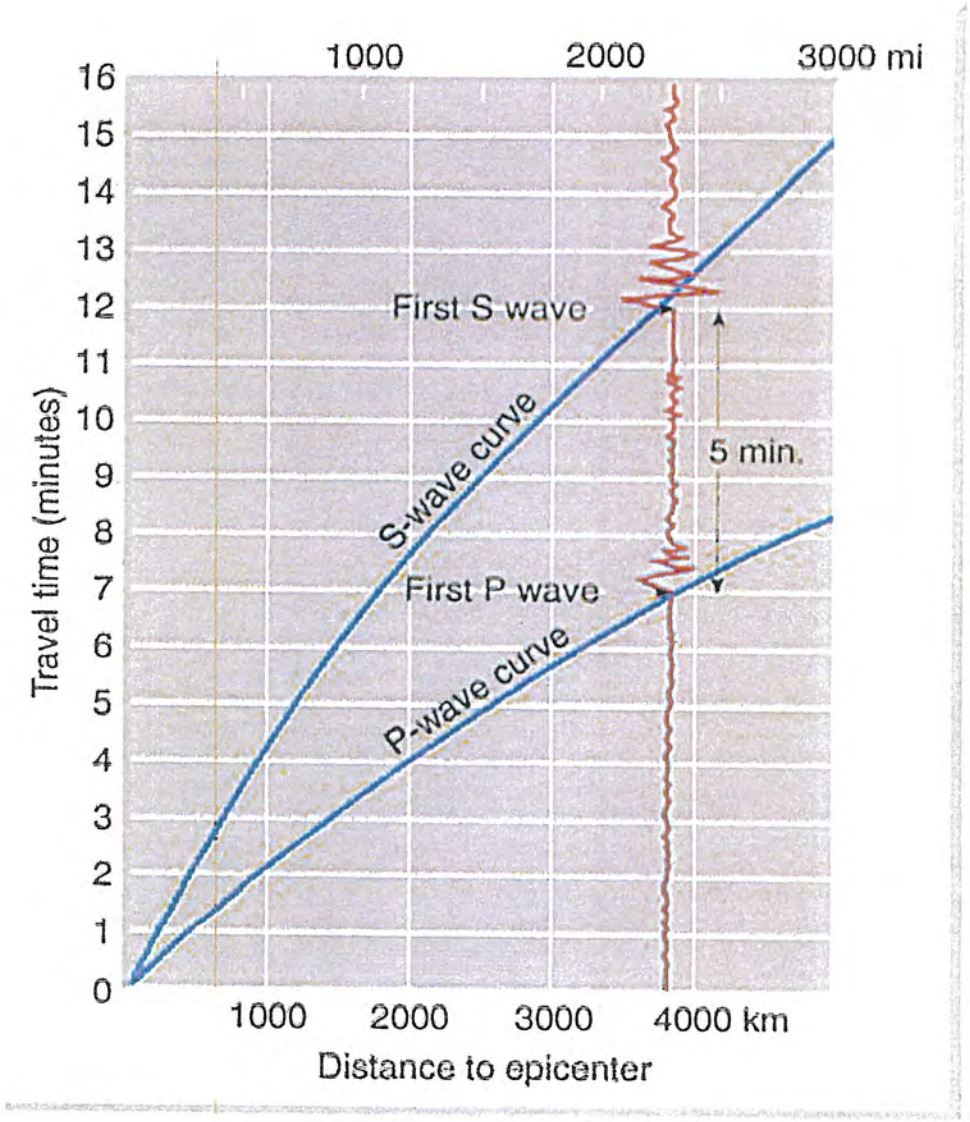
Surface Waves:



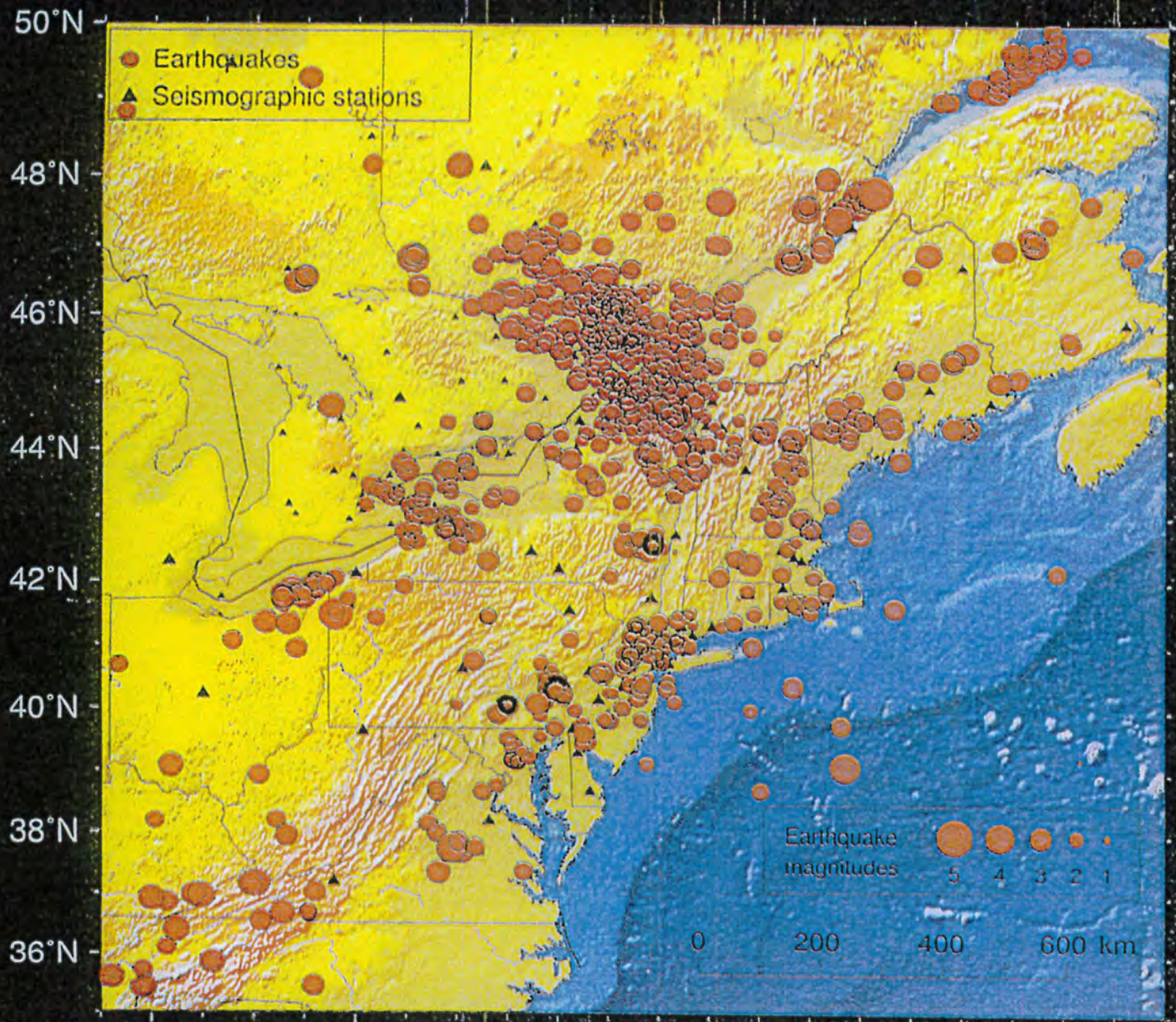
Seismogram


Surface waves
First P wave
First S wave
1 minute
(Earlier)
T I M E
(Later)

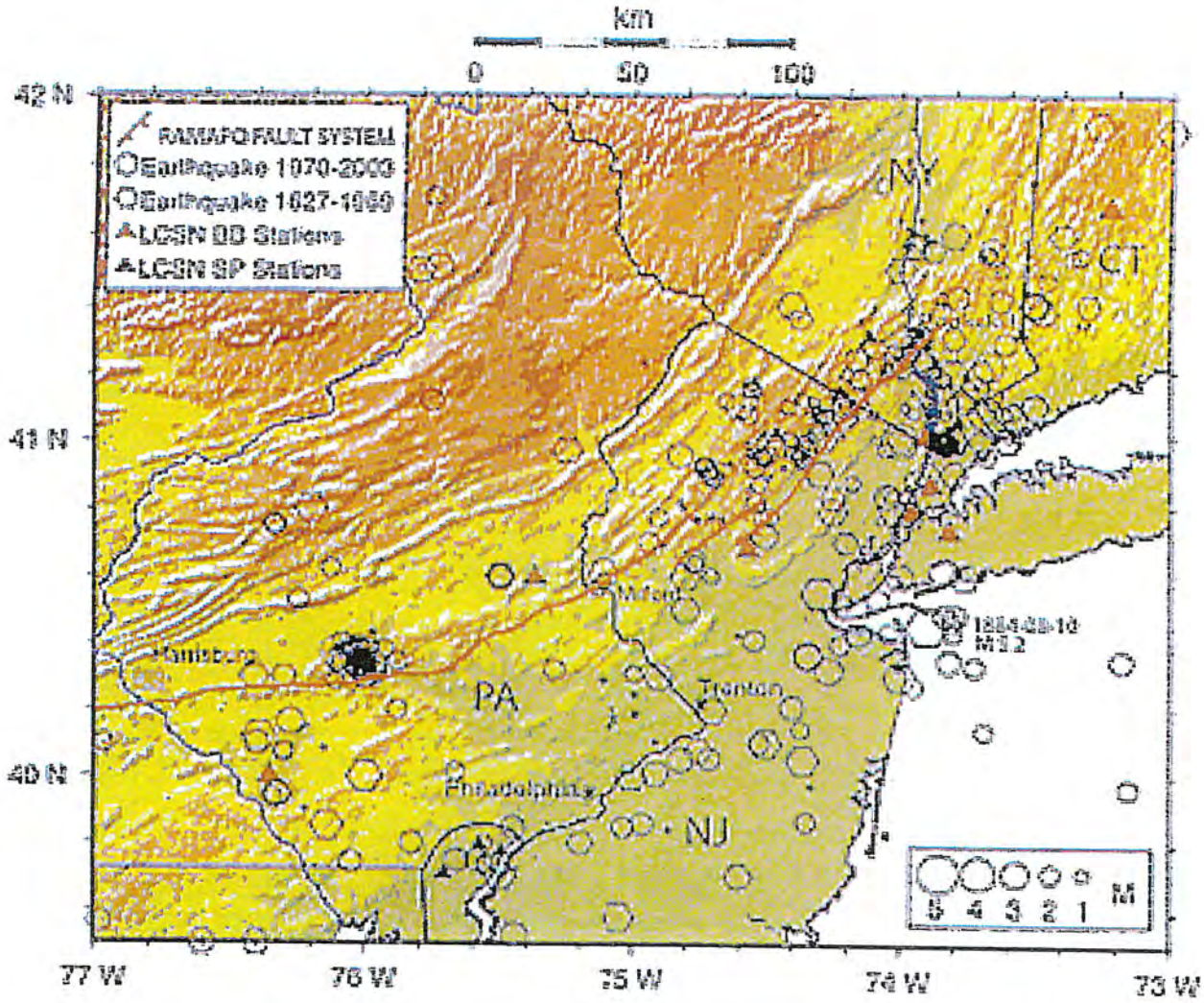
Earthquake Location



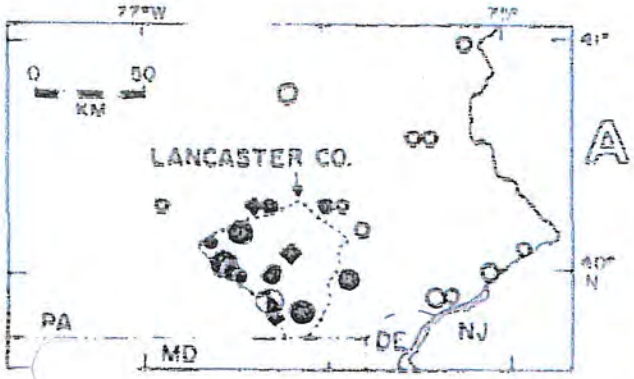
Earthquakes in NE United States and Canada 1990 - 2010



Earthquake locations by the Lamont Cooperative Seismographic Network, US Geological Survey and the Geological Survey of Canada.
June 2010, Won-Young Kim, Lamont-Doherty Earth Obse[illegible]of Columbia University, <www.ldeo.columbia.edu/LCSN>.



www.earthinstitute.columbia.edu/news/2004/story04-30-04b.html)



LANCASTER SEISMIC ZONE

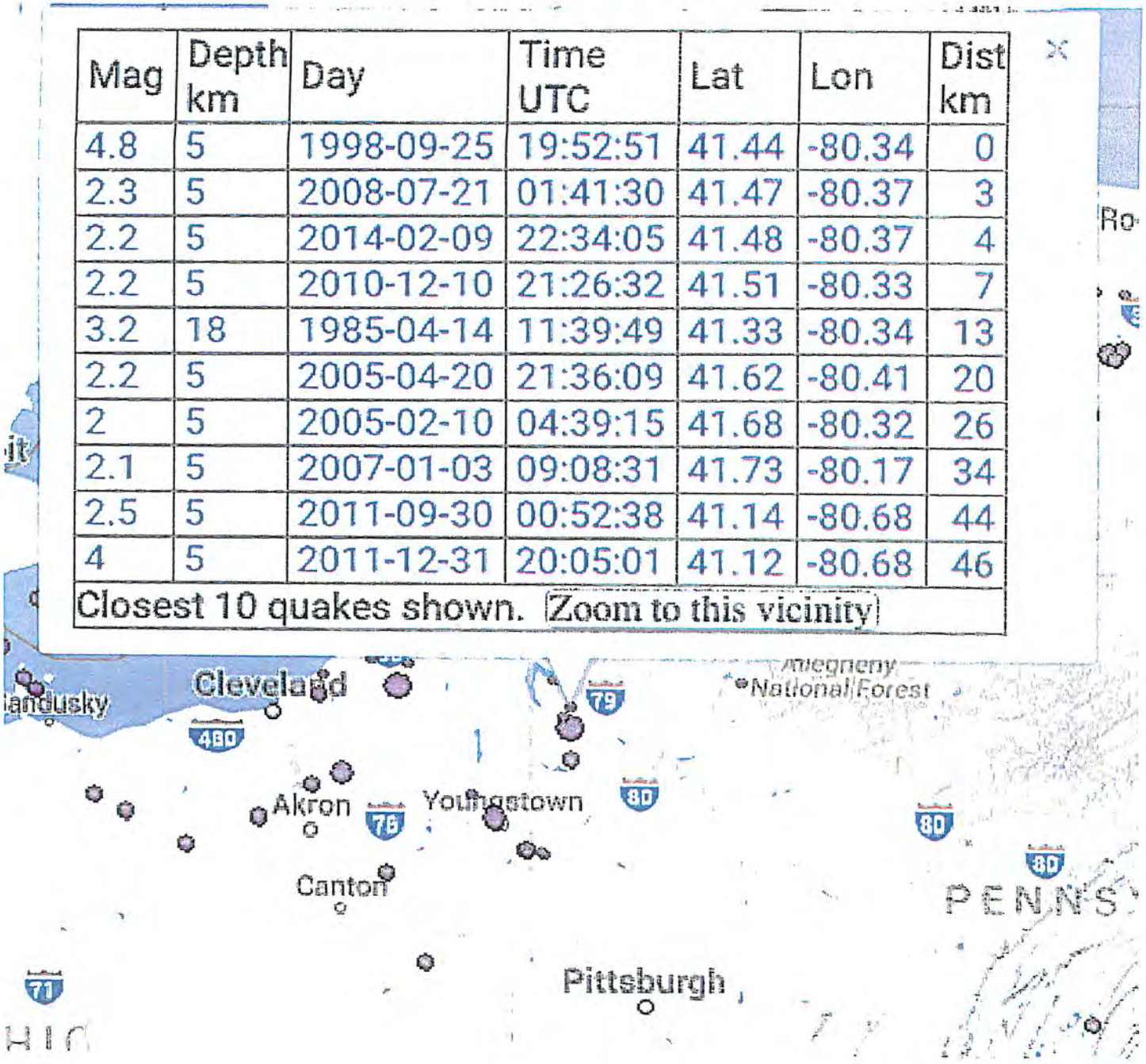
MAG
2 3 4
EPICENTERS FROM:
STOVER ET AL., 1981
DEWEY & GORDON, 1984
ARMBRUSTER & SEEBER

Armbruster and Seeber (1987)

IRIS Earthquake Browser

Mag	Depth km	Day	Time UTC	Lat	Lon	Dist km
4.8	5	1998-09-25	19:52:51	41.44	-80.34	0
2.3	5	2008-07-21	01:41:30	41.47	-80.37	3
2.2	5	2014-02-09	22:34:05	41.48	-80.37	4
2.2	5	2010-12-10	21:26:32	41.51	-80.33	7
3.2	18	1985-04-14	11:39:49	41.33	-80.34	13
2.2	5	2005-04-20	21:36:09	41.62	-80.41	20
2	5	2005-02-10	04:39:15	41.68	-80.32	26
2.1	5	2007-01-03	09:08:31	41.73	-80.17	34
2.5	5	2011-09-30	00:52:38	41.14	-80.68	44
4	5	2011-12-31	20:05:01	41.12	-80.68	46

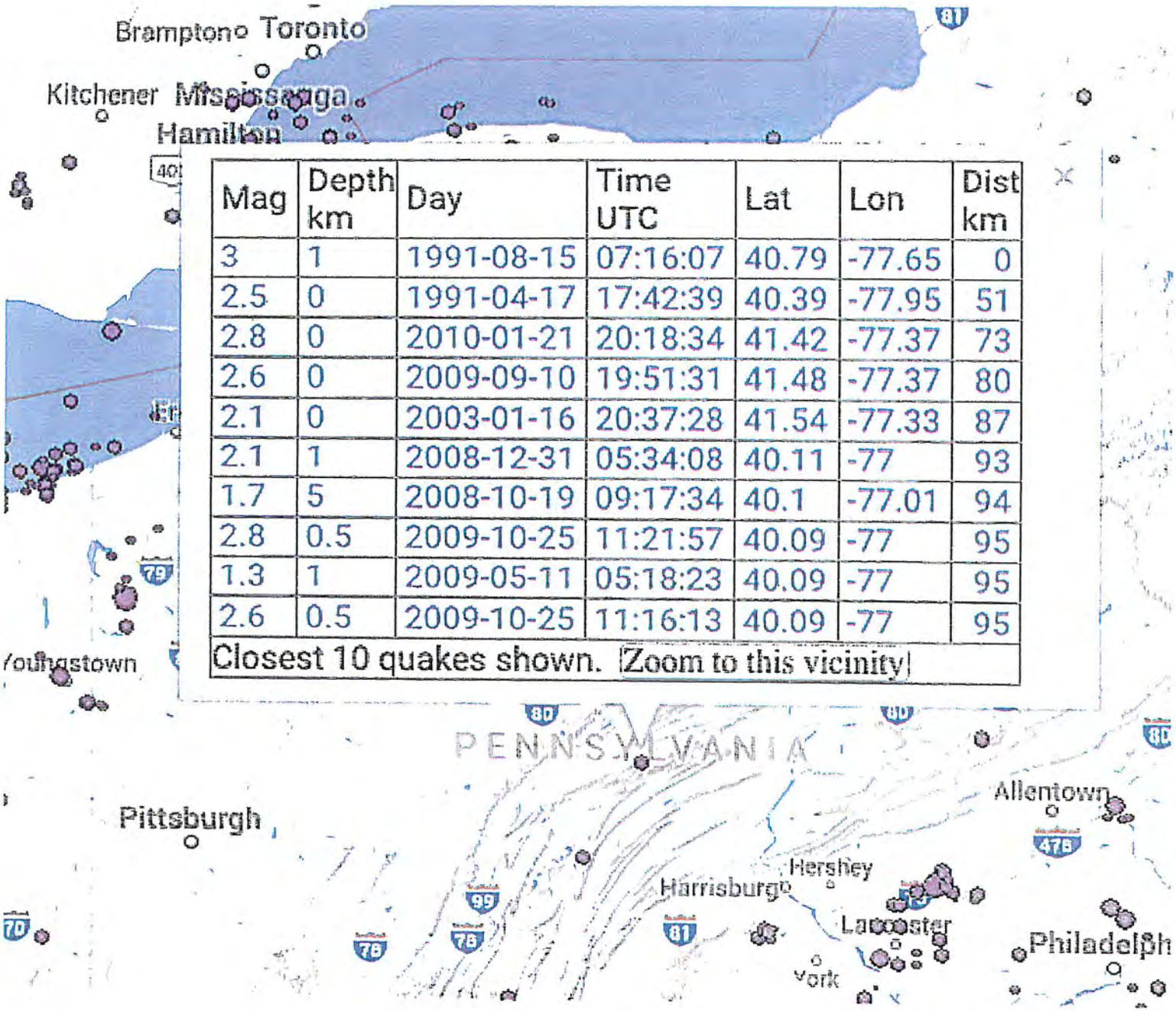
Closest 10 quakes shown. Zoom to this vicinity



IRIS=Incorporated Research Institutions for Seismology (www.iris.edu)

Sept. 25, 1998 Pymatuning, PA earthquake (Mag. 5.2)

IRIS Earthquake Browser



Mag	Depth km	Day	Time UTC	Lat	Lon	Dist km
3	1	1991-08-15	07:16:07	40.79	-77.65	0
2.5	0	1991-04-17	17:42:39	40.39	-77.95	51
2.8	0	2010-01-21	20:18:34	41.42	-77.37	73
2.6	0	2009-09-10	19:51:31	41.48	-77.37	80
2.1	0	2003-01-16	20:37:28	41.54	-77.33	87
2.1	1	2008-12-31	05:34:08	40.11	-77	93
1.7	5	2008-10-19	09:17:34	40.1	-77.01	94
2.8	0.5	2009-10-25	11:21:57	40.09	-77	95
1.3	1	2009-05-11	05:18:23	40.09	-77	95
2.6	0.5	2009-10-25	11:16:13	40.09	-77	95

Closest 10 quakes shown. Zoom to this vicinity

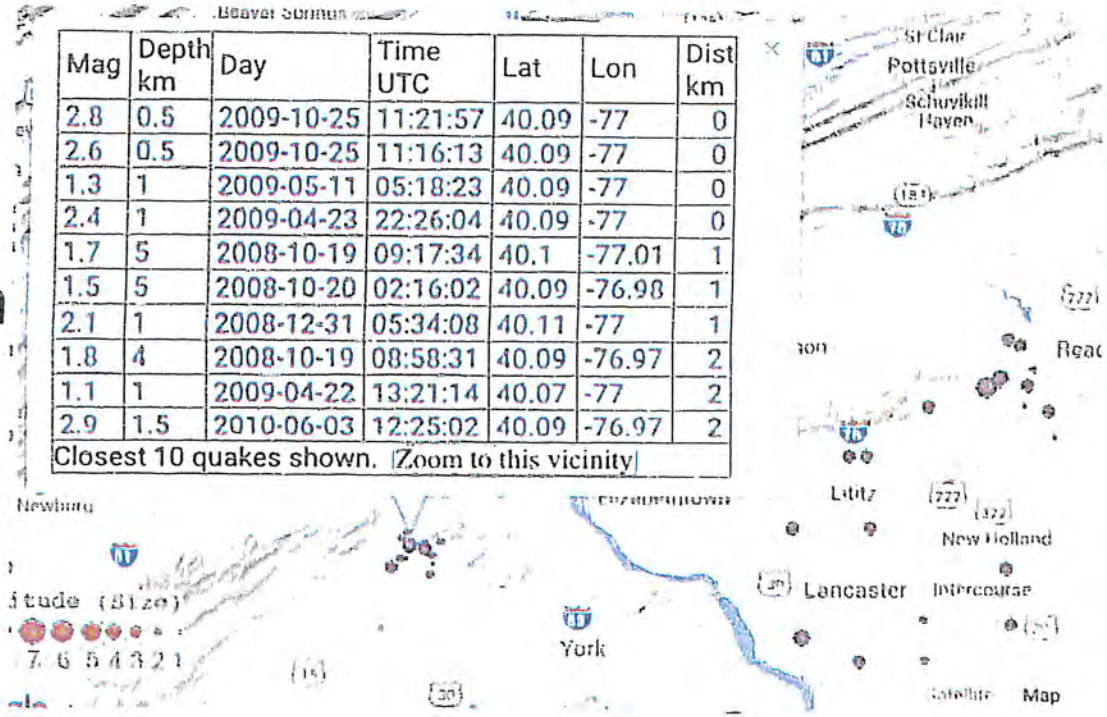
Aug. 15, 1991 Centre Hall earthquake (Mag. 3)

IRIS Earthquake Browser

Dillsburg swarm

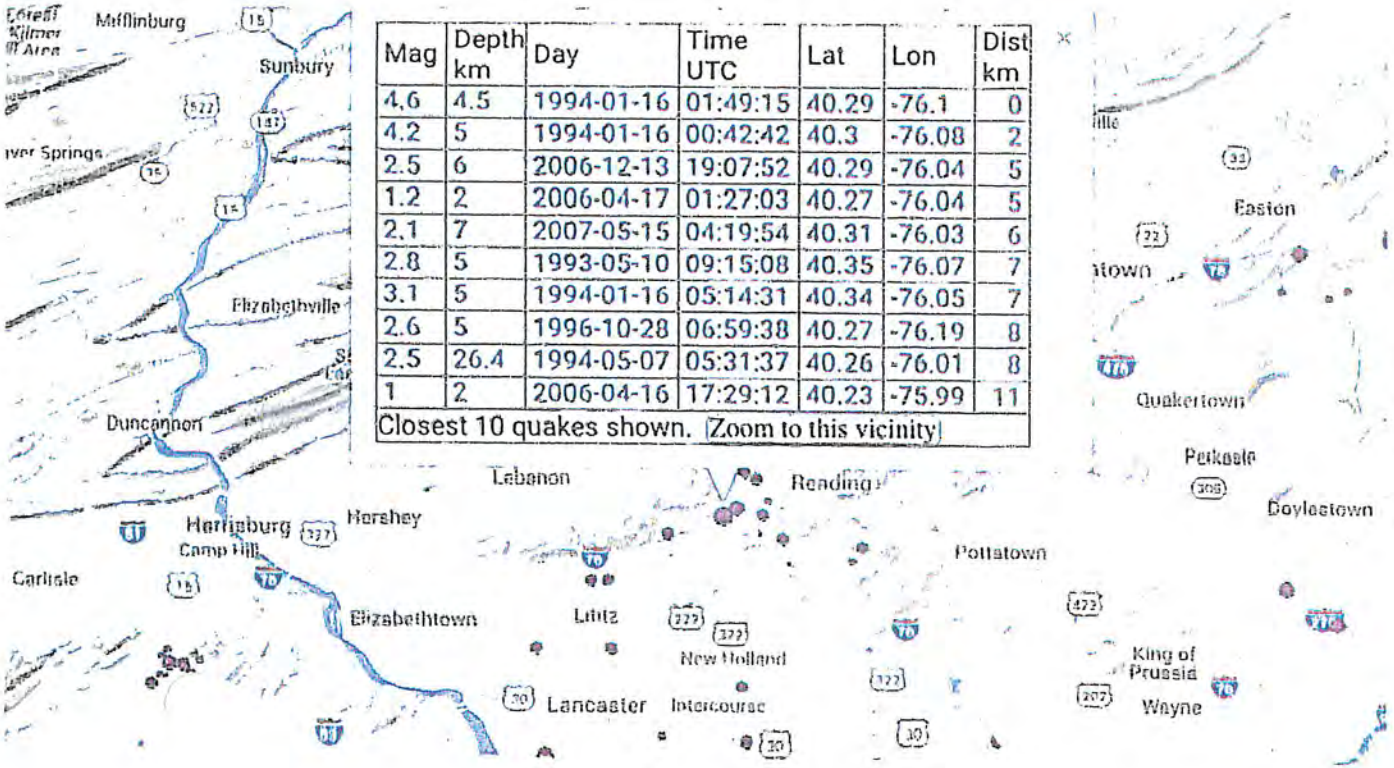
Mag	Depth km	Day	Time UTC	Lat	Lon	Dist km
2.8	0.5	2009-10-25	11:21:57	40.09	-77	0
2.6	0.5	2009-10-25	11:16:13	40.09	-77	0
1.3	1	2009-05-11	05:18:23	40.09	-77	0
2.4	1	2009-04-23	22:26:04	40.09	-77	0
1.7	5	2008-10-19	09:17:34	40.1	-77.01	1
1.5	5	2008-10-20	02:16:02	40.09	-76.98	1
2.1	1	2008-12-31	05:34:08	40.11	-77	1
1.8	4	2008-10-19	08:58:31	40.09	-76.97	2
1.1	1	2009-04-22	13:21:14	40.07	-77	2
2.9	1.5	2010-06-03	12:25:02	40.09	-76.97	2

Closest 10 quakes shown. Zoom to this vicinity



Mag	Depth km	Day	Time UTC	Lat	Lon	Dist km
4.6	4.5	1994-01-16	01:49:15	40.29	-76.1	0
4.2	5	1994-01-16	00:42:42	40.3	-76.08	2
2.5	6	2006-12-13	19:07:52	40.29	-76.04	5
1.2	2	2006-04-17	01:27:03	40.27	-76.04	5
2.1	7	2007-05-15	04:19:54	40.31	-76.03	6
2.8	5	1993-05-10	09:15:08	40.35	-76.07	7
3.1	5	1994-01-16	05:14:31	40.34	-76.05	7
2.6	5	1996-10-28	06:59:38	40.27	-76.19	8
2.5	26.4	1994-05-07	05:31:37	40.26	-76.01	8
1	2	2006-04-16	17:29:12	40.23	-75.99	11

Closest 10 quakes shown. Zoom to this vicinity



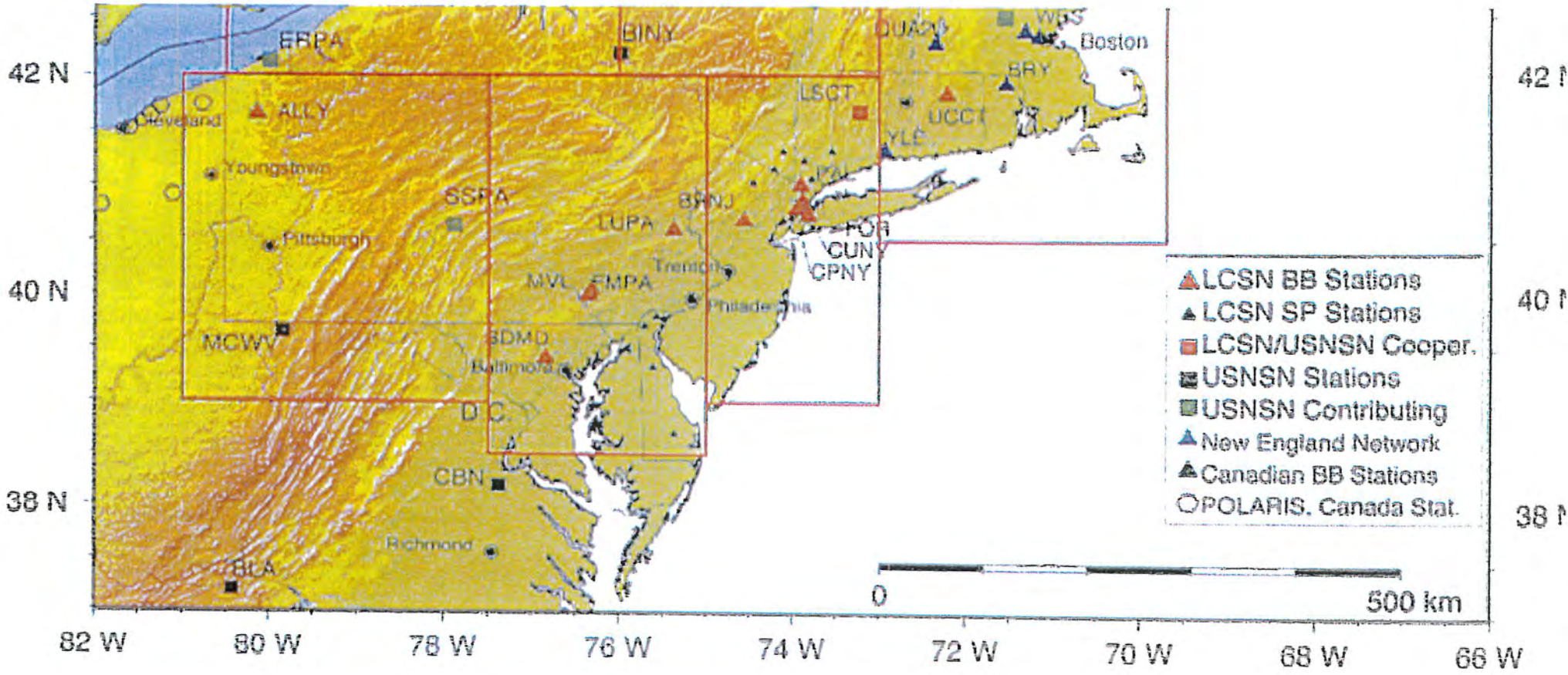
1994 Wyomissing Hills earthquakes (Mag. 4.0 foreshock and 4.6 mainshock)

Permanent Seismic Stations in PA through 2015

3 Networks:

- USGS National Network (2 stations)
- Lamont Doherty Earth Observatory Cooperative Seismic Network (LCSN) (supported as a regional network by the USGS) (6 stations)
- Initial 10 PASEIS stations

USGS and LCSN Stations

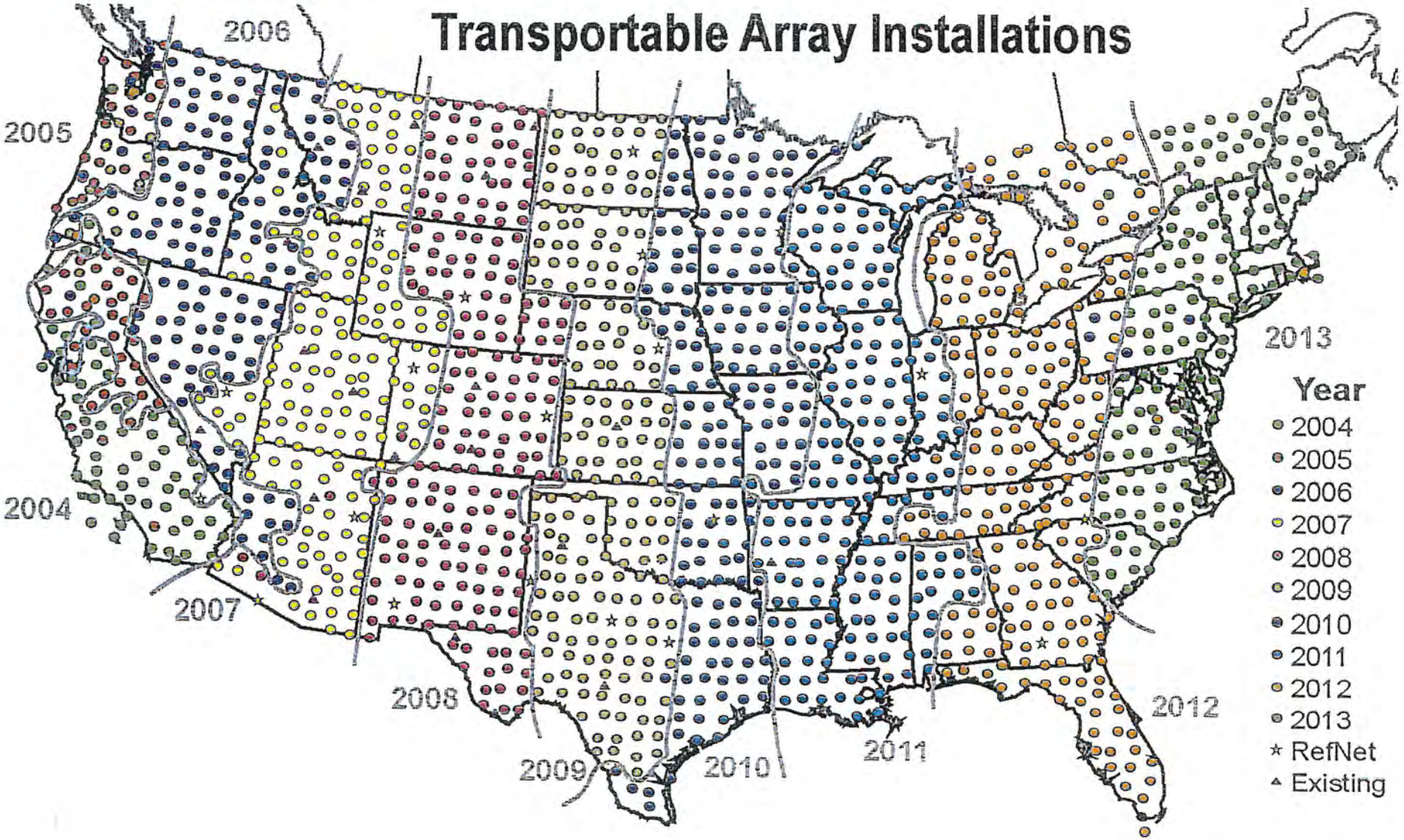


Initial 10 PASEIS stations

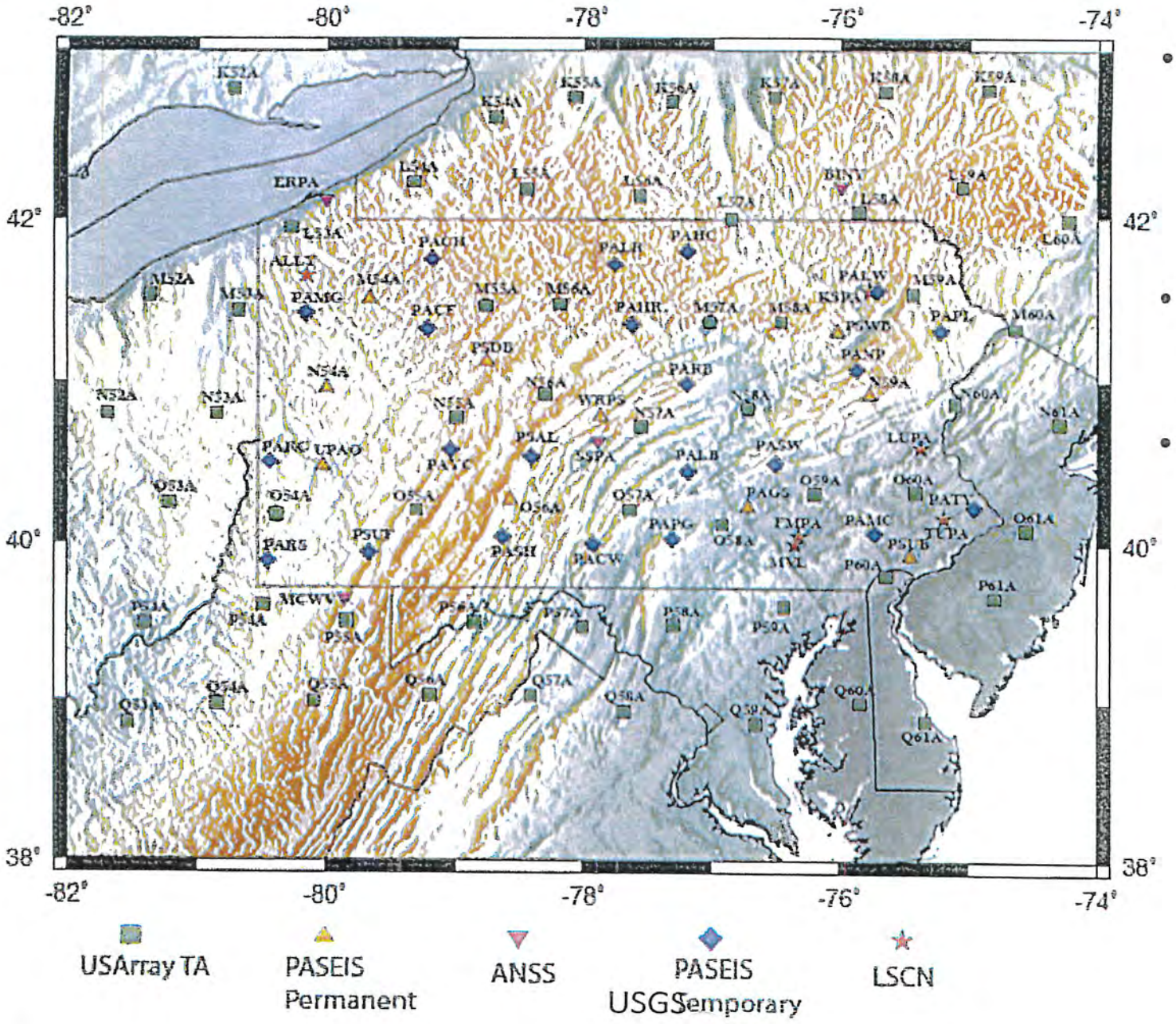
History of building a PA state seismic network

- 2006-2010 Establishment of the first 6 permanent PASEIS stations – DCNR
- 2009 Carbon sequestration technical assessment - DCNR
  - *25 portable seismic stations*
- 2010 Purchase of 4 USArray stations from IRIS – DCNR
- 2013 Earthquake monitoring during USArray - DCNR
  - *Support for temporary network to densify the USArray network, develop seismicity catalog*
- 2015 Expand the 10-station permanent network to 30 stations and provide seismic event information – DCNR and DEP

USArray


Transportable Array Installations
2006
2005
2004
2007
2008
2009
2010
2011
2012
2013
Year
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
RefNet
Existing

Stations 2/2013 to 12/2014



- Over 100 3-component high quality (broadband stations
- Recording continuously
- Sample rates of between 40 and 100 samples per second

PA seismicity 2/2013 to 12/2014 (from Kyle Homman's MS thesis)

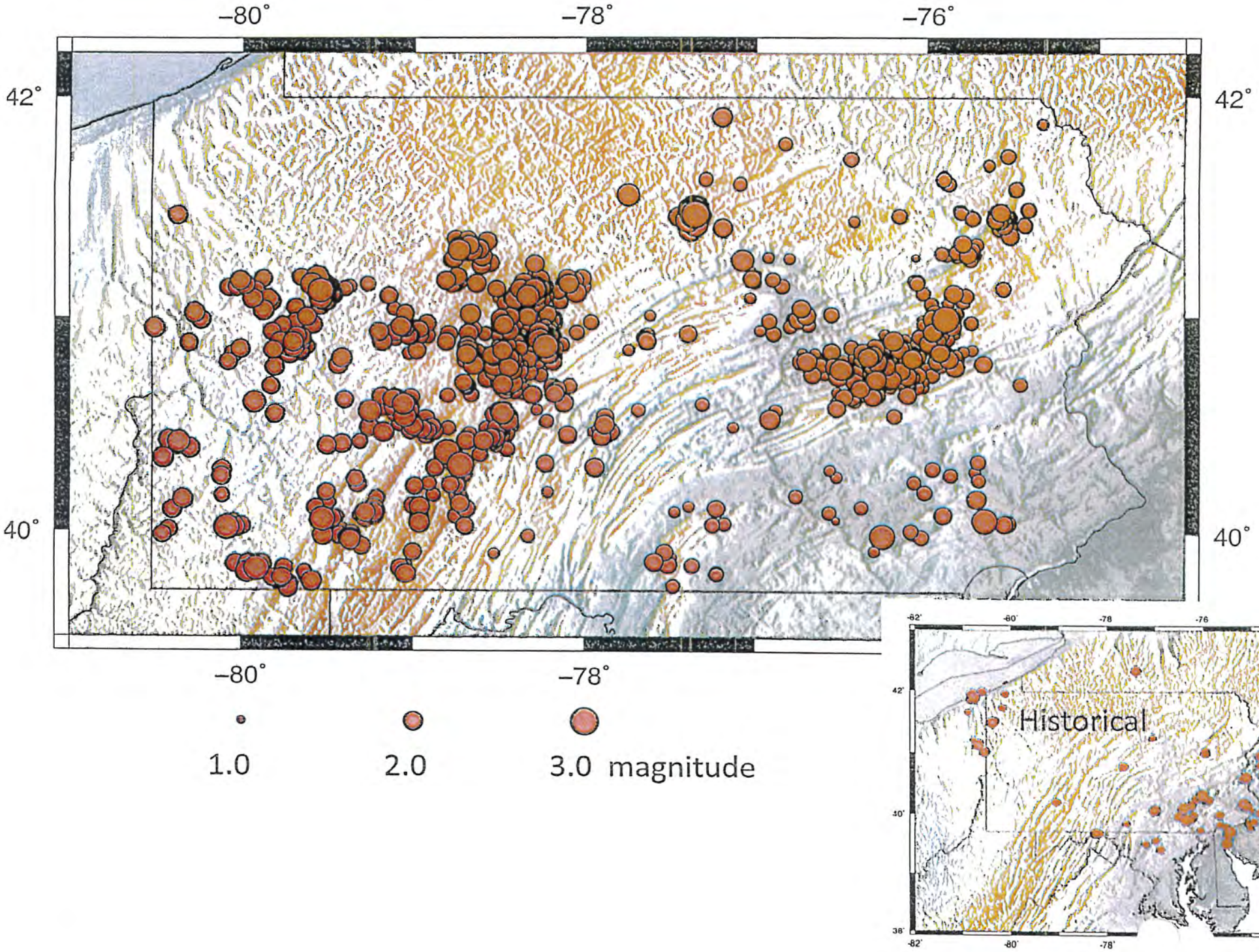
- Average number of stations used for each event: 10
- Minimum number of stations used was 4
- 1568 events with 1355 located in Pennsylvania

Picking and Locating Events

- Used Antelope Software package
- Manually picked arrival times
- Filtered with a 1-5 Hz bandpass filter
- Preliminary locations from Antelope using IASP91 velocity model
- Relocated using HYPOELLIPSE and a velocity model for Pennsylvania
- Magnitudes determined using Richter's method for local magnitude

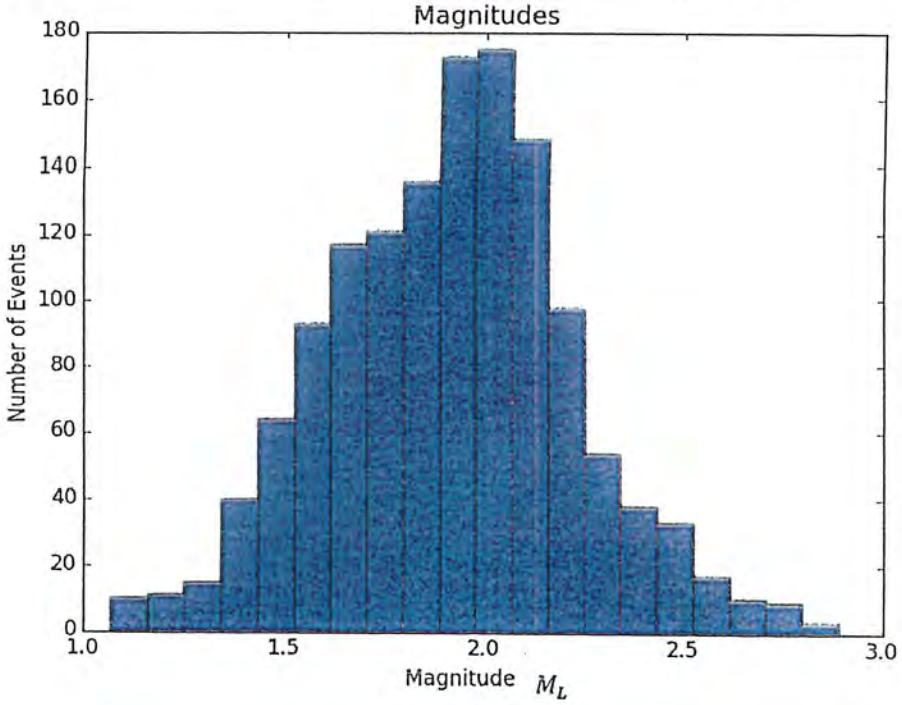
Layer	P-wave Velocity (km/s)	Depth of Interface (km)	Vp/Vs Ratio
1	6.0	0.0	1.74
2	6.3	10.0	1.74
3	6.6	20.0	1.74
4	6.9	30.0	1.74
5	8.1	37.0	1.74

Adapted from Katz (1955)


–80°
–78°
–76°
42°
40°
1.0
2.0
3.0 magnitude
Historical

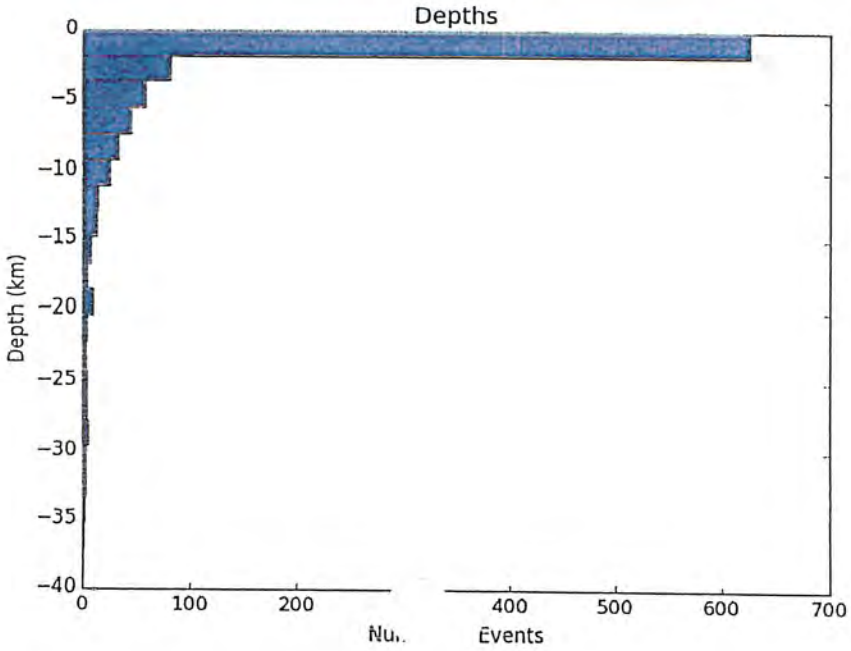
Magnitudes and Depths

- Local magnitudes range from 1.07 to 2.89



Catalog is complete to magnitude 2

- Depths mostly < 1 km

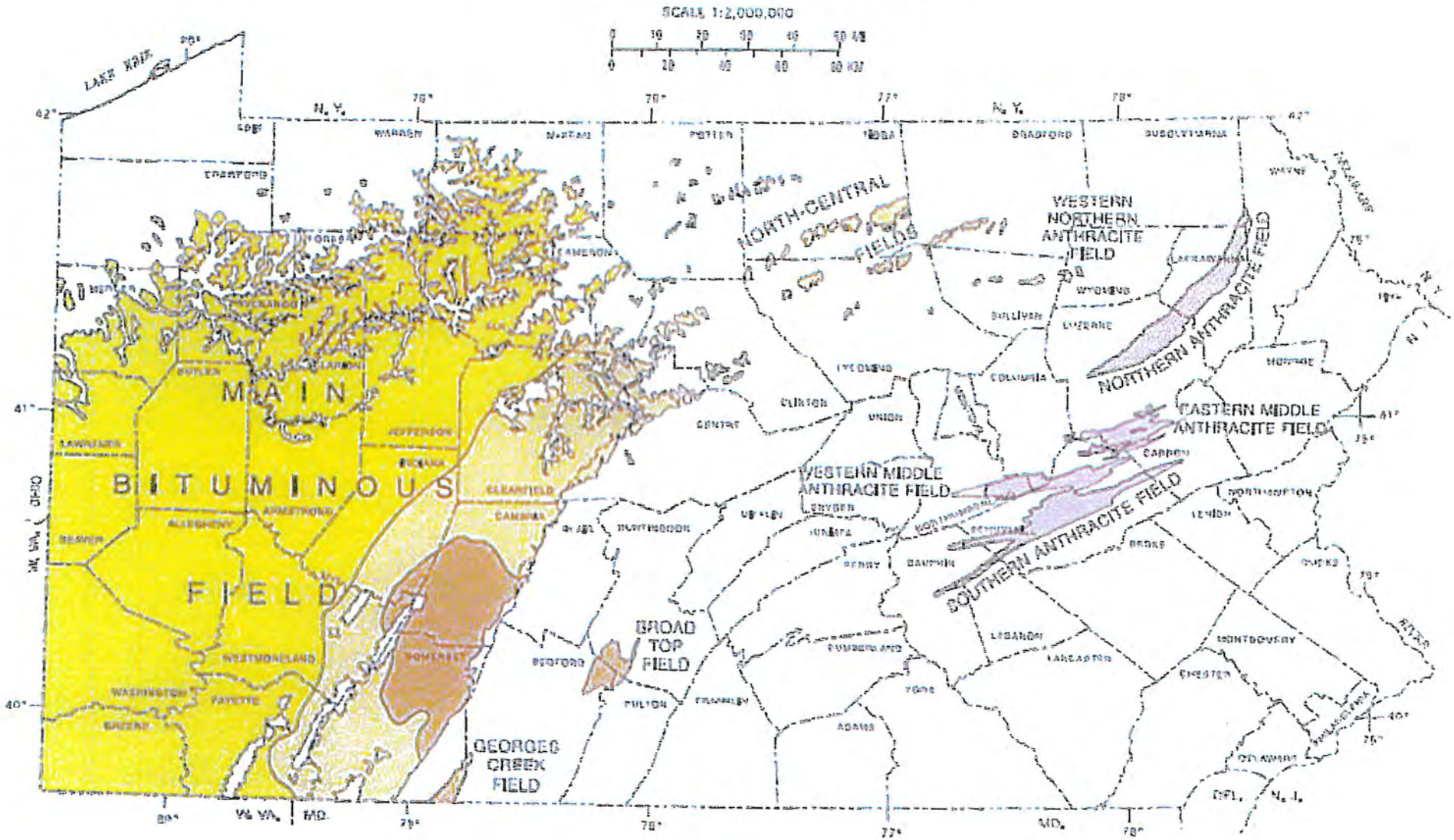


What are the sources of the seismic events?

Several possibilities

- tectonic earthquakes
- mine blasts (quarries, coal mines, other mines)
-induced seismicity from wastewater disposal wells
- induced seismicity from hydraulic fracking

DISTRIBUTION OF PENNSYLVANIA COALS



EXPLANATION

BITUMINOUS FIELDS

- High-volatile bituminous coal
- Medium-volatile bituminous coal
- Lower bituminous

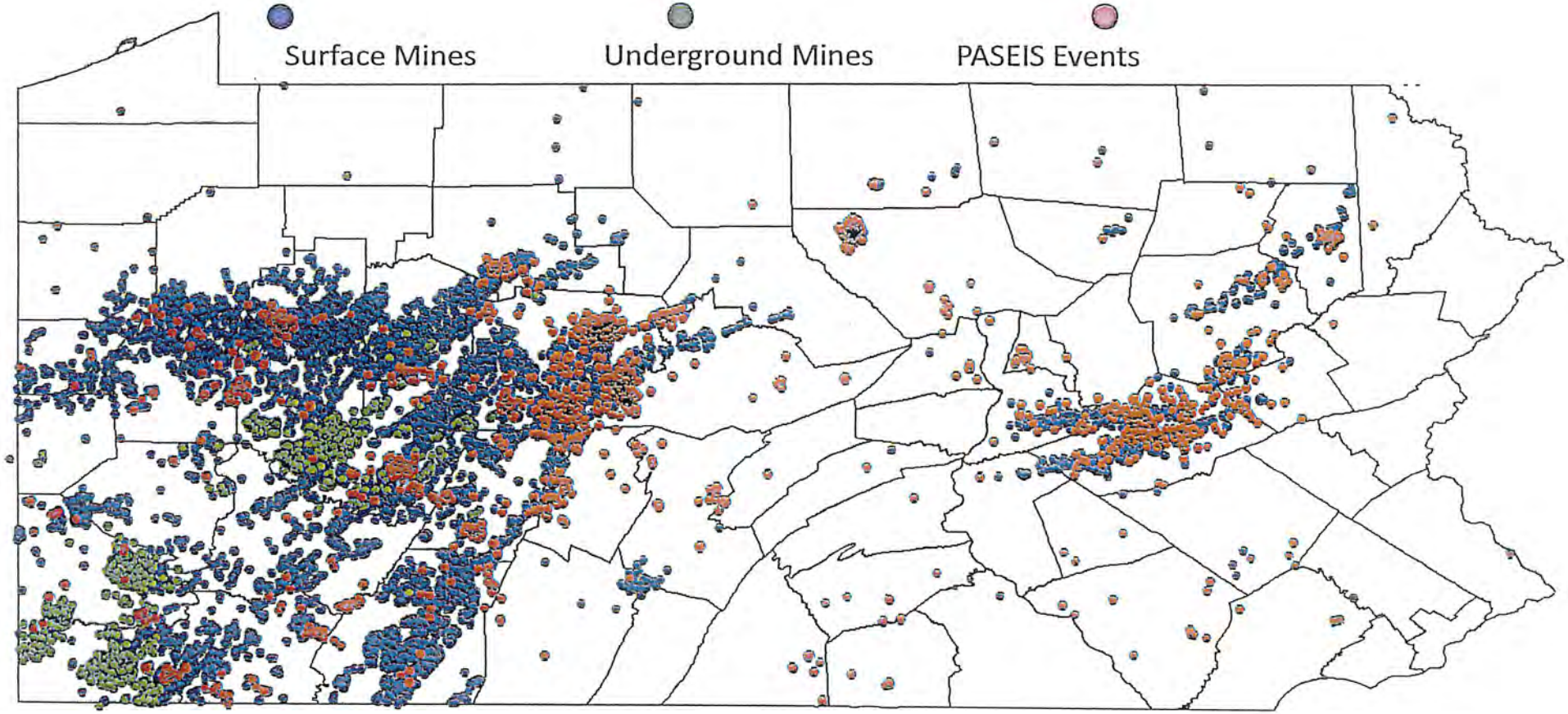
ANTHRACITE FIELDS

- Semianthracite
- Anthracite

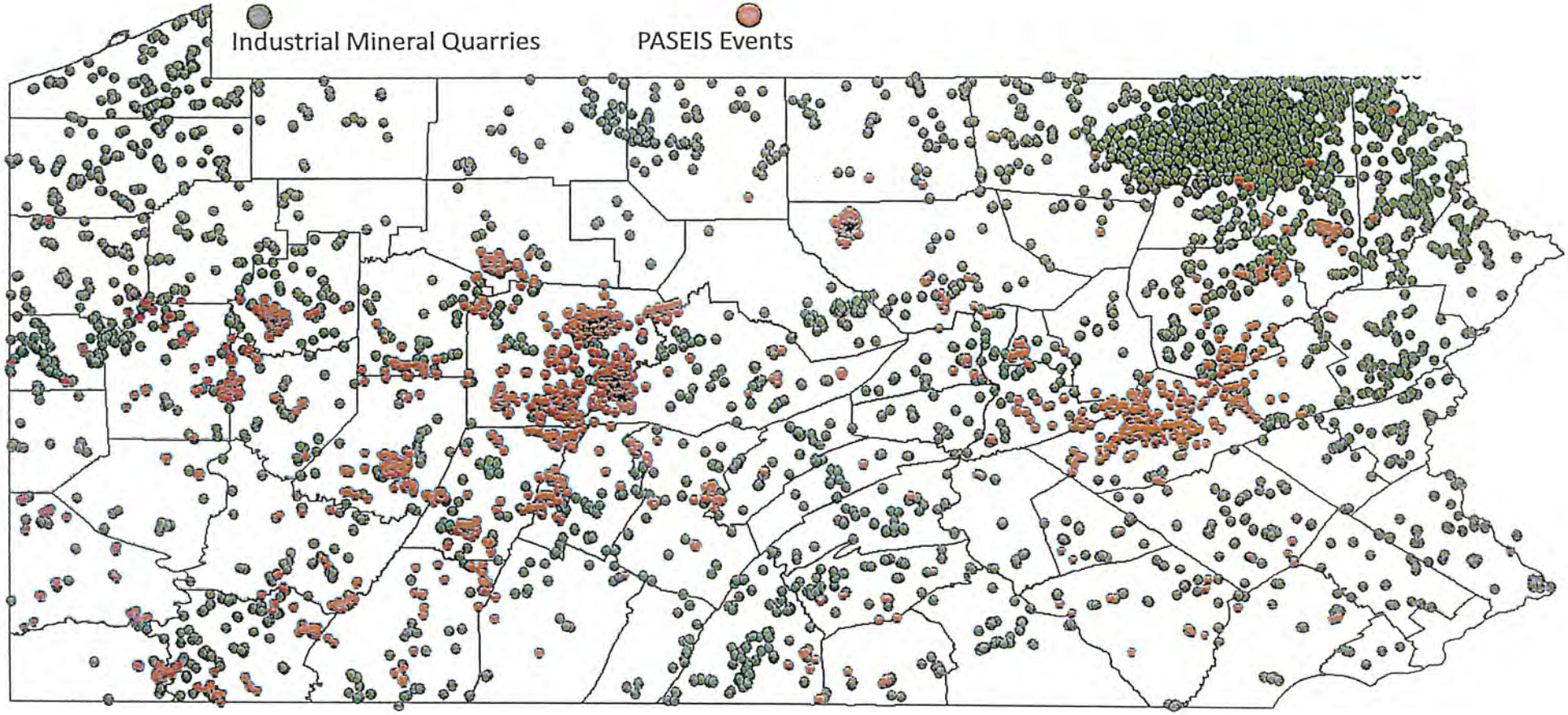
USGS Event Classification for Blasts

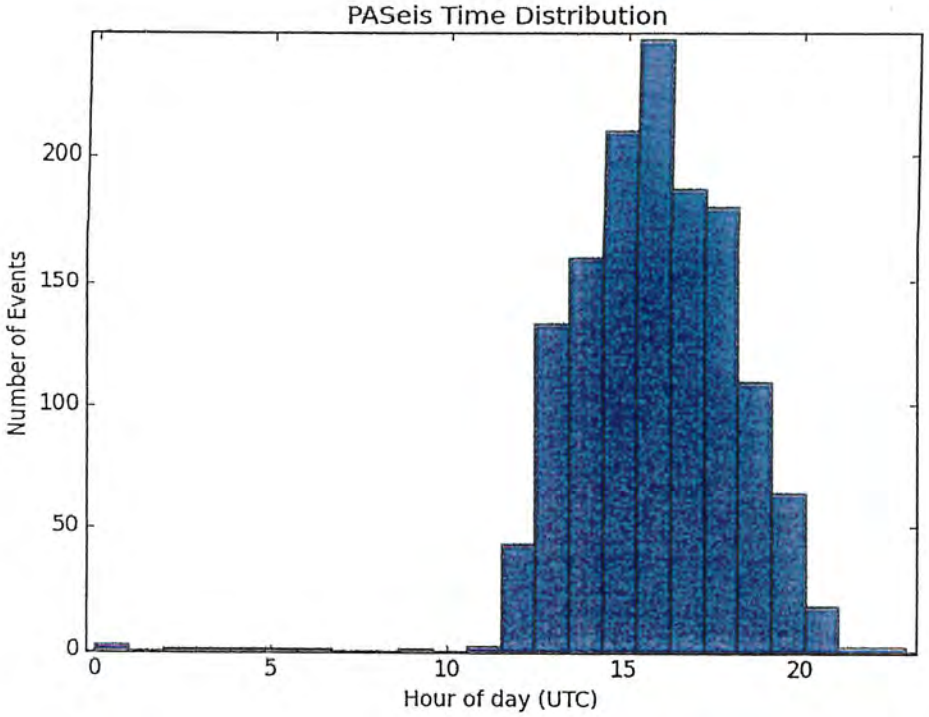
- Time of event (during working hours)
- Location of events relative to mines and quarries (within 5 km)
- Emergent phase arrivals
- Lack of clear S-wave arrivals
- Excessive low-frequency signal
- Presence of a short period surface wave

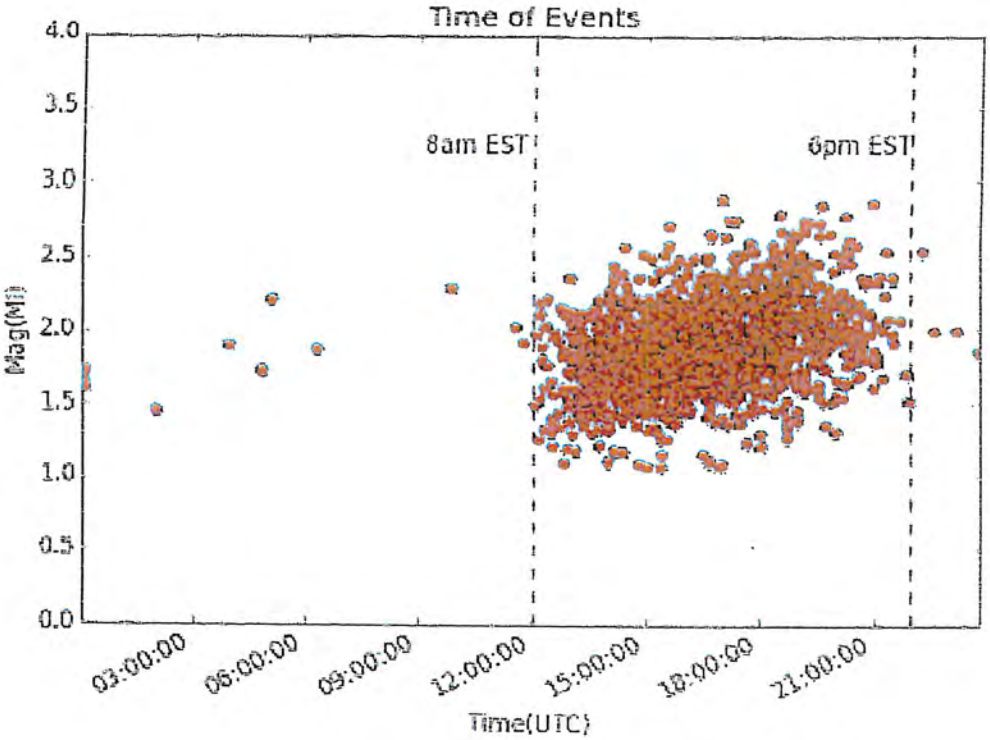
Spatial correlation with coal mines

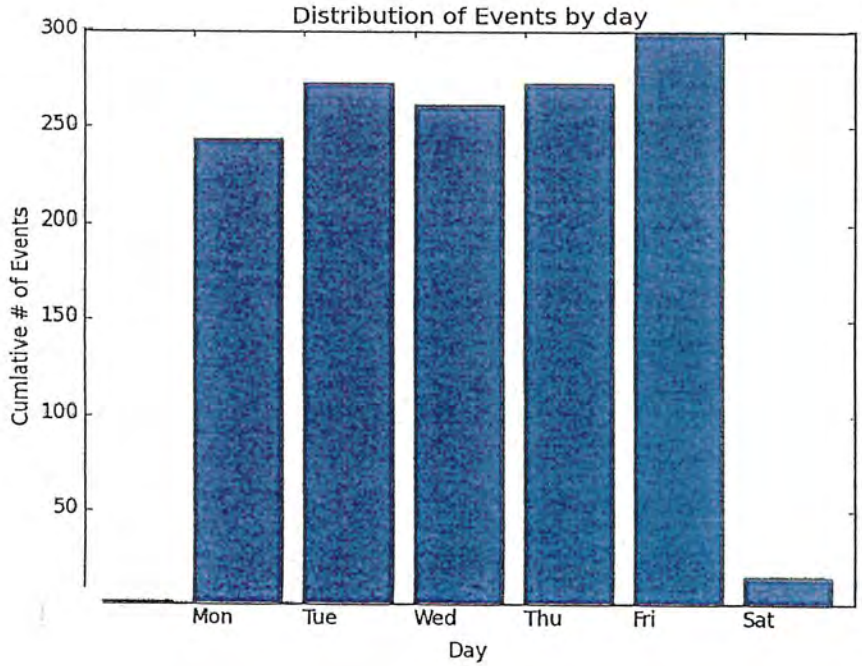


Spatial correlation with other mines

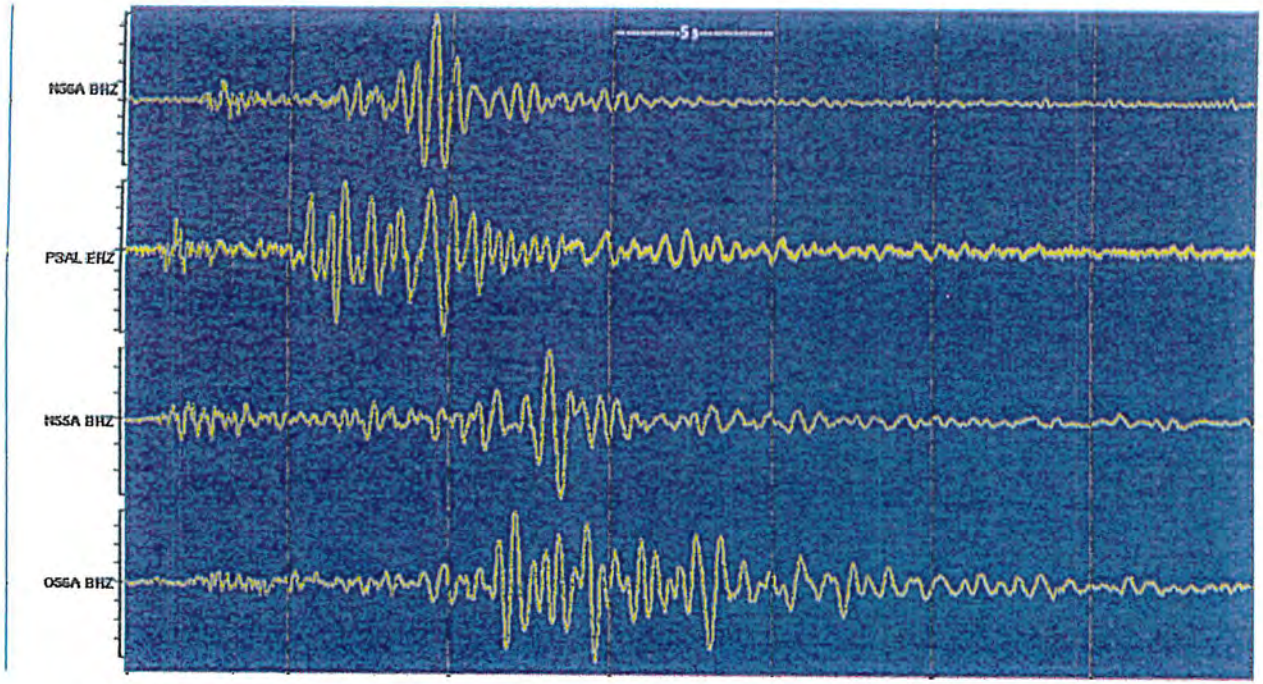








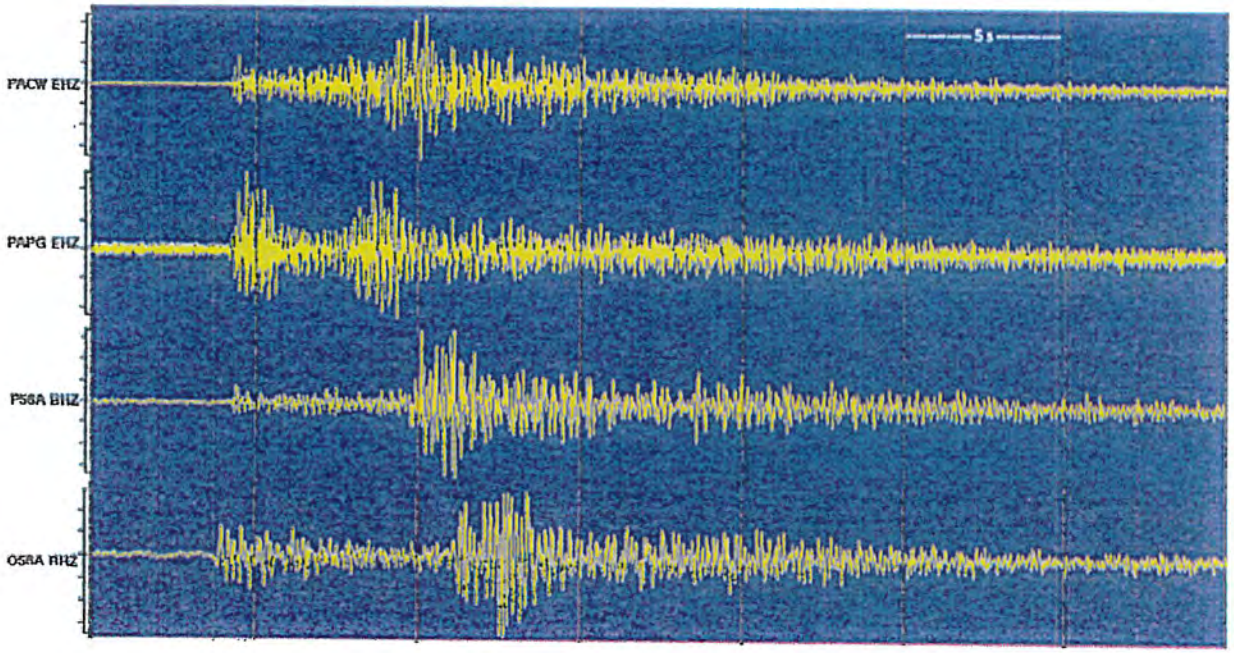
Timing of Events



Blasting event

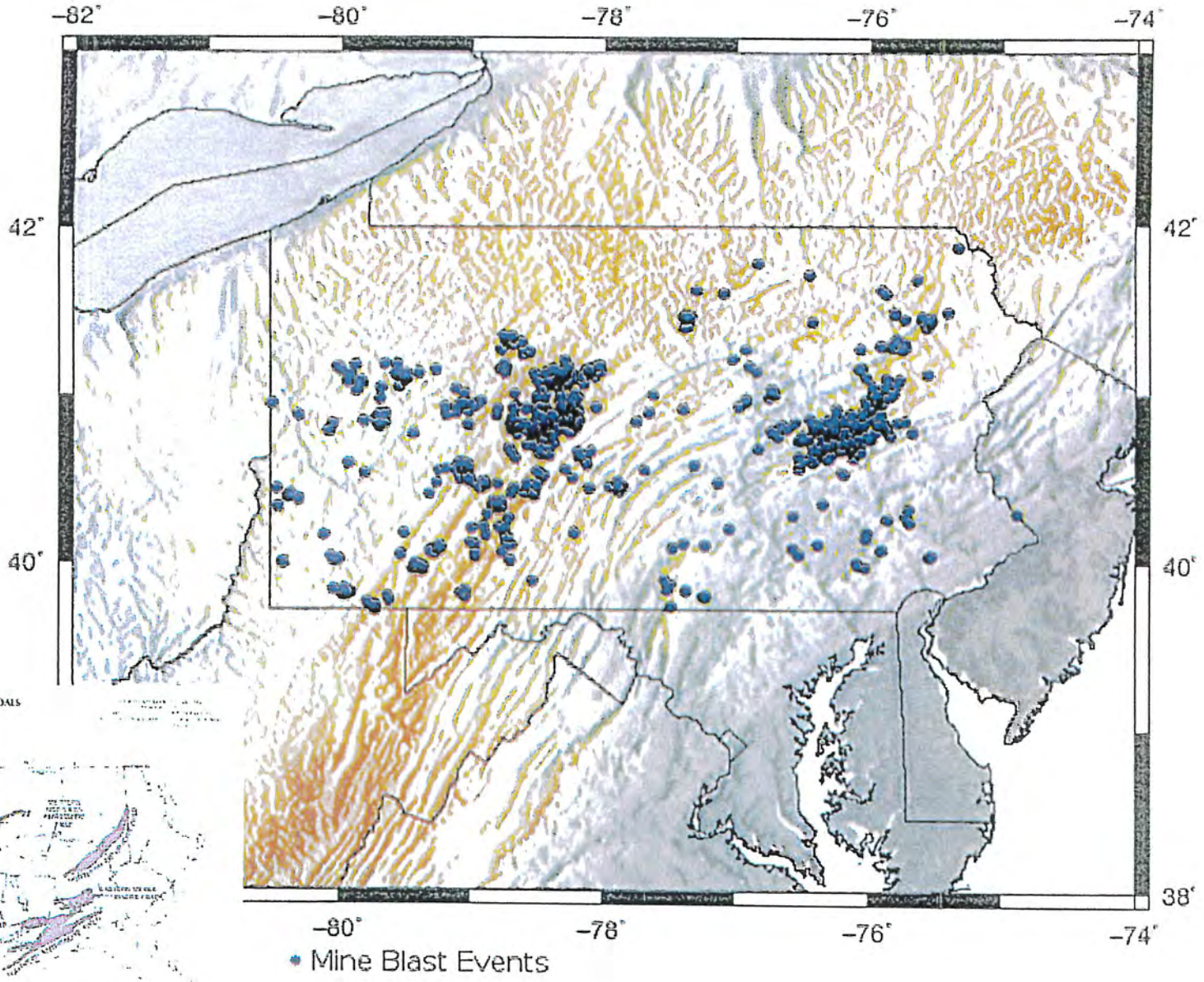
Waveform characteristics

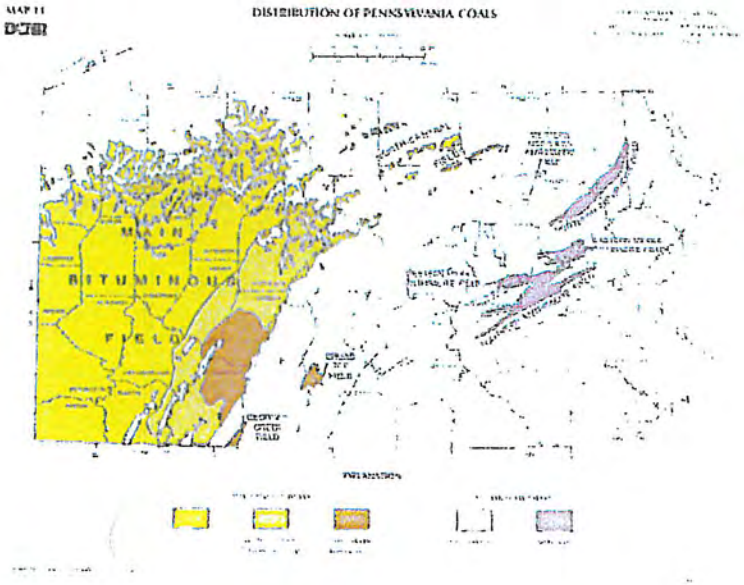
- Emergent phase arrivals
- Lack of clear S-wave arrivals
- Excessive low-frequency signal
- Presence of a short period surface wave



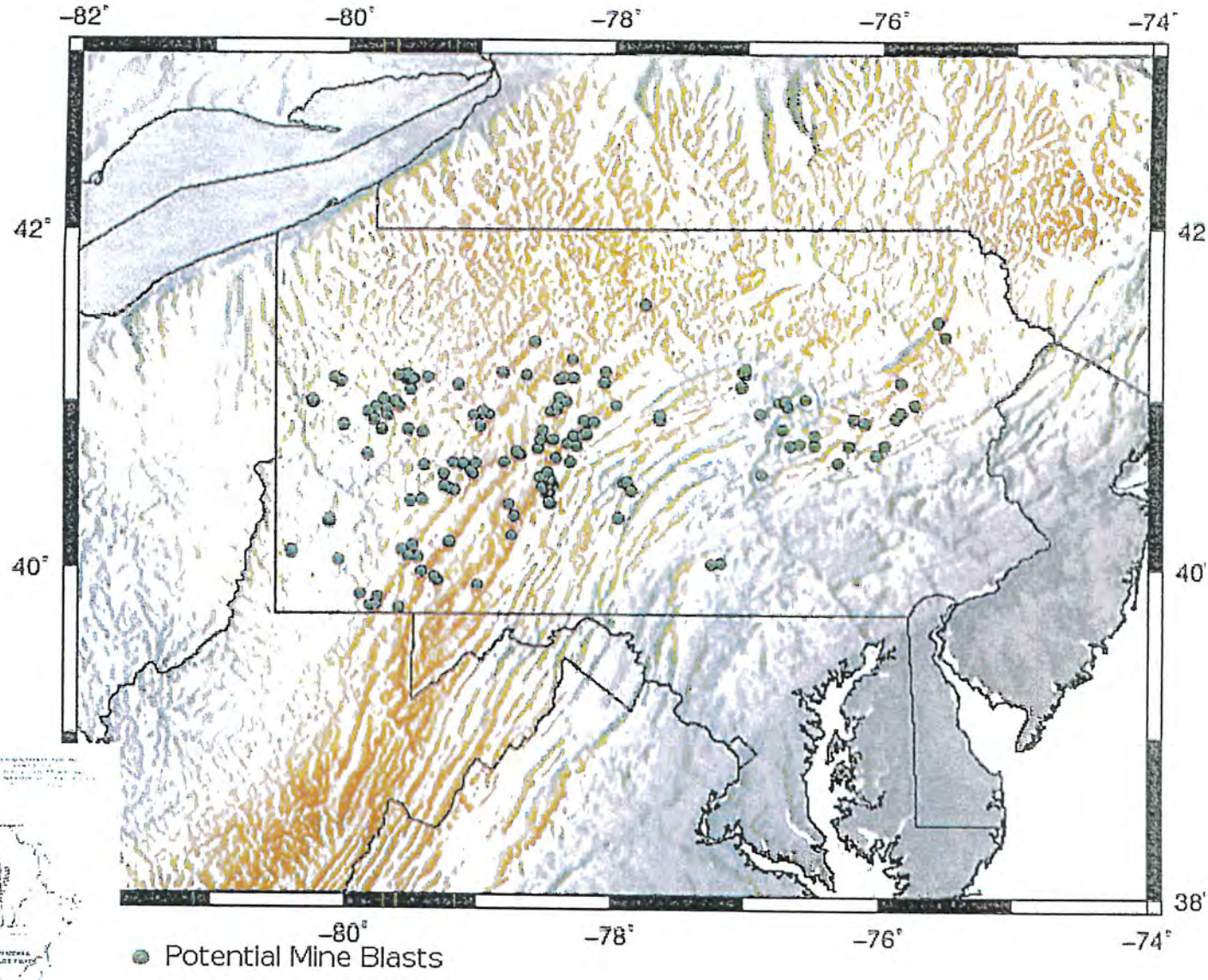
Earthquake

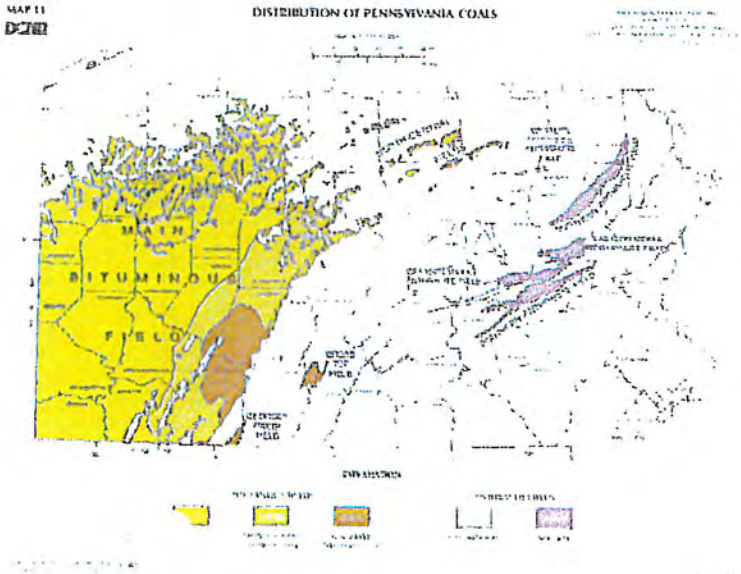
Mine or Quarry Blasts (1117 events)



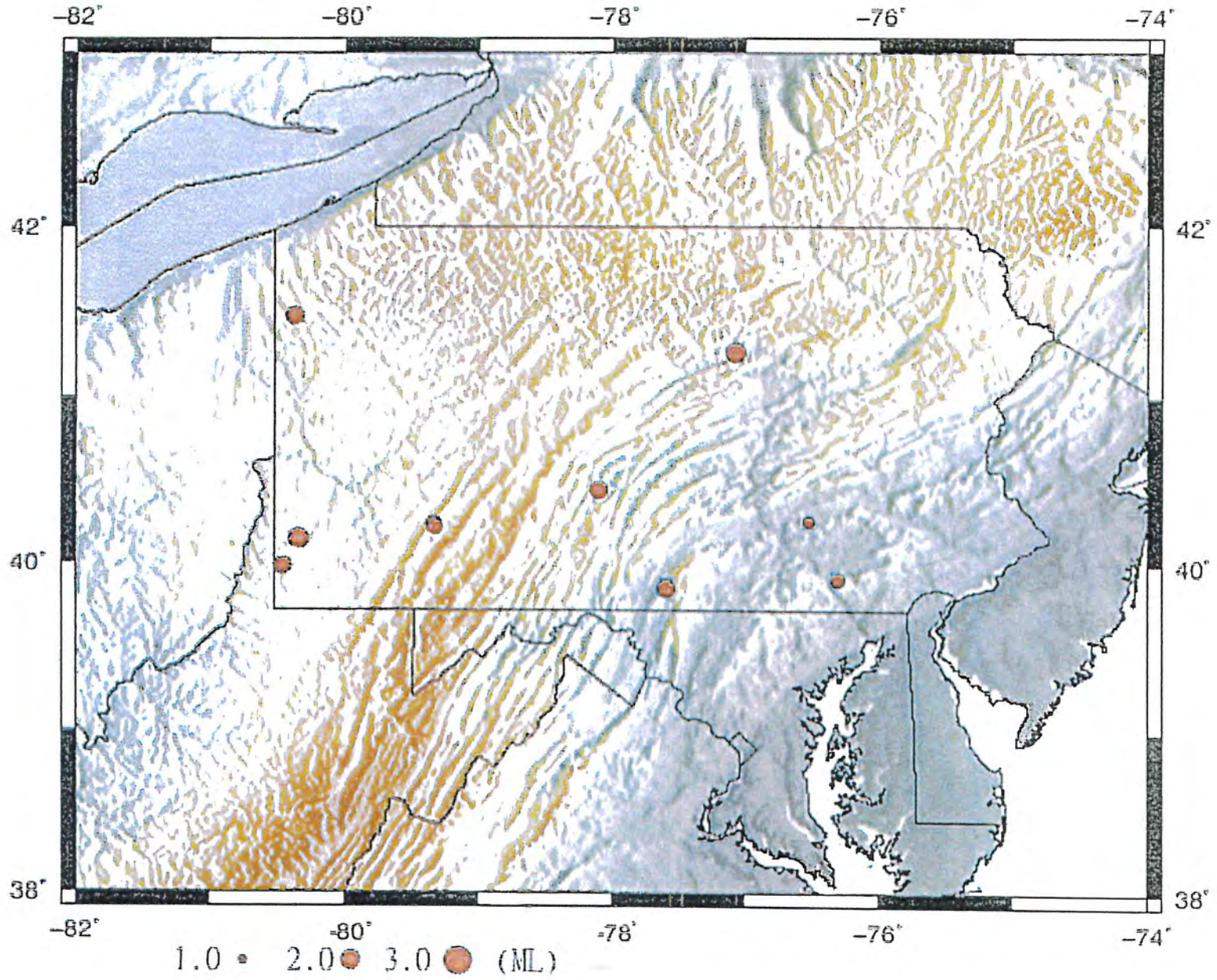


Potential Mine or Quarry Blasts (165 events)





Non-mining events – 11 of them.



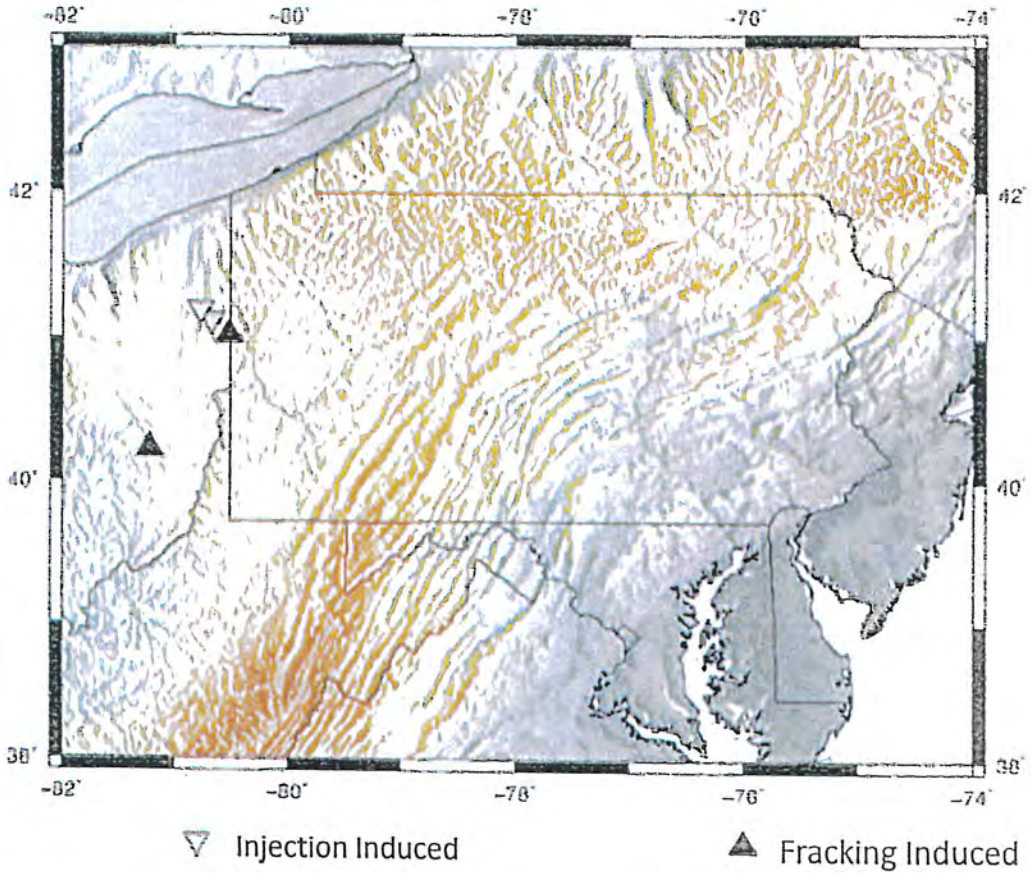
What are the sources of the non-mining seismic events?

Several possibilities

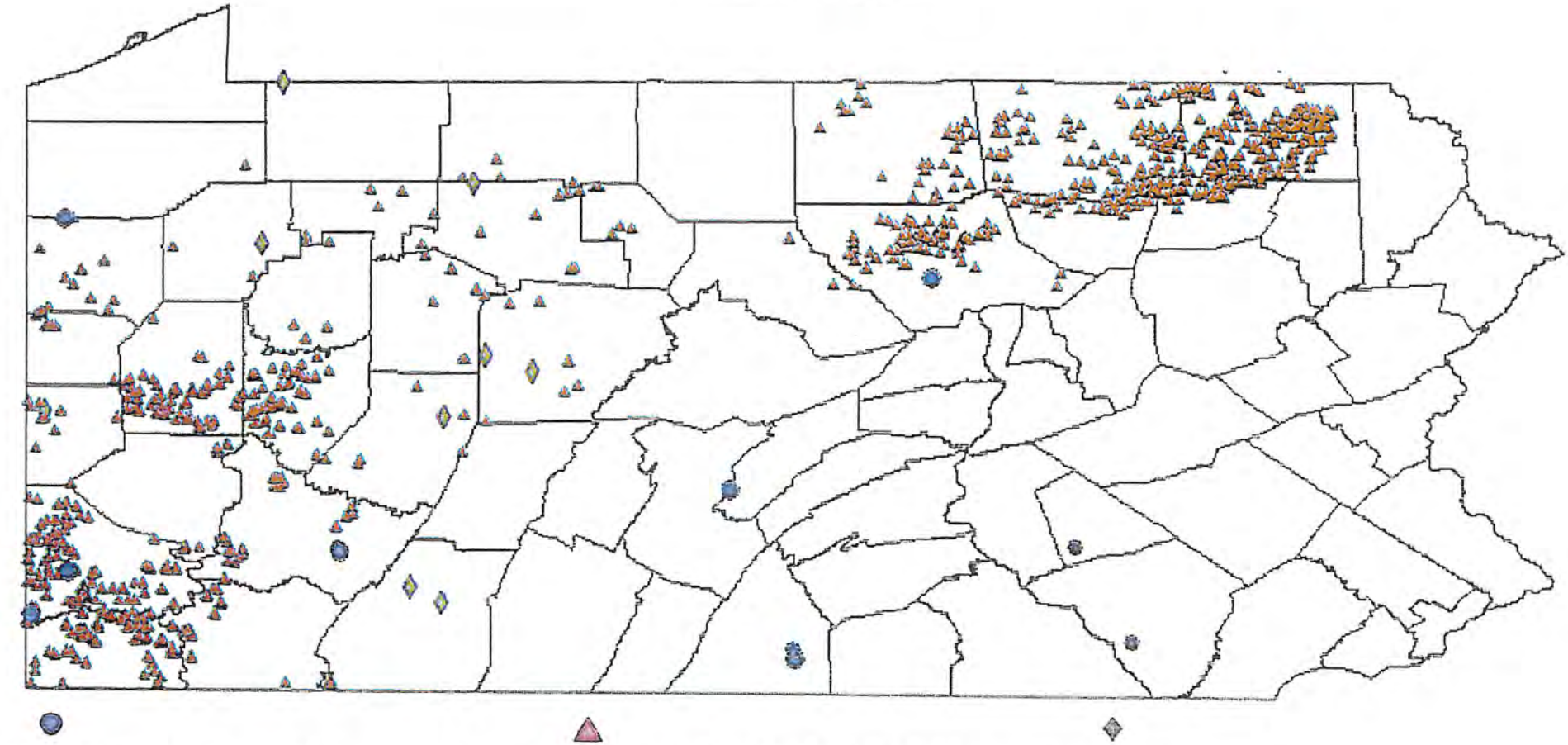
- tectonic earthquakes
- induced seismicity from wastewater disposal wells
- induced seismicity from hydraulic fracking

Induced Seismicity

- Induced events have occurred in several areas of the US
- Both wastewater injection and hydraulic fracturing can induce seismic activity – events of both kinds in Ohio
- Pennsylvania has both hydraulic fracture wells and wastewater injection wells



Are there spatial and temporal correlations with well activity?

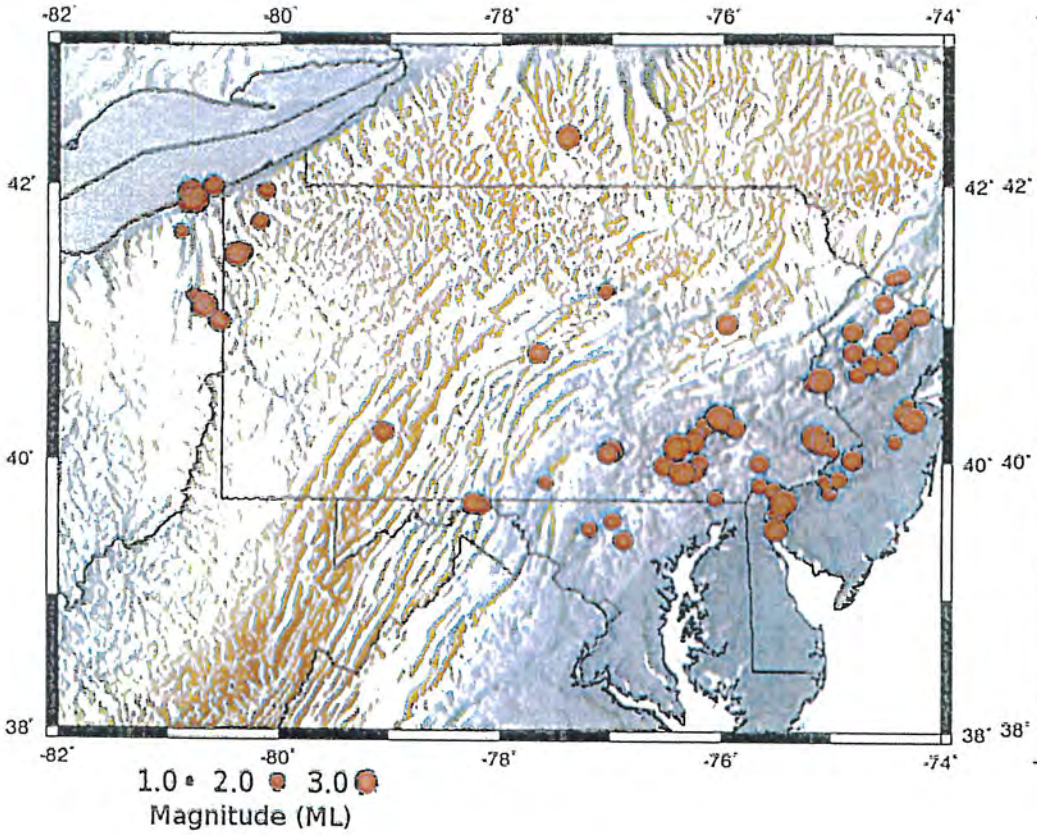


Non-mining events Production wells (2013/2014) Injection wells

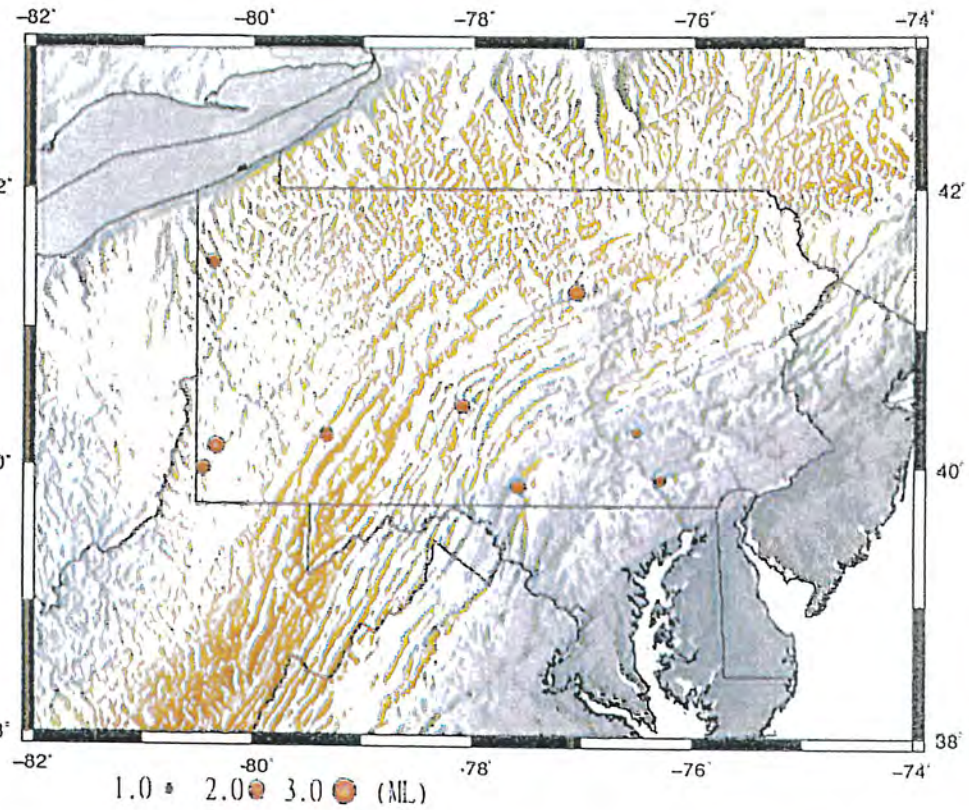
-No correlation has been found with either injection wells or fracked wells

Summary of findings: 1344 mining related events

11 Non-mining events – they are all probably tectonic earthquakes



Historical

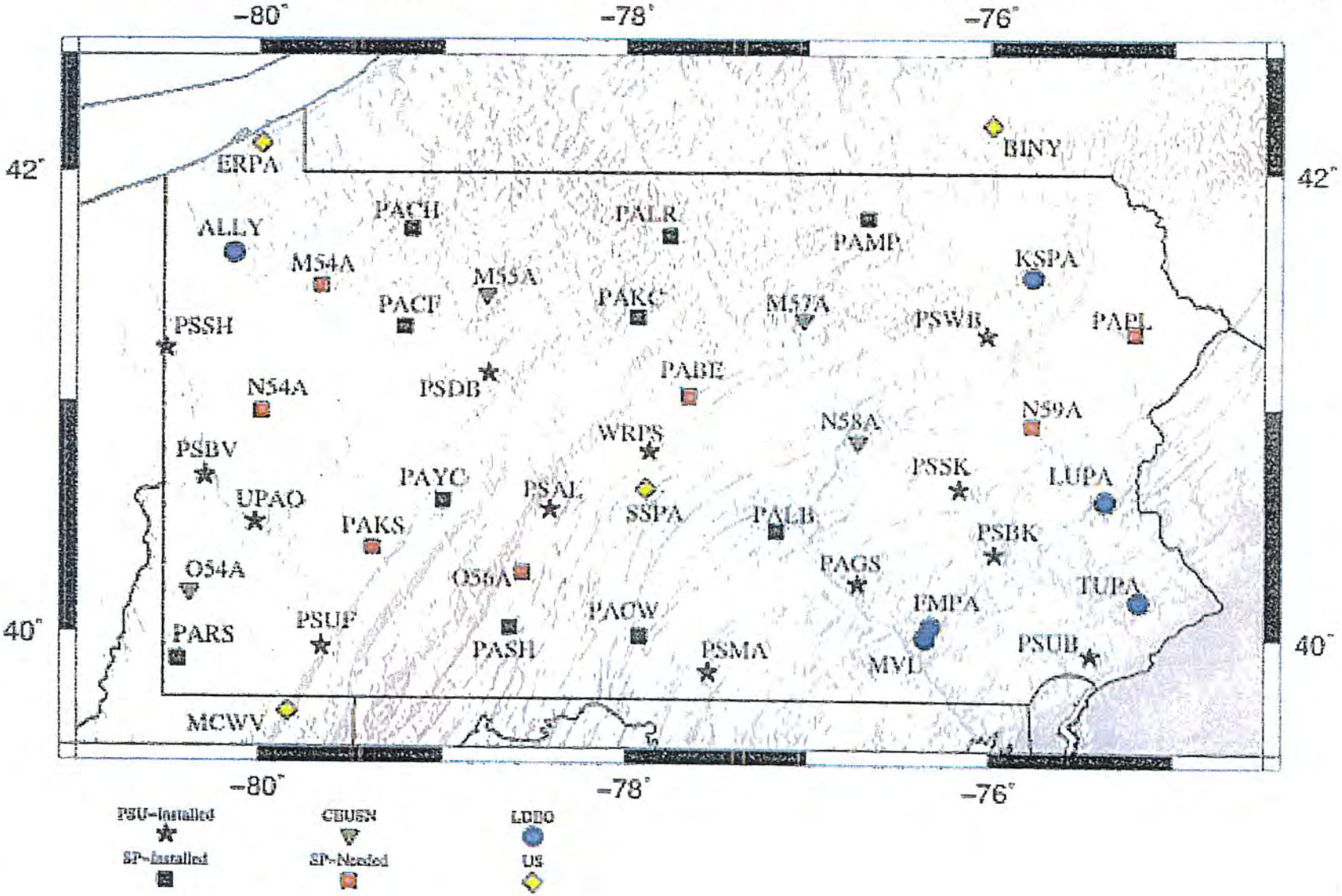


2013-2014

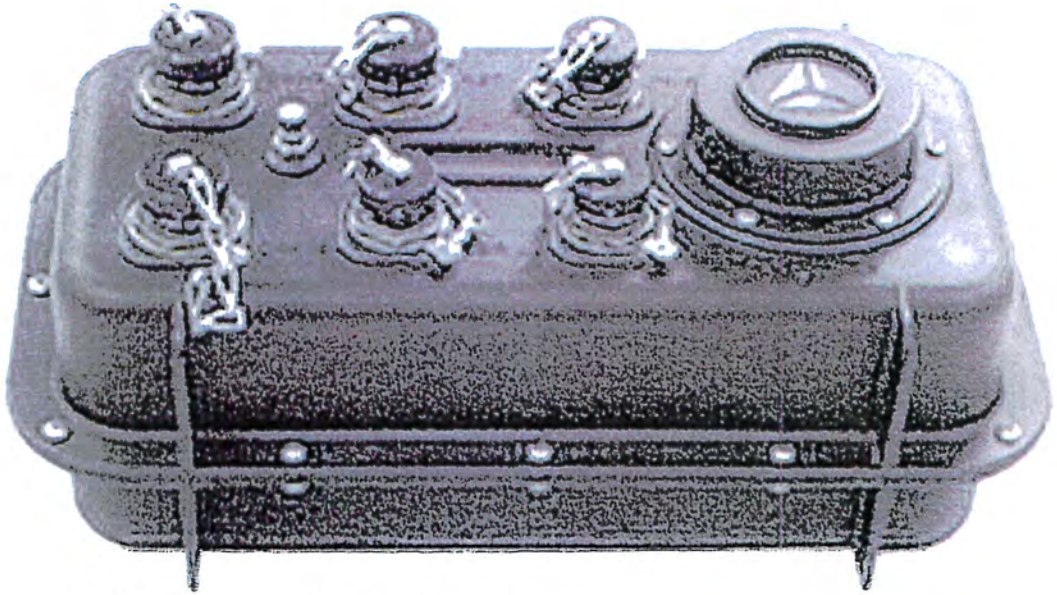
Expanding the Pennsylvania State Seismic Network

- 30 stations in the PASEIS network by summer 2016
- 6 stations operated by LCSN (LDEO)
- 2 stations operated by the USGS (US)
- 4 stations in the CEUSN network operated by IRIS/USGS

+ several stations in neighboring states



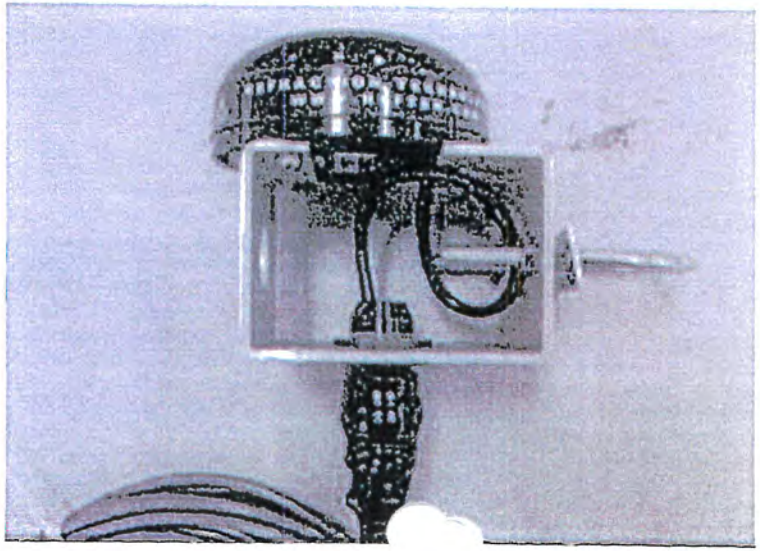
PASEIS Seismic Equipment



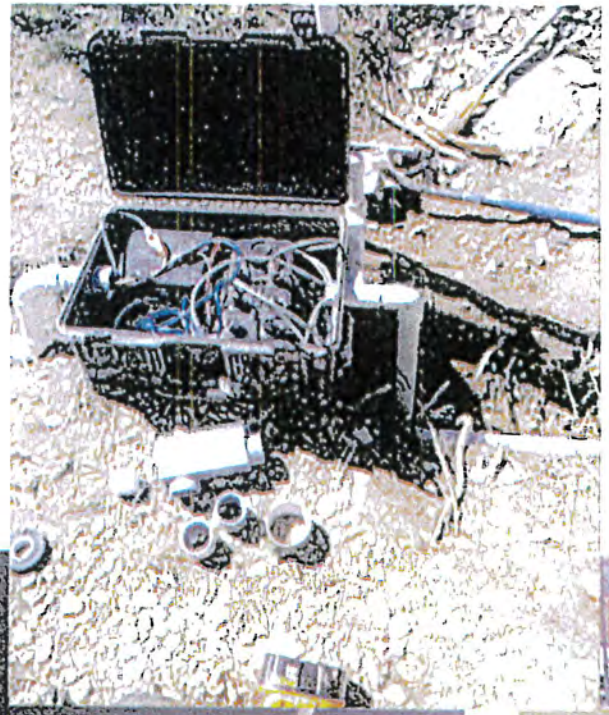
Data logger/Digitizer

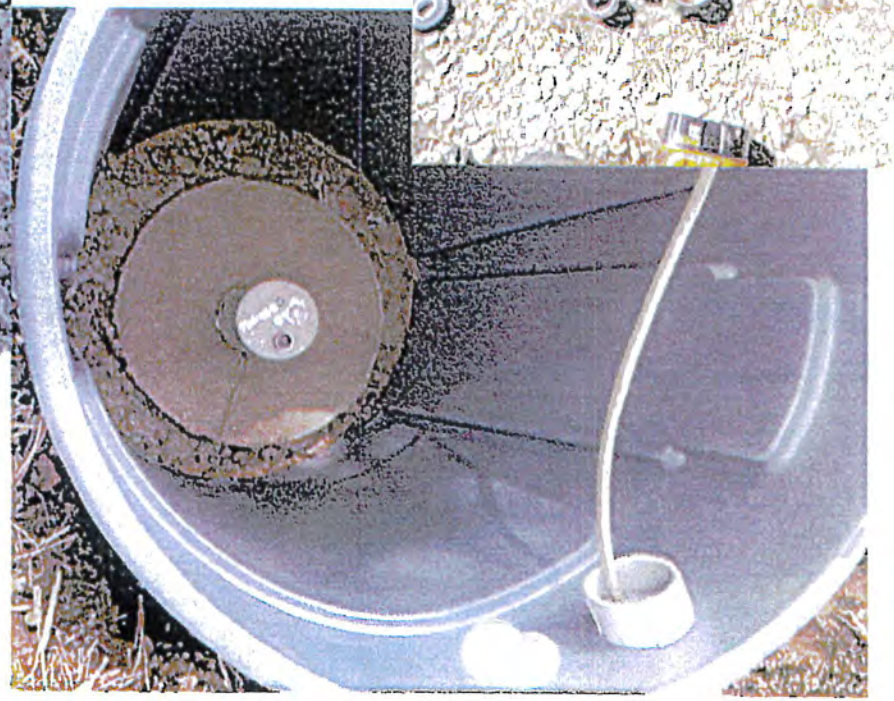
3-component ground motion sensor (vertical, north-south, east-west)

GPS clock



What does a PASEIS station look like?





PASEIS data are openly available from the IRIS Data Management Center (http://ds.iris.edu/mda/_PENN) or (http://ds.iris.edu/mda/PE)

IRIS MDA Usage

IRIS DMC MetaData Aggregator

Legend: R A

Virtual network summary (1 time span)

Virtual Network	_PENN :: Pennsylvania State Geological Survey :: _PENN Network Map
Start	2004/04/01 00:00:00
End	2599/12/31 23:59:59

Stations for _PENN virtual network (25 stations) :: Click column title to sort

	Network	Station	Site	Latitude	Longitude	Elevation	Vnet start	Vnet end
A	PE	NCAT	NC A&T Campus	36.078958	-79.771183	243	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PACH	Chapman State Park, Clarendon, PA	41.756660	-79.171430	431	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PAGS	PA Geological Survey, Middletown, PA, USA	40.230000	-76.720000	120	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PAKC	Kettle Creek State Park, Renovo, PA	41.374710	-77.932530	294	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PALB	Little Buffalo State Park, PA, USA	40.458910	-77.167830	145	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PALR	Lyman Run State Park, Galeton, PA	41.725095	-77.760062	537	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PAMP	Mt. Pisgah State Park, Troy, PA	41.805900	-76.668890	348	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PARS	Chapman State Park, Clarendon, PA	39.886320	-80.445220	305	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PASH	Shawnee State Park, Schnellsburg, PA	40.026000	-78.635690	393	2004/01/01 00:00:00	2500/12/30 23:59:59
R A	PE	PSAL	PSU Altoona Campus, PA, USA	40.543700	-78.414500	402	2004/01/01 00:00:00	2500/12/30 23:59:59

Station summary (1 time span)

Network	PE :: Penn State Network :: PE Network Map
Station	PACH :: Chapman State Park, Clarendon, PA :: Penn State Network :: PACH Station Map :: RESP :: SAC PZs :: XML
Latitude	41.756660
Longitude	-79.171430
Elevation	431
Start	2016/03/18 (078) 00:00:00
End	2599/12/31 (365) 23:59:59
Epoch	**2016/03/18 (078) 00:00:00 - 2599/12/31 (365) 23:59:59**
Instrument	Reftek 130 Datalogger
Channels (Hz)	Location --: LOG (0)
Instrument	Nanometrics Trillium Compact/Reftek 130 Datalogger
Channels (Hz)	Location --: HHE (100) R A, HHN (100) R A, HHZ (100) R A, LHE (1), LHN (1), LHZ (1)
MetaData Load	2016/04/15 (106) 14:10:37

Virtual network affiliations:

Name	Description	Primary DC	Secondary DC
_PENN	Pennsylvania State Geological Survey	PENN	IRIS DMC
_REALTIME	Stations collected and served in real time at the DMC	IRIS DMC	IRIS DMC
_UNRESTRICTED	All unrestricted stations, generated via cron	IRIS DMC	IRIS DMC
_US-REGIONAL	US Regional Networks	PSU	IRIS DMC

Real-time data availability (view Station Monitor)

View some of the data

Earliest	Latest
R 2016/05/06 (127) 00:00:00	2016/05/18 (139) 00:00:00

Archive data availability - Make a batch request for data (breq_fast) - (data access overview)

Information on how to request the data

Station Monitor

Choose a station

Network: PE Station: WRPS

or choose: List Stations in Network WRPS - PSU, University Park, PA, USA

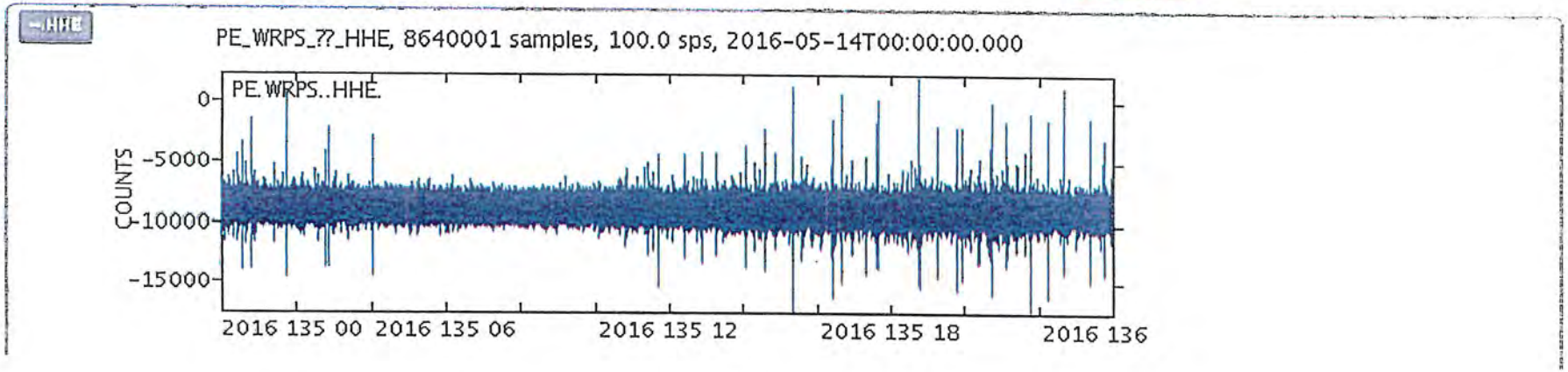
Show Station

WRPS - PSU, University Park, PA, USA

Network: PE - Penn State Network
Location: 40.79°N - 77.87°W

Daily Data

Day: 2016-05-14 Location/Channels: --:HHE/HHN/HHZ Update



PASEIS web site – coming soon

- Station information
- Station and event maps
- Instructions on obtaining data
- Seismic event information determined from the 42 stations in PA plus open stations in neighboring states – event location, depth, origin time and magnitude

Minor earthquake measures near city

Posted: Tuesday, April 19, 2016 12:00 am

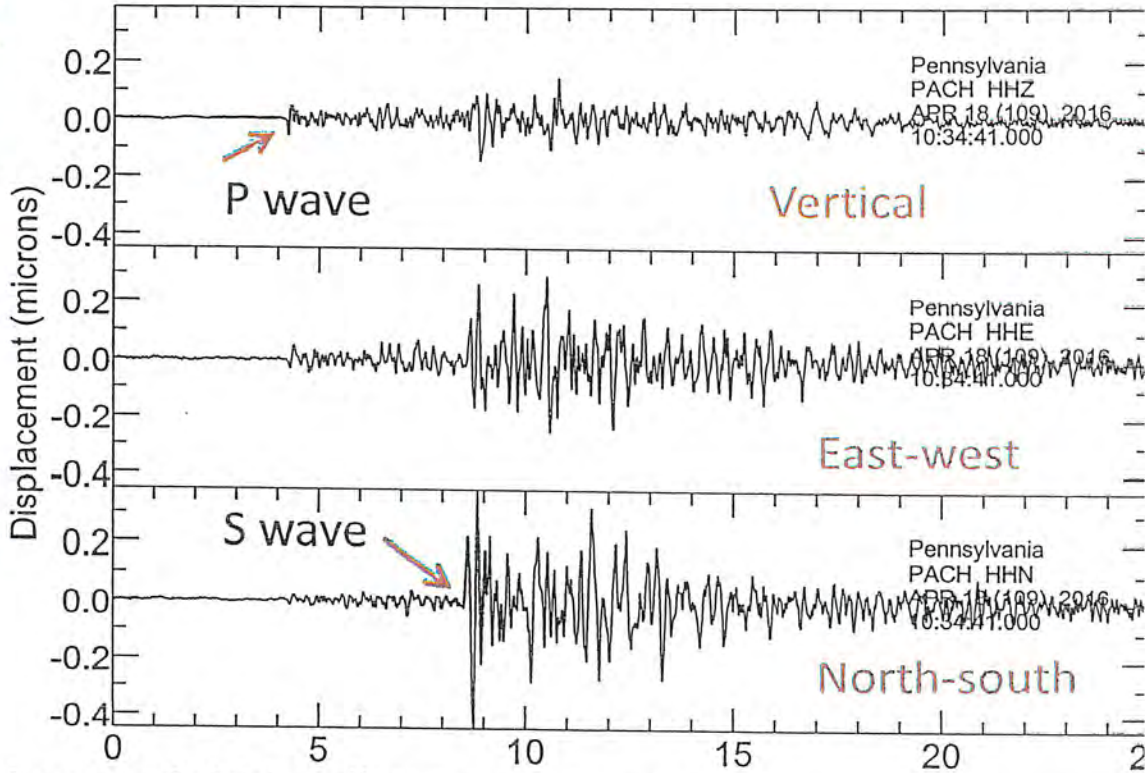
By Stella Ruggiero sruggiero@titusvilleherald.com | 0 comments

A small earthquake, which was likely too weak to be noticed by anyone other than geologists, measured in the Titusville area on Monday, around 6:34 a.m.

The quake was magnitude 2.2, according to AccuWeather meteorologist Jordan Root. He said it was fairly weak on the scale, and not likely felt by many people, or maybe no one at all. As of late Monday afternoon, Root had received no reports of anyone experiencing the quake.

Magnitude 2.2
Time: 2016/04/18 06:34:40 local
Depth 3.3 miles (5.2 km)
Near Titusville, PA

What do the data look like? (Chapman State Park)



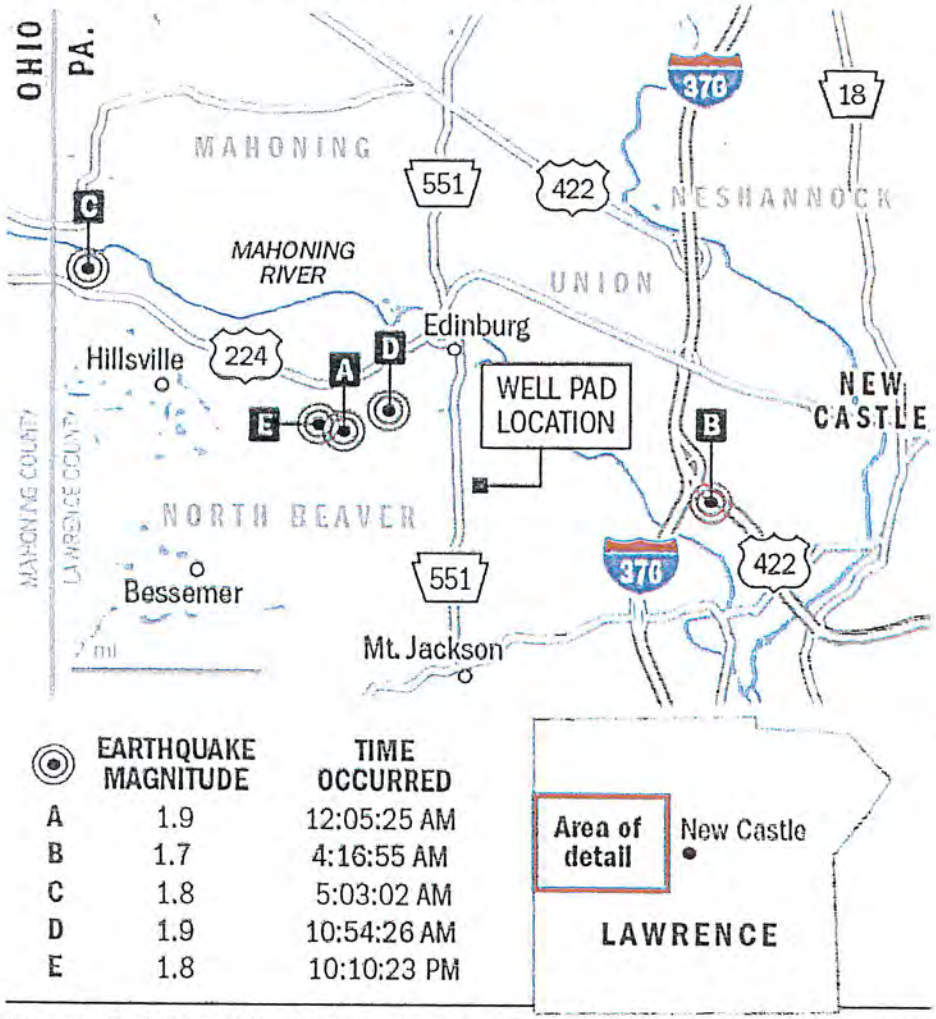
1 micron = 0.001 millimeter

Figure cour. C. Ammo

State studying link between fracking, Lawrence County earthquakes

By Laura Legere / Pittsburgh Post-Gazette April 29, 2016

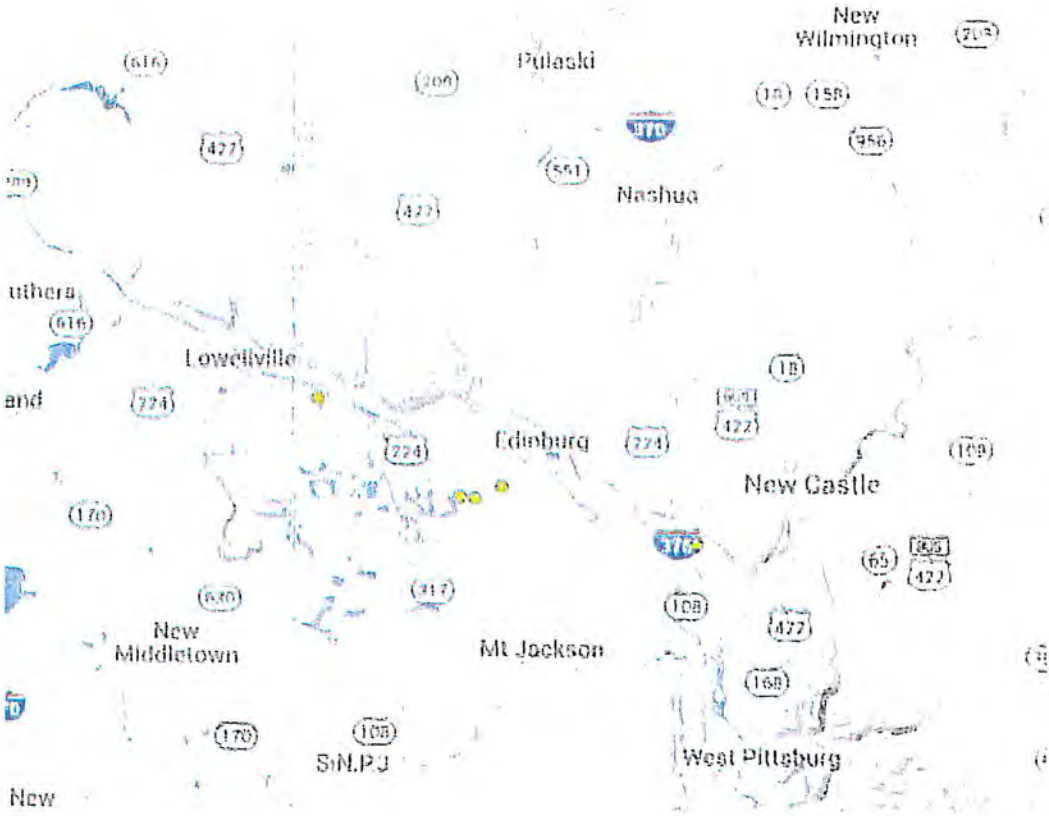
Epicenters of Monday's earthquakes in Lawrence County compared with the location of the shale gas well pad that potentially triggered them.



	EARTHQUAKE MAGNITUDE	TIME OCCURRED
A	1.9	12:05:25 AM
B	1.7	4:16:55 AM
C	1.8	5:03:02 AM
D	1.9	10:54:26 AM
E	1.8	10:10:23 PM

Source: Esri, Pennsylvania Department of Environmental Protecti[illegible]d States Geological Survey

Post-Gazette

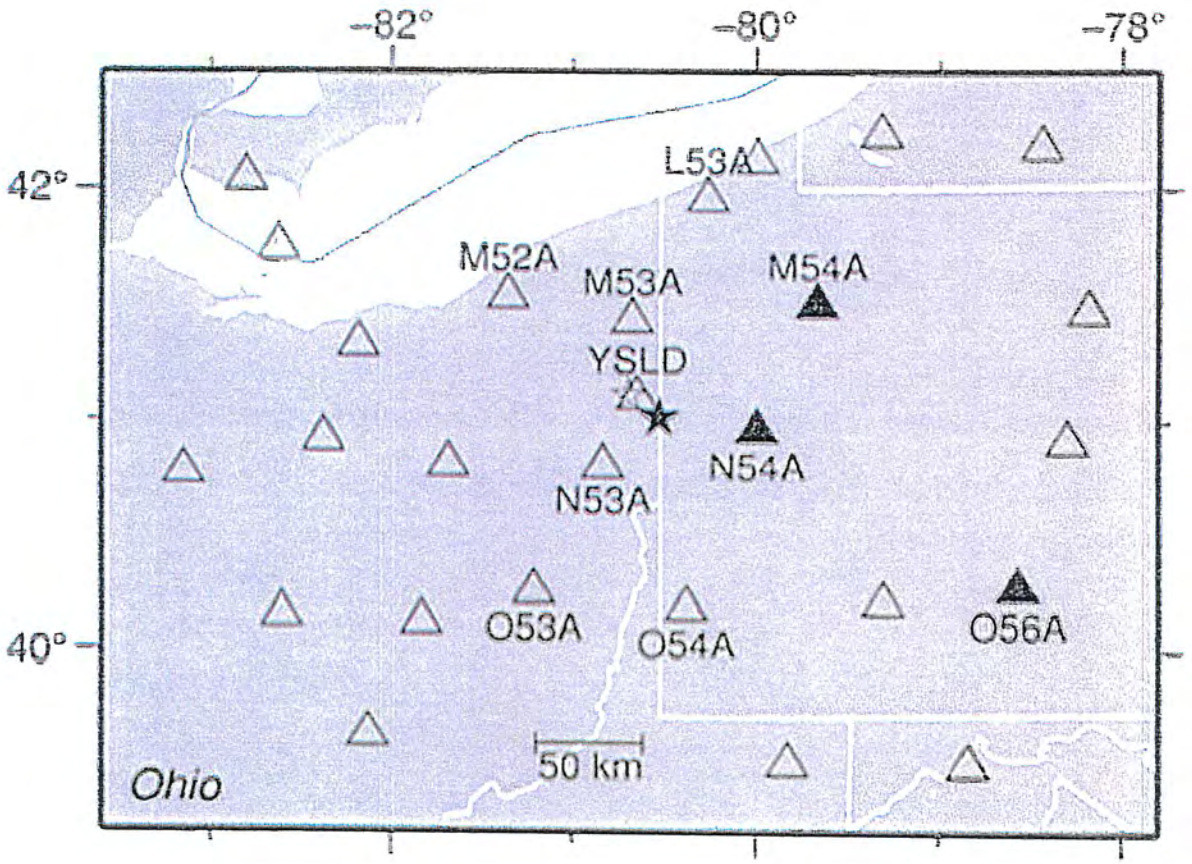


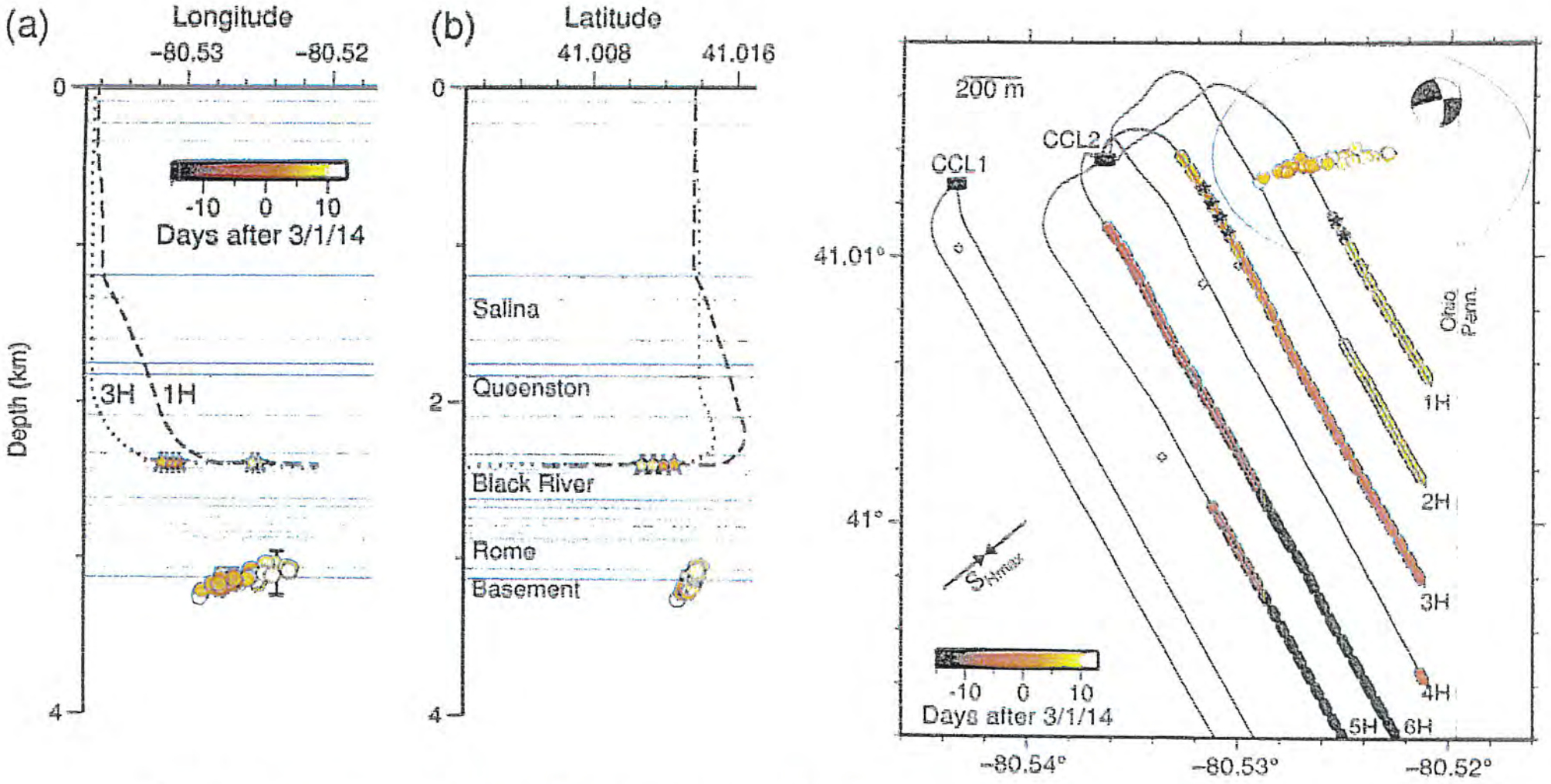
Bulletin of the Seismological Society of America, Vol. 105, No. 1, pp. –, February 2015, doi: 10.1785/0120140168

Earthquakes Induced by Hydraulic Fracturing in Poland Township, Ohio

by Robert J. Skoumal, Michael R. Brudzinski, and Brian S. Currie

- March 4-12, 2014
- 77 events identified
- Magnitudes 1 to 3
- Correlated with fracking of the Utica Shale





Did a similar thing happen with the Lawrence County earthquakes? Possibly.

-initial analysis of data indicates >30 events with magnitude >1

Initial Performance of PASEIS network

2014 Poland Township events:

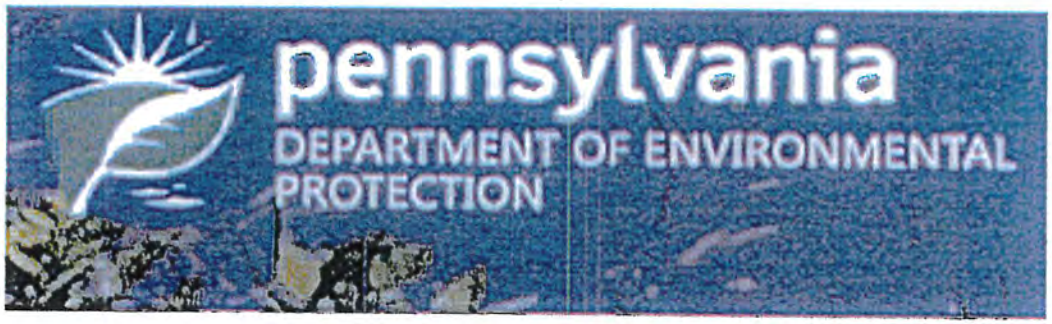
- Initial event detected was magnitude 3

2016 Lawrence County events:

- Initial event detected was magnitude 1.9

PASEIS network is designed for detecting and locating magnitude 2 and larger events.

Thanks to DCNR and DEP for promoting open data access!



Thanks to IRIS for providing data archiving and distribution!

Seismic Monitoring and Mitigation Plan

for

Penneco Environmental Solutions, LLC

Sedat #3A Class II-D Injection Well

Plum Borough, Allegheny County, PA

June 4, 2020

Prepared for

Penneco Environmental Solutions, LLC
6608 Route 22
Delmont, PA 15626-0300

and

Pennsylvania Department of Environmental Protection

Prepared by

GeoEnergy Monitoring Systems, Inc.
PO Box 4994
White Rock, NM 87547

Table of Contents

Background

This document is a Seismic Monitoring and Mitigation Plan designed specifically to satisfy permit requirements for continuous seismic monitoring at the Penneco Environmental Solutions, LLC ("Penneco") Sedat #3A Class II-D commercial brine disposal Injection Well located in Plum Borough, Allegheny County, PA (Figure 1). The coordinates of the Injection Well are: Latitude 40° 31' 38.5'' and Longitude -79° 42' 48.5".

Purpose of Monitoring

The purpose of this monitoring effort is to provide a continuous record of any seismic and earthquake events, with detection and notification of specific naturally occurring and man-made seismic occurrences or events at the Penneco facility and vicinity. The specific sources of seismic events can include the following:

- Tectonic derived earthquakes, activity
- Mine blasts (quarries, coal, stone, etc.)
- Induced seismicity (from hydraulic fracturing, and injection well activity)

All seismic events of magnitude 1.0 or greater occurring within 10 kilometers (6.21 miles) of each injection well, and earthquakes of magnitude 1.5 and above, located within 20 kilometers (12.42 miles) of each well will be recorded and reported to Penneco (Figure 2). The detection levels shown on Figure 2 will cover the entire facility.

Installation of System

GeoEnergy Monitoring Systems, Inc. (GeoEMS) of Los Alamos, NM will install two seismometer stations at the Sedat facility consisting of a primary station (Station SED1) whose data is to be transmitted to Incorporated Research Institutions for Seismology (IRIS; https://www.iris.edu/hq/), and shared with Pennsylvania Seismic Network (PASEIS) via Penn State University, and an auxiliary station (Station SED2) as back-up.

This two-station approach is employed to:

1) reduce false detections,
2) provide verification to aid in defining the location of small events and,
3) provide backup hardware redundancy for Station SED1.

The auxiliary sensor will be deployed at a separate location from the main sensor, far enough away that it can be used to reduce false detections. The system is configured the same as the primary station, but will not be transmitting data to IRIS. GeoEMS stations also record continuously on an SD card in the units.

Monitoring Equipment

The installed equipment is from GeoSpace, LP, a seismic monitoring equipment manufacturer in Houston, TX, which provides instruments for real-time data acquisition of seismic events. The GeoSpace, LP GS-11D is a high output, rotating coil geophone designed and built to withstand the shocks of rough handling. The precision springs of this field-proven geophone are computer designed and matched to optimize performance specifications under even the most extreme conditions. The natural frequency is 4.5 Hz, with standard coil resistance of 4000 ohms. The PC-21 Land Case is used with the GS-11D geophone. An example station configuration is shown in Figure 3. Appendix A provides a detailed specification sheet for the equipment used.

Operations

The seismic monitoring equipment from GeoSpace, LP will be integrated into the Penneco operations program with remote regular daily checks of the equipment, and confirmation of recording and transmission to IRIS and PASEIS networks. In addition, a regular calibration cycle is in place to check instrumentation, providing a complete record of date of calibration, etc. starting from the original installation date. Penneco operations personnel will be trained by GeoEMS to troubleshoot minor items, and to clean and check the equipment, mitigating any weather derived effects or other problems that may arise.

Monitoring

The procedure for seismic monitoring of the Penneco site consists of GeoEMS and Penneco personnel reviewing all anomalies, annotating data and reporting any unexpected occurrences. If

significant events or anomalies are identified or recorded, evaluation and interpretation of the data will be made by GeoEMS personnel in concert with Penneco personnel.

Seismic data will be stored digitally on flash memory in the instrument, and SED1 data also transferred via website digitally to IRIS and PASEIS, and downloadable as well. Additionally, data will be recorded at the other Station SED2, as part of the redundancy aspect of the system.

Special Permit Conditions (Permit conditions are shown in **Bold)**

Penneco will work with GeoEMS to insure that all aspects of the PA-DEP Seismic Monitoring and Mitigation Plan Special Permit Conditions are implemented, as follows:

(1) Installation of a seismometer that, at minimum, includes the following: One 3-component velocity sensor (X, Y, Z axes), high-frequency seismometer. (e) All seismometers shall be installed in accordance with the manufacturer's instructions prior to operation of the disposal well.

The primary and auxiliary seismic stations SED1 and SED2 will be installed at the Penneco site by GeoEMS and Penneco. Each station consists of a 3-component high-frequency seismometer. The seismometers will be installed in accordance with the manufacturer's instructions. Installation requires a separate bubble level to be placed on top of the geophone for proper leveling per manufacturer's instructions. Should circumstances require the subsequent incorporation of four-station network, GeoEMS will provide Penneco with 3 additional seismic stations that can be rapidly deployed at predetermined locations around the Sedat facility.

(2) A description of and specification sheet for the seismometer installed at the disposal well site.

The seismometer is a 3-component, 4.5 Hz GS-11D manufactured by GeoSpace, LP of Houston, TX. The instrument specification and response data sheets are provided in Appendix A.

(3) The installation of a recorder that, at a minimum, continuously records 100 samples per second using a data logger with 24-bit digitizer and Global Positioning System (GPS) timing, in accordance with the manufacturer's instructions prior to operation of the disposal well.

The stations will be at different areas of the Penneco facility. A 24-bit digitizer is used for sampling at a frequency rate of 125 samples per second with GPS timing.

(4) A description of and specification sheet for the seismic recorder installed at the disposal well site.

The station consists of a ground-mounted protective external housing placed for the electronics and battery, a sensor buried 12 inches deep approximately 10 feet from the housing, and a 5-foot antenna mast. Sensors include Geo Space GS-11D 3C seismometers (See system diagram in Figure 4 and the system specification sheet in Appendix B). The system also records continuous data on-site using standard flash data storage drives.

(5) A description of the protocol for operating and completing calibration of the seismometer and seismic recorder installed at the disposal well site demonstrating that it conforms with the standards employed by the Pennsylvania State Seismic Network (PASEIS) and the manufacturer's instructions.

The system has been calibrated using a shake table, and also by comparison of waveforms with collocated commercial sensors. Metadata will be available for the equipment, including instrument response through the IRIS MetaData Aggregator.

(6) A description of the routine maintenance and service checks that will be implemented to monitor the operability or running condition of the seismometer and seismic recorder installed at the disposal well site. The description should detail how the checks satisfy the manufacturer's instructions.

Daily State-of-Health (SOH) of the system is monitored by examination of seismograms and from SOH on-board diagnostics such as internal temperature and battery voltage. No routine maintenance is required or planned except for visual inspection, but if there appear to be SOH problems, Penneco on-site personnel are trained to perform maintenance tasks. Penneco personnel will perform maintenance and service checks, as required, under the guidance of GeoEMS.

(7) Verification that tectonic seismic event data will be captured at the disposal well electronically and in a manner that is suitable for tectonic seismic event recordation and analysis.

Baseline data collection is occurring and shows successful installation and recording of data. These same units have been deployed at numerous injection sites nationwide and have recorded potential Injection-Induced Seismic Events with high fidelity.

(8) Verification that seismic data will be provided to the Incorporated Research Institutions for Seismology (IRIS) Network in real time and that the continuous, real time data conforms to the data format required by IRIS for archiving under PASEIS' network code (PE) and open distribution. If data transmission is interrupted, notification will be provided to the Department verbally within 24 hours and in writing within seven (7) days.

GeoEMS has previously transmitted seismic data to IRIS. The output from the IRIS MetaData Aggregator for GeoEMS station PBL2 is shown in Figure 5, providing verification that seismic data is being provided to IRIS as part of PASEIS network code (PE). Penneco will notify

PADEP verbally within 24 hours and in writing within seven (7) days if data transmission from both on-site stations are interrupted for 72 hours. If data transmission is interrupted for a significant period of time, Penneco personnel can still acquire continuous recording of data from the on-board flash drive. Note that minor data interruptions are almost a daily occurrence for many IRIS stations and those will not be reported to PADEP. The IRIS Buffer of Uniform Data (BUD) Monitor can be used to examine data and feed latency times (http://ds.iris.edu/bud_stuff/dmc/bud_monitor.ALL.html) for all stations of the PE network.

(9) A description of measures that will be taken to install the seismometer in a manner that will minimize interference from background sources and allow for optimal Seismic Event identification and location (epicenter and hypocenter). This shall include a plan view map of proposed seismometer location(s).

The seismometer locations will be chosen through coordination of GeoEMS and Penneco personnel in order to minimize interference and surface noise sources. Penneco will provide DEP with a plan view map of the seismometer locations.

(10) Contact information for the responsible person in charge of conduction seismic monitoring activities at the disposal well site.

Penneco personnel responsible for seismic monitoring activities on-site is Marc Jacobs (dmarcj@penneco.com, 724-468-8232).

GeoEMS personnel responsible for the seismometer and instruments are Stephen P. Jarpe (jarpe@pobox.com, 928-899-1875) and Steven R. Taylor (srt-rmg@comcast.net, 505-412-2841), either of which may be contacted for detailed information on the equipment.

(11) If the one sensor option is chosen, a tectonic seismic event contingency plan that includes monitoring, reporting and mitigation provisions consistent with the following:

a. **Contingent upon analyst review, immediate electronic notification to the Department and the Department of Conservation and Natural Resources' Bureau of Topographic and Geologic Survey (BTGS) of detection of any measurable event, within six (6) miles measured radially from the disposal well.**

b. **Notification within 10 minutes via email to the Department and 1 hour via telephone to the Department's statewide toll-free number in the case of seismic activity reference in a. above. Within 24 hours the operator will provide this data including filtering/ processing of raw seismic data to identify and remove non-tectonic events (e.g. mine blasts or system noise).**
c. **Should an Injection-Induced Seismic Event occur (i.e. not a surface-related event or system noise), the Operator will reduce the well's operation injection rates. Reduction of the disposal well's operating injection rates in use at the time of the Injection-Induced Seismic Event by 50% within 48 hours of the occurrence of 3 or more consecutive Injection-Induced Seismic Events greater than 1.0 and less than 2.0 local magnitude**

(ML) over a seven (7) day period occurring within three (3) miles measured radially from the disposal well. The seven (7) day period is defined as starting with the occurrence of any Injection-Induced Seismic Event of local magnitude 1.0 or greater. Reduced operating injection rates shall be maintained until the Department provides written notice addressing injection rates.

d. Termination of all injection activities within 48 hours of the occurrence of an Injection-Induced Seismic Event of local magnitude 2.0 or greater within three (3) miles measured radially from the disposal well until receipt of a written notice from the Department addressing continued well usage and operating conditions. The assessment of continued usage will include, but not limited to, the following criteria:

GeoEMS, together with Penneco, will insure that all aspects of the Seismic Monitoring and Mitigation Plan conform to Special Permit Conditions of PA-DEP. All actions for Item (11) will be followed by Penneco based on communication and input from GeoEMS. GeoEMS will monitor Station SED1 on a daily basis. Additionally, on a daily basis, GeoEMS will perform single-station reporting statistics as shown in Figure 6 and include the number of events recorded per day, cumulative number of events, and magnitude and slant (radial) distance from station. GeoEMS will monitor seismicity in the vicinity of Sedat#3A on a daily basis and, upon analyst review, will notify Penneco immediately if notable trends or changes in micro-seismicity occur. Direct notification to PA-DEP will occur pending confirmation of event(s).

(13) Provisions for submitting an updated Seismic Monitoring and Mitigation Plan

This Seismic Monitoring and Mitigation Plan meets the requirements of the PADEP Special Permit Conditions. Should conditions in the field alter or change any parameter or monitoring approach, a revised updated Plan will be submitted to PADEP.

(14) Upon commencement of disposal activities at the disposal well, the permittee shall record tectonic seismic event data electronically for review at the request of the Department. Tectonic seismic event records must be maintained for one (1) year.

Data archival of all Station recorded monitoring data will be permanently maintained by Penneco, LLC, GeoEMS, IRIS and PASEIS.

(15) The permittee shall maintain all calibration, maintenance and repair records for the seismometer for at least (5) years.

Penneco, LLC and GeoEMS will maintain these calibration, maintenance, test, and repair records for the seismometer and provide them to PA-DEP or IRIS and PASEIS upon request.

16) The permittee shall maintain all calibration, maintenance and repair records for the seismic recorder for at least five (5) years.

Penneco, LLC and GeoEMS will maintain these calibration, maintenance, test and repair records for the seismic recorder at least five (5) years and provide them to PA-DEP or IRIS and PASEIS upon request.

Under U.S. EPA Permit Conditions, and standard UIC injection guidelines, Penneco has continuous monitoring procedures in place to insure that all operating injection wells have Mechanical Integrity – internal and external. Any anomaly or deviation from Mechanical Integrity will be followed by cessation of injection operations by Penneco operations personnel, and will be diagnosed, reported to EPA and DEP, and assessed further.

"I, Steven R. Taylor, hereby certify, under penalty of law as provided in 18 Pa.C.S. § 4904 that I prepared the seismic Monitoring Plan for Penneco and the information provided is true, accurate and complete to the best of my knowledge and belief."

Steven R. Taylor

Secretary, GeoEnergy Monitoring Systems, Inc.

FIGURES

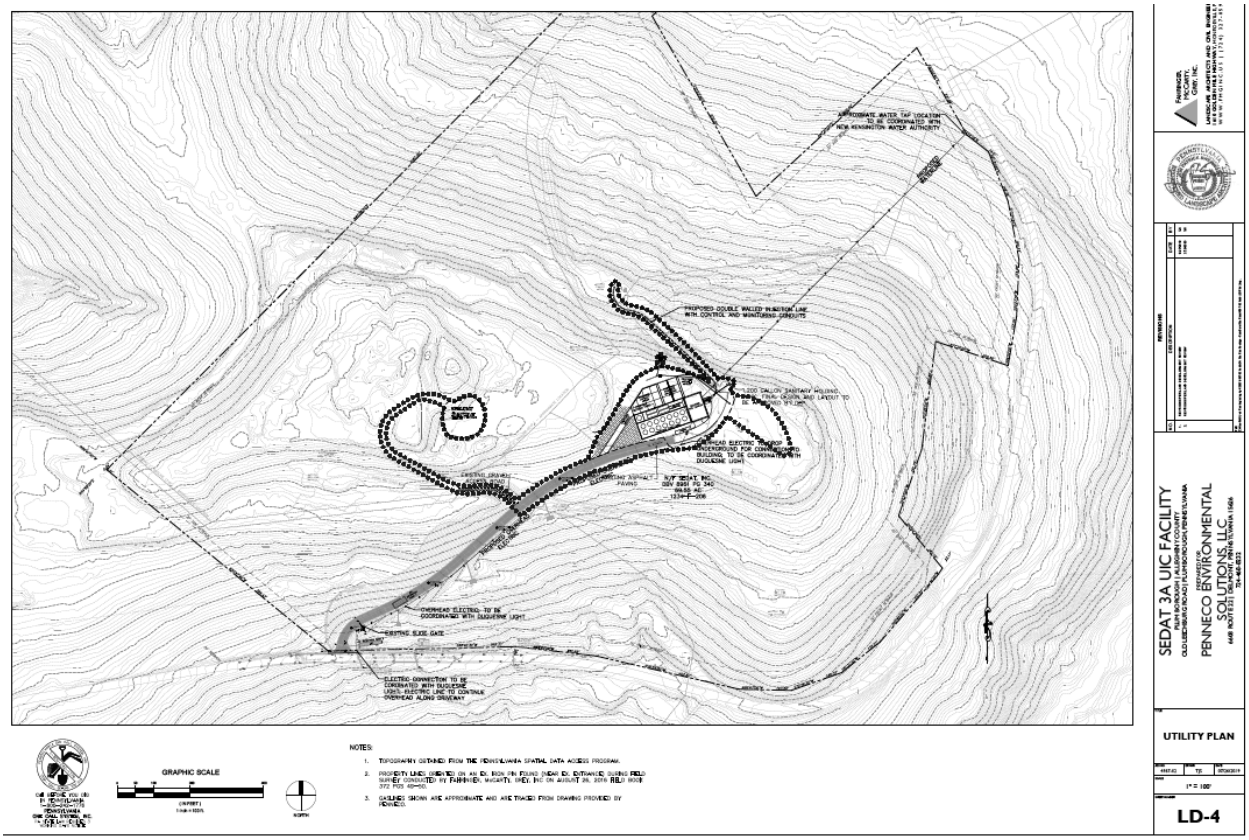


Figure 1. Map showing Penneco Sedat #3A Class II-D commercial brine disposal Injection Well facility.

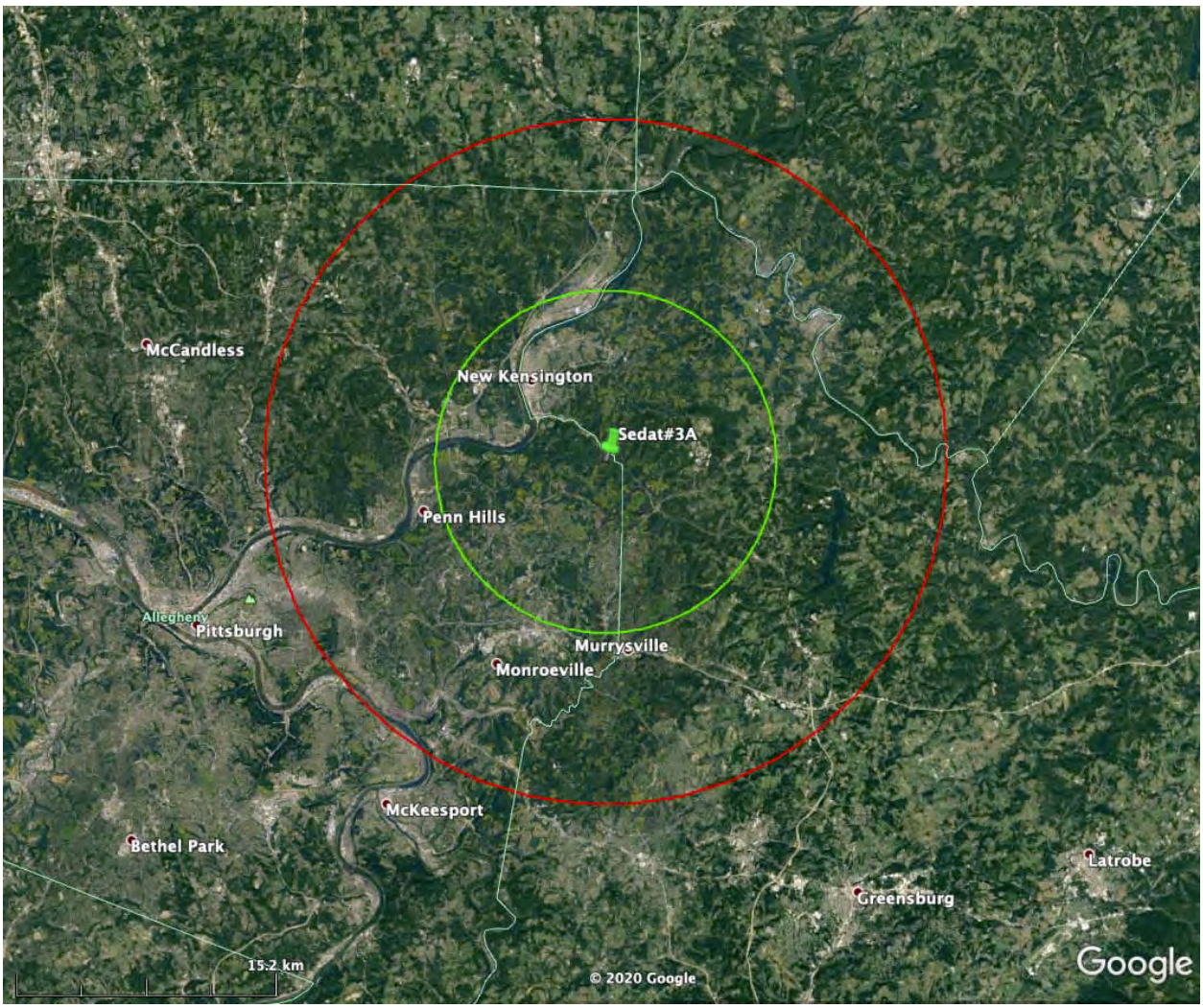


Figure 2. Seismic station as green push pin near Sedat #3A well. Green circle of radius 10 km and red circle of radius 20 km indicate estimated epicentral detection limits for ML 1.0 and ML 1.5 events.

Figure 3. Example station configuration.

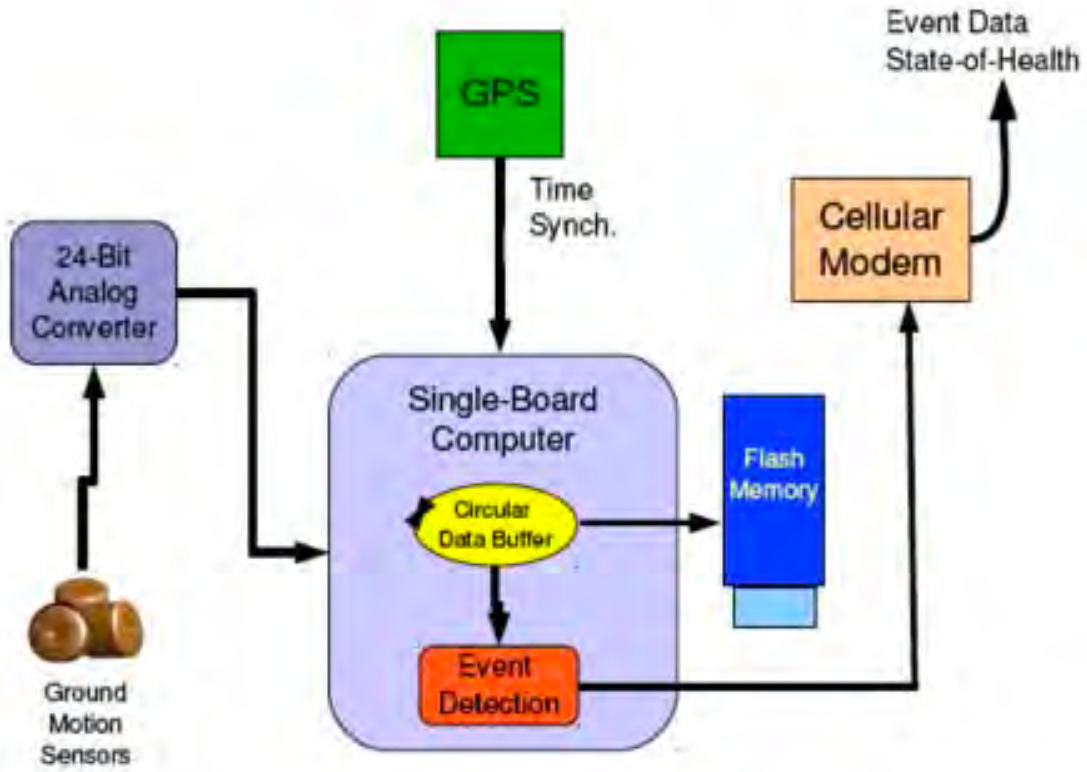


Figure 4. Seismic Monitoring system diagram.

Channel summary (1 time span)

Information limited to 2017/09/29 00:00:00 to 2599/12/31 23:59:59 - Clear timewindow

Network	PE :: Penn State Network :: PE Network Map :: DOI
Station	PBL2 :: Bear Lake Properties offload facility :: GeoEnergy Monitoring Systems :: PBL2 Station Map
Location	--
Channel	ELZ :: RESP :: SAC PZs :: XML
Latitude	41.998100
Longitude	-79.528808
Elevation (m)	506
Depth (m)	0 :: (Local depth or overburden)
Azimuth	0 :: (SEED convention: Clockwise from north, Z=0, reversed=0)
Dip	90 :: (SEED convention: From horizontal, Z=-90, reversed=90)
Start	2017/09/29 (272) 00:00:00
End	2599/12/31 (365) 23:59:59
Sample Rate (Hz)	125.00
Max Drift (s)	0.0000 :: (Seconds per sample)
Instrument	GS-11D, 4.5 Hz, 96.4 V/m/s, Rc=4000 Ohms, Rs=56160
Units	Instrument: M/S (Velocity in Meters Per Second) Response: M/S (Velocity in Meters Per Second)
Sensitivity	6.738850e+09 @ 1.000e+01 Hz (SEED Stage 0)
Optional Comment	
MetaData Load	2017/10/06 (279) 08:25:02

No data available in real-time systems for 2017/09/29 00:00:00 - 2599/12/31 23:59:59

No data available in archive for 2017/09/29 00:00:00 - 2599/12/31 23:59:59

Frequency and phase response plot (RESP SAC PZs XML):

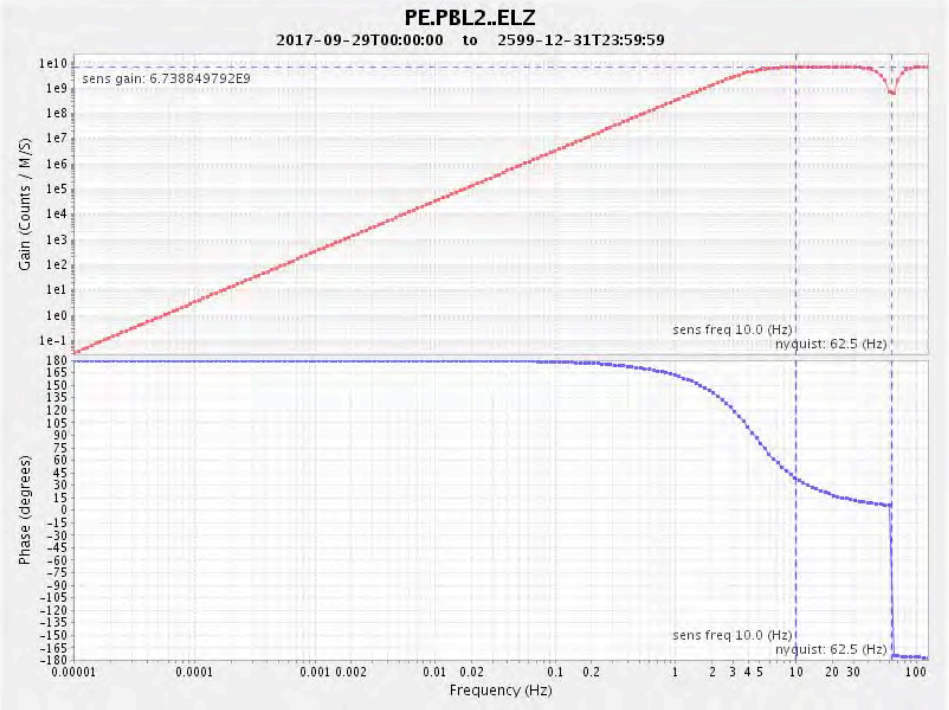


Figure 5. GeoEMS station PBL2 IRIS MetaData Aggregator Listing

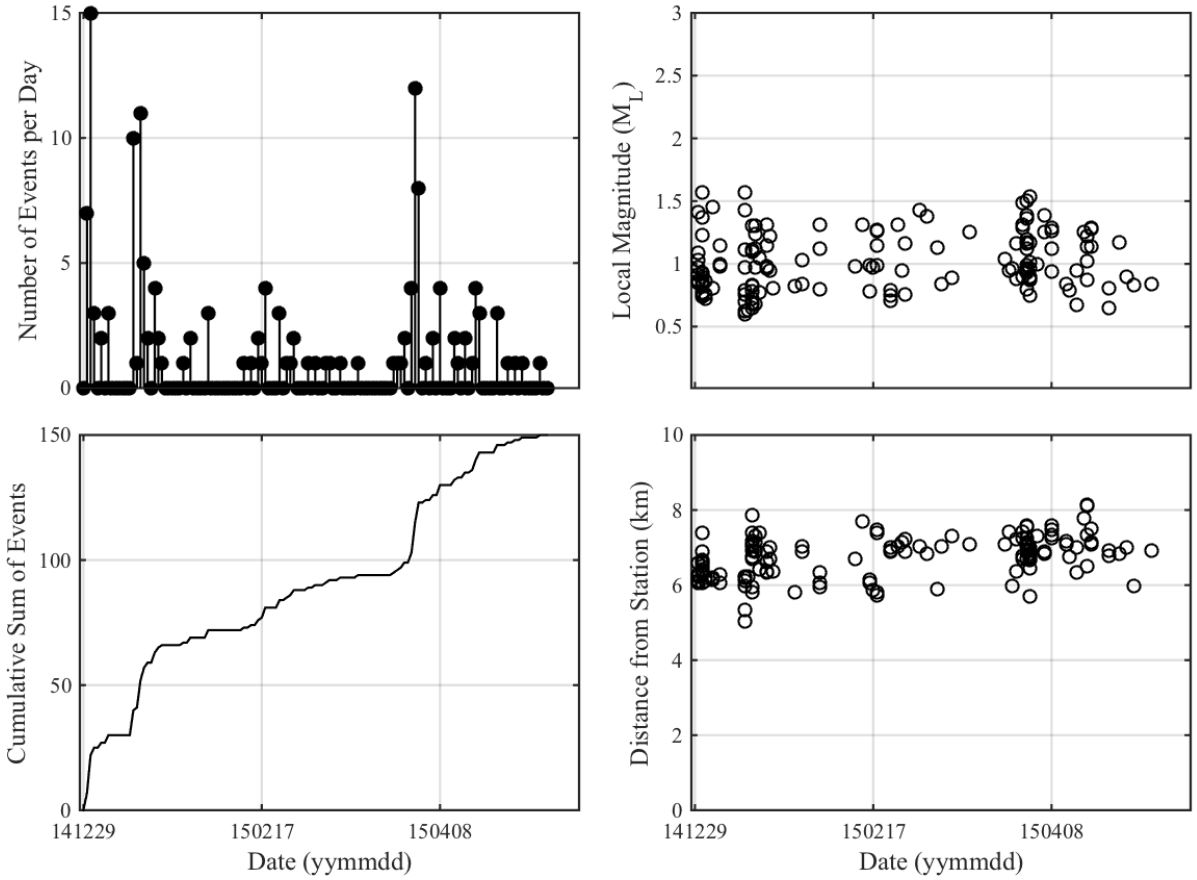


Figure 6. Example of single station reporting statistics.

APPENDICES

Appendix A. Specification Sheet and Response Diagram for GS-11D Seismometer

Geophones GS-11D

February 7, 2012 By

GS-11D

Rotating Coil Geophone

- Field proven design
- Shock resistant, rotating dual coil construction
- Gold plated contacts for positive electrical connection
- Precision springs, computer designed and matched
- Full one year warranty

The GS-11D is a high output, rotating coil geophone designed and built to withstand the shocks of rough handling. The precision springs of this field proven geophone are computer designed and matched to optimize performance specifications even under the most extreme conditions.

Gold plated contacts assure positive electrical connections. The Geo Space manufacturing process includes checking all geophone operating parameters with the ATS, an automated computerized test system.

Natural frequencies are 4.5, 8, 10 and 14 Hz, with standard coil resistance of 380 ohms. The PC-21 Land Case is used with the GS-11D geophone.

Cases Available

PC-21 Land Case

Spec Sheet:

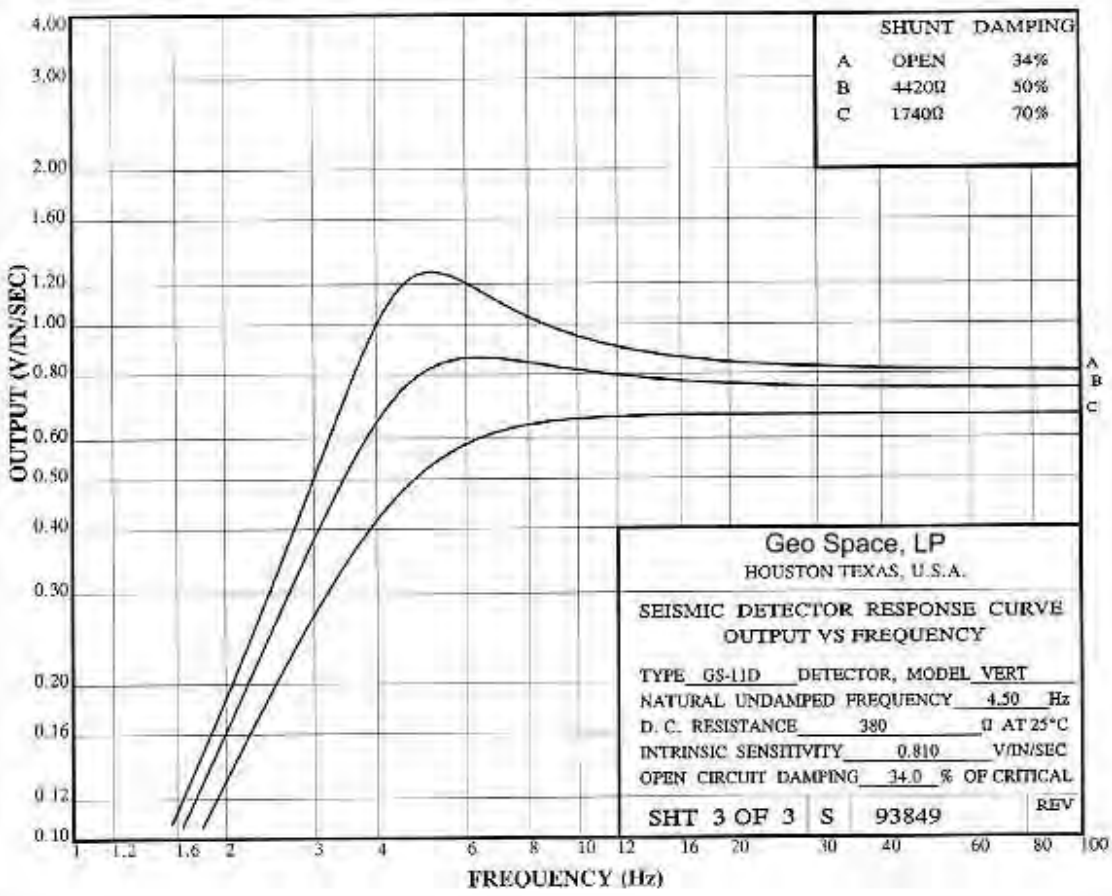
GS-11D Specifications

Natural Frequency	4.5 ± .75 Hz	8 ± .75 Hz	10 ± .75 Hz	14 ± .75 Hz
Coil Resistance @ 25°C ± 5%	——380 Ohms ——			
Intrinsic Voltage Sensitivity with 380 Ohm Coil ± 10%	——.81 V/in/sec (.32 V/cm/sec) ——			
Normalized Transduction Constant (V/in/sec)	——042 (sq.root of Rc) ——			
Open Circuit Damping	.34 ± 20%	.39 ± 10%	.32 ± 10%	.23 ± 10%
Damping Constant with 380 Ohm Coil	762	602	482	344
Optional Coil Resistances ± 5%	——56,160 Ohms ———			
Moving Mass ± 5%	23.6 g	16.8 g	16.8 g	16.8 g
Typical Case to Coil Motion P-P	.07 in (.18 cm)	.07 in (.18 cm)	.07 in (.18 cm)	.07 in (.18 cm)
Harmonic Distortion with Driving Velocity of 0.7 in/sec (1.8 cm/sec) P-P	N/S	——0.2% or less —— @ 12 Hz @ 12 Hz @ 12 Hz		
Dimensions				
Height (less terminals*)	———1.32 in (3.35 cm) ———			
Diameter	———1.25 in (3.18 cm) ———			
Weight	———3.9 oz (111 g) ———			

*Terminal height is .135 inches

Specifications are subject to change without notice.

GS-11D Seismic Detector Response Curve
Output vs. Frequency Chart (GS-11D @ 4.5 Hz @ 380 Ohms)



Appendix B. Specification Sheet for GeoEMS Seismic Recording System

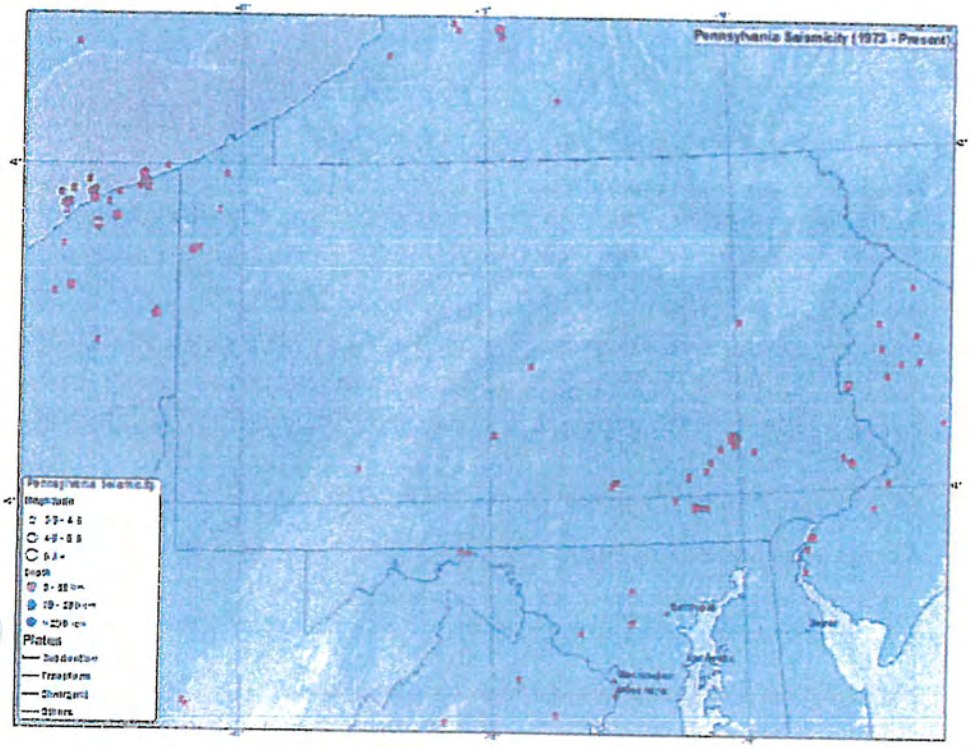
Specifications

Mechanical		
Size: 30x20x18 cm		Base unit, NEMA 4X watertight enclosure.
Weight: 5 kg		Includes sensors. Battery: 12 kg, solar panel: 5 kg
Power		
Input Voltage:	**10 to 16 VDC**	System includes 35 amp-hour sealed lead acid battery.
Charging:	**100 watt solar panel**	Solar panel and brackets for T-post mounting included.
Power:	**2.8 watts**	230 mA @ 12V
Communications		
CDMA or GSM Cellular		Other options available: Orbcomm low-bandwidth satellite, wired ethernet, local low-power radio.
Sensors		
3-component, 4.5 Hz, Oyo GS-11D		Mounted inside enclosure.
Data Conversion		
Type: Delta-sigma, 24 bit		Synchronous sampling for all channels
Channels: 3 or 6		Analog inputs
Gain: x10,x20,x40,x80		Gain is fixed at time of shipment.
Input full scale: 1.2V / gain		
Noise: At 150 sps and x10 gain, 1uV RMS		Gain and sample rate dependent
Sample Rates: 10 to 500 sps		
Accelerometer:		MEMS, ±2g full scale, 14-bit resolution
Time Base		
Type: GPS		GPS receiver is integrated into system electronics. GPS antenna is external.
Accuracy with continuous GPS:		1 msec
Recording		
Continuous and event-detected		Event data is transmitted within minutes of detection, continuous data is stored on USB flash memory.

Earthquake Hazards Program

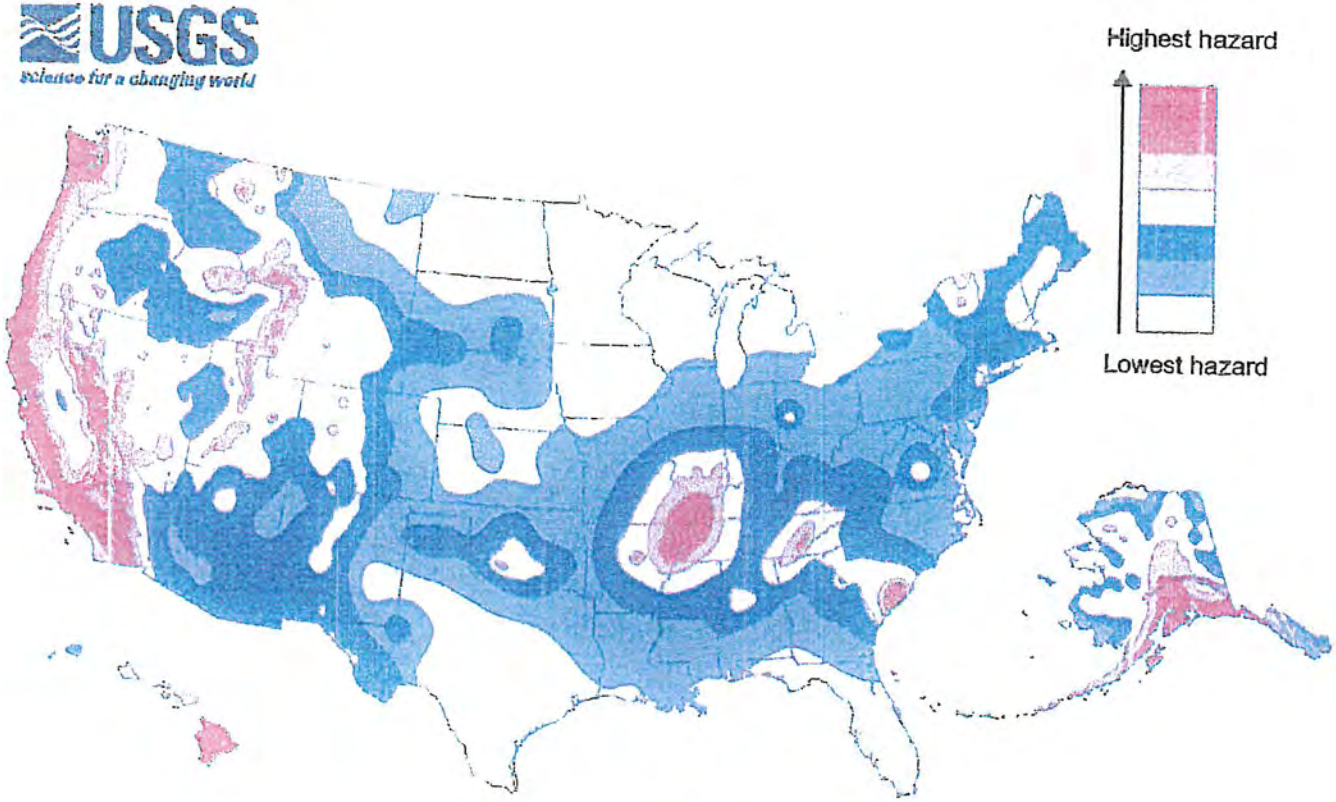
Pennsylvania

Seismicity Map - 1973 to March 2012



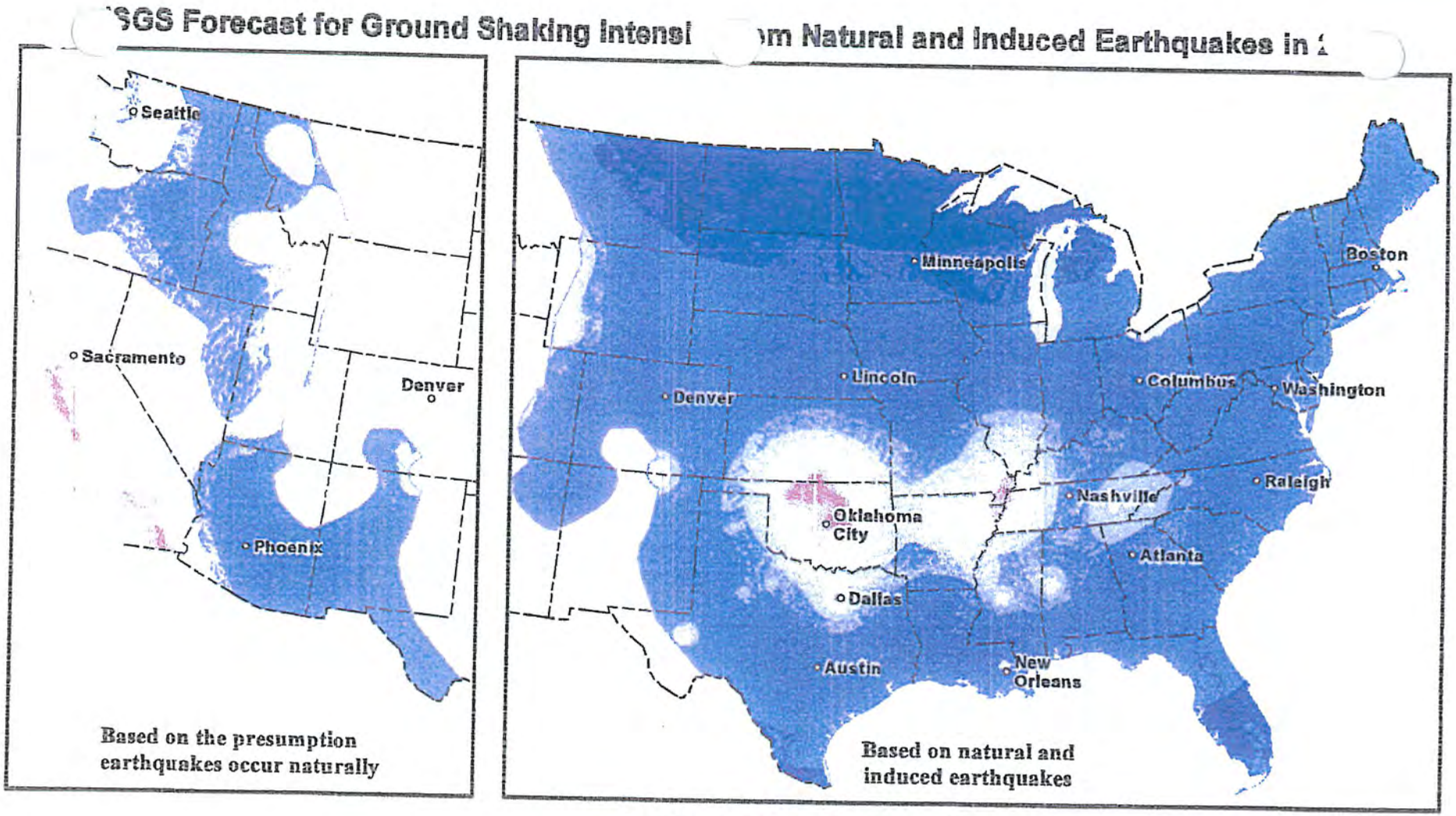
Share this page: Facebook Twitter Google Email

Earthquake Map 1



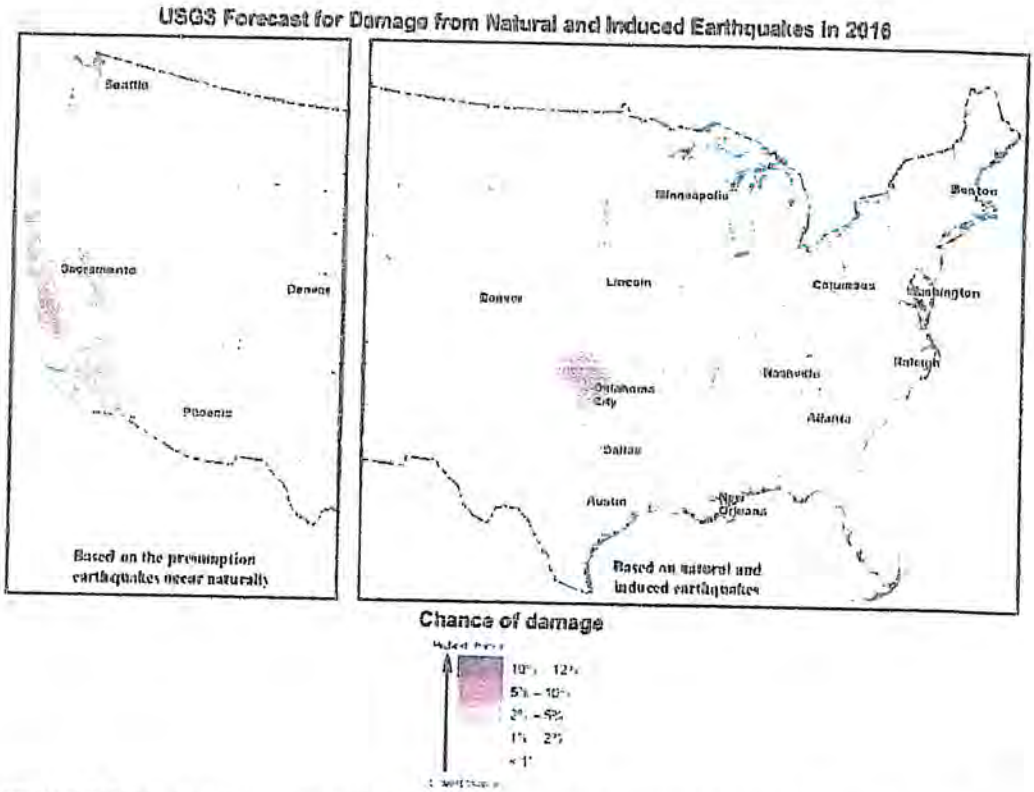
Earthquake Map 2

http://earthquake.usgs.gov/hazards/products/conterminous/2014/HazardMap2014_lg.jpg



Earthquake Map 3

USGS map displaying intensity of potential ground shaking from natural and human-induced earthquakes. There is a small chance (one percent) that ground shaking intensity will occur at this level or higher. There is a greater chance (99 percent) that ground shaking will be lower than what is displayed in these maps.



USGS map displaying potential to experience damage from natural or human-induced earthquakes in 2016. Chances range from less than 1 percent to 12 percent.

USGS map displaying potential to experience damage from a natural or human-induced earthquake in 2016. Chances range from less than one percent to 12 percent.

Six States Face the Highest Hazards

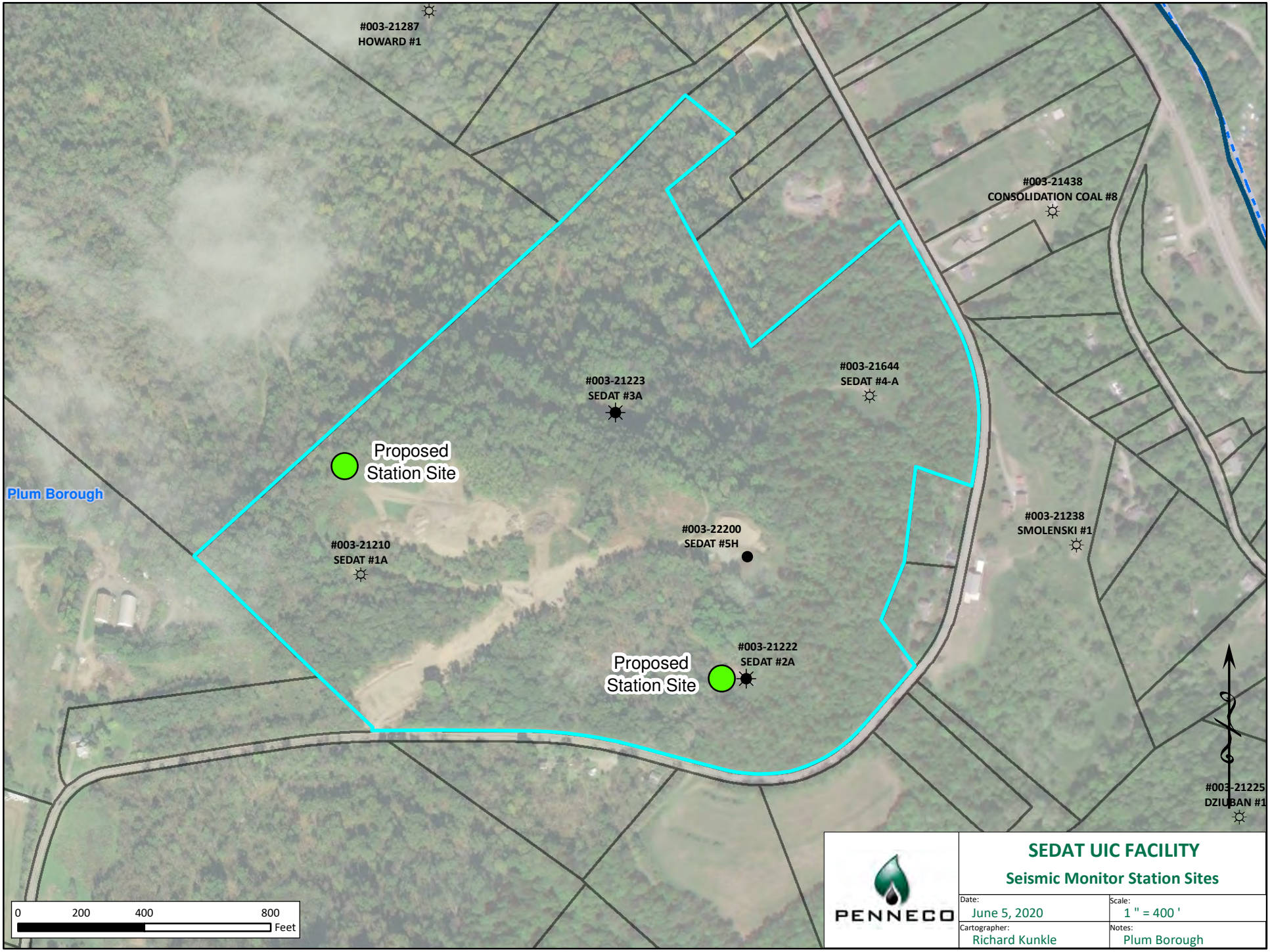
The most significant hazards from induced seismicity are in six states, listed in order from highest to lowest potential hazard: Oklahoma, Kansas, Texas, Colorado, New Mexico and Arkansas. Oklahoma and Texas have the largest populations exposed to induced earthquakes.

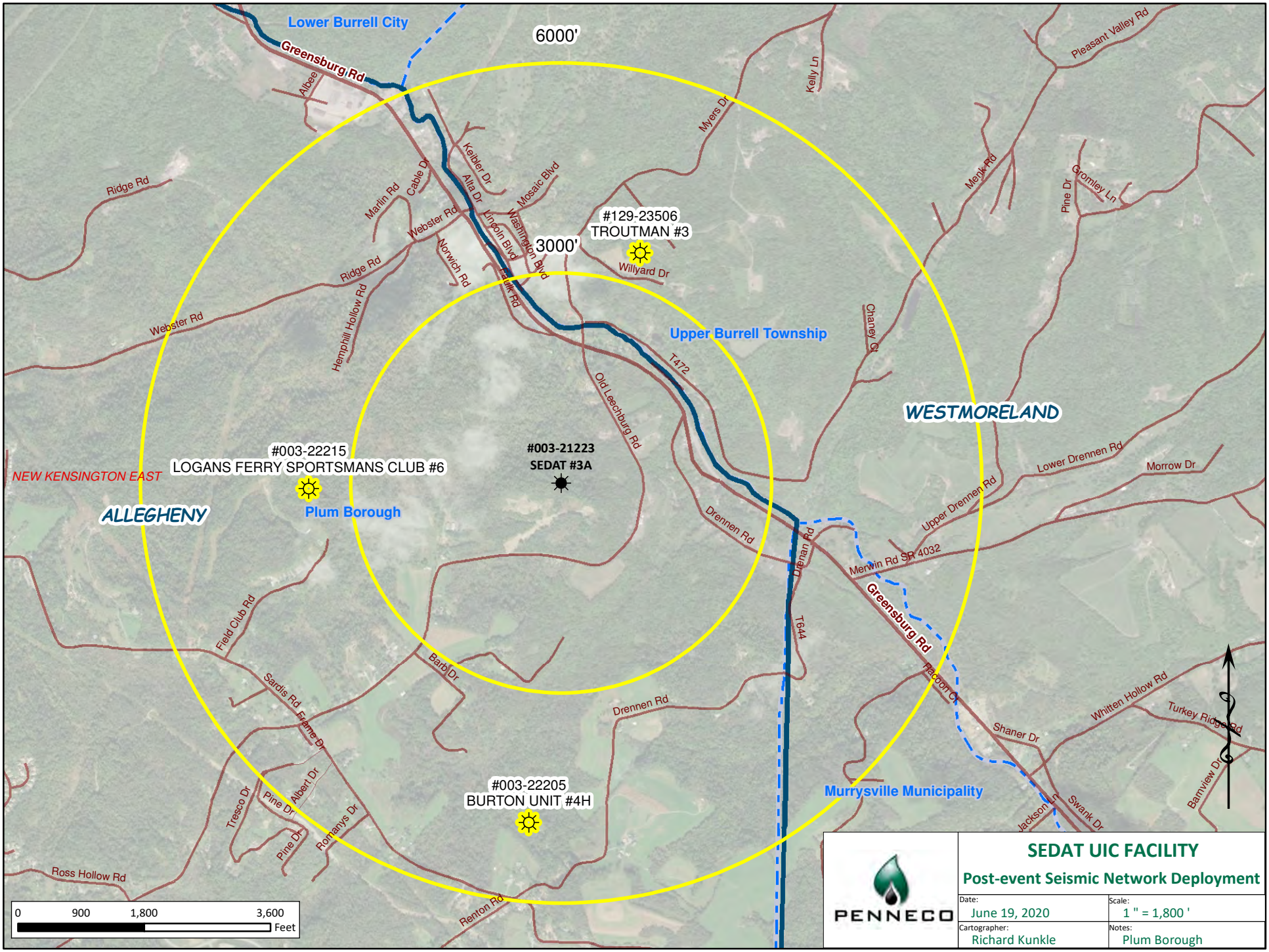
"In the past five years, the USGS has documented high shaking and damage in areas of these six states, mostly from induced earthquakes," said Petersen. "Furthermore, the USGS Did You Feel It? website has archived tens of thousands of reports from the public who experienced shaking in those states, including about 1,500 reports of strong shaking or damage."

In developing this new product, USGS scientists identified 21 areas with increased rates of induced seismicity. Induced earthquakes have occurred within small areas of Alabama and Ohio but a recent decrease in induced earthquake activity has resulted in a lower hazard forecast in these states for the next year. In other areas of Alabama and small parts of Mississippi, there has been an increase in activity, and scientists are still investigating whether those events were induced or natural.

People living in areas of higher earthquake hazard should learn how to be prepared for earthquakes, and guidance can be found through FEMA's Ready Campaign.

Earthquake Map 4


#003-21287
HOWARD #1
#003-21438
CONSOLIDATION COAL #8
#003-21644
SEDAT #4-A
#003-21223
SEDAT #3A
Proposed
Station Site
Plum Borough
#003-21210
SEDAT #1A
#003-22200
SEDAT #5H
#003-21238
SMOLENSKI #1
#003-21222
SEDAT #2A
Proposed
Station Site
#003-21225
DZIUBAN #1
0
200
400
800
Feet
PENNECO
SEDAT UIC FACILITY
Seismic Monitor Station Sites
Date:
June 5, 2020
Scale:
1 " = 400 '
Cartographer:
Richard Kunkle
Notes:
Plum Borough


Lower Burrell City
6000'
3000'
Greensburg Rd
Albee
Ridge Rd
Webster Rd
Marlin Rd
Cable Dr
Keibler Dr
Alta Dr
Mosaic Blvd
Lincoln Blvd
Washington Blvd
Norwich Rd
Hemphill Hollow Rd
Myers Dr
Kelly Ln
Pleasant Valley Rd
Merpk Rd
Pine Dr
Gromley Ln
#129-23506
TROUTMAN #3
Willyard Dr
Chaney Ct
Upper Burrell Township
T472
Old Leechburg Rd
WESTMORELAND
#003-22215
LOGANS FERRY SPORTSMANS CLUB #6
#003-21223
SEDAT #3A
NEW KENSINGTON EAST
ALLEGHENY
Plum Borough
Drennen Rd
Lower Drennen Rd
Morrow Dr
Upper Drennen Rd
Merwin Rd SR 4032
Greensburg Rd
T644
Field Club Rd
Barbi Dr
Sardis Rd
Frame Dr
Albert Dr
Tresco Dr
Pine Dr
Romanys Dr
Ross Hollow Rd
Renton Rd
#003-22205
BURTON UNIT #4H
Peacon Ct
Shaner Dr
Whitten Hollow Rd
Turkey Ridge Rd
Barnview Dr
Jackson Ln
Swank Dr
Murrysville Municipality
0
900
1,800
3,600
Feet
PENNECO
SEDAT UIC FACILITY
Post-event Seismic Network Deployment
Date:
June 19, 2020
Scale:
1 " = 1,800 '
Cartographer:
Richard Kunkle
Notes:
Plum Borough

TETRA TECH

July 21, 2021

Mr. D. Marc Jacobs, Jr.
Senior Vice President
Penneco Environmental Solutions, LLC
6608 Route 22
Delmont, PA 15626-2408

Subject: Zone of Endangering Influence (ZEI) Modeling
Underground Injection
Penneco - Sedat #3A and Sedat 4A Wells
Allegheny County, PA

Dear Mr.Jacobs:

This letter report summarizes the analytical modeling performed by Tetra Tech, Inc. (Tetra Tech) for the Area of Review (AOR) /Zone of Endangering Influence (ZEI) analysis for the Penneco Environmental Solutions, LLC (Penneco) Sedat #3A and #4A wells. Sedat #3A has received its UIC Class IID well permits from US EPA and PADEP and is operational, while Sedat #4A has not yet received its UIC well permits from US EPA and PADEP. Both wells are located in Plum Borough of Allegheny County, Pennsylvania and target the Murrysville Sand as the injection zone. We understand that as part of the permit application review process, US EPA has requested a ZEI analysis be performed under the condition of both the Sedat #3A and Sedat #4A injecting. As such, the scenario we have modeled involved injecting simultaneously at both wells. The relevant parameters for our analysis were obtained from existing permit-related documents and information provided by Penneco or estimated/based on literature values in the absence of any well-specific information. Our analysis is described in more detail below.

OVERVIEW AND METHODOLOGY

There are several methods proposed for calculating the ZEI of an injection well. The most simplistic method is the use of a fixed radius, based on the type of injection well being permitted. Other methods involve calculation of the radius based on well and formation properties. Most regulatory agencies require the use of calculations to determine the ZEI. The method used here is the graphical method first used by US EPA Region 6. It involves the calculation of the increase of pressure in the formation due to injection, then converting that pressure into equivalent feet of head. The increase in head in the formation due to injection is then compared to the equivalent head of the lowest most underground source of drinking water (USDW). When plotted graphically, the intersection of those two curves at some radial distance, r, determines the radius of the ZEI.

The increase in pressure in the formation due to injection depends on the properties of the injection fluid and the formation, the rate of fluid injection, and the length of time of injection. The most common mathematical expression to describe this increase in pressure was developed by Matthews and Russell (1967). Matthews and Russell assume that, for a single well injecting into an infinite, homogeneous and isotropic, non-leaking formation, the increase in pressure (delta p) can be described as:

delta p = 162.6 Qμ / kh * [(log(kt / ΦμCr^2) – 3.23] where:

delta p = pressure change (psi) at radius, r and time, t

Q = injection rate (barrels (bbls)/day)

μ = injectate viscosity (centipoise)

k = formation permeability (millidarcies (md))

h = formation thickness (feet)

t = time since injection began (hours)

C = compressibility (total, sum of water and rock compressibility) (psi^{-1})

r = radial distance from wellbore to point of investigation (feet)

Φ = average formation porosity (decimal)

PARAMETERS USED IN THE ANALYSIS

The following parameters were used in the ZEI analysis. For injection rate, we used a daily rate of 3,600 bbls/day for the Sedat #3A well (based on the permitted monthly rate of 108,000 bbls divided by 30 days) and the proposed daily rate of 1,800 bbls/day for the Sedat #4A well (based on the proposed monthly rate of 54,000 bbls divided by 30 days). For this analysis, permeability was assigned a value of 100 md, which is based on literature values which state that permeability of the Murrysville Sand in southwest Pennsylvania ranges from 0.005 to 1,000 md, with an average of 100 md (Sager, 2007; Smosna and Sager, 2008). The literature shows that permeability is related to porosity, with higher porosity values corresponding to higher permeability values (Figure 1). As indicated in the US EPA Statement of Basis for the Sedat #3A draft UIC Class IID well permit, average porosity for Murrysville Sand in the Sedat #3A area averages 24%. The 100 md average permeability value is also referenced in the US EPA Statement of Basis document. It is noted that HFRAC, as part of formation testing on the Sedat #3A well, estimated a permeability value of 1.8 md; however, as indicated in the attached technical memo from HFRAC, the result is considered to not be representative of formation conditions primarily due to only a small percentage of perforations being accessed during the test and near well bore tortuosity. The initial pressure at the top of the injection formation was based upon observed measurements during the formation test for the Sedat #3A well conducted by HFRAC. The above input parameters and others required

for the modeling are provided below for each well along with the basis for the assigned input parameter value.

Sedat #3A Murrysville Sand Well

Q = 3600 barrels/day (Permitted monthly injection rate / 30 days)

t = 10 years = 87,600 hours (Modeled scenario)

μ = 1 centipoise (Default)

k = 100 md (Based on average Murrysville permeability per Sager (2007))

h = 81 feet (Thickness of proposed perforated interval)

C = 3.0e-06 psi^{-1} (Default)

Φ = 0.24 (Porosity log value)

Specific gravity of injectate = 1.23 (Anticipated specific gravity of injected brine)

Surface elevation = 1106 feet (Well Completion Report)

Depth to injection formation = 1896 feet (EPA UIC Well Permit)

Base of lowest most USDW (MSL) = 656 feet (Surface elevation – 450 feet (depth to lowest most USDW from Sadat #3A USEPA Statement of Basis document))

Initial pressure at top of injection formation = 232 psi (Initial reservoir pressure reported by HFRAC for the Sadat #3A well as part of formation testing)

Sedat #4A Murrysville Sand Well

Q = 1800 barrels/day (Proposed monthly injection rate / 30 days)

t = 10 years = 87,600 hours (Modeled scenario)

μ = 1 centipoise (Default)

k = 100 md (Based on average Murrysville permeability per Sager (2007))

h = 60 feet (Thickness of proposed perforated interval)

C = 3.0e-06 psi^{-1} (Default)

Φ = 0.24 (Porosity log)

Specific gravity of injectate = 1.23 (Anticipated specific gravity of injected brine)

Surface elevation = 1068 feet (Well Completion Report)

Depth to injection formation = 1740 feet (UIC Well Permit Application)

Base of lowest most USDW (MSL) = 656 feet (Surface elevation – 412 feet (depth to lowest most USDW elevation from Sadat #3A USEPA Statement of Basis document)

Initial pressure at top of injection formation = 232 psi (Initial reservoir pressure reported by HFRAC for the Sadat #3A well as part of formation testing)

RESULTS

The Matthews and Russell equation was solved for the distance from the wells based on the parameters listed above. The distance between the Sedat #3A and Sedat #4A wells is approximately 815 ft.

The Matthews and Russell equation was used to calculate the increase in pressure in the formation with only one well injecting. This was done for both wells. Then, this value was added to the value of existing pressure in the injection formation to obtain the total pressure in the formation when both wells are injecting.

These values were then converted to feet of head of formation brine. The values are plotted against distance from the wellbore and are shown in Figure 2 for the Sedat #3A well and Figure 3 for the Sedat #4A well. The plot shows the calculated pressure surface within the injection formation, measured as feet of head of formation brine above the top of the injection formation. Also shown is the head of the lowest most USDW. Where the two lines intersect, the radius of the ZEI can be estimated. The results indicate that the radial distance of the ZEI is approximately 360 feet for the Sedat #3A well and approximately 250 feet for the Sedat #4A well. These distances are well within the ¼ mile standard fixed radius for AOR/ZEI.

CONCLUSIONS

Our analysis of the AOR/ZEI for the Sedat #3A and #4A wells (injecting together) is based on a methodology typically used by US EPA. Based on the results, we believe the Sedat #3A and #4A wells are excellent candidates for use as brine disposal wells from a ZEI perspective. The analysis indicates that the AOR of ¼ mile is sufficiently protective given the ZEI results of 360 feet for Sedat #3A and 250 feet for Sedat #4A.

REFERENCES

Matthews, C.S., Russell, D.G., (1967) Pressure Buildup and Flow Test in Wells, SPE Monograph Series, Volume1, New York.

Sager, M., (2007) Petrologic Study of the Murrysville Sandstone in Southwestern Pennsylvania, West Virginia University Libraries.

Smosna, R., Sager, M., (2008) The Making of a High-Porosity, High-Permeability Reservoir – The Murrysville Sandstone of Pennsylvania, AAPG Eastern Section Meeting, Pittsburgh, PA.

Please feel free to contact me at 724-766-5987 or by email at dale.skoff@tetratech.com with any questions or comments.

Respectfully submitted,
Tetra Tech, Inc.

Dale E. Skoff, PG, CHMM
Account Manager

cc: Jeff Benegar – Tetra Tech

Figures

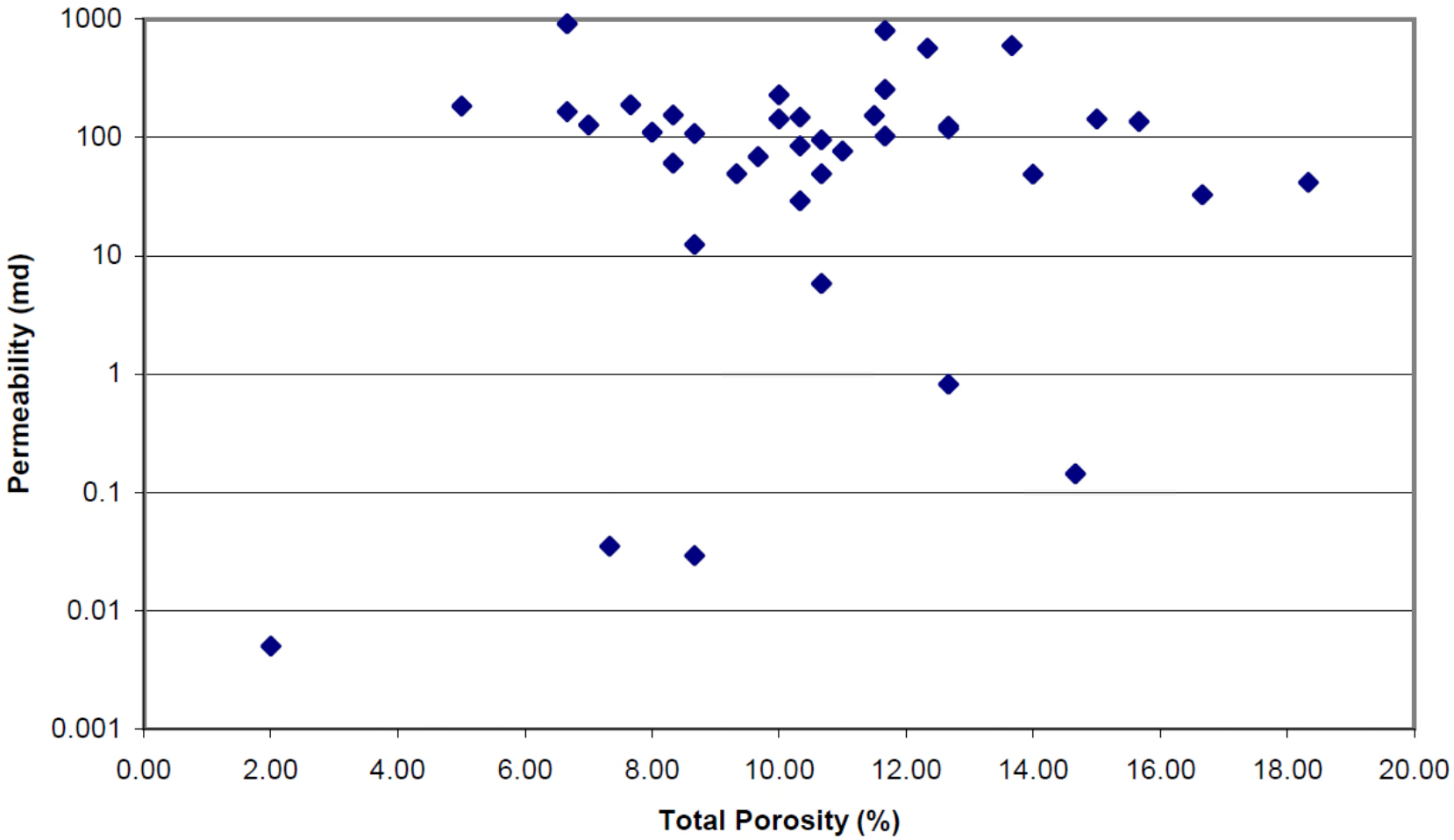


Figure 1. Porosity vs. permeability for the Murrysville Sand (from Sager, 2007)

TETRA TECH, INC.

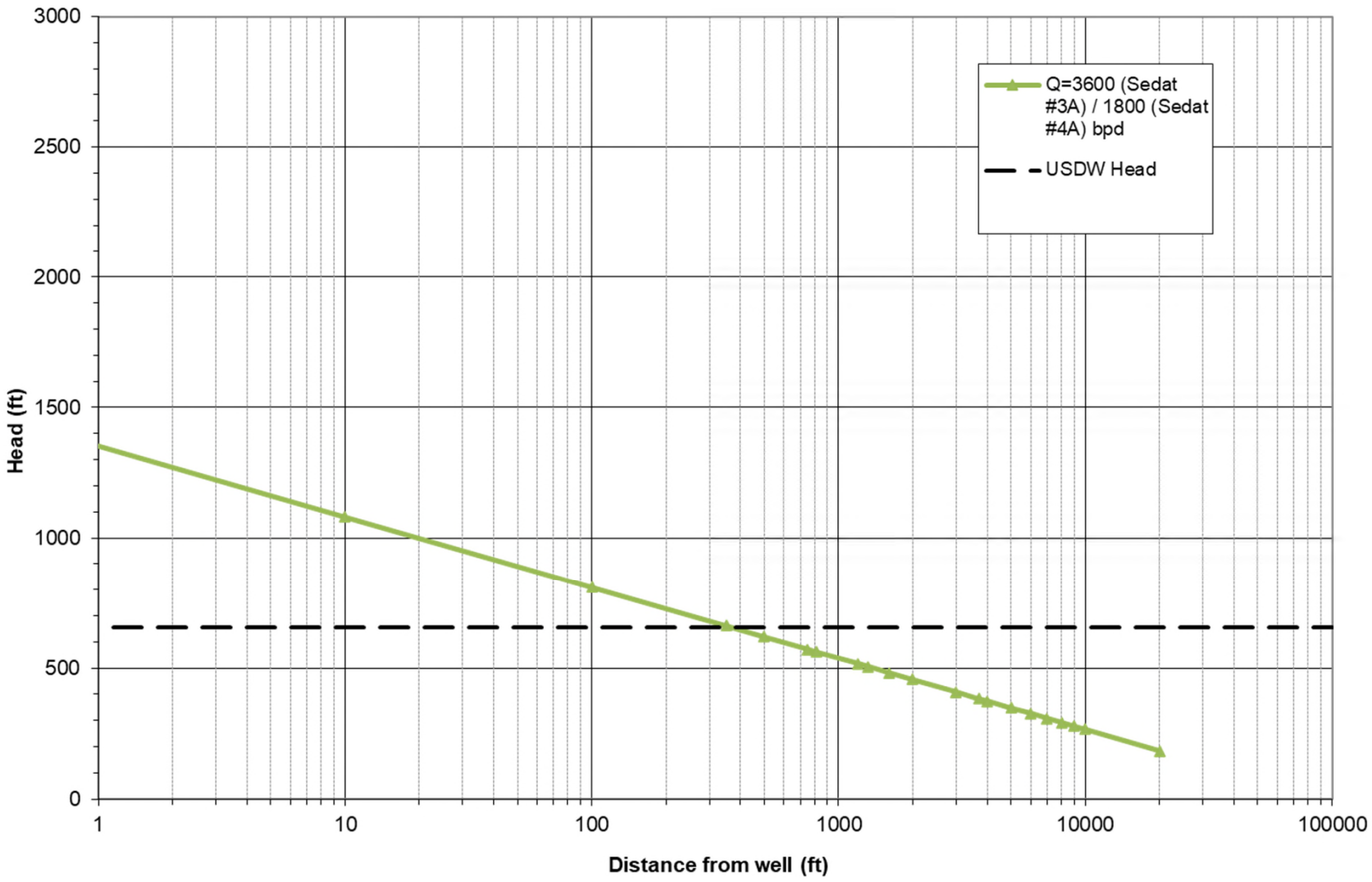


Figure 2. Feet of head of injection formation and USDW vs. distance for Sedat #3A when both wells (Sedat #3A and #4A) are injecting, K = 100 md

TETRA TECH, INC.

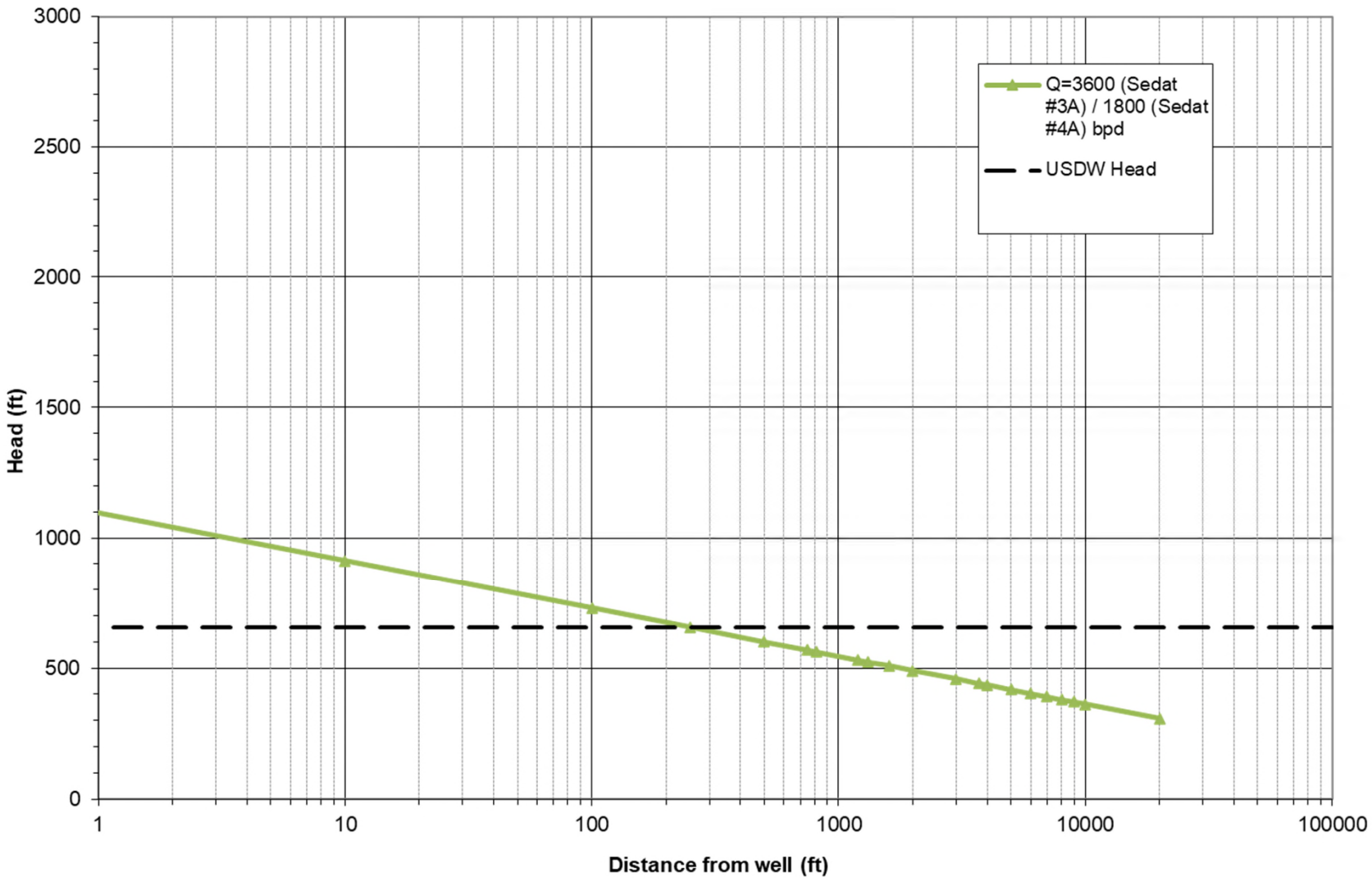


Figure 3. Feet of head of injection formation and USDW vs. distance for Sedat #4A when both wells (Sedat #3A and #4A) are injecting, K = 100 md

TETRA TECH, INC.

HFRAC January 14, 2019 Letter

Sedat #3A (Murrysville) – Permeability Determination

HFRAC Consulting Services, LLC

January 14, 2019

Mr. Marc Jacobs, Jr.
Senior Vice President
Penneco
6608 Route 22
Delmont, PA 15626

Re: Sedat #3A (Murrysville) – Permeability Determination

Dear Marc,

On September 1, 2015 a DFIT was pumped to determine the closure stress, reservoir pressure, and reservoir transmissibility (kH/mu). The DFIT was pumped at 4 bpm for 1500 gals. Bottomhole pressure was recorded with a bottomhole gauge set 1910 ft. The results from the DFIT using the Nolte G function gave a bottomhole closure stress of 553 psi which gives a closure stress gradient of 0.29 psi/ft. The pressure decline data after closure (ACA) was analyzed with the Nolte FR function to determine reservoir transmissibility. Based on the pressure response it appears that pseudoradial flow was reached. The reservoir transmissibility was 88 mD-ft/cP assuming a reservoir fluid viscosity of 1 cP. The actual results will vary based on the actual reservoir fluid viscosity. The formation capacity (kH) was 88 mD-ft. Assuming a height of 50 ft gives a reservoir permeability of 1.8 mD.

The reservoir permeability of 1.8 mD is less than the reported permeability values for the Murrysville formation. The permeability values reported in the "Petrologic Study of the Murrysville Sandstone in Southwestern PA" are shown to be closer to 100 mD.

A possible reason for the difference in the permeability determined from the DFIT and the permeability reported in the study is a poor connection between the wellbore and reservoir. The injection test was the first injection into the formation. Subsequent injections were conducted to breakdown additional perforations and remove near wellbore tortuosity.

330.401.1921
hjacot@hfrac.com
www.hfrac.com

P.O. Box 801 • New Philadelphia, OH 44663

The rate stepdown test indicated only five out of forty perforations open.

As a result of the poor connection between the wellbore and the reservoir the reservoir permeability of 1.8 mD may not be representative of the actual Murrysville reservoir permeability which may be closer to 100 mD as stated in the “Petrologic Study of the Murrysville Sandstone in Southwestern Pennsylvania”.

Thank you for the opportunity to work on the Sedat #3A project with Penneco. If you have any questions or comments let me know.

Sincerely,

Henry Jacot

Attachment “H”

Operating Data

Attachment H
Operating Data
Sedat #4A Injection Well

Injection Rates and Volumes

1) The proposed average injection rate is 1,800 BBLs of water per day and the maximum rate should be no greater than 2,000 BBLs of water per day or 54,000 BBLs per month.

Injection Pressures

2) Injection pressure is expected to be at minimum MASIP of 1,322 psi while injecting 1.23 Sg water, the calculated maximum injection pressure at the well head, without accounting for any friction through the perforations in the 7" casing and the pipe friction through the 2⅞" injection string. The measured bottom hole reservoir pressure as measured with a bottom hole pressure gage during testing at #3A is 232 psi static.

The maximum allowable surface injection pressure baseline of 1,322 psi, is calculated using the formula published in 40 CFR Subpart NN - Pennsylvania § 147.1953, Pm= [(FG (generically .733) – (0.433)(Sg)]D, for a column of water. The fracture gradient of this well is 1.23 PSI/FT calculated from the Reservoir and Characterization study at Sedat #3A found at the end of Attachment G. The maximum Sg baseline used for the calculation is 1.23 Sg (not to be confused with the 1.23 Psi/ft. fracture gradient), the maximum Sg of the produced brine water anticipated at the facility. Therefore, the Maximum Allowable Surface Injection Pressure (MASIP or Pressure Maximum- PM) for this well would be [Pm = 1.23 FG– (0.433 PSI/ft. of Sg 1.0) (1.23 Sg of worst case local produced brine water))1896 (test depth at Sedat #3)]; Pm=1,322 PSI while pumping 1.23 SG (10.25/gal). Should the Sg of the injectate fall below the value baseline (1.23 Sg), the maximum surface injection pressure will correspondingly adjust higher through automation to maintain the measured bottom hole pressure of 2332 psi. Example assuming no effect from friction:

1.08 SG= 1.23- (.433x1.08) x 1896 0r 1.23-.4676 = .7624 PSI/ft x 1896= 1446 PW. This example equates to .4676 PSI/ft. x 1896=886.57 PSI + 1446 MASIP/PW= 2332 Bottom Hole injection pressure without regard to friction loss. See attached spreadsheet.

Annulus Fluid

3) Fresh water will be in placed in the 2⅞" by 4½" annulus, mixed with a chemical such as Corr Plex 300 which acts as a corrosion inhibitor and bacteria growth preventer. Twenty gallons of Corr Plex 300 will be mixed with approximately 2,500 gallons of fresh water. The MSD sheet for the chemical mixture Corr Plex

300 listing ingredients and physical data is included in this section. Positive pressure will be maintained on the annulus to monitor mechanical integrity.

Source and Analysis of Injection Fluid

4) The source of the injection fluid will be produced water from oil and gas wells and flow back fluid from oil and gas well stimulation activities and rainwater that falls into the un-roofed PES facility containments. Three representative sample analyses are included with this attachment. Before injection the produced fluid will be analyzed for the parameters required by the permit. The produced fluid and flow back water will be subjected to treatment and passed through a filter to remove large particles and suspended solids from the fluid before injection. The solids removed will be transported to an appropriate waste disposal site.

Unchanging MASIP based on Max Sg 1.23

1322 MASIP no matter the SPG .9-1.23

MASIP at 1.23Sg	SPG	BHP Injecting	BHP psi Loss
1322	0.90	2061	-271
1322	0.91	2069	-263
1322	0.92	2077	-255
1322	0.93	2086	-246
1322	0.94	2094	-238
1322	0.95	2102	-230
1322	0.96	2110	-222
1322	0.97	2118	-214
1322	0.98	2127	-205
1322	0.99	2135	-197
1322	1.00	2143	-189
1322	1.01	2151	-181
1322	1.02	2159	-173
1322	1.03	2168	-164
1322	1.04	2176	-156
1322	1.05	2184	-148
1322	1.06	2192	-140
1322	1.07	2200	-132
1322	1.08	2209	-123
1322	1.09	2217	-115
1322	1.10	2225	-107
1322	1.11	2233	-99
1322	1.12	2241	-91
1322	1.13	2250	-82
1322	1.14	2258	-74
1322	1.15	2266	-66
1322	1.16	2274	-58
1322	1.17	2283	-49
1322	1.18	2291	-41
1322	1.19	2299	-33
1322	1.20	2307	-25
1322	1.21	2315	-17
1322	1.22	2324	-8
1322	1.23	2332	0

					MASIP (PW) by Sg 'MASIPat Sg		BHP w/
Sg x.433 x 1896=xxxx.x					Steady BHP		Various Sg
At SPG	Hydrostatic at 1896 ft.				2332 PSI MASIP (PW)		No Friction BHP
0.90	738.9	+			1593	=	2332.0
0.91	747.1	+			1585	=	2332.0
0.92	755.3	+			1577	=	2332.0
0.93	763.5	+			1568	=	2332.0
0.94	771.7	+			1560	=	2332.0
0.95	779.9	+			1552	=	2332.0
0.96	788.1	+			1544	=	2332.0
0.97	796.3	+			1536	=	2332.0
0.98	804.5	+			1527	=	2332.0
0.99	812.8	+			1519	=	2332.0
1.00	821.0	+			1511	=	2332.0
1.01	829.2	+			1503	=	2332.0
1.02	837.4	+			1495	=	2332.0
1.03	845.6	+			1486	=	2332.0
1.04	853.8	+			1478	=	2332.0
1.05	862.0	+			1470	=	2332.0
1.06	870.2	+			1462	=	2332.0
1.07	878.4	+			1454	=	2332.0
1.08	886.6	+			1445	=	2332.0
1.09	894.9	+			1437	=	2332.0
1.10	903.1	+			1429	=	2332.0
1.11	911.3	+			1421	=	2332.0
1.12	919.5	+			1413	=	2332.0
1.13	927.7	+			1404	=	2332.0
1.14	935.9	+			1396	=	2332.0
1.15	944.1	+			1388	=	2332.0
1.16	952.3	+			1380	=	2332.0
1.17	960.5	+			1371	=	2332.0
1.18	968.7	+			1363	=	2332.0
1.19	977.0	+			1355	=	2332.0
1.20	985.2	+			1347	=	2332.0
1.21	993.4	+			1339	=	2332.0
1.22	1001.6	+			1330	=	2332.0
1.23	1009.8	+			1322	=	2332.0

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

LABORATORY REPORT SUMMARY

Client: C00117

Tuesday, April 18, 2017

SMITH LAND SURVEYING, INC.
P.O. BOX 150
GLENVILLE WV 26351-

Total Number of Pages: 7
(Not Including C.O.C.)

Lab ID	Sample ID	Sample ID 2	Sample Date
265743-2017-W	CONVENTIONAL REPRESENTATIVE	CONV	4/12/2017
265744-2017-W	MARCELLUS REPRESENTATIVE	MARC	4/12/2017
265745-2017-W	ORISKANY REPRESENTATIVE	ORSK	4/12/2017

The enclosed results have been analyzed according to the referenced method and SOP. Any deviations to the method have been noted on the report. Unless otherwise noted, all results have been verified to meet quality control requirements of the method. All analysis performed by Reliance Laboratories, Bridgeport, WV unless otherwise noted. Parameters analyzed by Reliance Laboratories, Martinsburg, WV are noted with @ on laboratory report.This report may not be reproduced, except in full, without written approval of Reliance Laboratories, Inc.

Report Reviewed By: Tenley Miller

Digitally signed by Tenley Miller
Date: 2017.04.20 09:28:17 -04'00'

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

SMITH LAND SURVEYING, INC.
P.O. BOX 150

GLENVILLE, WV 26351-

Lab Number: 265743-2017-W **Sample ID:** CONVENTIONAL REPRESENTATIVE CONV

Parameter	Value	Units	Method	Date/Time Analyzed	Analyst	MDL	MRL
Analyte Group: Inorganics							
Total Organic Carbon	ND	mg/l	SM5310C-00	4/17/2017 9:50	TH	0.1	0.5
Total Suspended Solids	5920	mg/l	SM2540D-97	4/13/2017 12:25	AAB	4	5
Specific Gravity	1.13	g/cc	ASTM D1429-08	4/18/2017 11:00	TM		
E.coli(MPN)**	< 1	Index/100ml	SM9223B-97	4/12/2017 16:22	CP		
pH	# 4.28	S.U.	SM4500H+B-00	4/13/2017 15:12	AAB		
Total Aluminum	105	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.009	0.05
Total Arsenic	15.1	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.007	0.05
Total Barium	288	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.003	0.05
Total Calcium	17130	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.078	0.5
Total Chloride	235742	mg/l	EPA 300.0 R2.1	4/18/2017 11:28	TM	0.15	0.5
Total Coliform(MPN)**	< 1	Index/100ml	SM9223B-97	4/12/2017 16:22	CP		
Total Dissolved Solids	210110	mg/l	SM2540C-97	4/13/2017 12:25	AAB	10	20
Total Iron	210	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.004	0.05
Total Manganese	48.4	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.007	0.05
Total Sodium	57890	mg/l	EPA 200.7 R4.4	4/14/2017 13:04	TH	0.011	0.5
Total Sulfate	479	mg/l	EPA 300.0 R2.1	4/18/2017 11:28	TM	0.12	0.5
Total Surfactant	1.20	mg/l	SM5540C-00	4/14/2017 10:38	JL	0.05	0.2

Remarks:

Date Sample Collected: 4/12/2017 11:30
Sample Submitted By: A.WILSON
Date Sample Received: 4/12/2017 13:55
Sample temp. upon receipt: 3.8 Deg C

ND = Not Detected at the MDL or MRL
MDL - Minimum Detectable Limit
MRL - Minimum Reporting Limit
MCL - Maximum Contaminant Level, USEPA Regulated
J = Reported value is an estimate because concentration is less than the MRL

*Method Code: STANDARD METHODS ONLINE ED; US EPA METHODS FOR THE CHEMICAL ANALYSIS OF WATER AND WASTES, Rev. 83; US EPA METHODS FOR THE DETERMINATION OF METALS IN ENVIRONMENTAL SAMPLES, May 1994; TEST METHODS FOR EVALUATING SOLID WASTE, SW-846, 3rd ED; USEPA Manual for Certification of Laboratories Analyzing Drinking Water, 5th ED. In accordance with EPA Regulations, all reports, including raw data and quality control data, are maintained by the laboratory for a minimum of 5 years.

NOTE: #Holding time exceeded for this analysis. This falls outside criteria set by 40CFR136.

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

SMITH LAND SURVEYING, INC.
P.O. BOX 150

GLENVILLE, WV 26351-

Lab Number: 265743-2017-W **Sample ID:** CONVENTIONAL REPRESENTATIVE CONV

Parameter	Value	Units	Method	Date/Time Analyzed	Analyst	MDL	MRL
Analyte Group: Total Petroleum Hydrocarbons							
Benzene	ND	mg/l	SW8021B/5030B	4/18/2017 13:07	TM	0.0007	0.01
Ethylbenzene	ND	mg/l	SW8021B/5030B	4/18/2017 13:07	TM	0.0014	0.01
MTBE	ND	mg/l	SW8021B/5030B	4/18/2017 13:07	TM	0.003	0.005
Toluene	ND	mg/l	SW8021B/5030B	4/18/2017 13:07	TM	0.002	0.01
TPH - DRO	ND	mg/l	SW8015B/3535A	4/18/2017 11:48	TM	0.68	1
TPH - GRO	ND	mg/l	SW8015B/5030B	4/18/2017 13:07	TM	0.04	0.5
Xylene	ND	mg/l	SW8021B/5030B	4/18/2017 13:07	TM	0.003	0.01
4-Bromochlorobenzene (Surrogate	127	%	SW8021B/8015B	4/18/2017 13:07	TM		
o-Terphenyl (Surrogate)	75.8	%	SW8015B	4/18/2017 11:48	TM		
TPH - ORO	ND	mg/l	SW8015B/3535A	4/18/2017 11:48	TM	0.54	1
o-Terphenyl (Surrogate)	75.8	%	SW8015B	4/18/2017 11:48	TM		

Remarks:

Date Sample Collected: 4/12/2017 11:30
Sample Submitted By: A.WILSON
Date Sample Received: 4/12/2017 13:55
Sample temp. upon receipt: 3.8 Deg C

MDL - Minimum Detectable Limit
MCL - Maximum Contaminant Level, USEPA Regulated

ND = Not Detected at the MDL or MRL
MRL - Minimum Reporting Limit
J = Reported value is an estimate because concentration is less than the MRL

*Method Code: STANDARD METHODS ONLINE ED; US EPA METHODS FOR THE CHEMICAL ANALYSIS OF WATER AND WASTES, Rev. 83; US EPA METHODS FOR THE DETERMINATION OF METALS IN ENVIRONMENTAL SAMPLES, May 1994; TEST METHODS FOR EVALUATING SOLID WASTE, SW-846, 3rd ED; USEPA Manual for Certification of Laboratories Analyzing Drinking Water, 5th ED. In accordance with EPA Regulations, all reports, including raw data and quality control data, are maintained by the laboratory for a minimum of 5 years.

NOTE: #Holding time exceeded for this analysis. This falls outside criteria set by 40CFR136.

RELIANCE LABORATORIES, INC

2044 MEADOWBROOK ROAD
POST OFFICE BOX 4657
BRIDGEPORT, WV 26330
TEL. (304) 842-5285 • FAX (304) 842-5351
E-MAIL reliancelabs@wvdsl.net
INTERNET www.RelianceLabs.net

CHAIN OF CUSTODY RECORD

☐ RIDGEFIELD BUSINESS CENTER
25 CRIMSON CIRCLE
MARTINSBURG, WV 25403
TEL. (304) 596-2084 • FAX (304) 596-2086

CLIENT NAME SLS LAND & ENERGY DEV.
ADDRESS P.O. Box 150, GLENVILLE, WV 26351
CUSTOMER # C&D117 *TEL.# 304-462-5634 FAX # 304-462-5656
SAMPLER (S) A. WILSON E-MAIL awilson@slssurveys.com

SHEET NO. 1 OF 1

LABORATORY #	*DATE	*TIME	COMP.	GRAB	MATRIX W, DW, S, O, M	TEMP. ≤ 4°C Yes No	*# OF CONTAIN.	HNO3	H2SO4	HCL	NaOH	BAC-T	NO PRES.		See Hach						*PROJECT/REMARKS
CONV	4-12-17	11:30 AM	✓		W	3.8	11	1		5V		1	2P 1G	ICUBE		2	6	5	7	4	3	CONVENTIONAL REPRESENTATIVE
MARC	4-12-17	11:30 AM	✓		W	↓	11	1		5V		1	2P 1G	ICUBE		2	6	5	7	4	4	MARCELLUS REPRESENTATIVE
ORSK	4-12-17	11:30 AM	✓		W	↓	11	1		5V		1	2P 1G	ICUBE		2	6	5	7	4	5	ORISKANY REPRESENTATIVE

SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR HOLDING TIMES
SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR CHEMICAL PRESERVATIVES
SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR SAMPLE CONTAINERS
SAMPLES ARE ____ ARE NOT ____ FOR REGULATORY COMPLIANCE PURPOSES

*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT: ADAM WILSON	DATE: 4-12-17	PRINT: C. Hach
SIGN:	TIME: 1:55 PM	SIGN:
*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT:	DATE:	PRINT:
SIGN:	TIME:	SIGN:
*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT:	DATE:	PRINT:
SIGN:	TIME:	SIGN:
COURIER:	*DATE/TIME	*RECEIVED BY:
TRACKING #:	DATE:	PRINT:
	TIME:	SIGN:

REMARKS:

PWS# ____

Results by Monday

WEATHER/TEMPERATURE:

☑ **RUSH STATUS** (INITIAL ACCEPTANCE ADW)

*** ADDITIONAL LABORATORY FEES MAY APPLY***

EXTENT OF LIABILITY

SHOULD RELIANCE LABORATORIES, INC. BE AT FAULT AND ANY DISPUTE ARISE REGARDING ANALYTICAL DATA GENERATED BY THE LABORATORY, THE EXTENT OF THE LIABILITY TO RELIANCE WILL BE A DUPLICATE ANALYSIS OF THAT SAMPLE (PROVIDING ADEQUATE SAMPLE REMAINS) OR A REFUND OF THE ANALYTICAL FEE. IN NO EVENT WILL RELIANCE LABORATORIES BE LIABLE FOR DAMAGES INCLUDING BUT NOT LIMITED TO DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES ARISING FROM SUCH DISPUTE.

NOTE: TYPICAL SAMPLE TURN AROUND FOR ROUTINE SAMPLES IS 5 TO 10 WORKING DAYS. THIS IN NOT A GUARANTEE THAT SAMPLES WILL BE COMPLETED IN THIS TIME FRAME, HOWEVER. NON-ROUTINE SAMPLES MAY REQUIRE ADDITIONAL TIME.

*** TO BE COMPLETED BY CLIENT ***

ORIGINAL CHAIN OF CUSTODY DOCUMENT MUST BE EXECUTED IN INK

WHITE - LABORATORY YELLOW - CLIENT

From: Adam Wilson [mailto:awilson@slssurveys.com]
Sent: March 16, 2017 7:52 AM
To: Tenley Miller <tmiller@wvdsl.net>
Subject: Bottle Requirements

Tenley,

We are going to be taking a few representative samples of some brine water and the DEP wants them analyzed for the specifics listed below, how much fluid would we need in order to fill all the bottles or if you gave me the sizes of all the bottles needed I can add it up.

Total Petroleum Hydrocarbons (DRO, GRO, ORO), BTEX, pH, Aluminum, Arsenic, Barium, Calcium, Chloride, Iron, Manganese, Sodium, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Organic Carbon (TOC), Sulfate, Detergents (MBAS), Dissolved Methane, Dissolved Ethane, Dissolved Butane, Dissolved Propane, Bacteria (total coliform), Radiation (NORM), and specific gravity.

Total Petroleum Hydrocarbons (GRO, DRO, ORO), BTEX, pH, Aluminum, Arsenic, Barium, Calcium, Chloride, Detergents (MBAS), Iron, Manganese, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Organic Carbon (TOC), Sulfate, Dissolved Methane, Dissolved Ethane, Dissolved Butane, Dissolved Propane, and Bacteria (total coliform).

Thanks,

Adam Wilson
Environmental Services Manager
Office – (304)462-5634
Fax- (304)462-5656
E-mail – awilson@slssurveys.com

SLS
Land & Energy Development
Solutions from the ground up.
P.O. Box 150 • 12 Vanhorn Drive • Glenville, WV 26351 • (304) 462-5634
www.slssurveys.com

Check us out on Facebook.

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

SMITH LAND SURVEYING, INC.
P.O. BOX 150

GLENVILLE, WV 26351-

Lab Number: 265744-2017-W **Sample ID:** MARCELLUS REPRESENTATIVE MARC

Parameter	Value	Units	Method	Date/Time Analyzed	Analyst	MDL	MRL
Analyte Group: Inorganics							
Total Organic Carbon	ND	mg/l	SM5310C-00	4/17/2017 9:50	TH	0.1	0.5
Total Suspended Solids	6370	mg/l	SM2540D-97	4/13/2017 12:25	AAB	4	5
Specific Gravity	1.19	g/cc	ASTM D1429-08	4/18/2017 11:00	TM		
E.coli(MPN)**	< 1	Index/100ml	SM9223B-97	4/12/2017 16:22	CP		
pH	# 5.44	S.U.	SM4500H+B-00	4/13/2017 15:12	AAB		
Total Aluminum	1.47	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.009	0.05
Total Arsenic	24.5	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.007	0.05
Total Barium	707	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.003	0.05
Total Calcium	20270	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.078	0.5
Total Chloride	476956	mg/l	EPA 300.0 R2.1	4/18/2017 11:41	TM	0.15	0.5
Total Coliform(MPN)**	< 1	Index/100ml	SM9223B-97	4/12/2017 16:22	CP		
Total Dissolved Solids	298340	mg/l	SM2540C-97	4/13/2017 12:25	AAB	10	20
Total Iron	138	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.004	0.05
Total Manganese	1.91	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.007	0.05
Total Sodium	74370	mg/l	EPA 200.7 R4.4	4/14/2017 13:06	TH	0.011	0.5
Total Sulfate	298	mg/l	EPA 300.0 R2.1	4/18/2017 11:41	TM	0.12	0.5
Total Surfactant	0.58	mg/l	SM5540C-00	4/14/2017 10:38	JL	0.05	0.2

Remarks:

Date Sample Collected: 4/12/2017 11:30
Sample Submitted By: A.WILSON
Date Sample Received: 4/12/2017 13:55
Sample temp. upon receipt: 3.8 Deg C

ND = Not Detected at the MDL or MRL
MDL - Minimum Detectable Limit
MRL - Minimum Reporting Limit
MCL - Maximum Contaminant Level, USEPA Regulated
J = Reported value is an estimate because concentration is less than the MRL

*Method Code: STANDARD METHODS ONLINE ED; US EPA METHODS FOR THE CHEMICAL ANALYSIS OF WATER AND WASTES, Rev. 83; US EPA METHODS FOR THE DETERMINATION OF METALS IN ENVIRONMENTAL SAMPLES, May 1994; TEST METHODS FOR EVALUATING SOLID WASTE, SW-846, 3rd ED; USEPA Manual for Certification of Laboratories Analyzing Drinking Water, 5th ED. In accordance with EPA Regulations, all reports, including raw data and quality control data, are maintained by the laboratory for a minimum of 5 years.

NOTE: #Holding time exceeded for this analysis. This falls outside criteria set by 40CFR136.

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

SMITH LAND SURVEYING, INC.
P.O. BOX 150

GLENVILLE, WV 26351-

Lab Number: 265744-2017-W **Sample ID:** MARCELLUS REPRESENTATIVE MARC

Parameter	Value	Units	Method	Date/Time Analyzed	Analyst	MDL	MRL
Analyte Group: Total Petroleum Hydrocarbons							
Benzene	ND	mg/l	SW8021B/5030B	4/18/2017 14:20	TM	0.0007	0.01
Ethylbenzene	ND	mg/l	SW8021B/5030B	4/18/2017 14:20	TM	0.0014	0.01
MTBE	ND	mg/l	SW8021B/5030B	4/18/2017 14:20	TM	0.003	0.005
Toluene	ND	mg/l	SW8021B/5030B	4/18/2017 14:20	TM	0.002	0.01
TPH - DRO	3.58	mg/l	SW8015B/3535A	4/18/2017 12:29	TM	0.68	1
TPH - GRO	ND	mg/l	SW8015B/5030B	4/18/2017 14:20	TM	0.04	0.5
Xylene	ND	mg/l	SW8021B/5030B	4/18/2017 14:20	TM	0.003	0.01
4-Bromochlorobenzene (Surrogate	118	%	SW8021B/8015B	4/18/2017 14:20	TM		
o-Terphenyl (Surrogate)	79.7	%	SW8015B	4/18/2017 12:29	TM		
TPH - ORO	1.42	mg/l	SW8015B/3535A	4/18/2017 12:29	TM	0.54	1
o-Terphenyl (Surrogate)	79.7	%	SW8015B	4/18/2017 12:29	TM		

Remarks:

Date Sample Collected: 4/12/2017 11:30
Sample Submitted By: A.WILSON
Date Sample Received: 4/12/2017 13:55
Sample temp. upon receipt: 3.8 Deg C

ND = Not Detected at the MDL or MRL
MDL - Minimum Detectable Limit
MRL - Minimum Reporting Limit
MCL - Maximum Contaminant Level, USEPA Regulated
J = Reported value is an estimate because concentration is less than the MRL

*Method Code: STANDARD METHODS ONLINE ED; US EPA METHODS FOR THE CHEMICAL ANALYSIS OF WATER AND WASTES, Rev. 83; US EPA METHODS FOR THE DETERMINATION OF METALS IN ENVIRONMENTAL SAMPLES, May 1994; TEST METHODS FOR EVALUATING SOLID WASTE, SW-846, 3rd ED; USEPA Manual for Certification of Laboratories Analyzing Drinking Water, 5th ED. In accordance with EPA Regulations, all reports, including raw data and quality control data, are maintained by the laboratory for a minimum of 5 years.

NOTE: #Holding time exceeded for this analysis. This falls outside criteria set by 40CFR136.

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

SMITH LAND SURVEYING, INC.
P.O. BOX 150

GLENVILLE, WV 26351-

Lab Number: 265745-2017-W **Sample ID:** ORISKANY REPRESENTATIVE ORSK

Parameter	Value	Units	Method	Date/Time Analyzed	Analyst	MDL	MRL
Analyte Group: Inorganics							
Total Organic Carbon	39.8	mg/l	SM5310C-00	4/17/2017 9:50	TH	0.1	0.5
Total Suspended Solids	3840	mg/l	SM2540D-97	4/13/2017 12:25	AAB	4	5
Specific Gravity	1.14	g/cc	ASTM D1429-08	4/18/2017 11:00	TM		
E.coli(MPN)**	< 1	Index/100ml	SM9223B-97	4/12/2017 16:22	CP		
pH	# 5.79	S.U.	SM4500H+B-00	4/13/2017 15:12	AAB		
Total Aluminum	0.43	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.009	0.05
Total Arsenic	ND	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.007	0.05
Total Barium	2762	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.003	0.05
Total Calcium	15210	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.078	0.5
Total Chloride	382047	mg/l	EPA 300.0 R2.1	4/18/2017 11:54	TM	0.15	0.5
Total Coliform(MPN)**	< 1	Index/100ml	SM9223B-97	4/12/2017 16:22	CP		
Total Dissolved Solids	219310	mg/l	SM2540C-97	4/13/2017 12:25	AAB	10	20
Total Iron	98.1	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.004	0.05
Total Manganese	3.33	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.007	0.05
Total Sodium	67480	mg/l	EPA 200.7 R4.4	4/14/2017 13:09	TH	0.011	0.5
Total Sulfate	282	mg/l	EPA 300.0 R2.1	4/18/2017 11:54	TM	0.12	0.5
Total Surfactant	1.44	mg/l	SM5540C-00	4/14/2017 10:38	JL	0.05	0.2

Remarks:

Date Sample Collected: 4/12/2017 11:30
Sample Submitted By: A.WILSON
Date Sample Received: 4/12/2017 13:55
Sample temp. upon receipt: 3.8 Deg C

ND = Not Detected at the MDL or MRL
MDL - Minimum Detectable Limit
MRL - Minimum Reporting Limit
MCL - Maximum Contaminant Level, USEPA Regulated
J = Reported value is an estimate because concentration is less than the MRL

*Method Code: STANDARD METHODS ONLINE ED; US EPA METHODS FOR THE CHEMICAL ANALYSIS OF WATER AND WASTES, Rev. 83; US EPA METHODS FOR THE DETERMINATION OF METALS IN ENVIRONMENTAL SAMPLES, May 1994; TEST METHODS FOR EVALUATING SOLID WASTE, SW-846, 3rd ED; USEPA Manual for Certification of Laboratories Analyzing Drinking Water, 5th ED. In accordance with EPA Regulations, all reports, including raw data and quality control data, are maintained by the laboratory for a minimum of 5 years.

NOTE: #Holding time exceeded for this analysis. This falls outside criteria set by 40CFR136.

Reliance Laboratories, Inc.
2044 Meadowbrook Road | P.O. Box 4657
Bridgeport, WV 26330
Phone: 304.842.5285 | Fax: 304.842.5351

Martinsburg Laboratory
Ridgefield Business Center | 25 Crimson Circle
Martinsburg, WV 25403
Phone: 304.596.2084 | Fax: 304.596.2086

Certifications: WV Department of Health #: 00354, 00443 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

SMITH LAND SURVEYING, INC.
P.O. BOX 150

GLENVILLE, WV 26351-

Lab Number: 265745-2017-W **Sample ID:** ORISKANY REPRESENTATIVE ORSK

Parameter	Value	Units	Method	Date/Time Analyzed	Analyst	MDL	MRL
Analyte Group: Total Petroleum Hydrocarbons							
Benzene	ND	mg/l	SW8021B/5030B	4/18/2017 15:17	TM	0.0007	0.01
Ethylbenzene	ND	mg/l	SW8021B/5030B	4/18/2017 15:17	TM	0.0014	0.01
MTBE	ND	mg/l	SW8021B/5030B	4/18/2017 15:17	TM	0.003	0.005
Toluene	ND	mg/l	SW8021B/5030B	4/18/2017 15:17	TM	0.002	0.01
TPH - DRO	ND	mg/l	SW8015B/3535A	4/18/2017 14:16	TM	0.68	1
TPH - GRO	ND	mg/l	SW8015B/5030B	4/18/2017 15:17	TM	0.04	0.5
Xylene	ND	mg/l	SW8021B/5030B	4/18/2017 15:17	TM	0.003	0.01
4-Bromochlorobenzene (Surrogate	109	%	SW8021B/8015B	4/18/2017 15:17	TM		
o-Terphenyl (Surrogate)	79.6	%	SW8015B	4/18/2017 14:16	TM		
TPH - ORO	ND	mg/l	SW8015B/3535A	4/18/2017 14:16	TM	0.54	1
o-Terphenyl (Surrogate)	79.6	%	SW8015B	4/18/2017 14:16	TM		

Remarks:

Date Sample Collected: 4/12/2017 11:30
Sample Submitted By: A.WILSON
Date Sample Received: 4/12/2017 13:55
Sample temp. upon receipt: 3.8 Deg C
MDL - Minimum Detectable Limit
MCL - Maximum Contaminant Level, USEPA Regulated

ND = Not Detected at the MDL or MRL
MRL - Minimum Reporting Limit
J = Reported value is an estimate because concentration is less than the MRL

*Method Code: STANDARD METHODS ONLINE ED; US EPA METHODS FOR THE CHEMICAL ANALYSIS OF WATER AND WASTES, Rev. 83; US EPA METHODS FOR THE DETERMINATION OF METALS IN ENVIRONMENTAL SAMPLES, May 1994; TEST METHODS FOR EVALUATING SOLID WASTE, SW-846, 3rd ED; USEPA Manual for Certification of Laboratories Analyzing Drinking Water, 5th ED. In accordance with EPA Regulations, all reports, including raw data and quality control data, are maintained by the laboratory for a minimum of 5 years.

NOTE: #Holding time exceeded for this analysis. This falls outside criteria set by 40CFR136.

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

ANALYTICAL REPORT

TestAmerica Laboratories, Inc.
TestAmerica Nashville
2960 Foster Creighton Drive
Nashville, TN 37204
Tel: (615)726-0177

TestAmerica Job ID: 490-126242-1
Client Project/Site: RSK / 265743, 265744, 265745

For:
Reliance Laboratories Inc
PO BOX 4657
Bridgeport, West Virginia 26330

Attn: Tenley Miller

Jennifer Gambill

Authorized for release by:
4/18/2017 4:22:20 PM

Jennifer Gambill, Project Manager I
(615)301-5044
jennifer.gambill@testamericainc.com

Table of Contents

Sample Summary

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
490-126242-1	265743-2017-W	Water	04/12/17 11:30	04/13/17 09:45
490-126242-2	265744-2017-W	Water	04/12/17 11:30	04/13/17 09:45
490-126242-3	265745-2017-W	Water	04/12/17 11:30	04/13/17 09:45

Job ID: 490-126242-1

Laboratory: TestAmerica Nashville

Narrative

Job Narrative
490-126242-1

Comments
No additional comments.

Receipt
The samples were received on 4/13/2017 9:45 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperature of the cooler at receipt was 4.3° C.

GC Semi VOA
Method(s) RSK-175: Surrogate recovery for the following samples were outside the upper control limit: 265743-2017-W (490-126242-1) and 265744-2017-W (490-126242-2). This sample did not contain any target analytes; therefore, re-extraction and/or re-analysis was not performed.

Method(s) RSK-175: Surrogate recovery for the following sample was outside control limits: 265745-2017-W (490-126242-3). Evidence of matrix interference is present and there is insufficient volume for re-extraction; therefore, re-extraction and/or re-analysis was not performed.

Method(s) RSK-175: Insufficient sample volume was available to perform a matrix spike/matrix spike duplicate (MS/MSD) associated with analytical batch 490-422627. A laboratory control sample duplicate 9LCSD) and sample duplicate (DU) were analyzed for batch precision.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Qualifiers

GC VOA

Qualifier	Qualifier Description
X	Surrogate is outside control limits

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CNF	Contains no Free Liquid
DER	Duplicate error ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision level concentration
MDA	Minimum detectable activity
EDL	Estimated Detection Limit
MDC	Minimum detectable concentration
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
NC	Not Calculated
ND	Not detected at the reporting limit (or MDL or EDL if shown)
PQL	Practical Quantitation Limit
QC	Quality Control
RER	Relative error ratio
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Client Sample ID: 265743-2017-W
Date Collected: 04/12/17 11:30
Date Received: 04/13/17 09:45

Lab Sample ID: 490-126242-1
Matrix: Water

Method: RSK-175 - Dissolved Gases in Water

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Butane	ND		10.0	5.80	ug/L			04/17/17 11:14	1
Ethane	ND		5.00	2.70	ug/L			04/17/17 11:14	1
Methane	ND		5.00	1.70	ug/L			04/17/17 11:14	1
Propane	ND		5.00	3.30	ug/L			04/17/17 11:14	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Acetylene (Surr)	*157*	*X*	*62 - 124*		*04/17/17 11:14*	*1*

Client: Reliance Laboratories Inc
oject/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Client Sample ID: 265744-2017-W
Date Collected: 04/12/17 11:30
Date Received: 04/13/17 09:45

Lab Sample ID: 490-126242-2
Matrix: Water

Method: RSK-175 - Dissolved Gases in Water

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Butane	ND		10.0	5.80	ug/L			04/17/17 11:18	1
Ethane	ND		5.00	2.70	ug/L			04/17/17 11:18	1
Methane	ND		5.00	1.70	ug/L			04/17/17 11:18	1
Propane	ND		5.00	3.30	ug/L			04/17/17 11:18	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Acetylene (Surr)	*225*	*X*	*62 - 124*		*04/17/17 11:18*	*1*

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Client Sample ID: 265745-2017-W
Date Collected: 04/12/17 11:30
Date Received: 04/13/17 09:45

Lab Sample ID: 490-126242-3
Matrix: Water

Method: RSK-175 - Dissolved Gases in Water

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Butane	ND		10.0	5.80	ug/L			04/17/17 11:23	1
Ethane	ND		5.00	2.70	ug/L			04/17/17 11:23	1
Methane	39.5		5.00	1.70	ug/L			04/17/17 11:23	1
Propane	ND		5.00	3.30	ug/L			04/17/17 11:23	1

Surrogate	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Acetylene (Surr)	*186*	*X*	*62 - 124*		*04/17/17 11:23*	*1*

Method: RSK-175 - Dissolved Gases in Water

Lab Sample ID: MB 490-422627/7
Matrix: Water
Analysis Batch: 422627

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Butane	ND		10.0	5.80	ug/L			04/17/17 10:43	1
Ethane	ND		5.00	2.70	ug/L			04/17/17 10:43	1
Methane	ND		5.00	1.70	ug/L			04/17/17 10:43	1
Propane	ND		5.00	3.30	ug/L			04/17/17 10:43	1

Surrogate	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
Acetylene (Surr)	*91*		*62 - 124*		*04/17/17 10:43*	*1*

Lab Sample ID: LCS 490-422627/8
Matrix: Water
Analysis Batch: 422627

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Butane	1020	994.7		ug/L		98	80 - 120
Ethane	527	532.2		ug/L		101	80 - 120
Methane	287	288.8		ug/L		101	80 - 120
Propane	771	777.6		ug/L		101	80 - 120

Surrogate	*LCS %Recovery*	*LCS Qualifier*	*Limits*
Acetylene (Surr)	*97*		*62 - 124*

Lab Sample ID: LCSD 490-422627/9
Matrix: Water
Analysis Batch: 422627

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Butane	1020	998.0		ug/L		98	80 - 120	0	33
Ethane	527	530.8		ug/L		101	80 - 120	0	30
Methane	287	287.4		ug/L		100	80 - 120	1	33
Propane	771	772.8		ug/L		100	80 - 120	1	33

Surrogate	*LCSD %Recovery*	*LCSD Qualifier*	*Limits*
Acetylene (Surr)	*96*		*62 - 124*

Lab Sample ID: 490-126350-I-1 DU
Matrix: Water
Analysis Batch: 422627

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Butane	ND		ND		ug/L		NC	30
Ethane	ND		ND		ug/L		NC	30
Methane	ND		ND		ug/L		NC	30
Propane	ND		ND		ug/L		NC	30

Surrogate	*DU %Recovery*	*DU Qualifier*	*Limits*
Acetylene (Surr)	*80*		*62 - 124*

QC Association Summary

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

GC VOA

Analysis Batch: 422627

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
490-126242-1	265743-2017-W	Total/NA	Water	RSK-175	
490-126242-2	265744-2017-W	Total/NA	Water	RSK-175	
490-126242-3	265745-2017-W	Total/NA	Water	RSK-175	
MB 490-422627/7	Method Blank	Total/NA	Water	RSK-175	
LCS 490-422627/8	Lab Control Sample	Total/NA	Water	RSK-175	
LCSD 490-422627/9	Lab Control Sample Dup	Total/NA	Water	RSK-175	
490-126350-I-1 DU	Duplicate	Total/NA	Water	RSK-175	

Lab Chronicle

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Client Sample ID: 265743-2017-W
Date Collected: 04/12/17 11:30
Date Received: 04/13/17 09:45

Lab Sample ID: 490-126242-1
Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	RSK-175		1	21 mL	21 mL	422627	04/17/17 11:14	AAB	TAL NSH

Client Sample ID: 265744-2017-W
Date Collected: 04/12/17 11:30
Date Received: 04/13/17 09:45

Lab Sample ID: 490-126242-2
Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	RSK-175		1	21 mL	21 mL	422627	04/17/17 11:18	AAB	TAL NSH

Client Sample ID: 265745-2017-W
Date Collected: 04/12/17 11:30
Date Received: 04/13/17 09:45

Lab Sample ID: 490-126242-3
Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dil Factor	Initial Amount	Final Amount	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	RSK-175		1	21 mL	21 mL	422627	04/17/17 11:23	AAB	TAL NSH

Laboratory References:

TAL NSH = TestAmerica Nashville, 2960 Foster Creighton Drive, Nashville, TN 37204, TEL (615)726-0177

Method Summary

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Method	Method Description	Protocol	Laboratory
RSK-175	Dissolved Gases in Water	RSK	TAL NSH

Protocol References:

RSK = Sample Prep And Calculations For Dissolved Gas Analysis In Water Samples Using A GC Headspace Equilibration Technique, RSKSOP-175, Rev. 0, 8/11/94, USEPA Research Lab

Laboratory References:

TAL NSH = TestAmerica Nashville, 2960 Foster Creighton Drive, Nashville, TN 37204, TEL (615)726-0177

Accreditation/Certification Summary

Client: Reliance Laboratories Inc
Project/Site: RSK / 265743, 265744, 265745

TestAmerica Job ID: 490-126242-1

Laboratory: TestAmerica Nashville

The accreditations/certifications listed below are applicable to this report.

Authority	Program	EPA Region	Identification Number	Expiration Date
West Virginia DEP	State Program	3	219	02-28-18

TestAmerica
THE LEADER IN ENVIRONMENTAL TESTING

Nashville, TN

COOLER RECEIPT FORM

490-126242 Chain of Custody

Cooler Received/Opened On 4-13-17 @ 0945

Time Samples Removed From Cooler 1621 Time Samples Placed In Storage 1710 (2 Hour Window)

1. Tracking # 3756 (last 4 digits, FedEx) Courier: FedEx

IR Gun ID_31470368 pH Strip Lot NA Chlorine Strip Lot NA

2. Temperature of rep. sample or temp blank when opened: 4.3 *Degrees Celsius*

3. If Item #2 temperature is 0°C or less, was the representative sample or temp blank frozen? YES NO NA

4. Were custody seals on outside of cooler? YES NO NA

If yes, how many and where:

5. Were the seals intact, signed, and dated correctly? YES...NO...NA

6. Were custody papers inside cooler? YES...NO...NA

I certify that I opened the cooler and answered questions 1-6 (intial) DA

7. Were custody seals on containers: YES NO and intact YES...NO...NA

Were these signed and dated correctly? YES...NO...NA

8. Packing mat'l used? Bubblewrap Plastic bag Peanuts Vermiculite Foam Insert Paper Other None

9. Cooling process: Ice Ice-pack Ice (direct contact) Dry ice Other None

10. Did all containers arrive in good condition (unbroken)? YES...NO...NA

11. Were all container labels complete (#, date, signed, pres., etc)? YES...NO...NA

12. Did all container labels and tags agree with custody papers? YES...NO...NA

13a. Were VOA vials received? YES...NO...NA

b. Was there any observable headspace present in any VOA vial? YES...NO...NA 4/13/17

14. Was there a Trip Blank in this cooler? YES...NO...NA If multiple coolers, sequence #

I certify that I unloaded the cooler and answered questions 7-14 (intial) AJ

15a. On pres'd bottles, did pH test strips suggest preservation reached the correct pH level? YES..NO..NA

b. Did the bottle labels indicate that the correct preservatives were used YES...NO...NA

16. Was residual chlorine present? YES...NO...NA

I certify that I checked for chlorine and pH as per SOP and answered questions 15-16 (intial)

17. Were custody papers properly filled out (ink, signed, etc)? YES...NO...NA

18. Did you sign the custody papers in the appropriate place? YES...NO...NA

19. Were correct containers used for the analysis requested? YES...NO...NA

20. Was sufficient amount of sample sent in each container? YES...NO...NA

I certify that I entered this project into LIMS and answered questions 17-20 (intial)

I certify that I attached a label with the unique LIMS number to each container (intial)

21. Were there Non-Conformance issues at login? YES...NO Was a NCM generated? YES...NO...#

BIS = Broken in shipment
Cooler Receipt Form.doc

LF-1
End of Form

Revised 12 15 15

RELIANCE LABORATORIES, INC. - CHAIN OF CUSTODY RECORD

2044 MEADOWBROOK ROAD
POST OFFICE BOX 4657
BRIDGEPORT, WV 26330
TEL. (304) 842-5285 • FAX (304) 842-5351
E-MAIL reliancelabs@wvdsl.net
INTERNET www.RelianceLabs.net

☐ RIDGEFIELD BUSINESS CENTER
25 CRIMSON CIRCLE
MARTINSBURG, WV 25403
TEL. (304) 596-2084 • FAX (304) 596-2086

*CLIENT NAME Reliance Laboratories

*ADDRESS

CUSTOMER # *TEL. # FAX #

*SAMPLER (S) A. Wilson E-MAIL

SHEET NO. 1 OF 1

LABORATORY #	*DATE	*TIME	GRAB	GRAB	MATRIX W, DW, S, O, M	TEMP. ≤ 4°C Yes No	*# OF CONTAIN.	HN03	H2S04	HCL	NaOH	BAC-T	NO PRES.	Dissolved methane	Ethane	Butene	propane	*PROJECT/REMARKS
	4/12/17	1130			W		1			IV								2165743-2017-W
	4/12/17	1130			W		1			IV								2165744-2017-W
	4/12/17	1130			W		1			IV								2165745-2017-W

Loc: 490
126242

SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR HOLDING TIMES
SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR CHEMICAL PRESERVATIVES
SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR SAMPLE CONTAINERS
SAMPLES ARE ✓ ARE NOT ____ FOR REGULATORY COMPLIANCE PURPOSES

*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT: A. Wilson	DATE: 4/12/17	PRINT:
SIGN: A. Wilson	TIME: 1550	SIGN: FedEx
*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT:	DATE:	PRINT: 4/13/17 0945
SIGN: FedEx	TIME:	SIGN:
*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT:	DATE:	PRINT:
SIGN:	TIME:	SIGN:
*COURIER:	*DATE/TIME	*RECEIVED BY:
TRACKING #:	DATE:	PRINT:
	TIME:	SIGN:

REMARKS:

PWS# ____

3 Day rush

WEATHER/TEMPERATURE:

☒ RUSH STATUS (INITIAL ACCEPTANCE AMF)

** ADDITIONAL LABORATORY FEES MAY APPLY***

EXTENT OF LIABILITY

SHOULD RELIANCE LABORATORIES, INC. BE AT FAULT AND ANY DISPUTE ARISE REGARDING ANALYTICAL DATA GENERATED BY THE LABORATORY, THE EXTENT OF THE LIABILITY TO RELIANCE WILL BE A DUPLICATE ANALYSIS OF THAT SAMPLE (PROVIDING ADEQUATE SAMPLE REMAINS) OR A REFUND OF THE ANALYTICAL FEE. IN NO EVENT WILL RELIANCE LABORATORIES BE LIABLE FOR DAMAGES INCLUDING BUT NOT LIMITED TO DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES ARISING FROM SUCH DISPUTE.

NOTE: TYPICAL SAMPLE TURN AROUND FOR ROUTINE SAMPLES IS 5 TO 10 WORKING DAYS. THIS IS NOT A GUARANTEE THAT SAMPLES WILL BE COMPLETED IN THIS TIME FRAME, HOWEVER NON-ROUTINE SAMPLES MAY REQUIRE ADDITIONAL TIME.

TO BE COMPLETED BY CLIENT

ORIGINAL CHAIN OF CUSTODY DOCUMENT MUST BE EXECUTED IN INK

WHITE - LABORATORY YELLOW - CLIENT

4/18/2017

RELIANCE LABORATORIES, INC.

ENVIRONMENTAL ANALYSTS AND CONSULTANTS

BRIDGEPORT, WV www.RelianceLabs.net *MARTINSBURG, WV*

Certifications: WV Department of Health #: 00354, 00433 | WV Department of Environmental Protection #: 158, 181 | MD Department of Environment #: 336, 337| US Environmental Protection Agency #: WV00042, WV00901

Wednesday, April 12, 2017

Loc: 490
126242

TestAmerica - Nashville
2960 Foster Creighton Drive
Nashville, TN 37204

Please analyze the following sample(s) for: **Dissolved Methane/Ethane/Butane/Propane**

Please identify as:

265743-2017-W	DATE/TIME SAMPLED: 4/12/2017 11:30
265744-2017-W	DATE/TIME SAMPLED: 4/12/2017 11:30
265745-2017-W	DATE/TIME SAMPLED: 4/12/2017 11:30

Sampled by: A.Wilson

*****3 DAY RUSH*****

PLEASE SEND RESULTS & INVOICE TO:

RELIANCE LABORATORIES, INC.
ATTN: TENLEY MILLER
P.O. BOX 4657
BRIDGEPORT, WV 26330
tmiller@wvdsl.net

Thank You

2044 MEADOWBROOK ROAD | P.O. BOX 4657 | BRIDGEPORT, WV 26330 | VOICE: 304-842-5285 | FAX: 304-842-5351
RIDGEFIELD BUSINESS CENTER | 25 CRIMSON CIRCLE | MARTINSBURG, WV 25403 | VOICE: 304-596-2084 | FAX: 304-596-2086

Login Sample Receipt Checklist

Client: Reliance Laboratories Inc

Job Number: 490-126242-1

Login Number: 126242
List Number: 1
Creator: Vest, Laura E

List Source: TestAmerica Nashville

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	N/A	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	N/A	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

April 19, 2017

Ms. Tenley Miller
Reliance Laboratories, Inc.
2044 Meadowbrook Road
P.O. Box 4657
Bridgeport, WV 26330

RE: Project: 265743
Pace Project No.: 30216038

Dear Ms. Miller:
Enclosed are the analytical results for sample(s) received by the laboratory on April 13, 2017. The results relate only to the samples included in this report. Results reported herein conform to the most current, applicable TNI/NELAC standards and the laboratory's Quality Assurance Manual, where applicable, unless otherwise noted in the body of the report.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Robbin Robl
robbin.robl@pacelabs.com
(724)850-5613
Project Manager

Enclosures

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

CERTIFICATIONS

Project: 265743
Pace Project No.: 30216038

Pennsylvania Certification IDs

1638 Roseytown Rd Suites 2,3&4, Greensburg, PA 15601
L-A-B DOD-ELAP Accreditation #: L2417
Alabama Certification #: 41590
Arizona Certification #: AZ0734
Arkansas Certification
California Certification #: 04222CA
Colorado Certification
Connecticut Certification #: PH-0694
Delaware Certification
Florida/TNI Certification #: E87683
Georgia Certification #: C040
Guam Certification
Hawaii Certification
Idaho Certification
Illinois Certification
Indiana Certification
Iowa Certification #: 391
Kansas/TNI Certification #: E-10358
Kentucky Certification #: 90133
Louisiana DHH/TNI Certification #: LA140008
Louisiana DEQ/TNI Certification #: 4086
Maine Certification #: PA00091
Maryland Certification #: 308
Massachusetts Certification #: M-PA1457
Michigan/PADEP Certification
Missouri Certification #: 235
Montana Certification #: Cert 0082
Nebraska Certification #: NE-05-29-14
Nevada Certification #: PA014572015-1
New Hampshire/TNI Certification #: 2976
New Jersey/TNI Certification #: PA 051
New Mexico Certification #: PA01457
New York/TNI Certification #: 10888
North Carolina Certification #: 42706
North Dakota Certification #: R-190
Oregon/TNI Certification #: PA200002
Pennsylvania/TNI Certification #: 65-00282
Puerto Rico Certification #: PA01457
Rhode Island Certification #: 65-00282
South Dakota Certification
Tennessee Certification #: TN2867
Texas/TNI Certification #: T104704188-14-8
Utah/TNI Certification #: PA014572015-5
USDA Soil Permit #: P330-14-00213
Vermont Dept. of Health: ID# VT-0282
Virgin Island/PADEP Certification
Virginia/VELAP Certification #: 460198
Washington Certification #: C868
West Virginia DEP Certification #: 143
West Virginia DHHR Certification #: 9964C
Wisconsin Certification
Wyoming Certification #: 8TMS-L

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

SAMPLE SUMMARY

Project: 265743
Pace Project No.: 30216038

Lab ID	Sample ID	Matrix	Date Collected	Date Received
30216038001	265743-2017-W	Water	04/12/17 11:30	04/13/17 09:20
30216038002	265744-2017-W	Water	04/12/17 11:30	04/13/17 09:20
30216038003	265745-2017-W	Water	04/12/17 11:30	04/13/17 09:20

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

SAMPLE ANALYTE COUNT

Project: 265743
Pace Project No.: 30216038

Lab ID	Sample ID	Method	Analysts	Analytes Reported
30216038001	265743-2017-W	EPA 901.1	MAH	8
30216038002	265744-2017-W	EPA 901.1	MAH	8
30216038003	265745-2017-W	EPA 901.1	MAH	8

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

PROJECT NARRATIVE

Project: 265743
Pace Project No.: 30216038

Method: EPA 901.1
Description: 901.1 Gamma Spec
Client: Reliance Laboratories, Inc.
Date: April 19, 2017

General Information:
3 samples were analyzed for EPA 901.1. All samples were received in acceptable condition with any exceptions noted below or on the chain-of custody and/or the sample condition upon receipt form (SCUR) attached at the end of this report.

Hold Time:
The samples were analyzed within the method required hold times with any exceptions noted below.

Method Blank:
All analytes were below the report limit in the method blank, where applicable, with any exceptions noted below.

Laboratory Control Spike:
All laboratory control spike compounds were within QC limits with any exceptions noted below.

Matrix Spikes:
All percent recoveries and relative percent differences (RPDs) were within acceptance criteria with any exceptions noted below.

Additional Comments:

This data package has been reviewed for quality and completeness and is approved for release.

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: 265743
Pace Project No.: 30216038

Sample: 265743-2017-W Lab ID: 30216038001 Collected: 04/12/17 11:30 Received: 04/13/17 09:20 Matrix: Water
PWS: Site ID: Sample Type:

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Bismuth-212	EPA 901.1	327.610 ± 132.230 (123.400) C:NA T:NA	pCi/L	04/17/17 15:26	14913-49-6	
Bismuth-214	EPA 901.1	700.010 ± 82.638 (23.440) C:NA T:NA	pCi/L	04/17/17 15:26	14733-03-0	
Lead-212	EPA 901.1	68.421 ± 15.874 (20.090) C:NA T:NA	pCi/L	04/17/17 15:26	15092-94-1	
Lead-214	EPA 901.1	663.130 ± 79.557 (25.140) C:NA T:NA	pCi/L	04/17/17 15:26	15067-28-4	
Potassium-40	EPA 901.1	799.020 ± 145.850 (87.120) C:NA T:NA	pCi/L	04/17/17 15:26	13966-00-2	
Radium-226	EPA 901.1	1707.900 ± 365.970 (317.300) C:NA T:NA	pCi/L	04/17/17 15:26	13982-63-3	
Radium-228	EPA 901.1	949.540 ± 112.330 (38.070) C:NA T:NA	pCi/L	04/17/17 15:26	15262-20-1	
Thallium-208	EPA 901.1	34.798 ± 11.241 (9.934) C:NA T:NA	pCi/L	04/17/17 15:26	14913-50-9	

Sample: 265744-2017-W Lab ID: 30216038002 Collected: 04/12/17 11:30 Received: 04/13/17 09:20 Matrix: Water
PWS: Site ID: Sample Type:

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Bismuth-212	EPA 901.1	175.570 ± 263.500 (286.400) C:NA T:NA	pCi/L	04/17/17 15:27	14913-49-6	
Bismuth-214	EPA 901.1	1131.200 ± 136.550 (40.350) C:NA T:NA	pCi/L	04/17/17 15:27	14733-03-0	
Lead-212	EPA 901.1	33.941 ± 22.117 (34.830) C:NA T:NA	pCi/L	04/17/17 15:27	15092-94-1	
Lead-214	EPA 901.1	999.290 ± 123.980 (42.150) C:NA T:NA	pCi/L	04/17/17 15:27	15067-28-4	
Potassium-40	EPA 901.1	2450.300 ± 367.940 (146.900) C:NA T:NA	pCi/L	04/17/17 15:27	13966-00-2	
Radium-226	EPA 901.1	3655.400 ± 668.800 (496.800) C:NA T:NA	pCi/L	04/17/17 15:27	13982-63-3	
Radium-228	EPA 901.1	1592.900 ± 189.230 (74.450) C:NA T:NA	pCi/L	04/17/17 15:27	15262-20-1	
Thallium-208	EPA 901.1	15.320 ± 20.399 (22.260) C:NA T:NA	pCi/L	04/17/17 15:27	14913-50-9	

Sample: 265745-2017-W Lab ID: 30216038003 Collected: 04/12/17 11:30 Received: 04/13/17 09:20 Matrix: Water
PWS: Site ID: Sample Type:

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Bismuth-212	EPA 901.1	403.510 ± 194.930 (188.800) C:NA T:NA	pCi/L	04/18/17 11:27	14913-49-6	
Bismuth-214	EPA 901.1	1907.300 ± 209.730 (34.160) C:NA T:NA	pCi/L	04/18/17 11:27	14733-03-0	
Lead-212	EPA 901.1	131.490 ± 24.734 (29.610) C:NA T:NA	pCi/L	04/18/17 11:27	15092-94-1	

REPORT OF LABORATORY ANALYSIS

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

ANALYTICAL RESULTS - RADIOCHEMISTRY

Project: 265743
Pace Project No.: 30216038

Sample: 265745-2017-W **Lab ID: 30216038003** Collected: 04/12/17 11:30 Received: 04/13/17 09:20 Matrix: Water
PWS: Site ID: Sample Type:

Parameters	Method	Act ± Unc (MDC) Carr Trac	Units	Analyzed	CAS No.	Qual
Lead-214	EPA 901.1	**1704.900 ± 189.800 (37.460) C:NA T:NA**	pCi/L	04/18/17 11:27	15067-28-4	
Potassium-40	EPA 901.1	**1318.000 ± 209.980 (113.900) C:NA T:NA**	pCi/L	04/18/17 11:27	13966-00-2	
Radium-226	EPA 901.1	**7002.700 ± 867.150 (423.200) C:NA T:NA**	pCi/L	04/18/17 11:27	13982-63-3	
Radium-228	EPA 901.1	**2456.700 ± 276.420 (54.680) C:NA T:NA**	pCi/L	04/18/17 11:27	15262-20-1	
Thallium-208	EPA 901.1	**31.429 ± 14.206 (14.640) C:NA T:NA**	pCi/L	04/18/17 11:27	14913-50-9	

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

QUALITY CONTROL - RADIOCHEMISTRY

Project: 265743
Pace Project No.: 30216038

QC Batch: 255497 Analysis Method: EPA 901.1
QC Batch Method: EPA 901.1 Analysis Description: 901.1 Gamma Spec
Associated Lab Samples: 30216038001, 30216038002, 30216038003

METHOD BLANK: 1258651 Matrix: Water
Associated Lab Samples: 30216038001, 30216038002, 30216038003

Parameter	Act ± Unc (MDC) Carr Trac	Units	Analyzed	Qualifiers
Bismuth-212	0.000 ± 15.492 (71.680) C:NA T:NA	pCi/L	04/17/17 12:10	
Bismuth-214	6.097 ± 5.947 (12.140) C:NA T:NA	pCi/L	04/17/17 12:10	
Lead-212	2.314 ± 7.344 (8.978) C:NA T:NA	pCi/L	04/17/17 12:10	
Lead-214	0.000 ± 4.170 (10.510) C:NA T:NA	pCi/L	04/17/17 12:10	
Potassium-40	10.855 ± 44.170 (54.910) C:NA T:NA	pCi/L	04/17/17 12:10	
Radium-226	0.000 ± 63.151 (129.200) C:NA T:NA	pCi/L	04/17/17 12:10	
Radium-228	0.000 ± 3.671 (23.390) C:NA T:NA	pCi/L	04/17/17 12:10	
Thallium-208	1.081 ± 3.881 (4.683) C:NA T:NA	pCi/L	04/17/17 12:10	

Results presented on this page are in the units indicated by the "Units" column except where an alternate unit is presented to the right of the result.

Pace Analytical Services, LLC
1638 Roseytown Road - Suites 2,3,4
Greensburg, PA 15601
(724)850-5600

QUALIFIERS

Project: 265743
Pace Project No.: 30216038

DEFINITIONS

DF - Dilution Factor, if reported, represents the factor applied to the reported data due to dilution of the sample aliquot.

ND - Not Detected at or above adjusted reporting limit.

J - Estimated concentration above the adjusted method detection limit and below the adjusted reporting limit.

MDL - Adjusted Method Detection Limit.

PQL - Practical Quantitation Limit.

RL - Reporting Limit.

S - Surrogate

1,2-Diphenylhydrazine decomposes to and cannot be separated from Azobenzene using Method 8270. The result for each analyte is a combined concentration.

Consistent with EPA guidelines, unrounded data are displayed and have been used to calculate % recovery and RPD values.

LCS(D) - Laboratory Control Sample (Duplicate)

MS(D) - Matrix Spike (Duplicate)

DUP - Sample Duplicate

RPD - Relative Percent Difference

NC - Not Calculable.

SG - Silica Gel - Clean-Up

U - Indicates the compound was analyzed for, but not detected.

N-Nitrosodiphenylamine decomposes and cannot be separated from Diphenylamine using Method 8270. The result reported for each analyte is a combined concentration.

Act - Activity

Unc - Uncertainty: SDWA = 1.96 sigma count uncertainty, all other matrices = Expanded Uncertainty (95% confidence interval). Gamma Spec = Expanded Uncertainty (95.4% Confidence Interval)

(MDC) - Minimum Detectable Concentration

Trac - Tracer Recovery (%)

Carr - Carrier Recovery (%)

Pace Analytical is TNI accredited. Contact your Pace PM for the current list of accredited analytes.

TNI - The NELAC Institute.

RELIANCE LABORATORIES, INC.

2044 MEADOWBROOK ROAD
POST OFFICE BOX 4657
BRIDGEPORT, WV 26330
TEL. (304) 842-5285 • FAX (304) 842-5351
E-MAIL reliancelabs@wvdsl.net
INTERNET www.RelianceLabs.net

CHAIN OF CUSTODY RECORD

☐ RIDGEFIELD BUSINESS CENTER
25 CRIMSON CIRCLE
MARTINSBURG, WV 25403
TEL. (304) 596-2084 • FAX (304) 596-2086

30216038

*CLIENT NAME Reliance Laboratories

*ADDRESS

CUSTOMER # *TEL.# FAX#

*SAMPLER (S) A Wilson E-MAIL

SHEET NO. 1 OF 1

LABORATORY #	*DATE	*TIME	COMP	GRAB	MATRIX W, DW, S, O, M	TEMP. ≤ 4°C Yes No	*# OF CONTAIN.	HN03	H2S04	HCL	NaOH	BAC-T	NO PRES.	NORM	*PROJECT/REMARKS
	4/12/17	11:30			W		1	Cope						X	2165743-2017-LW
	4/12/17	11:30			W		1	Cope						X	2165744-2017-LW
	4/12/17	11:30			W		1	Cope						X	2165745-2017-LW

WO#:30216038

SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR HOLDING TIMES
SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR CHEMICAL PRESERVATIVES
SAMPLES DO ✓ DO NOT ____ MEET USEPA GUIDELINES FOR SAMPLE CONTAINERS
SAMPLES ARE ____ ARE NOT ____ FOR REGULATORY COMPLIANCE PURPOSES

*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT: C. Grant	DATE: 4/12/2017	PRINT: FedEx
SIGN:	TIME: 15:55	SIGN:
*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT: FedEx	DATE:	PRINT: Shipmate Michener
SIGN:	TIME:	SIGN: Peter 4/13/17
*RELINQUISHED BY:	*DATE/TIME	*RECEIVED BY:
PRINT:	DATE:	PRINT:
SIGN:	TIME:	SIGN: 4/13/17 1021 CDP
*COURIER:	*DATE/TIME	*RECEIVED BY:
TRACKING #:	DATE:	PRINT:
	TIME:	SIGN:

REMARKS:

PWS#

WEATHER/TEMPERATURE:

☐ RUSH STATUS (INITIAL ACCEPTANCE EG) 3 Day

*** ADDITIONAL LABORATORY FEES MAY APPLY ***

EXTENT OF LIABILITY

SHOULD RELIANCE LABORATORIES, INC. BE AT FAULT AND ANY DISPUTE ARISE REGARDING ANALYTICAL DATA GENERATED BY THE LABORATORY, THE EXTENT OF THE LIABILITY TO RELIANCE WILL BE A DUPLICATE ANALYSIS OF THAT SAMPLE (PROVIDING ADEQUATE SAMPLE REMAINS) OR A REFUND OF THE ANALYTICAL FEE. IN NO EVENT WILL RELIANCE LABORATORIES BE LIABLE FOR DAMAGES INCLUDING BUT NOT LIMITED TO DIRECT, INDIRECT OR CONSEQUENTIAL DAMAGES ARISING FROM SUCH DISPUTE.

NOTE: TYPICAL SAMPLE TURN AROUND FOR ROUTINE SAMPLES IS 5 TO 10 WORKING DAYS. THIS IN NOT A GUARANTEE THAT SAMPLES WILL BE COMPLETED IN THIS TIME FRAME, HOWEVER. NON-ROUTINE SAMPLES MAY REQUIRE ADDITIONAL TIME.

TO BE COMPLETED BY CLIENT

ORIGINAL CHAIN OF CUSTODY DOCUMENT MUST BE EXECUTED IN INK

WHITE - LABORATORY YELLOW - CLIENT

RELIANCE LABORATORIES, INC.

30216038

ENVIRONMENTAL ANALYSTS AND CONSULTANTS

BRIDGEPORT, WV www.RelianceLabs.net *MARTINSBURG, WV*

Certifications: WV Department of Health #: 00354, 00433 | WV Department of Environmental Protection #: 158, 181
MD Department of Environment #: 336, 337 | US Environmental Protection Agency #: WV00042, WV00901

Wednesday, April 12, 2017

Pace Analytical Services
1638 Roseytown Road
Suites 2,3,4
Greensburg, PA 15601

Please analyze the following sample for: **NORM**

Please identify as:

265743-2017-W	Date/Time Sampled: 4/12/2017 11:30
265744-2017-W	Date/Time Sampled: 4/12/2017 11:30
265745-2017-W	Date/Time Sampled: 4/12/2017 11:30

Sampled by: A.Wilson

*****3 DAY RUSH*****

PLEASE SEND RESULTS & INVOICE TO:

RELIANCE LABORATORIES, INC.
ATTN: TENLEY MILLER
P.O. BOX 4657
BRIDGEPORT, WV 26330
tmiller@wvdsl.net

Thank You

RTB

Sample Condition Upon Receipt Pittsburgh

Pace Analytical

Client Name: Reliance Project # 30216038

Courier: ☑ Fed Ex ☐ UPS ☐ USPS ☐ Client ☐ Commercial ☐ Pace Other _____

Tracking #: 778889239405

Custody Seal on Cooler/Box Present: ☐ yes ☑ no Seals intact: ☐ yes ☐ no

Thermometer Used N/A Type of Ice: Wet Blue (None)

Cooler Temperature Observed Temp ___ °C Correction Factor: ___ °C Final Temp: ___ °C

Temp should be above freezing to 6°C

Date and initials of person examining contents: ARM 4/13/17

Comments:	Yes	No	N/A	
Chain of Custody Present:	✓			1.
Chain of Custody Filled Out:	✓			2.
Chain of Custody Relinquished:	✓			3.
Sampler Name & Signature on COC:		✓		4.
Sample Labels match COC:	✓			5.
-Includes date/time/ID Matrix: WT				
Samples Arrived within Hold Time:	✓			6.
Short Hold Time Analysis (<72hr remaining):		✓		7.
Rush Turn Around Time Requested:	✓			8.
Sufficient Volume:	✓			9.
Correct Containers Used:	✓			10.
-Pace Containers Used:		✓		
Containers Intact:	✓			11.
Orthophosphate field filtered			✓	12.
Organic Samples checked for dechlorination:			✓	13.
Filtered volume received for Dissolved tests			✓	14.
All containers have been checked for preservation.	✓			15.
All containers needing preservation are found to be in compliance with EPA recommendation.	✓			pH<2
exceptions: VOA, coliform, TOC, O&G, Phenolics				Initial when completed: ARM Date/time of preservation
				Lot # of added preservative
Headspace in VOA Vials (>6mm):			✓	16.
Trip Blank Present:			✓	17.
Trip Blank Custody Seals Present			✓	
Rad Aqueous Samples Screened > 0.5 mrem/hr			✓	Initial when completed: ARM Date: 4/13/17

Client Notification/ Resolution:

Person Contacted: _____ Date/Time: _____ Contacted By: _____

Comments/ Resolution: _____

☐ A check in this box indicates that additional information has been stored in ereports.

Note: Whenever there is a discrepancy affecting North Carolina compliance samples, a copy of this form will be sent to the North Carolina DEHNR Certification Office (i.e. out of hold, incorrect preservative, out of temp, incorrect containers)

*PM review is documented electronically in LIMS. When the Project Manager closes the SRF Review schedule in LIMS. The review is in the Status section of the Workorder Edit Screen.

CLEARWATER
Engineered Chemistry

Material Safety Data Sheet
ALPHA 3207

HEALTH	2
FLAMMABILITY	4
REACTIVITY	0
PERSONAL PROTECTION	G

24 hr. Emergency Contact (CHEMTREC) US Tel: 1-800-424-9300 - Int'l. Tel. 703-527-3887

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

SUPPLIER: CLEARWATER INTERNATIONAL L.L.C.
515 POST OAK BLVD., SUITE 600
HOUSTON, TX 77027

MANUFACTURER: CLEARWATER INTERNATIONAL L.L.C.
4420 SOUTH FLORES RD
ELMENDORF, TEXAS 78112

PRODUCT NAME: ALPHA 3207
PRODUCT CODE: XFP0477B
PRODUCT USE/CLASS: CORROSION INHIBITOR

MSDS REVISION DATE: 06/15/04 PREPARER: MJW PHONE: 724-318-1050

2. COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT	EXPOSURE LIMITS	CAS#	% BY WEIGHT
ISOPROPANOL	ACGIH TLV – 400 ppm TWA , 500 ppm STEL OSHA PEL – 400 ppm TWA,	67-63-0	10-30 %

3. HAZARD IDENTIFICATION

EYE: Liquid, aerosols and vapors of this product may be irritating and can cause pain, tearing, reddening and swelling accompanied by a stinging sensation and/or a feeling like that of fine dust in the eyes.

SKIN: May cause skin irritation. Allergic reactions are possible.

INGESTION: This material may be harmful if swallowed. May be irritating to mouth, throat, and stomach.

INHALATION: Prolonged inhalation may be harmful and can cause headaches, dizziness, nausea, anesthesia, narcosis, decreased blood pressure, changes in heart rate and cyanosis. May be irritating to mucous membranes and lung tissue.

CHRONIC INFORMATION: None Known

PRIMARY ROUTE(S) OF ENTRY: Inhalation, Ingestion

4. FIRST AID MEASURES

EYE CONTACT: Immediately flush eyes with plenty of water for at least 15 minutes while holding eyelids open. Get medical attention, if irritation persists.

SKIN CONTACT: Wash with soap and water. Get medical attention if irritation develops or persist.

INHALATION: Remove victim to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get immediate medical attention.

INGESTION: Place victim on left side with head down to prevent aspiration into lungs. Induce vomiting as directed by medical personnel. Never give anything by mouth to an unconscious person. Call a physician or poison control center immediately.

5. FIRE FIGHTING MEASURES

FLASH POINT: 70 F
(TAGLIABUE CLOSED CUP)

LOWER EXPLOSIVE LIMIT: N.D.
UPPER EXPLOSIVE LIMIT: N.D.

AUTOIGNITION TEMPERATURE: N.D.

EXTINGUISHING MEDIA: ALCOHOL FOAM CO2 DRY CHEMICAL

UNUSUAL FIRE AND EXPLOSION HAZARDS: Can release vapors that form explosive mixtures at temperatures at or above the flash point. Empty containers retain product residue (liquid and/or vapor) and can be dangerous.

SPECIAL FIRE FIGHTING PROCEDURES: Containers can build up pressure if exposed to heat (fire). As in any fire, wear a self-contained breathing apparatus pressure-demand (MSHA/NIOSH approved or equivalent) and full protective gear. Apply alcohol-type foam or all purpose foam by manufacturers recommended techniques for large fires. Use carbon dioxide or dry chemical for small fires. Use water spray to keep containers cool.

6. ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Extinguish any possible ignition source until the area is determined to be free from fire or explosion hazard. Absorb spill with inert material (e.g. dry sand or earth), then place in a chemical waste container. (See exposure controls / personal protection section) Spilled material should be disposed of according to applicable regulations.

7. HANDLING AND STORAGE

HANDLING: Handle all chemicals with care. Ground and bond containers when transferring materials.

STORAGE: Keep away from heat, sparks, and flames. Keep container closed when not in use. Store in a cool, dry, well ventilated place away from incompatible materials.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

ENGINEERING CONTROLS: Local exhaust ventilation may be necessary to control any air contaminants to within their exposure limits.

RESPIRATORY PROTECTION: No protection needed under normal use and conditions. Use a NIOSH/MSHA approved air purifying respirator with an organic vapor cartridge when airborne concentrations are expected to exceed exposure limits. Protection by air purifying respirators is limited.

SKIN PROTECTION: When contact is likely wear chemical resistant gloves and boots.

EYE PROTECTION: Wear safety glasses with side shields or goggles.

OTHER PROTECTIVE EQUIPMENT: Emergency eye wash stations and deluge showers should be available in the work area.

HYGIENIC PRACTICES: Wash hands before eating. Use only with adequate ventilation. Remove contaminated clothing and wash before reuse. Ground and bond containers when transferring material.

9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE: Dark amber
ODOR: SI alcohol
BOILING POINT (RANGE): N.D.
FREEZE POINT: N.D.
VAPOR DENSITY: Heavier than air
VAPOR PRESSURE: N.D.
PHYSICAL STATE: Liquid
SOLUBILITY IN WATER: Soluble
PH (AS IS): 4.5-6.0
SPECIFIC GRAVITY: 0.94-1.00

10. STABILITY AND REACTIVITY DATA

CONDITIONS TO AVOID: Avoid temperature extremes. Excessive heat causes the vapor pressure to increase rapidly

INCOMPATIBILITY: Avoid contact with strong oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS: Oxides of carbon and nitrogen.

HAZARDOUS POLYMERIZATION: Will not occur under normal use and storage conditions.

CHEMICAL STABILITY: This product is stable under normal storage conditions.

11. TOXICOLOGICAL INFORMATION

ORAL: No product information is available.

DERMAL: No product information is available.

INHALATION: No product information is available.

12. ECOLOGICAL INFORMATION

ECOTOXICITY: No product information is available.

CHEMICAL FATE INFORMATION: No product information is available.

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL: Consult local, state, or federal regulatory agencies for acceptable disposal procedures and disposal locations. Disposal in streams or sewers may be prohibited by federal, state, and local regulations.

RCRA STATUS: D001 –Characteristic of ignitability

14. TRANSPORTATION INFORMATION

(NON-BULK SHIPMENTS)
D.O.T. PROPER SHIPPING NAME: Isopropanol Solution
D.O.T. TECHNICAL NAME:
D.O.T. HAZARD CLASS: 3 HAZARD SUBCLASS: N/A
D.O.T. UN NUMBER: UN1219 PACKING GROUP: II RESP. GUIDE PAGE: 129

(BULK SHIPMENTS)
D.O.T. PROPER SHIPPING NAME: Isopropanol Solution
D.O.T. TECHNICAL NAME:
D.O.T. HAZARD CLASS: 3 HAZARD SUBCLASS: N/A
D.O.T. UN NUMBER: UN1219 PACKING GROUP: II RESP. GUIDE PAGE: 129

T.D.G. PROPER SHIPPING NAME: Isopropanol Solution
T.D.G. TECHNICAL NAME:
T.D.G. HAZARD CLASS: 3 HAZARD SUBCLASS: N/A
T.D.G. UN NUMBER: UN1219 PACKING GROUP: II RESP. GUIDE PAGE: 129

IMDG PROPER SHIPPING NAME: Isopropanol Solution
IMDG TECHNICAL NAME:
IMDG HAZARD CLASS: 3.2 HAZARD SUBCLASS: N/A
IMDG UN NUMBER: UN1219 PACKING GROUP: II EmS No: F-E, S-C

15. REGULATORY INFORMATION

CERCLA – SARA HAZARD CATEGORY:

Material Safety Data Sheet
ALPHA 3207

SECTION 311/312: This product has been reviewed according to the EPA 'Hazard Categories' promulgated under Sections 311 and 312 of the Superfund Amendments and Reauthorization Act of 1986 (SARA Title III) and is considered, under applicable definitions, to meet the following categories:

IMMEDIATE HEALTH HAZARD FIRE HAZARD

SARA SECTION 313: This product contains the following substances subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

COMPONENT	CAS#	% BY WEIGHT

TSCA STATUS:

All components of this product are listed on the Toxic Substance Control Act Inventory or are excluded from the listing requirements.

INTERNATIONAL REGULATIONS:

CANADIAN WHMIS: This MSDS has been prepared in compliance with Controlled Product Regulations except for the use of the 16 headings.

CANADIAN WHMIS CLASS: B-2, D-2B

CANADIAN ENVIRONMENTAL PROTECTION ACT:

All components of this product are listed on the Canadian Domestic Substance List (DSL).

16 OTHER INFORMATION

HMIS RATING – HEALTH: 2 FLAMMABILITY: 4 REACTIVITY: 0 PERSONAL PROTECTIVE RATING: G

LEGEND: N.A. – NOT APPLICABLE, N.E. - NOT ESTABLISHED, N.D. – NOT DETERMINED

THIS PRODUCT'S HEALTH AND SAFETY INFORMATION IS PROVIDED TO ASSIST OUR CUSTOMERS IN ASSESSING COMPLIANCE WITH HEALTH, SAFETY AND ENVIRONMENTAL REGULATIONS. THE INFORMATION CONTAINED HEREIN IS BASED ON DATA AVAILABLE TO US, AND IS BELIEVED TO BE ACCURATE, ALTHOUGH NO GUARANTEE OR WARRANTY IS PROVIDED OR IMPLIED BY THE COMPANY IN THIS RESPECT. SINCE THE USE OF THIS PRODUCT IS WITHIN THE EXCLUSIVE CONTROL OF THE USER, IT IS THE USER'S RESPONSIBILITY TO DETERMINE THE CONDITIONS OF SAFE USE. SUCH CONDITIONS MUST COMPLY WITH ALL GOVERNMENTAL REGULATIONS.

ATTACHMENT “I”
Formation Testing Program

ATTACHMENT “J”

Stimulation Program

December 7, 2015

Mr. Marc Jacobs, Jr.
Senior Vice President
Penneco
6608 Route 22
Delmont, PA 15626

Re: Sedat #3A (Murrysville) – Reservoir and Fracture Characterization

Dear Marc,

The following summarizes the reservoir and fracture characterization for the Murrysville formation in the Sedat #3A located in Plum Borough, Allegheny County, Pennsylvania.

A series of tests were designed and conducted at the Sedat #3A to gain a better understanding of the reservoir and fracture characteristics of the Murrysville formation which underlies a sizeable portion of Penneco's proximate lease acreage.

The tests were comprised of (1) formation breakdown, (2) DFIT (diagnostic fluid injection test) to determine closure stress, reservoir pressure, and reservoir transmissibility (kH/mu), (3) Step Rate to determine the fracture extension pressure, and (4) Rate Stepdown to determine the near wellbore friction which includes perforation friction and friction caused by near wellbore tortuosity.

Table 1 shows the timeline of the work performed on the Sedat #3A.

Several high level observations from the work performed was that (1) the well goes on vacuum very quickly after injection stops (i.e., pressure goes to zero on the surface) and (2) the surface treating pressures were excessively high given the depth of the well and the closure stress.

On September 1, 2015 a DFIT was pumped to determine the closure stress, reservoir pressure, and reservoir transmissibility (kH/mu). The DFIT was pumped at 4 bpm for 1500 gals. Bottomhole pressure was recorded with a bottomhole gauge set 1910 ft. The results from the DFIT using the Nolte G function gave a bottomhole closure stress of 553 psi which gives a closure stress gradient of 0.29 psi/ft.

330.401.1921
hjacot@hfrac.com
www.hfrac.com

PO Box 801 • New Philadelphia, OH 44663

The pressure decline data after closure (ACA) was analyzed with the Nolte FR function to determine reservoir transmissibility. Based on the pressure response it appears that pseudoradial flow was reached. The reservoir transmissibility was 88 mD-ft/cP assuming a reservoir fluid viscosity of 1 cP. The actual results will vary based on the actual reservoir fluid viscosity. The formation capacity (kH) was 88 mD-ft. Assuming a height of 50 ft gives a reservoir permeability of 1.8 mD.

Following the DFIT, an attempt was made on September 29, 2015 to breakdown additional perforations with 500 gals of 15 percent HCL acid and small concentrations of sand pumped in a 20 lb/1000 gal linear gel. The surface pressure was reduced when the acid entered the perforations but quickly increased as low concentration (0.25 lb/gal) of 40/70 sand entered the perforations. The sand was cut and the well flushed.

On October 1, 2015 a Step Rate was pumped to determine the fracture extension pressure. The initial rate was 0.25 bpm and increased to 1.0 bpm in increments of 0.25 bpm. The rate was then increased to 4 bpm in increments of 0.50 bpm. The injection time for each rate was four hours.

The results from the Step Rate gave a fracture extension pressure of 1.70 psi/ft which is abnormally high and cannot be used for formation evaluation. The cause of the excessively high fracture extension pressure was near wellbore friction comprised of perforation friction and friction caused by tortuosity (i.e., a poor connection between the wellbore and the created hydraulic fracture).

Based on the results from the Step Rate another attempt was made to reduce the near wellbore friction with additional acid and higher injection rates. On November 17, 2015 several injections were performed to reduce near wellbore friction. The first injection consisted of 1500 gals 7.5 percent HCl acid and the second injection used 750 gals 15 percent HCl acid. Following the second acid injection the injection rate was 26 bpm and the surface pressure was 2980 psi.

A Stepdown was performed after the second acid injection to quantify the amount of near wellbore friction and break out the perforation friction and friction caused by tortuosity. Perforation friction varies with the flow rate squared and tortuosity varies with the square root of the flow rate. The results from the Stepdown show a total near wellbore friction of 2011 psi at 26 bpm of which 1300 psi is perforation friction and 711 psi is friction caused by tortuosity. The number of open perforations was 5 assuming a discharge coefficient of 0.60.

The perforation efficiency is very low with only 5 out of 41 perforations open.

The ISIP at the end of the last injection was 1446 psi giving a F.G (fracture gradient) of 1.23 psi/ft suggesting a possible horizontal component to the created fracture. The high fracture gradient could also be the result of near to mid-field fracture complexity. As with the other injections the surface pressure quickly fell to zero. This rapid pressure decrease following the rate shutdown is a common response for mid-field fracture complexity (i.e., restriction away from the wellbore).

The results from the tests on the Sedat #3A are shown in Table 2.

In summary the Murrysville formation in the Sedat #3A is characterized by low reservoir pressure, 232 psi, low closure stress, 0.29 psi/ft., and higher than anticipated pumping pressures because of complex near or mid-field fracture complexity. Low perforation efficiency also contributed to the higher than expected pumping pressures.

Thank you for the opportunity to work on the Sedat #3A project with Penneco. If you have any questions or comments let me know.

Sincerely,

Henry Jacot
H-Frac Consulting Services, LLC

Table 1 – Timeline

Activity	Date
Perforate	August 7, 2015
Spot Acid and Pull Tubing	August 28, 2015
Break Formation and Pump DFIT	September 1, 2015
Perforation Cleanup	September 29, 2015
Step Rate	October 1, 2015
Perforation Breakdown	November 17, 2015

Table 2 - Results

Parameter	Value
Breakdown Pressure	3115 psi
Bottomhole Closure Stress	553 psi
Closure Stress Gradient	0.29 psi/ft
Surface ISIP	1446 psi
Fracture Gradient	1.23 psi/ft
Reservoir Pressure	232 psi
Reservoir Transmissibility (kH/mu)	88 mD-ft/cP
Formation Capacity (kH)	88 mD-ft
Reservoir Permeability	1.8 mD
Fracture Extension Pressure	N/A

PENNECO
SEDAT #3A
PLUM BOROUGH
ALLEGHENY COUNTY, PA

December 7, 2015

TEST OBJECTIVES

- ✓ Formation Breakdown Pressure
- ✓ Closure Stress
- ✓ Fracture Gradient (F.G.)
- ✓ Reservoir Pressure
- ✓ Reservoir Transmissibility (kH/mu)
- ~~x Fracture Extension Pressure~~

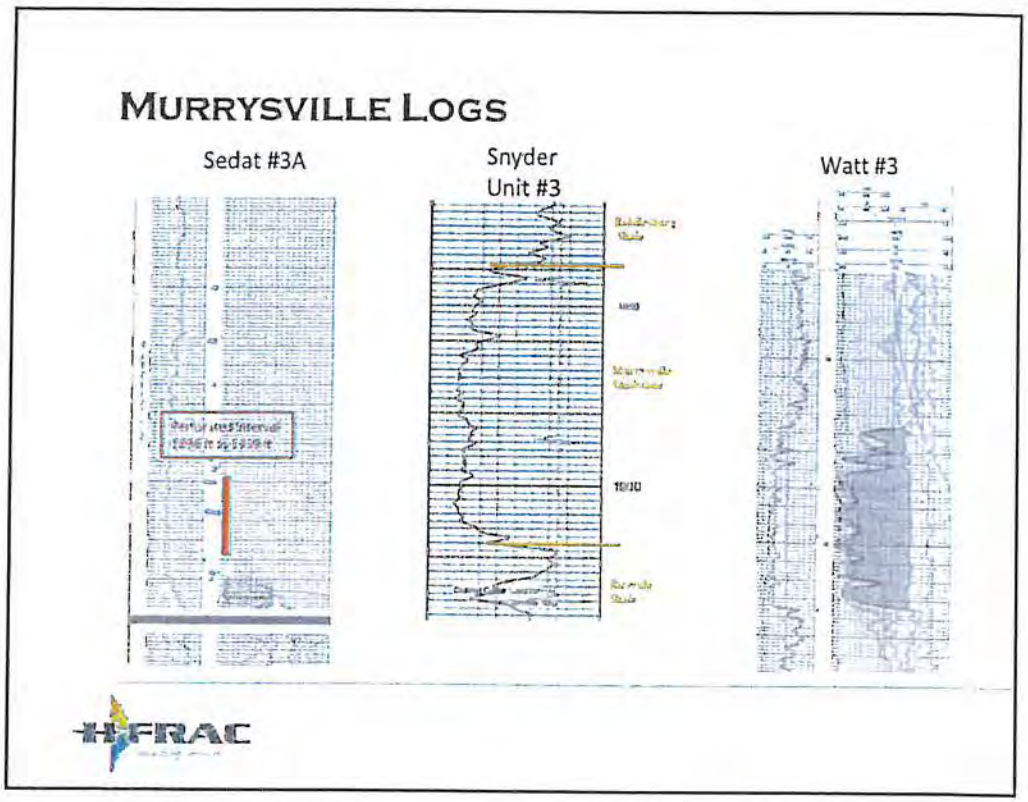
TIME LINE

Activity	Date
Perforate	August 7, 2015
Spot Acid and Pull Tubing	August 28, 2015
Break Formation/Pump DFIT	September 1, 2015
Perforation Cleanup	September 29, 2015
Step Rate	October 1, 2015
Perforation Breakdown	November 17, 2015

H-FRAC

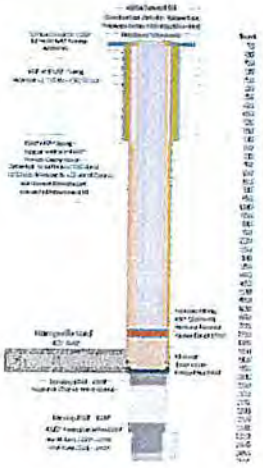
Test Results

Parameter	Value
Breakdown Pressure	3115 psi
Closure Stress	553 psi
Closure Stress Gradient	0.29 psi/ft
ISIP	1446 psi
Fracture Gradient	1.23 psi/ft
Reservoir Pressure	232 psi
Reservoir Transmissibility (kH/mu)	88 mD-ft/cP
Formation Capacity (kH)	88 mD-ft
Reservoir Permeability	1.8 mD
Fracture Extension Pressure	N/A



Murrysville type logs.

SEDAT #3A
WELLBORE SCHEMATIC

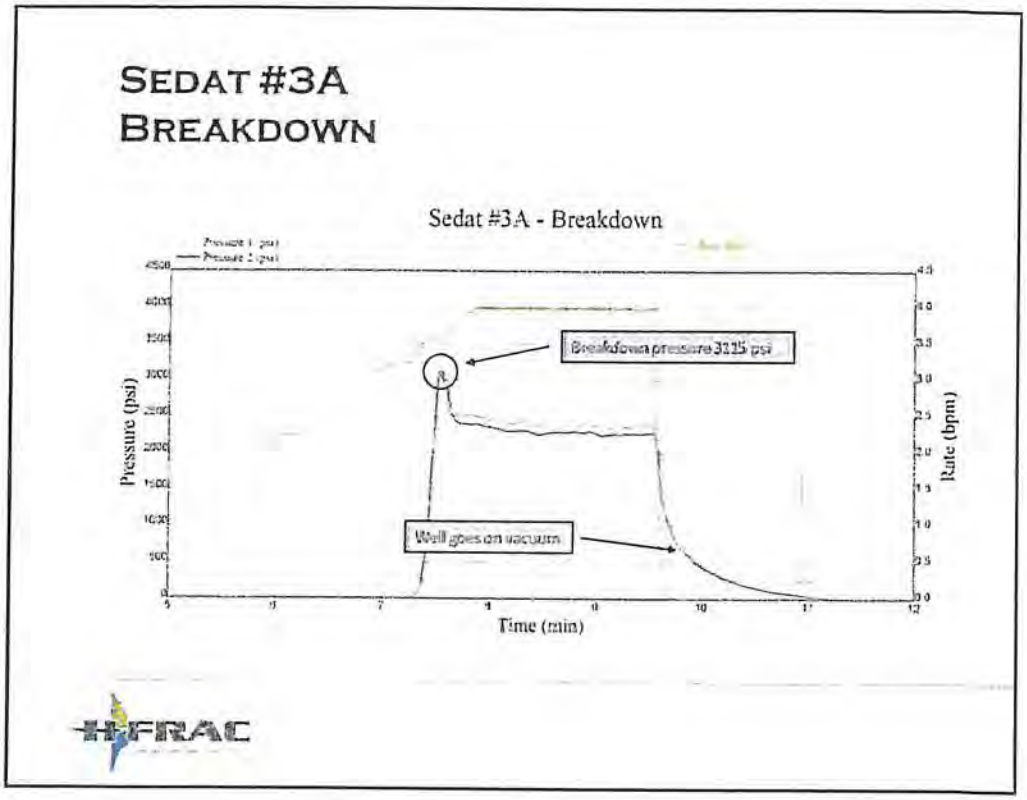


PERFORATION DATA

Description	Value
Entry Hole Diameter	0.58"
Phasing	60 degree
Type	EHC
Charge	25 grams
Depth	1896 ft to 1939 ft
Perforations	41 ea

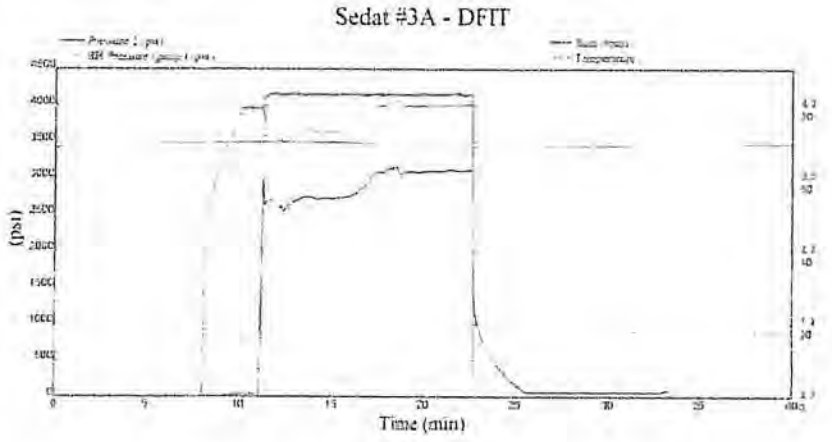
The Sedat #3A was perforated in the Murrysville from 1896 ft to 1939 ft with 41 0.58 in entry hole perforations. Perforation phasing was 60 degrees and the charge was 25 grams.

SEDAT #3A
BREAKDOWN



The Murrysville formation in the Sedat #3A was broke down on September 1, 2015. The breakdown pressure was 3115 psi. Following the breakdown the acid was displaced at 4 bpm The well was on vacuum after shutdown with the pressure decreasing to zero in less than two minutes.

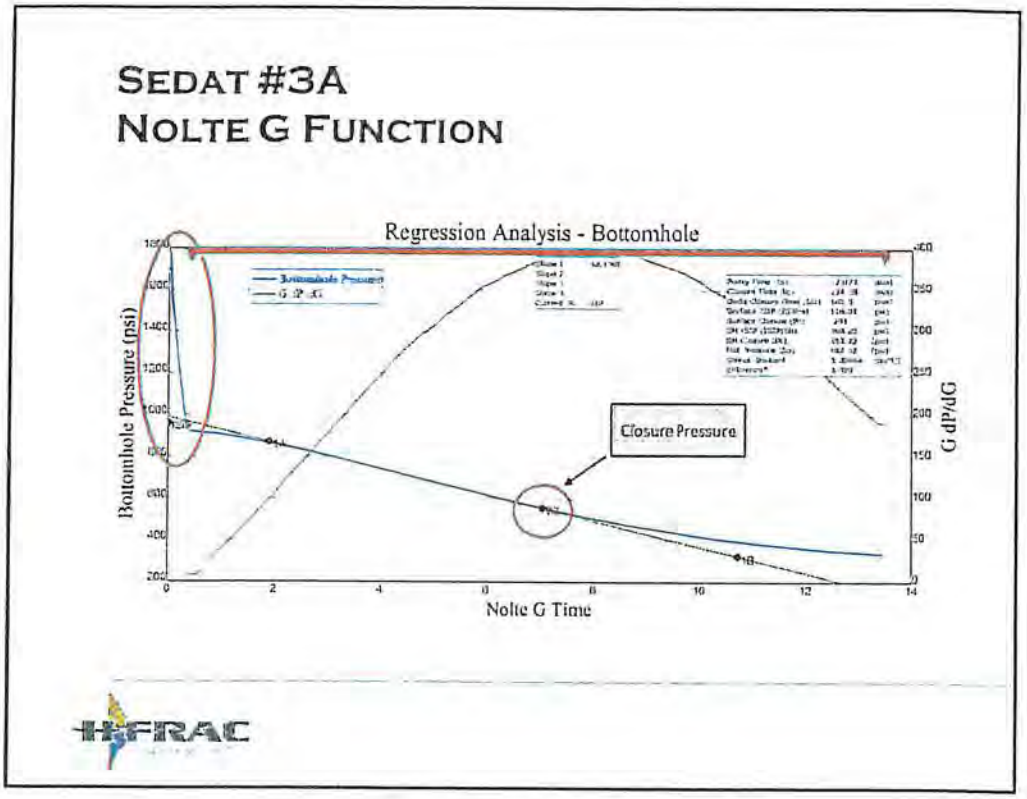
SEDAT #3A
DFIT DATA



Following the formation breakdown a DFIT (diagnostic fluid injection test) was pumped in the Murrysville to determine closure stress, reservoir pressure, and reservoir transmissibility (kh/mu). Prior to starting the DFIT the whole was loaded with water. After the hole was loaded 1500 gals of water was pumped at 4.1 bpm. The average surface treating pressure was 2902 psi and the average bottomhole treating pressure was 3816 psi.

During the injection the surface pressure increased from 2700 psi to 3100 psi with a constant rate indication some type of restriction.

After the rate went to zero the surface pressure declined rapidly and went to zero. The bottomhole pressure was recorded with a bottomhole pressure gauge at 1910 ft.



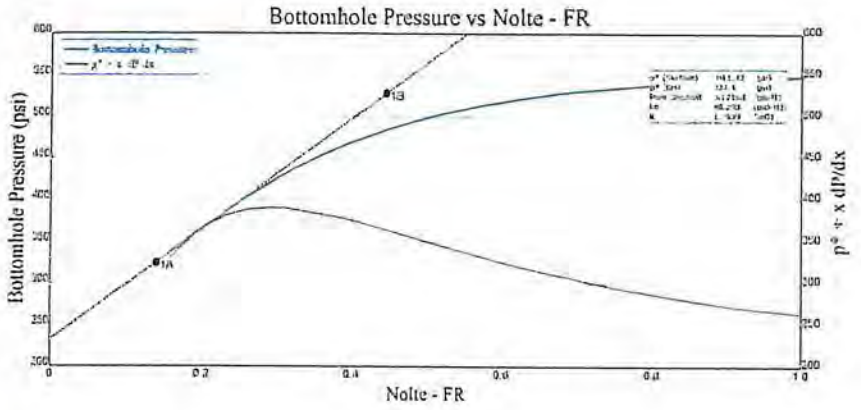
The bottomhole pressure from the DFIT was analyzed with the Nolte G function to determine the closure pressure and closure stress gradient.

Following the injection the pressure declined rapidly. The rapid pressure decline is most likely caused by fracture complexity and low closure stress and not leakoff into the formation.

The estimated bottomhole ISIP is 960 psi resulting in a fracture gradient of 0.50 psi/ft.

Closure occurred at a Nolte G time of 7.2 giving a bottomhole closure of 553 psi. The closure stress gradient is 0.29 psi. The net pressure was 407 psi and the fluid efficiency was 79 percent.

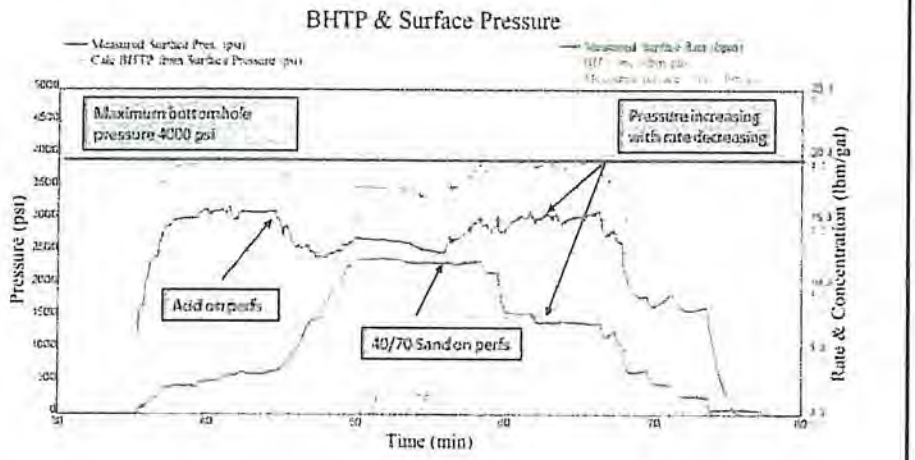
SEDAT #3A
AFTER CLOSURE ANALYSIS



The bottomhole pressure after closure was analyzed using the Nolte FR function. If the late time data reaches pseudoradial flow estimates of reservoir transmissibility (kh/mu) and reservoir pressure can be determined.

The results from the Nolte FR function show that pseudoradial flow was reached. P* was 232 psi. The formation capacity (kH) was 88 mD-ft assuming a reservoir fluid viscosity of 1 cP. Using a formation height of 50 ft the reservoir permeability is 1.8 mD.

SEDAT #3A
PERFORATION CLEANUP



On September 29, 2015 an attempt was made to remove excess friction seen on the DFIT. 500 gals of 15% HCL was pumped. A decrease on the surface treating pressure was seen when the acid was on the perforations. The surface pressure decreased and the injection rate was increased to 12 bpm. The surface pressure continued to decrease to 2500 psi.

Low concentration (0.25 lb/gal) of 40/70 sand was pumped in an effort to remove the excess friction. The surface pressure initially decreased with the 40/70 sand on the perforations but increased rapidly to over 3000 psi on the surface. The maximum pressure on the packer was 4000 psi so the injection was decreased to 11 bpm then to 7 bpm.

The calculated bottomhole pressure remained close to 4000 psi and was erratic.

The rate was reduced and the pressure declined to zero in less than two minutes.

SEDAT #3A
STEP RATE TEST

A Step Rate Test was pumped on October 1, 2015 to determine the fracture extension pressure. The initial rate was 0.25 bpm and increased in 0.25 bpm increments until 1 bpm where it was increased to 4 bpm in 0.5 bpm increments. Injection period for each rate stage was 4 hours.

Following the rate increases the rate was decreased from 4 bpm in 1 bpm increments until the rate reached zero.

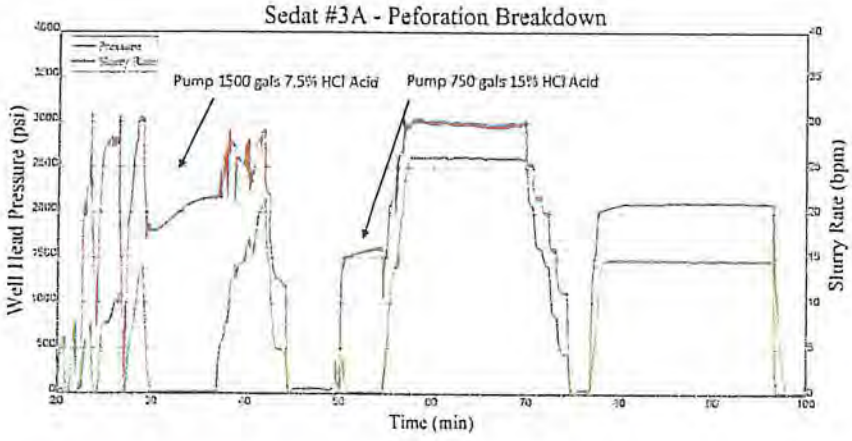
Total injected volume was 4292 bbls.

SEDAT #3A
STEP RATE

Analysis of the Step Rate gave a fracture extension pressure of 3255 psi and fracture extension gradient of 1.70 psi/ft. This high of extension pressure gradient is unrealistic and cannot be used.

The high fracture extension pressure gradient is a result of excess near wellbore friction as evidenced by the sudden pressure increase with each rate increase (slide 13).

SEDAT #3A
PERFORATION BREAKDOWN



On November 17, 2015 additional acid was pumped in an attempt to breakdown additional perforations and remove excess near wellbore friction to establish better communication between the wellbore and created hydraulic fracture.

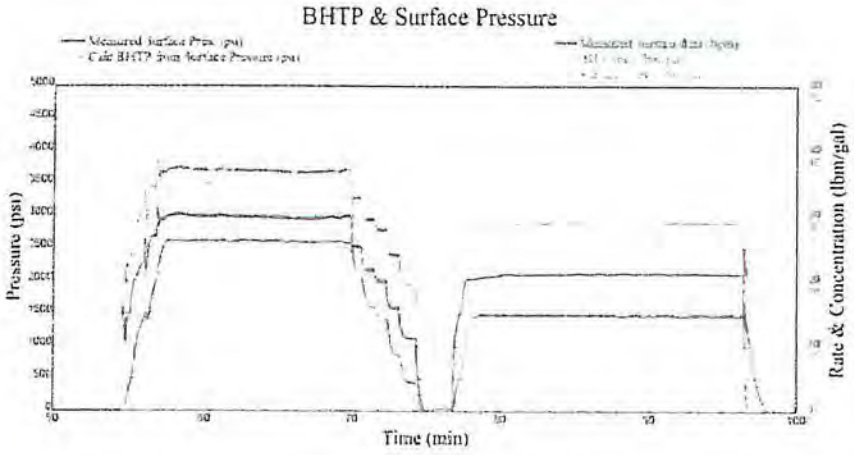
The first acid injection consisted of 1500 gals 7.5% HCl and the second acid injection was 750 gals 15% HCl acid.

Following the acid injections the maximum rate was 26 bpm at an average surface pressure of 2980 psi.

A rate stepdown was performed at the end of the acid breakown. An additional injection was pumped at 15 bpm to establish an ISIP.

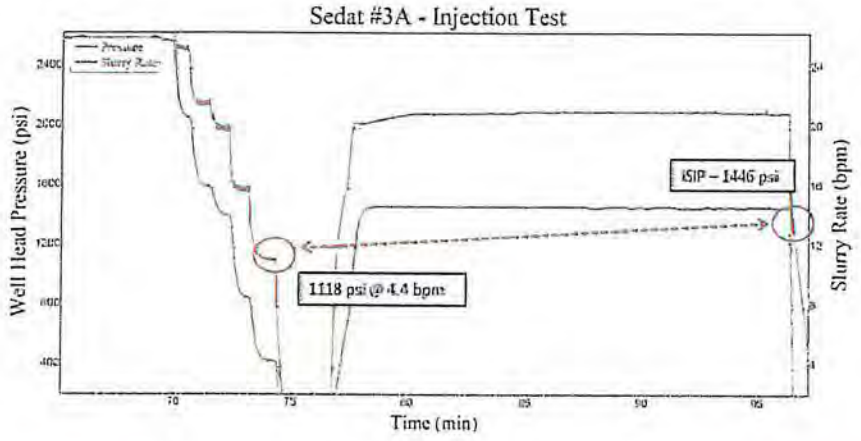
The ISIP was 1441 psi.

SEDAT #3A
SURFACE & CALC'D BH PRESSURE



This plot shows the calculated bottomhole pressure from the acid breakdown.

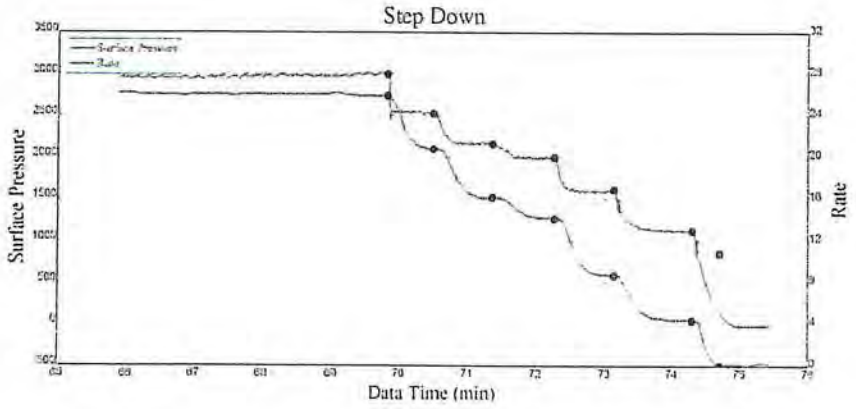
SEDAT #3A
INJECTION TEST (ZOOMED)



This plot zooms in on the rate stepdown and final injection. The final rate on the stepdown was 4.4 bpm and the pressure was 1118 psi. The final ISIP was 1446 psi giving a fracture gradient of 1.23 psi/ft

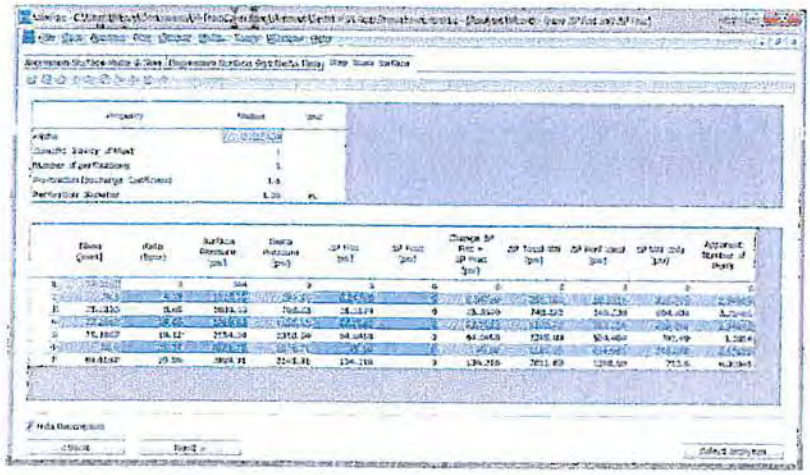
This high of fracture gradient may be caused by either a horizontal fracture or excess fracture complexity.

SEDAT #3A
STEPDOWN POINT SELECTION



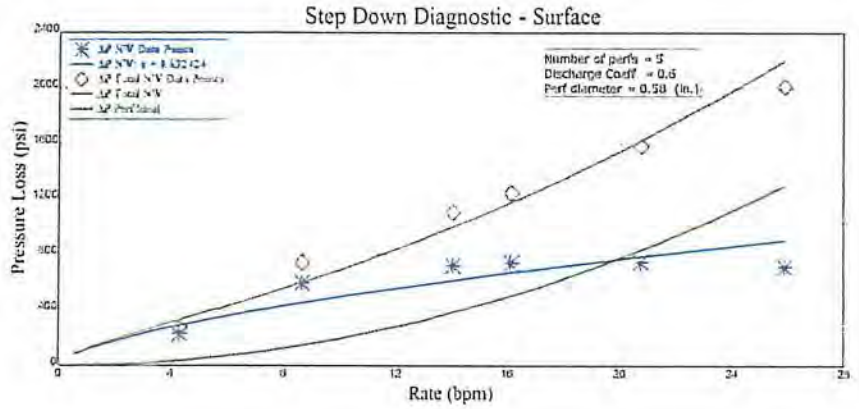
A Stepdown Analysis was conducted to determine the cause of the excess near wellbore friction.

SEDAT #3A
STEPDOWN TABLE



Stepdown Table showing the point selection and friction values.

SEDAT #3A
STEPDOWN ANALYSIS



The Stepdown Analysis gives a total near wellbore friction of 2011 psi at 26 bpm. Of which 1300 psi is perforation friction and 711 is near wellbore tortuosity. The resulting number of perforations is 5 assuming a discharge coefficient of 0.60.

SEDAT #3A
SUMMARY

- A series of injections were pumped on the Sedat #3A to determine closure stress, fracture gradient, reservoir pressure, reservoir transmissibility (permeability), and breakdown pressure.
- During the injection tests excess friction existed either because of limited number of perforations open or near wellbore fracture complexity.
- Attempts were made to reduce the excess friction with acid, higher rates, and low concentrations of 40/70 sand. Acid and higher injection rates removed some of the excess friction but the high excess pressures still existed.
- The rate stepdown analysis showed total near wellbore friction of 2000 psi comprised of 1300 psi of perforation friction and 700 psi of near wellbore tortuosity of fracture complexity.

SEDAT #3A
SUMMARY (CONT.)

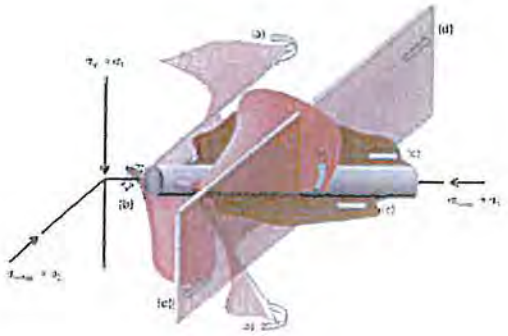
- The rate stepdown shows only 5 perforations open out of 41 perforations.
- After each injection the pressure quickly fell to zero at the surface because of the low closure stress of the Murrysville.
- The closure stress determined from the DFIT was 553 psi giving a closure stress gradient of 0.29 psi/ft. The Murrysville in the Sedat #3A cannot support a column of water.
- The DFIT reached pseudoradial flow. The After Closure Analysis with the Nolte FR function gave a reservoir transmissibility (kH/mu) of 88 mD-ft/cP assuming a reservoir fluid viscosity of 1 cP. Assuming a height of 50 ft the reservoir permeability is 1.76 mD.

SEDAT #3A
SUMMARY (CONT.)

- The ISIP at the end of the last injection was 1446 psi giving a fracture gradient of 1.23 psi/ft suggesting a possible horizontal fracture. The high fracture gradient could also be the result of near or mid-field fracture complexity.

Appendix

Complex Fracture Propagation
Horizontal Wellbore



H-FRAC

AFTER CLOSURE ANALYSIS

- The reservoir transmissiblity (kh/μ) can be calculated by analyzing the pressure decline data after closure; if the late time pressure data reaches pseudo-radial flow.
- Similar to a Horner analysis with the reservoir transmissibility calculated from the slope of the late time data.
- The pressure data when plotted on log-log scale will exhibit a slope of unity when pseudo-radial flow has developed.

RADIAL FLOW TIME FUNCTION

$$F_R(t,t_c) = \frac{1}{4}\ln\left(1+\frac{\chi t_c}{t-t_c}\right)$$

where

$\chi = 16 \cdot \pi^2$

t_c = time to closure, min

t = time, min

F_R = radial flow function

After Closure Analysis

$$kh/\mu = 251{,}000\left(\frac{V_i}{m_R t_c}\right)$$

where

k = reservoir permeability, mD

h = net pay, ft

μ = reservoir fluid viscosity, cP

V_i = volume injected, bbl

m_R = slope

t_c = time to closure, min

API Permit #: 37-003-21223

Customer: PENNECO

Lease and Well Name: SEDAT #3A

A.F.E #: N/A

UNIVERSAL WELL SERVICES, INC.

Job Type: MISC. PUMP PTA

Cement Operator: LANCE SHIREY

Date Cemented: 8/28/2015

Drilling Contractor: SERVICE RIG

Cement Slurry Information

No. of Sacks	Cement Blend Composition	Yield (ft^3/sk)	MixWater (gal/sk)	Density (lb/gal)	(bbl) Mix Water	(ft3) Of Slurry	(bbl) Of Slurry
				Totals			

Wellbore Information

	New/Used	Diameter (in)	Weight (lb/ft)	Top (ft)	Bottom (ft)	Collapse/Burst Pressures (psi)
Casing	Used	4 1/2	10.5	SURFACE	1,941	
Previous Casing						
Tubing or Drillpipe	Used	1 1/2	4.6	SURFACE	1,930	
Open Hole						
Open Hole						

Requested TOC (ft)	SURFACE
TVD (ft)	N/A
Displacement Depth (ft)	
Displacement (bbl)	

Pumping Returns	
Spacer or Gel Sweep Return Seen At Surface	
Cement Returns Seen at Surface	
Amount of Cement Returns (BBL)	

Cement Slurry Temperature Record (°F)				
Cement	Reading 1	Reading 2	Reading 3	Average
Blend 1				
Blend 2				
Blend 3				

Fluid Information	
Mix Water Temp (°F)	
Displacement Fluid Type	Brine
Displacement Fluid Temp (°F)	
Displacement Fluid Density (lb/gal)	8.3

Time	Rate (bpm)	Volume (bbl)	Pressure (psi)	Event or Stage Description
12:15				Arrive On Location, Wait for Rig to Run Casing
				Spot Trucks, Hold JSEA,
				Hold Safety Meeting
				Load Lines, Test Lines
13:00	0-2	1	0-25	PUMP WATER
13:02	2	4.8	25	PUMP ACID 7.5%IRON CHEK
13:04	2	4	25	PUMP WATER
13:06				SHUT DOWN PULL TUBING
				FILL 4.5 W/ RIG
15:09-15:27	0-4	6	0-3000	PUMP WATER TO PUSH ACID BACK IN FORMATION
15:27				SHUT DOWN
				RACK UP
16:00				LEAVE LOCATION

Comments:

HFRAC Report – Page 29

Thank You for your Business

UWS Cement Operator Signature: LANCE SHIREY

Customer Representative Signature:

TREATMENT SUMMARY

Customer Name:	Penneco	DFIT	Date: 9/29/15
Well Name:	Sedat #3A		

PRESSURES IN PSI

BREAKDOWN 2900 TOP PERF MD 1896
AVERAGE 2341 BTM PERF MD 1936
SHUT IN: INSTANT 1251 5-MIN 0 10-MIN na

CLEAN VOLUMES IN GAL

TOP PERF TVD 1896 PAD 70
BTM PERF TVD 1936 DISPL 30
TREATMENT 247 TTL VOL 100

HYDRAULIC HORSEPOWER

USED 671

RATES IN B.P.M.

AVG TREATING 11.7 MAXIMUM 11.9

DESCRIPTION OF JOB DFIT

Time	Rate (bpm)	Slurry Volume (gal)	Pressure (psi)	Description of Stage or Event
8:45	na	na	na	Hold Safety Meeting
9:11	na	na	na	Prime Pumps
9:17	na	na	4752	Pressure Test Lines
9:20	na	na	na	Fix Leak
9:28	na	na	na	Prime Pumps
9:29	na	na	5132	Pressure Test Lines
9:33	0.0	0	0	Load Hole
9:37	0.0	21	45	Pump Pad
9:41	na	na	na	Prime Acid
9:44	0.0	40	68	Pump Acid
9:50	0.1	40	1328	Displace Acid/Pump Pad
10:00	4.0	64	2900	Break Formation
10:05	11.9	107	2700	Establish Rate
10:05	11.9	110	2693	Start Sand @ 0.25 40/70
10:12	11.6	175	2852	Start Sand @ 0.30 40/70
10:12	11.7	193	2885	Cut Sand/Flush
10:22	5.0	273	2640	Establish 5.0 bpm
10:23	3.2	275	2031	Establish 3.0 bpm
10:25	2.4	280	1755	Establish 2.0 bpm
10:26	1.4	284	1624	Establish 1.0 bpm
10:28	0.0	287	1251	Shutdown

Totals

Sand	40/70	9	Sks
Chemicals	Unislick ST-50	5	Gals
	Unigel 5F	175	Lbs
	LEB 10X Breaker	0.4375	Gals
	15% HCL	495	Gals

UNIVERSAL WELL SERVICES, INC.

API Permit #: 37003212230000

Customer: PENNECO OIL COMPANY

Lease and Well Number: SEDAT 3A

A.F.E #: N/A

UNIVERSAL WELL SERVICES, INC

Job Type: DFIT

Cement Operator: JAMES CAMPBELL

Date Cemented: 10/1/2015

Drilling Contractor: N/A

Cement Slurry Information

No. of Sacks	Cement Blend Composition	Yield (ft^3/sk)	MixWater (gal/sk)	Density (lb/gal)	(bbl) Mix Water	(ft^3) Of Slurry	(bbl) Of Slurry
				Totals			

Wellbore Information

	New/Used	Diameter (in)	Weight (lb/ft)	Top (ft)	Bottom (ft)	Collapse/Burst Pressures (psi)
Casing	USED	4 1/2	10.5	SURFACE	1,930	
Previous Casing						
Tubing or Drillpipe						
Open Hole						
Open Hole						

Requested TOC (ft)	
TVD (ft)	
Displacement Depth (ft)	
Displacement (bbl)	

Pumping Returns	
Spacer or Gel Sweep Returns Seen At Surface	
Cement Returns Seen at Surface	
Amount of Cement Returns (BBL)	

Cement Slurry Temperature Record (°F)					
Cement	Reading 1	Reading 2	Reading 3	Average	
Blend 1					
Blend 2					
Blend 3					

Fluid Information	
Mix Water Temp (°F)	
Displacement Fluid Type	
Displacement Fluid Temp (°F)	
Displacement Fluid Density (lb/gal)	

Time	Rate (bpm)	Volume (bbl)	Pressure (psi)	Event or Stage Description
0730				ARRIVE ON LOCATION, HOLD JSEA
0745				SPOT TRUCKS, MAKE HOOKUPS, WAIT ON RIG
				HOLD SAFETY MEETING
0827	.1-1	1	0-3300	LOAD LINES, PSI TEST
0932	.3-2	14	0-100	PUMP WATER TO LOAD HOLE
0944	.25	2.7	0-450	PUMP WATER TO START DFIT
0955	0	0	0	SHUTDOWN, RELEASE PRESSURE, UNHOOK
				WELL HEAD FLANGE NEEDS TIGHTENED
1005	.25	60	0-700	PUMP WATER TO START DFIT
1405	.5	120	450-825	RATE CHANGE TO .5 BBL/MIN
1805	.75	180	825-1075	RATE CHANGE TO .75 BBL/MIN
2206	1	240	1075-1330	RATE CHANGE TO 1 BBL/MIN
0205	1.5	360	1330-1770	RATE CHANGE TO 1.5 BBL/MIN
0605	2	480	1770-2004	RATE CHANGE TO 2 BBL/MIN
1005	2.5	600	2004-2162	RATE CHANGE TO 2.5 BBL/MIN
1406	3	720	2162-2400	RATE CHANGE TO 3 BBL/MIN
1806	3.5	840	2300-2600	RATE CHANGE TO 3.5 BBL/MIN
2205	4	512	2450-2500	RATE CHANGE TO 4 BBL/MIN
0011	3	90	2200-2250	RATE CHANGE TO 3 BBL/MIN
0041	2	60	2025-2050	RATE CHANGE TO 2 BBL/MIN
0111	1	30	1400-1450	RATE CHANGE TO 1 BBL/MIN
0141	0	0	1427-0	SHUTDOWN, MONITOR PRESSURE 10 MIN.
0155				RELEASE PRESSURE, UNHOOK
0200				RACKUP
0230				JOB COMPLETE, LEAVE LOCATION

Comments: WELL WENT ON VACUUM WHEN PUMPS WERE SHUT DOWN TO MONITOR THE WELL.

"THANK YOU"

Customer Representative Signature:

TREATMENT SUMMARY

Customer Name:	Penneco Oil Co	Acid Breakdown	Date: 11/17/15
Well Name:	Sedat #3A		

PRESSURES IN PSI

BREAKDOWN	3114	TOP PERF MD	1896				
AVERAGE	2506	BTM PERF MD	1936				
INSTANT	1401	5-MIN	0	10-MIN	0		

CLEAN VOLUMES IN GAL

TOP PERF TVD	1896	PAD	
BTM PERF TVD	1936	DISPL	1270
TREATMENT	27888	TTL VOL	36750

HYDRAULIC HORSEPOWER

USED	1130

RATES IN B.P.M.

AVG TREATING	18.4	MAXIMUM	26.3

DESCRIPTION OF JOB: Slickwater Fracture

Time	Rate (bpm)	Slurry Volume (bbl)	Pressure (psi)	Description of Stage or Event
5:00				Arrive on location, rig up
7:06				Hold Safety Meeting
7:31			4160	Test Lines
7:33				Fix Leak
7:37			4665	Re-Test Lines, Good Test
8:09				Open Well
8:17	2.7	0	1766	Pump Water
8:19				Shutdown, Re-Prime Pump
8:21	2.7			Pump Water
8:23				Shutdown, Replace Hose
8:27				Re-Prime Pump, Inspect Pump
8:52	5	32	2320	Pump Water
8:55	7.2	40	3114	Break Formation
8:57	10.7	55	3058	Pump Tripped Out, Resume Pumping
8:58	14.1	68	3031	Establish Rate
8:59	4.0	75	1815	Pump Acid
9:07	6.4	110	2167	Displace Acid
9:09	14.1	126	2733	Acid to Perfs
9:12	20.1	171	2802	Establish Rate
9:13	16.0	183	2236	Stepdown Rate
9:14	5.1	198	1279	Stepdown Rate
9:15	0.0	203	261	Shut Down
9:21	3.7	204	1401	Pump Water
9:21	4.0	204	1520	Pump Acid
9:25	4.0	239	1385	Displace Acid
9:28	26.0	284	3005	Establish Rate
9:41	20.8	609	2541	Stepdown Rate - 20 BPM
9:41	16.1	620	2164	Stepdown Rate - 15 BPM
9:42	14.2	636	2006	Stepdown Rate - 14 BPM
9:43	8.6	650	1387	Stepdown Rate - 10 BPM
9:45	4.4	656	1117	Stepdown Rate - 5 BPM
9:46	0.0	664	0	Shut Down
		Totals		

Chemicals	Unigel 5F	0	Lbs
	LEB 10X Breaker	0	Qts
	FRP 121	110	Lbs
Acid	15% HCL	750	Gals
	7.5% HCL	1,500	Gals

UNIVERSAL WELL SERVICES, INC.

CWM Environmental
101 Parkview Drive Ext.
Kittanning, Pennsylvania 16201
724-543-3011
Lab # 03-457

Lab Analysis Report

Sample Number: 07163702

Customer: Penneco Oil Co., Inc.	**Collection Date:** 07/29/16 13:00
Site: Gas Well	**Received Date:** 07/29/16 15:43
Monitoring Pt: DeSimone #3	**Matrix:** Non Potable Water (NPW)
Source Type: Discharge	**Collection Method:** Grab

07163702	Result	Reporting Limit	Method	Analysis Date	Analyst
Specific Gravity	1.1027 grams/ml	grams/ml	ASTM D1429	8/3/16 0:00	33-325
Total Dissolved Solids	140958 mg/L	5 mg/L	SM 2540 C	8/3/16 8:12	PLP
pH	5.78 SU	SU	SM4500 H+B	8/1/16 13:00	EJK

ample Comments:

pH: The pH result measured @ temperature of 25 deg C pH: The pH was analyzed outside of the 15 minutes holding time.

an C Shafer, Vice President of Operations

nalyst Reference: 33-325 - G & C Laboratory

CWM Environmental
11931 State Route 85
Kittanning, Pennsylvania 16201
724-543-3011
Lab # 03-457

Lab Analysis Report

Sample Number: 09150657

Customer: Penneco Oil Co., Inc.	**Collection Date:** 08/28/15 08:00
Site: Sedat #3A	**Received Date:** 09/04/15 16:17
Monitoring Pt: Tank Water	**Matrix:** Non Potable Water (NPW)
Source Type: Discharge	**Collection Method:** Grab

09150657	Result	Reporting Limit	Method	Analysis Date	Analyst
Specific Gravity	11084 gr/ml	0 gr/ml	ASTM D-1298	9/9/15 0:00	33-325
pH	4.69 SU	SU	SM4500 H+B	9/9/15 13:30	JRD
Total Dissolved Solids	155476 mg/L	5 mg/L	SM 2540 C	9/8/15 16:03	ARB

Sample Comments:

pH: The pH result measured @ temperature of 25 deg C pH: The pH was analyzed outside of the 15 minutes holding time.

Ryan C Shafer, Vice President of Operations

HFRAC Report – Page 34

Analyst Reference: 33-325 - G & C Laboratory

Analyte names in bold are listed under the laboratory's current NELAP scope of accreditation.

Universal Well Services, Inc.
Chemical Technology
13549 S. Mosiertown Road
Meadville, PA
814-373-3107

Laboratory Water Analysis

Sample Information

Company	Penneco
Well Name	Sedat 3a
Sample ID	Frac Water
Formation	
Date Sampled	9/23/2015
Date Analyzed	9/23/2015
Analyst	Bilich

Analysis Results

	Sample 1	Sample 2	
pH	4.90	5.10	
Temperature	74.4	74.3	°F
Specific Gravity	1.110	1.132	
Fluid Density	9.26	9.44	lb/gal
Chlorides (titrated)	100,000	120,000	mg/L
Total Dissolved Solids	159,500	191,400	mg/L
Total Suspended Solids	N/A	N/A	mg/L
Approximate Salt Percentage	14.4	16.9	%
Total Hardness	67,000	70,000	mg/L
Ca Hardness	63,000	60,000	mg/L
Ca^{2+}	25,200	24,000	mg/L
Mg Hardness	4,000	10,000	mg/L
Mg^{2+}	971	2,428	mg/L
Total Iron (titrated)	437	319	mg/L
Sulfates	39	10	mg/L
Hydroxide Alkalinity as $CaCO_3$	0	0	mg/L
Carbonate Alkalinity as $CaCO_3$	0	0	mg/L
Bicarbonate Alkalinity as $CaCO_3$	0	0	mg/L
Total Alkalinity as $CaCO_3$	0	0	mg/L
Tannin/ Lignin	N/A	N/A	mg/L
Barium/ Strontium PS	< 1	< 1	mg/L
Specific Conductance	172,500	193,200	µmhos/cm

The Fracture Gradient (F.G.) 1.23 psi/ft was calculated using the ISIP (instantaneous shut-in pressure) of 1446 psi and fluid S.G. of 1.10 psi/ft. The mid-perforation depth was 1917.5 ft (1896 ft – 1939 ft).

$$F.G. = \frac{ISIP + HydrostaticHead}{Depth}$$

$$F.G = \frac{1446 + 913}{1917.5} = 1.23$$

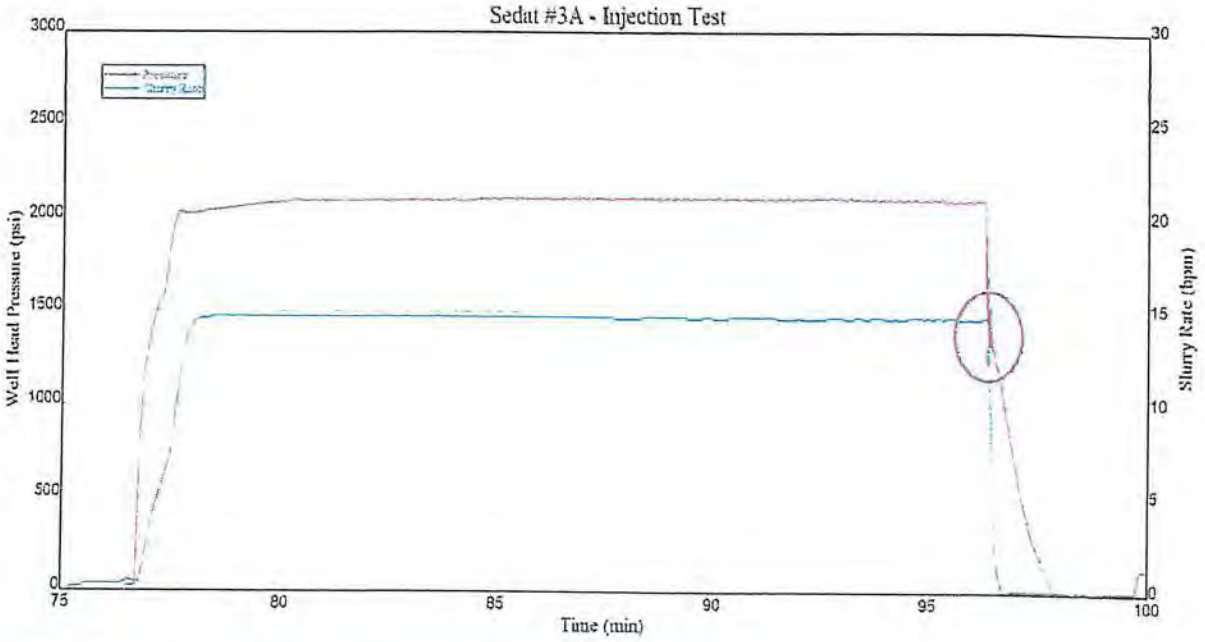


Figure 1 - Sedat 3A Injection Test pumped on November 17, 2015. ISIP 1446 psi

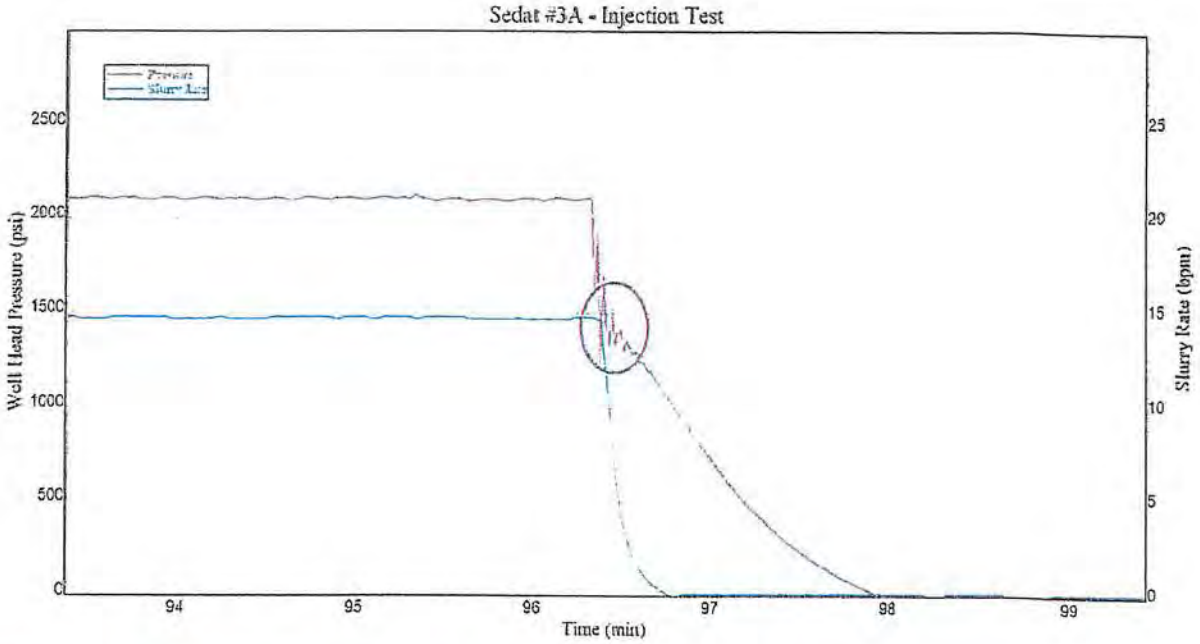


Figure 2 - Sedat #3A Injection Test pumped on November 17, 2015 (zoomed). ISIP 1446 psi

The reservoir permeability of 1.80 mD was an average permeability using a formation height of 50 ft. Using a reservoir permeability of 1.8 mD and formation height of 50 ft the formation capacity (k/H) was 90 mD/ft.

The bottomhole pressure after closure was analyzed using the Nolte FR function. If the late time data reaches pseudoradial flow estimates of reservoir transmissibility (kh/mu) and reservoir pressure can be determined.

The results from the Nolte FR function show that pseudoradial flow was reached. P* was 232 psi. The formation capacity (kH) was 90 mD-ft assuming a reservoir fluid viscosity of 1 cP. Using a formation height of 50 ft the reservoir permeability is 1.8 mD.

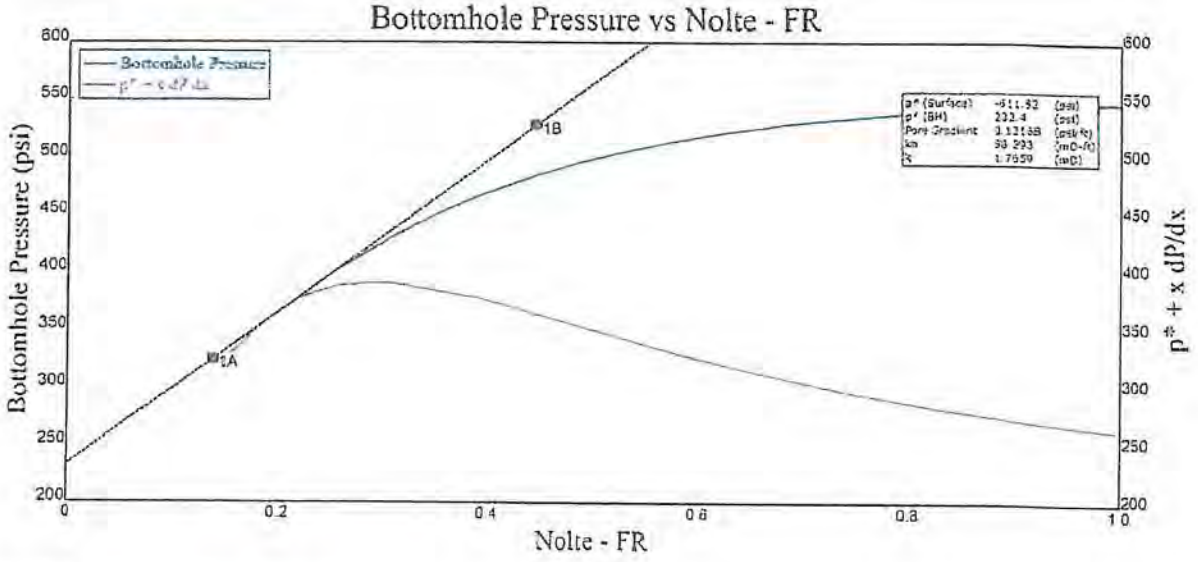


Figure 3 - Sector #3A After Closure Analysis (ACA

$$kh/\mu = 251{,}000\left(\frac{V_i}{m_R t_c}\right)$$

where

k = reservoir permeability, mD

h = net pay, ft

μ=reservoir fluid viscosity, cP

V_i=volume injected, bbl

m_R = slope

t_c = time to closure, min

Attachment J
Stimulation Program
Sedat #4A Injection Well

Stimulation Program for Sedat #4A Injection Well

There are currently no plans to stimulate the Sedat #4A Injection Well.

ATTACHMENT “K”

Injection Procedures

Attachment K
Injection Procedures
Sedat #4A Well

Injection Procedures:

Injection fluid will be delivered by trucks. Company personnel will measure the specific gravity of the sample with a hydrometer or some other appropriate method. Using the permitted maximum surface injection pressure and specific gravity values as a baseline, automation will throttle the MASIP in response to the actual Sg of the injectate to maintain the measured bottom hole pressure without regard to friction pressure, of 2332 Bottom Hole Injection pressure (BHIP). The produced fluids will be processed through a series of storage tanks and filters and treated with a scale inhibitor, bleach, and/or biocide additives as required.

The fluid will be pulled from the off loading tanks through a 20 micron filter to remove large suspended solids and transported through connecting pipes to additional tanks to hold the filter fluid until injection. From the tanks holding the filtered water the fluid will be transported by pipeline to high pressure pumps for transportation to the injection point where the rate of injection and pressure will be monitored and regulated so as not to exceed the maxim allowable surface injection pressure (MASIP) associated with the Sg being injected. and rate stated in the permit. The fluids will be pumped through a checkvalve at the wellhead down the 4 ½" injection string to the Murrysville injection zone not to exceed 2332 PSI Bottom Hole Injection Pressure (BHIP) ignoring friction loss.

The specific gravity will be continuously monitored by a mass flow meter. Should the specific gravity exceed the value set by permit at the well head P-max will be automatically adjusted to a lower P-max by installed logic controls to compensate for the change in specific gravity or if unable to compensate for the change in specific gravity, automatically shut in the injection well until the specific gravity of the fluid can be adjusted or the P-max is adjusted.

The injection string casing annulus pressures will be monitored and recorded by the Programmable Logic Controller (PLC). Should the annular pressure monitor equipment realize a dramatic, instantaneous increase or begin a steady, inexplicable climb, the EPA will be notified and their guidance followed.

Fluid levels will be checked in all monitoring wells on a quarterly schedule or more frequently if required by permit by either running a wireline or an Echometer fluid shot. Results will be reported to the EPA quarterly or as required by permit.

ATTACHMENT “L”

Construction Procedures

Attachment L
Construction Procedures
Sedat #4A Injection Well

Construction Details For:

Well Name: Sedat #4A
Location: Plum Boro, Allegheny Co, PA
(See AOR Map for Well Location)

The Sedat #4A injection well will be a repurposed depleted natural gas well that was drilled through the Upper Devonian Bradford Sands to a total casing depth of 3,886' and will be plugged back to 1,850' to just below the Murrysville injection zone.

The Sedat #4A was rotary air drilled with drilling operations starting on 6/21/2004 and finishing on 6/24/2004 reaching a Total Drilled Depth of 3,925'. The company installed 31' of 16" casing as conductor pipe which was sanded in, 302' of 13⅜" casing cemented to surface, 564' of 9⅝" casing cement-balanced through the mine and grouted to surface, 1,906' of 7" casing cemented to surface, and 3,886' of 4½" casing cemented to 2,400±'. Four sand formations were hydrofracked and the well was produced until 2018 through the 4 ½" casing. The company plans to plug back the Sedat #4A to a depth of 1,850' in accordance with Pennsylvania Department of Environmental Protection regulations. The uncemented portion of the 4½" casing will be removed and three cement plugs placed through and above the produced formations. A 7" cast iron solid bridge plug will be set at 1,850' in the 7" casing just below the Murrysville injection zone. A string of 4½" casing will be installed to a depth of approximately 1,680' and cemented to surface. The injection string will be made up of 2⅞" 6.5# L80 tubing on a WOS AS1-X Packer set on tension around 1,650' with a tail extended below the 4½" casing shoe. See original well record and completion report, wellbore diagram showing the wellbore configuration, and the casing cement data chart at the end of this Attachment.

The annulus between the 2⅞" injection tubing and the 4½" casing will be filled with fresh water mixed with a small amount of corrosion inhibitor and bacteria growth preventer and monitored for injection component integrity.

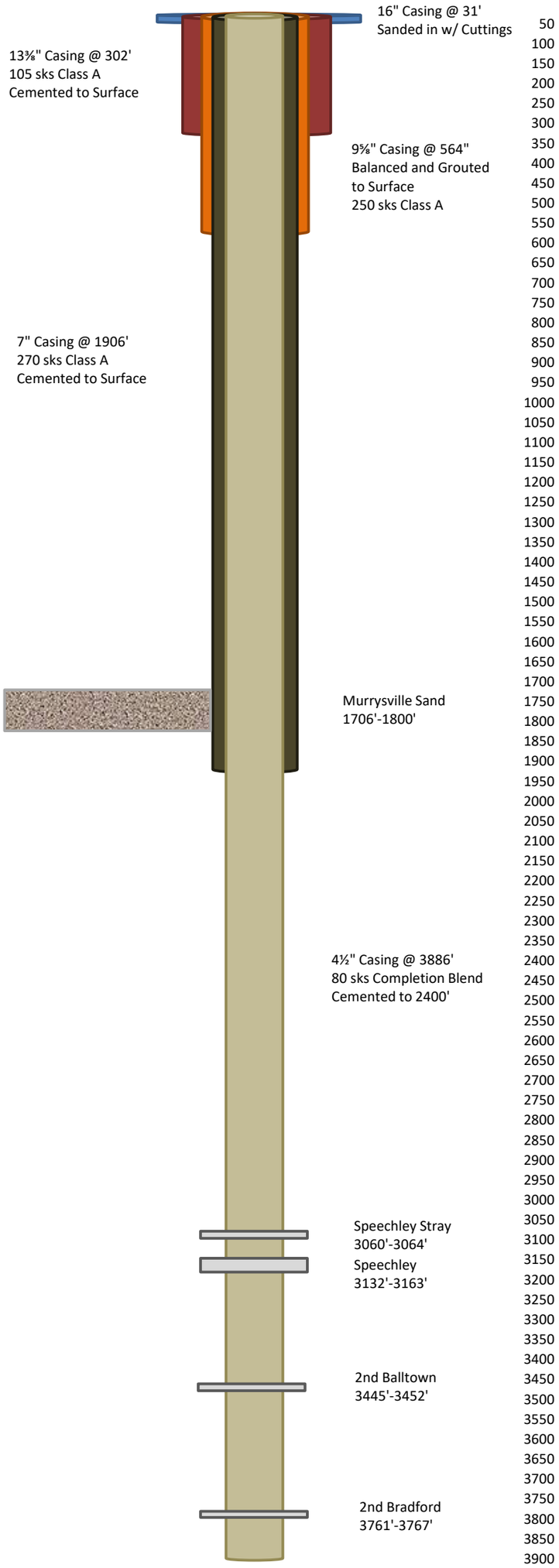
Logging Program:

The following open hole well logs were run: Gamma Ray, Compensated Density, Neutron, Dual Induction, Temperature and Caliper. The logs were run from TD to the bottom of the 7" with the Gamma Ray run to surface.

Cement bond logs will be run on the existing 7" casing and the new 4½" casing to verify a good cement bond to surface.

Penneco Oil Company

Sedat #4A 003-21644



5500-FM-OG0004 Rev. 2/2001

Client Id | Sub-facility Id

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL RECORD AND COMPLETION REPORT

Well Operator	DEP ID#	Well API # (Permit / Reg)	Project Number	Acres
Penneco Oil Company, Inc.	7674	37-003-21644-00		69.54

Address	Well Farm Name	Well #	Serial #
200 Rt. 22, PO Box 300 AUG 20 2004	Sedat	4A	PS-748

City	State	Zip Code	County	Municipality
Delmont	PA	15626	Allegheny	Plum Borough

Phone	Fax	USGS 7 5 min. quadrangle map
724-468-8232	724-468-8230	New Kensington East

Check all that apply: ☒ Original Well Record ☒ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete Log of Formations on back (page 2)

Well Type: ☒ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method: ☒ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation	Total Depth – Driller	Total Depth - Logger
06/21/04	06/24/04	1068 ft.	3925 ft.	3925 ft.

Casing and Tubing

Cement returned on surface casing? ☒ Yes ☐ No
Cement returned on coal protective casing? ☒ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run
17"	16"	N/A	N/A	31	sanded in with cuttings	N/A	N/A	31	6/21/04
15"	13 3/8"	48#	thread	302	105 sks Class A Regular	Float Shoe	13 3/8"	302	6/21/04
12"	9 5/8"	29.3#	thread	564	100 sks Class A Regular	Float Shoe	9 5/8"	564	6/22/04
3/4"	7"	19.41#	thread	1906	130 sks Class A Regular	Float Shoe	7"	1906	6/24/04
o 1/4"	4 1/2"	9.5#	thread	3886	80 sks Completion Blend Cement	Float Shoe	4 1/2"	3886	6/24/04

COMPLETION REPORT

Perforation Record

Date	*Interval Perforated* From	To
7/19/04	3054	3767
7/19/04	3445	3452
7/19/04	3132	3163
7/19/04	3054	3064

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection Rate
7/19/04	3054-3767	Water	11,634 gal	Sand	10,000#	28.4
7/19/04	3445-3452	Water	15,918 gal	Sand	11,000#	28.4
7/19/04	3132-3163	Water	36,456 gal	Sand	50,200#	26.7
7/19/04	3054-3064	Water	15,246 gal	Sand	15,200#	27.7

JAN 29 2008
DEP, SOUTHWESTREGION
CLERICAL

Natural Open Flow	Not Taken	Natural Rock Pressure	Not Taken	Hours	Days
After Treatment Open Flow	581 MCFPD	After Treatment Rock Pressure	500 PSI	72 Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Address	City - State – Zip	Phone
Hill Drilling	P.O. Box 309	Bradford, PA 16701	814-368-3831
BJ Services Company	Route 2, Box 506	Clarksburg, WV 26301	304-624-9802

5500-FM-OG0004 Rev. 2/2001

LOG OF FORMATIONS

Well API#: **37-003-21644**

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine; ft.)	Source of Data
Clay	0	6				Drillers Log
Shale – R bed	6	30				
Sand	30	34				
Sand & Shale	34	50				
Sand & Shale	50	100			Damp @ 100	
Shale & Sand	100	330				
Shale & Sand	330	440			1" @ 440	
Shale	440	510			3" @ 510	
Mine	510	520				
Shale & Sand	520	577				
Shale	577	760				
Sand & Shale	760	940				
Shale	940	1030				
Sand	1030	1150				
Sand & Shale	1150	1775				
Murrysville	1775	1870			2" @ 1789'	
Shale	1870	1900				
100'	1900	1922				
Sand 100'	1922	1935				
Sand & Shale	1935	2240				
Sand	2240	2245				
Shale & Sand	2245	2300				
5th Sand	2300	2330				
Shale	2330	2700	Show @ 2335			
Shale	2700	3000				
Sand & Shale	3000	3925				

Please delete empty rows if necessary to make all of page 2 fit on one page.

Well Operator's Signature:

Title: Vice President

Date: 8/19/04

DEP USE ONLY

Reviewed by: MA

Date: 11/24/08

Comments:

5500-PM-OG0002 Rev 3/97

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program

WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G
	Permit #	
	Project #	C

Well is located on topo map 5366.42 feet south of latitude 40 ° 32 ' 30 "

Denotes location of well on topo map.

True Latitude NORTH: 40 ° 31 ' 36.9 "

True Longitude WEST: 79 ° 42 ' 39.7 "

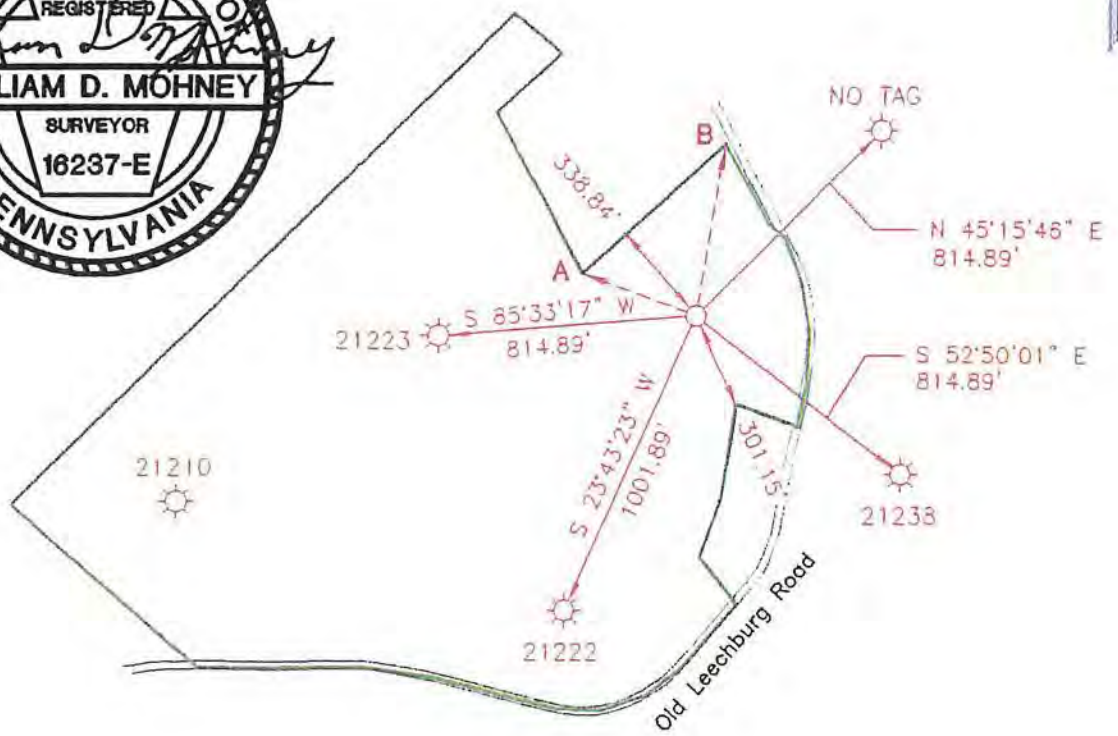
Loc-A	N 70°03'58" W	384.91'
Loc-B	N 09°11'04" E	537.62'
A-B	N 48°15'12" E	600.00'

Proposed Well Location
Existing Well
Plugged Well

Lease Line
Property Line
Roads
Streams/Water

Well is located on topo map 749.80 feet west of longitude 79 ° 42 ' 30 "

COMMONWEALTH OF PENNSYLVANIA
REGISTERED
WILLIAM D. MOHNEY
SURVEYOR
16237-E



Surveyor or Engineer: W.D. Mohney & Associates	Dwg. #: sedatplum	Date: December 15, 2003	Scale: 1" = 600'	Tract Acreage: 69.54 Acres	
Applicant / Well Operator Name: Penneco Oil Company, Inc.	DEP Co. #: 7674	Well (Farm) Name: SEDAT		Well #: 4 A	Serial #: PS-748
Address: P.O. Box 300, 200 US Route 22, Delmont PA 15626		County - Code: Allegheny – 65		Municipality: Plum Borough	
Surface Owner: Sedat Inc.		USGS 7½ Quadrangle Map Name: New Kensington East, PA			Map Section: 7
Surface Lessor: n/a		Angle & Course of Deviation (Drilling): None		Surface Elevation: 1068 ±	Anticipated Total Depth: 3800' ±

Surface Owner or Water Purveyor with a Water Supply within 1000'	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
See Attached Sheet		Noncoal Area	N/A

WOS
Workover Solutions

Production Packer

Reliable and Effective

The Workover Solutions AS1-X Packer is designed for applications where a high pressure production packer is needed. The packer is designed for operations in 7" casing. The packer is rated for pressures of up to 7,000 psi. The packer features a large internal by-pass that reduces swabbing when running and retrieving.

The WOS AS1-X Production Packer can be set in tension or compression. It holds pressure from both above and below allowing casing to be isolated and protected during the production of the well. Secondly, the WOS Multi-set Production Packer is used for long term zonal isolation and pressure integrity for the production of oil and gas wells. The WOS Production Multi-set packer can be set and reset multiple times for leak detection.

Applications / Features

- Production packer
- Zonal isolation
- Protection of casing during production
- Internal bypass to reduce swabbing when running and retrieving
- Available in 7" casing

Benefits

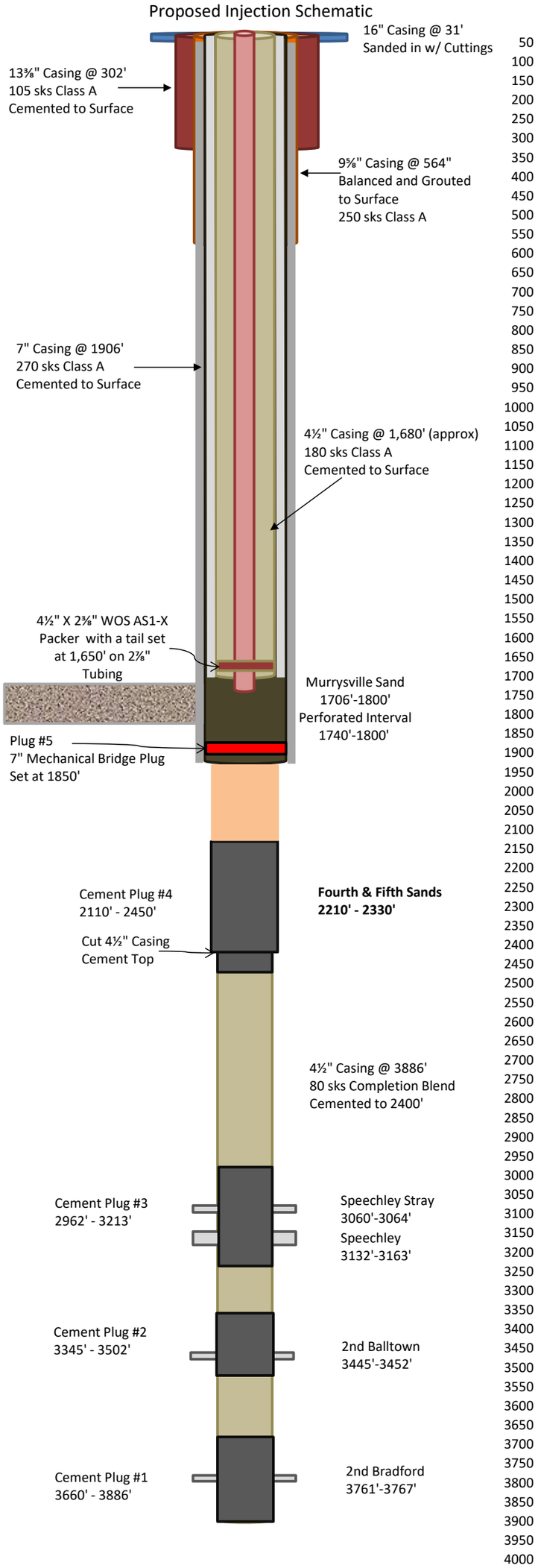
- Rated for up to 7,000 psi
- Holds pressure from above or below
- Can set tubing in compression or tension neutral
- Right hand set and right hand release

OD	Weight lbs / ft	Recommended Hole Size	Max OD of Tool
7"	17.0 – 26.0	6.276 – 6.538	6.125
7"	26.0 – 32.0	6.094 – 6.276	5.875
7"	35.0	6.004	5.812

Penneco Oil Company

Sedat #4A 003-21644

Proposed Injection Schematic



ATTACHMENT “M”

Construction Details

Attachment M
Casing and Cement Data
Penneco Sedat #4A Injection Well

Casing	Size Inches	Type	Weight Lbs/Ft	Grade	Set Depth Feet	Internal Yield Pressure PSI	Collapse Pressure PSI	Joint Yield Lbs	Body Yield Lbs
Conductor	16”	N/A	N/A	N/A	31	N/A	N/A	N/A	N/A
Surface	13⅜”	LS	48	H-40	302	1730	740	322000	541000
Mine String	9⅝”	ST&C	26	H-40	564	2270	1370	254000	365000
Intermediate String	7”	LT&C	20	J-55	1906	3740	2270	257000	316000
Integrity Buffer String	4½”	LT&C	10.5	J-55	1680	4790	4010	203000	166000
Injection String	2⅞”	EUE	6.5	L-80	1750	9660	8000	145000	114000

Cement Data

Casing	Size Inches	Class	Amount Sacks	Volume BBLs	Top of Cement
Conductor	16	Sanded in			
Surface	13⅜”	Class A	105	47.4	Surface
Mine String	9⅝”	Class A	250	Balance/Grout	Surface
Intermediate String	7”	Class A	270	78.5	Surface
Integrity Buffer String	4½”	Class A	180	80	Surface
Injection String	2⅞”				

Attachment M
Formation Tops and Bottoms
Penneco Sedat #4A Injection Well

Formation	Top	Bottom	Thickness
*Riddlesburg Shale	1505’	1705’	200’*
Murrysville Sand	1706’	1800’	94’
Riceville/Oswayo Shale	1801’	1883’	82’
Hundred Foot (Venango)	1884’	1978’	94’

*The top of the Riddlesburg is difficult to determine from the well log, so the 200’ interval of low permeability shale/slit section from 1,505’ to 1,705’ shown on the gamma ray log is included as part of the upper confining zone.

ATTACHMENT “O”

Plan for Well Failures

Attachment O
Plans for Well Failures
Sedat #4A Injection Well

Plans for Well Failures for Sedat #4A Injection Well

If there is a well failure that involves equipment the well will be shut-in until the faulty equipment is repaired or replaced. If the failure poses no environmental or operational hazard, and the well has been returned to a safe operating condition, the well will be placed back into operation and nothing further will be done.

If there is a casing leak or some other major failure the well will be immediately shut-in and the Pennsylvania DEP and the EPA notified of the problem**.** Depending on the condition, the corrective action may include squeezing off the leak with cement or running an additional string of casing. The well will not be placed into service until it has been determined that the problem has been corrected and approval is received from the EPA to resume operation. Any fluid produced during the shut-in will be stored on site or disposed of at another approved facility.

ATTACHMENT “P”

Monitoring Program

Attachment P
Monitoring Program
Sedat #4A Injection Well

Monitoring Program for Sedat #4A Injection Well

The Sedat #4A injection well will be monitored for the well's entire life in compliance with all EPA monitoring guidelines and reporting requirements.

The injection site is located so that the facilities cannot be seen from public roads or public or private properties adjacent to the site. The access road is gated and will be locked when the site is not operating.

There will be a second monitoring well on the lease, identified by its Pennsylvania issued permit number, 003-21222, converted in addition to the monitoring well (003-21210) permitted for observation of the Sedat #3A injection well. This is a depleted gas well that will be adapted for use as an observation well and is 1,002' to the south west of the Sedat #4A, see well plat map at end of Attachment. The well has satisfactory spacing and placement to provide adequate sampling area without having to drill a well or wells for the specific propose of sampling. A monitoring string set on a packer immediately above the Murrysville Sand will be installed to isolate the Murrysville injection zone. Penneco will sample, monitor, and record the fluid level in the Sedat #2A monitoring well as required by permit. The results will be reported as required by permit or according to EPA guidelines. Should the fluid level rise to within 100' of the base of the USDW, Penneco will stop disposal operations immediately, notify the EPA, and wait for instructions on how to precede.

Pressure and rate monitoring will be at the well site (wellhead); both injection pressure and the pressure on the 7" by 4 ½" annulus will be monitored. The company will also conduct quarterly mechanical integrity testing as required by Pennsylvania Oil and Gas regulations. Pressure will be measured by use of a continuously recording pressure gage and the injection rate by a continuously recording flow meter. Results will be reported to the EPA as required by the injection permit or according to EPA guidelines, but not less than annually.

The specific gravity of each truck load will be monitored to ensure the specific gravity of the fluid to be injected does not exceed the allowed value.

Injection fluids will be sampled and analyzed quarterly with the sample taken at the injection site (wellhead). The results will be reported as required by the permit or according to EPA guidelines.

The company will also be prepared to conduct any other monitoring or sampling as required by the permit.

6190'S 40°32'30"
(G)

RE

L 2

DF 39254
39255

3-4: Rev. 6/84

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
BUREAU OF OIL AND GAS REGULATION
PITTSBURGH, PENNSYLVANIA 15206-2988

NEW KENSINGTON EAST

~~21222~~

Office Use Only

003-21222

WELL RECORD

PERMIT NO. 37-003-21222-00 | PROJECT NO. | TYPE OF WELL: DEV — Gas and Oil

RENTON FIELD

WELL OPERATOR: Penneco Energy Corporation (OIL CO. INC. CORRECTION MADE BY PHONE BY AUDREY WOJNICKI-PENNECO 4-25-89) | TELEPHONE NO.: 412-468-8232

ADDRESS: 200 Route 22, Delmont, PA | ZIP: 15626

FARM NAME	FARM NO.	SERIAL NO.	ACRES
Sedat #2A		PS-8	70

TOWNSHIP	COUNTY
Plum Borough	Allegheny

DRILLING COMMENCED	DRILLING COMPLETED
1-12-89	1-19-89

ELEVATION	QUADRANGLE
1162'	New Kensington East ☒ 7½' ☐ 15'

CASING AND TUBING RECORD

PIPE SIZE	AMOUNT IN WELL	MATERIAL BEHIND PIPE: CEMENT (SKS.)	MATERIAL BEHIND PIPE: GEL (SKS.)	PACKER: TYPE	PACKER: SIZE	PACKER: DEPTH	DATE RUN
13-3/8"	16	Cuttings	None	N/A	N/A	16	1-12-89
9-5/8"	653	225	5	Float Shoe	9-5/8"	663	1-13-89
7"	1,985	280	11	Float Shoe	7"	1,995	1-17-89

T.D.	D.D.	D.P.I.	Class	O	G	Loss
4323		2375	D	1	1	

PERFORATION RECORD

DATE	INTERVAL PERFORATED FROM	TO

STIMULATION RECORD

DATE	INTERVAL TREATED	AMOUNT FLUID	AMOUNT SAND	INJECTION RATE

NATURAL OPEN FLOW	NATURAL ROCK PRESSURE	
294 MCF	50#	72 HRS. DAYS
AFTER TREATMENT OPEN FLOW	AFTER TREATMENT ROCK PRESSURE	
N/A	N/A	HRS. DAYS

REMARKS:

Good cement returned to surface after setting 9-5/8" casing and 7" casing. No water encountered in Renton Mine. Well is to be produced naturally.

RECEIVED
JUN 2 1989
PA GEOLOGICAL SURVEY
~~(Oil & Gas Geology Division)~~

PRODFM - Bradford

PMTP - BRALLIER

(FORMATION ON REVERSE SIDE)

N. 285
4-25-89

ER-OG-4: Rev. 6/84

FORMATIONS

NAME	TOP	BOTTOM	GAS AT	OIL AT	WATER AT (FRESH OR SALT WATER)	SOURCE OF DATA
Clay and Shale	0	10				Driller's Log
Shale and Sand	10	16				
Sand and Shale	16	105			Damp @ 60'	
Sand and Shale	105	460				
Sand and Shale	460	495				
Sandy Shale	495	611				
Shale	611	621				
Shale	621	669				
Sand and Shale	669	865			1/2" @ 700'	
Shale	865	940				
Sand and Shale	940	1040				
Sand	1040	1219				
Sand and Shale	1219	1490				
Sand and Shale	1490	1950				
Sand	1950	2029				
Sand and Shale	2029	2210				
Red Rock	2210	2330				
Sand	2330	2445	2375'			
Sand and Shale	2445	2485				
Shale	2485	2600				
Sand and Shale	2600	3140				
Shale and Sand	3140	3800				
Shale	3800	4323				
t.D.	4323					

GEOPHYSICAL LOG DATA

Fourth					2334-2351	
Fifth					2391-2426	
Speechley Stray					3170-3188	
Speechley					3250-3286	
2nd Balltown					3561-3570	
2nd Bradford					3874-3884	

March 22, 1989
DATE

APPROVED BY

Vice-President
TITLE

CORRELATED LOGS - DO NOT REMOVE
SEDAT 2A - PS-8

ECO

ALLEGHENY NUCLEAR SURVEYS INC.

PENNECO OIL COMPANY, INC.

SEDAT #2A PS-8

APPALACHIAN SUITE

LOCATION PLUM BORO
PRVNC/CO. ALLEGHENY
FIELD PLUM BORO
WELL: SEDAT #2A PS-8
COMPANY: PENNECO OIL COMPANY INC.

COMPANY PENNECO OIL COMPANY INC.
WELL SEDAT #2A PS-8
FIELD PLUM BORO
PROVINCE/COUNTY ALLECHENY
COUNTRY/STATE USA / PA
PERMIT NUMBER 37-003-21222

LOCATION PLUM BORO

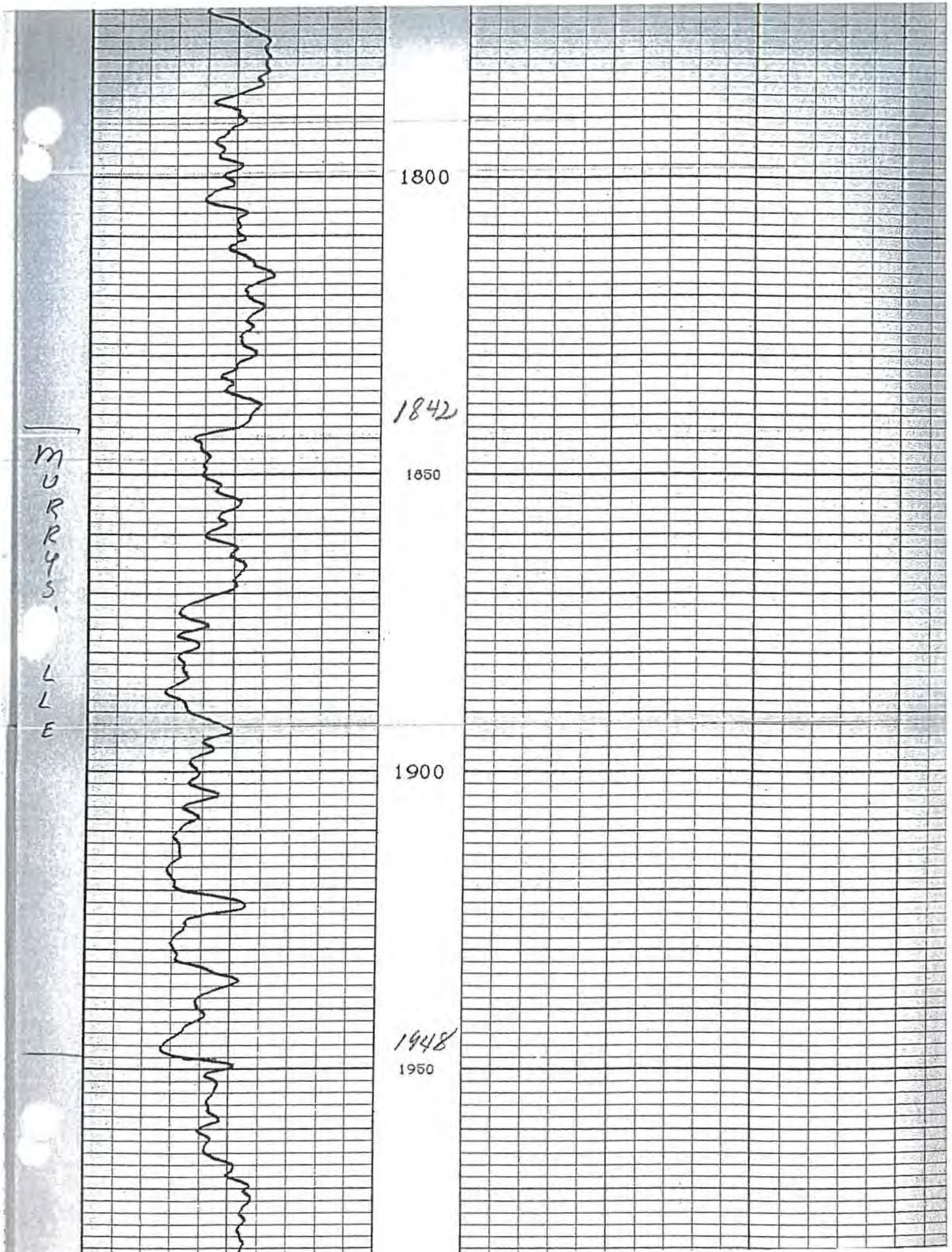
LSD	SEC	TWP	RGE

OTHER SERVICES
ANALYSIS

PERMANENT DATUM GROUND LEVEL . ELEVATION 1162 FT.
LOG MEASURED FROM K.B., 10 FT. ABOVE PERMANENT DATUM
DRILLING MEASURED FROM K.B.

ELEVATIONS
KB 1172 FT.
DF 1172 FT.
GL 1162 FT.

DATE	19-JAN-89			
RUN NUMBER	ONE			
DEPTH-DRILLER	4316 FT.			
DEPTH-LOGGER	4323 FT.			
FIRST READING	4323 FT.			
LAST READING	0			
CASING-DRILLER	1993 FT.			
CASING-LOGGER	1998 FT.			
BIT SIZE	6 1/4 IN.			
HOLE FLUID TYPE	AIR DRILLED			
DENS./VISC.				
PH/FLUID LOSS				
SAMPLE SOURCE				
RM @ MEAS TEMP				
RMF @ MEAS TEMP				
RMC @ MEAS TEMP				
SOURCE: RMF/RMC				
RM @ BHT				
TIME SINCE CIRC	3 HRS.			
MAX REC TEMP				
EQUIPMENT/BASE	"262" ELD.			
RECORDED BY	M. RIGGLEMAN			
WITNESSED BY	D. TATLOCK			
WITNESSED BY	T. JACOBS			

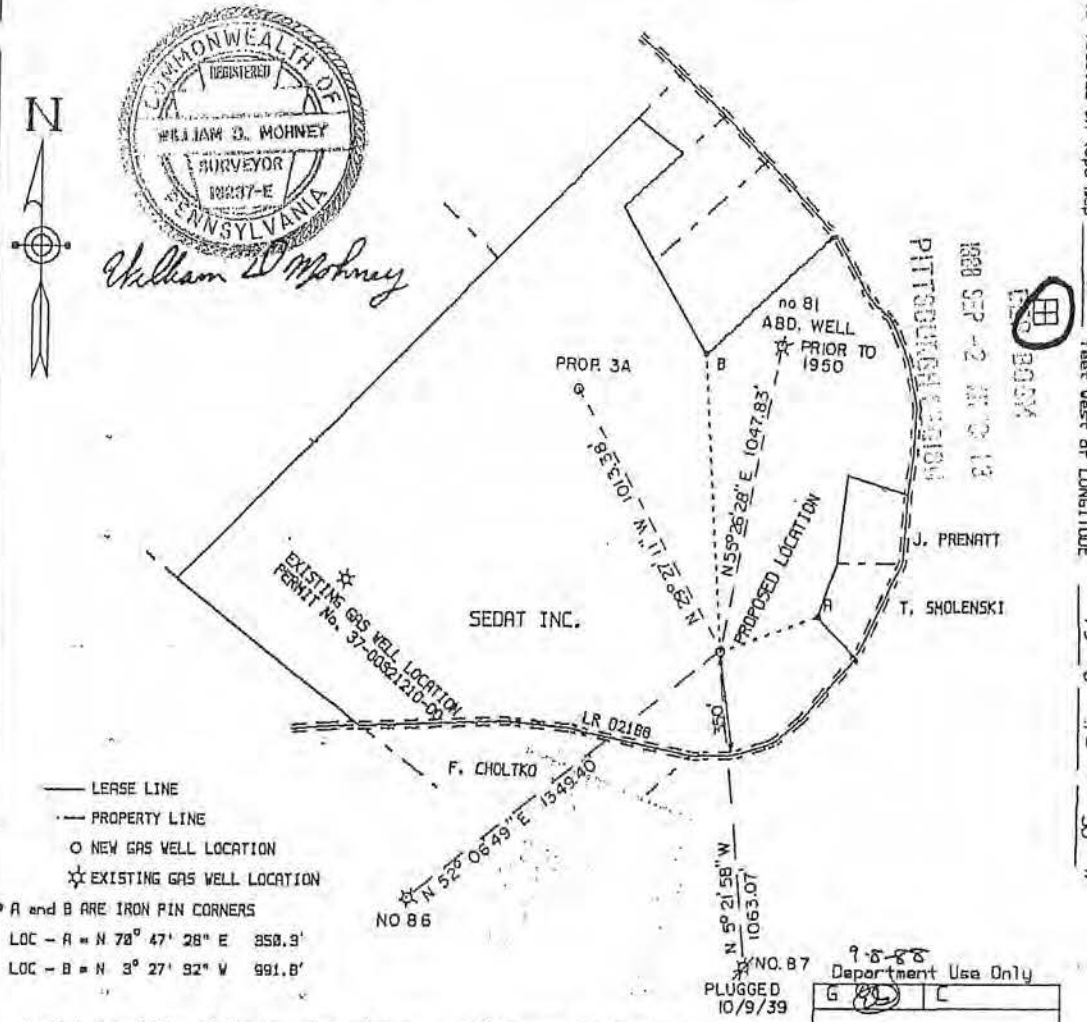

1800
1842
1850
MURRAYS.
LLE
1900
1948
1950

WELL LOCATION PLAT

Well is located on topo map 6190 feet south of LATITUDE 40 ° 32 ' 30 "

NOTE: The locations of the abandoned gas wells No. 80, 81, 86 and 87 have been located on the maps from the old Renton Mine maps.due to the absence of any evidence in the field.

Well is located on topo map 1290 feet west of LONGITUDE 79 ° 42 ' 30 "



—— LEASE LINE

·—· PROPERTY LINE

O NEW GAS WELL LOCATION

☆ EXISTING GAS WELL LOCATION

* A and B ARE IRON PIN CORNERS

LOC – A = N 78° 47' 28" E 950.9'

LOC – B = N 3° 27' 32" W 991.8'

9-8-88
Department Use Only
G | C

Include description of the property and courses and distances of the well(s) locations to two or more permanent identifiable points or land marks, all buildings and water supplies within 200', all springs, bodies of water and streams within 100' identified on the most current 7 1/2 topographic map and wetlands within 100'.
Reference to buildings, springs, bodies of water wetlands and water supplies within 1,000 is not required for well plugging

⊞ Denotes location of well on 7 1/2" topo map Permit No. 37-003-01222-00 Project No. _____

PENNECO OIL COMPANY INC.
Well Permittee/Registrant
200 U.S. ROUTE 22
Address
DELMONT PA 15626

SEDAT INC.
Surface Owner
N/A
Surface Lessor (If any)
SEDAT
Farm Name
2A PS - 8
Well No. Tract Serial No.
69.5 1162
Acres Ground Elevation
NONE 3400'
Type of Deviation (Drilling) Anticipated TD
HENY PLUM BORO
Quadrangle Municipality
KENSINGTON EAST G
Topo Quadrangle Section

Commonwealth of Pennsylvania
Department of Enviromental Resources
Bureau of Oil and Gas Management

Revision	☐
Alteration	☐
Storage Recondition	☐
New Location	☒
Drill Deeper	☐
Abandonment	☐
Registration	☐
Plugging	☐

W. D. MOHNEY
Surveyor/Engineer 16237-E
S-2A
Drawing Number
7-12-88, 8-29-88
Date
1" = 500'
Scale

Surface landowner and water purveyor with water supply within 1,000'	Approximate course and distance to water supply
J. PRENATT	N 86° E 825'
T. SMOLENSKI	N 61° E 995'
F. CHOLTKO	S 49° W 584'

RECEIVED
SEP 26 1988
PA GEOLOGICAL SURVEY

Owner/Operator/Lessee	Workable Coal Seams Name of Seam
VILLA COAL COMPANY	UPPER FREEPORT
SEDAT INC.	ALL OTHERS
CONSOLIDATION COAL CO.	UPPER FREEPORT

Pennsylvania Geological Survey

5500-PM-OG0002 Rev 3/97

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	
	Permit #	
	Project #	

Well is located on topo map 5366.42 feet south of latitude 40 ° 32 ' 30 "

Denotes location of well on topo map.

True Latitude: NORTH
40 ° 31 ' 36.8 "

True Longitude: WEST
79 ° 42 ' 39.7 "

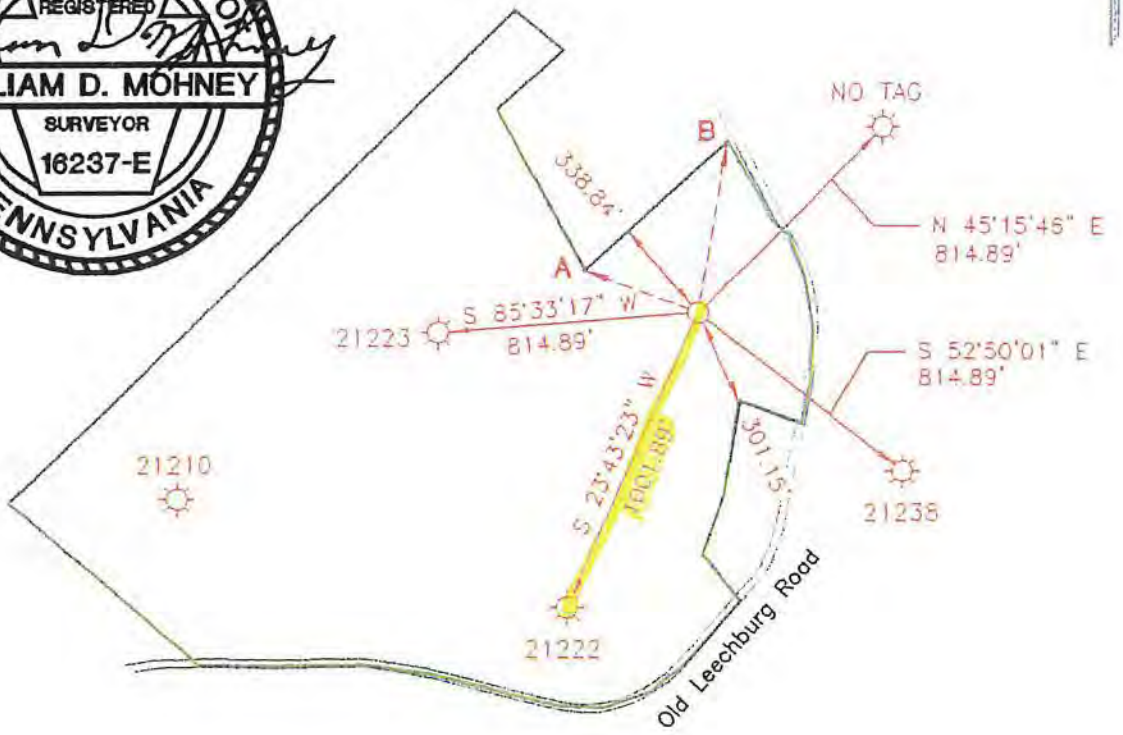
Loc-A	N 70°03'58" W	384.91'
Loc-B	N 09°11'04" E	537.62'
A-B	N 48°15'12" E	600.00'

Proposed Well Location
Existing Well
Plugged Well

Lease Line
Property Line
Roads
Streams/Water

Well is located on topo map 749.80 feet west of longitude 79 ° 42 ' 30 "

COMMONWEALTH OF PENNSYLVANIA
REGISTERED
WILLIAM D. MOHNEY
SURVEYOR
16237-E



Surveyor or Engineer: W.D. Mohney & Associates	Dwg. #: sedatplum	Date: December 15, 2003	Scale: 1" = 600'	Total Acreage: 69.54 Acres	
Applicant / Well Operator Name: Penneco Oil Company, Inc.	DEP Cd: 7674	Well Farm Name: SEDAT		Well #: 4 A	Series #: PS-748
Address: P.O. Box 300, 200 US Route 22, Delmont PA 15626	County – Code: Allegheny – 65		Municipality: Plum Borough		
Surface Owner: Sedat Inc.	USGS 7½ Quadrangle Map Name: New Kensington East, PA			Map Section: 7	
Surface Lessor: n/a	Angle & Course of Deviation (Drilling): None		Surface Elevation: 1068 ft.	Anticipated Total Depth: 3800' ft.	

Surface Owner or Water Purveyor with a Water Supply within 1000'	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
See Attached Sheet		Noncoal Area	N/A

Titanium Environmental Services, LLC

P.O. Box 4029
Longview, Texas 75606-4029

Phone (903) 234-8443
Fax (903) 234-1641

September 28, 2016

Mr. Marc Jacobs
Penneco Environmental Solutions, LLC
6608 Route 22
Delmont, Pa 15626-2408

RE: Proposal for a Surface Facility for your proposed Sedat #3 SWD

Dear Mr. Jacobs,

Titanium Environmental Services, LLC (TES) is pleased to present the draft drawings and process flow for Penneco Environmental Solutions, LLC (PES) Sedat #3 Salt Water Disposal (SWD) well surface facility. As previously discussed, PES and TES agree that safe and environmentally sound design and operations are paramount to meeting PES's expectations for their operation.

In that vein, TES has proposed a facility that would be acceptable for Resource Conservation and Recovery Act (RCRA) waste operations. TES believes that ultimately the requirements for wells and surface facilities that manage class II waste related to exploration and production will be raised to match those presently applicable to class 1 non-hazardous well and facility operations. Some of these requirements will be very expensive or even impossible to incorporate into existing wells and surface structures. As the cost to construct the well(s) and surface equipment with the safeguards that will be regulatory mandates is not significant, if incorporated with the construction design, we recommend and have incorporated these protective components into our plans.

The entire surface facility will be built atop a multilayered secondary containment system/structure. The facility will begin with a base layer of clay, felt liner, 60 mil High Density Polyethylene (HDPE) liner, and another felt liner, perforated liquid collection pipe system covered by pea gravel, concrete containment floor and walls. The edge of the HDPE liner will be folded up against the containment walls to keep rainwater from entering the system. The liquid collection system piping will be extended from under the containment to allow for inspection or liquid (condensation) removal and as the last mechanical containment to intercept a leak.

Notice the truck unloading pad is built to prevent rainwater run on and all rainwater or truck leakage will be collected by the truck bay collection system which empties into the solids settling tank containment which can hold all the trucks that could be in the truck bays. All sump pumps automatically empty the sumps without human intervention. If the receiving tanks can't hold the trucks trying to unload (Level transmitters) the system closes all unloading lines until there is sufficient room to

continue unloading. Further if there is insufficient room in the storage tanks, the system will not let the transfer pumps move fluid from the receiving/settling tanks to the storage tanks. Thus the unloading valves won't open nor will the transfer pumps transfer fluid into tanks that are already full. The water filtering pumps will transfer filtered water into the pre-injection tanks (Filtered Water) as long as the fluid level in the filtered water tanks does not exceed the upper limit established by the operator. The injection pumps will inject water into the well as long as there is sufficient filtered water to inject and all control parameters for the well are within preset value ranges.

All liquid unloading at the facility will enter tanks that are equipped with internal piping that allows fluids to be introduced under the liquid level in the tanks (submerged loading). Submerged loading is a recognized method of reducing emissions. All liquid transfer systems are connected together by a vent header to vapor balance the exchange between the receiving and transferring tanks. All used filters and tank cleanout solids are collected and disposed of to a permitted facility.

TES suggest Standard Operating Procedures (SOP) and daily facility inspections which would not be addendums to the Permit as they will have to be modified over time and could be "Permit Modifications" if they were addendums. All waste should have an approved profile to be accepted at the facility. All trucks would be unloaded through Mass Flow Meters recording density and volume. Likewise Mass Flow Meters would be used for injection measurement for reporting of density and volume.

Simplicity in design with many passive controls that don't require human attention or maintenance is TES's design goal. The design also reduces the number of incidents/accidents caused by operator error or inattention. Tanks that might fail, can be valved out of operation and bypassed with no effect on the operation. There is one transfer pump (plus one standby), one filter pump (plus one standby), one charge pump (plus one standby) and one injection pump (plus one standby). Three unloading bays and only one or two required. Since the PLC logic instructs the continuous filtration and injection of water, the only operator interaction is changing the filters when required and making sure inbound trucks/loads are approved into the facility and then enabling the specific unloading valve. All sump pumps activate automatically and are freeze protected as is the transfer pump. All containments have a fluid level alarm to detect leaks and have reduced height walls between them that together can contain 110% of any of the tank systems plus a twenty-five year 24 hour rainfall event.

If you have any questions about this letter or any of the drawings or process flow diagram please call TES' Special Projects Manager, Lynn Goldston – 903-235-1477.

Penneco Environmental Solutions
Pa. FACILITY
SECONDARY CONTAINMENT CALCULATIONS

Containment and Spill Calculations

NOTE:

Total Volume of Primary Containments (Tanks)	7,120	BBL
Total Storage inside Secondary Containment (Minus Tank Pads)	6512	BBL

Because (4) decimal places were used in calculations there may be minuscule rounding differences!

1 cuft =	7.4805	Gallons	1 BBL=	42	Gallons

Spill Calculations

	Tanks			BBL		
Tank #1	1	Gun Barrels #1 = 1x500	NA	500		
Tank #2	1	Gun Barrels #2 = 1x500	NA	500		
Tank #15	1	Oil Tank = 1x300	NA	300		
Note: No Tank Pads Required	2	WEIR tanks = (2x255) = 510	NA	510		
Note: No Tank Pads Required	2	WEIR tanks = (2x255) = 510	NA	510		
					Gallon	
Tanks #3 thru #12 Manifolded Together	10	Storage Tanks = 10x400		4,000	168,000	MAX Spill
Tanks #13 & #14 Manifolded Together	2	Filtered H2O Tanks = 2x400		800	33,600	Second Worst
	5"	Rainfall on 13,332 sqft		989	41,105	
Maximum Worst Case Spill (67% of all tanks) + 100 yr. 24 hr. Rainfall (5") to contain =				5,789		5789/6512=89%

	-5,789	
Total Storage inside Secondary Containment Walls - Minus Tank Pads	6,512	(6786 - 274 (pads))
	723	723/6512=11%

	BBL	Gallons	Cubic Feet
Excess capacity =	723	30,366	4,059

SEE Calculations on Page 2

Measurements based on Drawing File Name : Penneco - Sheet 1 - 6 - 7 - 2018

Penneco Environmental Solutions
Pa. FACILITY
SECONDARY CONTAINMENT CALCULATIONS

NOTE: Based on all tanks full and power off because of 100 year 24 hour Rainfall Event (tanks can't actually be filled completely ~90%).

See "Sheet With Areas"	AREA	L (ft)	W (ft)	H (ft)	Surface Area (ft^2)	Capacity (ft^3)	Capacity (GAL)	Capacity (BBL)
Weir Settling Tank Containment	W	119.25	24	3	2,862	8,586	64,228	1,529
Oil Tank Containment	X	24	24	3	576	1,728	12,926	308
Gun Barrel & Water Storage Tank Containment	Y	144	46	3	6,624	19,872	148,652	3,539
Unloading Pad with slope considered	U	59	53		3,127			
trough 'CuFt		(59x3x1.91)/2				169	1,260	30
Side 1 CuFt		(59x25x.667)/2				492	3,680	88
Side 2 CuFt		(59x25x.667)/2				492	3,680	88
Area above wall between containment W & X	(24x.667)	24	0.667	1	16	16	120	3
Area above wall between containment W + X and Y	(144x.667)	144	0.667	1	96	96	718	17
Area above wall between containment Y & Z	(46x.667)	46	0.667	1	31	31	232	6
						31,482	235,497	5,607
						31,482	235,497	5,607
Unroofed area open to collect rainfall					13,332			
Less 100 year 24 hour Rainfall event = 5"x144x13,332= 9,599,040 / 1728 = 5,555 CuFt					13,332	(5,555)	(41,554)	(989)
Pump Area Containment with Roof Not Subject to Rainfall accumulation	Z	48	46	3	2,208	6,624	49,551	1,180
Total SQFT of ALL Containment Areas					15,540			
CuFt Available After Rainfall						32,551		
Capacity available in Gallons after Rainfall event							243,494	5,797
Capacity in Barrels after Rainfall event Calculated on gallons as test							5,797	5,797
Total Secondary Containment volume = 38,106 CuFt 6786 BBL								
See Detail below — MAX spill - 10 manifolded 400 BBl tanks (#3 thru #12) = 4,000 BBl								(4,000)
Instead of 10% or largest use Largest 2 Tank System =800 BBL Filtered water tanks								(800)
Subtotal								997
Containment Capacity After 100 yr. 24 hour Rainfall + worst case spill + 2nd largest tank system								997
Minus Housekeeping pads (15 pads x18.26 BBL = 274 BBL								(274)
Excess Capacity								723

PA Containment Calculations

Per direct conversation between Penneco design consultant, Lynn Goldston and DEP permit application reviewer, Kevin Maskol, Penneco submits the enclosed containment calculation that represents a model of calculation that is more consistent with current expectations across the Pennsylvania oil and gas industry spectrum.

Containment and Spill Calculations

Summary

Total Volume of Primary Containments (Tanks)	7,120	BBL
Total Storage inside Secondary Containment	6787	BBL
Total Storage inside Secondary Containment (Minus Tank Pads)	6513	BBL
Worst Case Spill by Pennsylvania DEP Rule Plus 10% Precipitation	4400	BBL
Remaining Capacity after Worst Case Spill and Precipitation by PaDEP Spill Rule	1480	BBL
Remaining Capacity After 100 year - 24 hour Rainfall Event on un-covered area	491	BBL

1 CuFt =	7.4805	Gallons	1 BBL= 42	Gallons

.1781 BBL per ft^3

Primary Containment (Tanks)

	Tanks			BBL		
Tank #1	1	Gun Barrels #1 = 1x500	NA	500		
Tank #2	1	Gun Barrels #2 = 1x500	NA	500		
Tank #15	1	Oil Tank = 1x300	NA	300		
Note: No Tank Pads Required	2	WEIR tanks = (2x255) = 510	NA	510		
Note: No Tank Pads Required	2	WEIR tanks = (2x255) = 510	NA	510	Gallons	
Tanks #3 thru #12 Manifolded Together	10	Storage Tanks = 10x400		4,000	168,000	MAXIMUM Spill
Tanks #13 & #14 Manifolded Together	2	Filtered H2O Tanks = 2x400		800		
			Total Primary Containment	7120		

SEE Containment Calculations on Page 2

Measurements based on Drawing File Name : Penneco - Sheet 1 - 6 - 7 - 2018

Because (4) decimal places were used in calculations there may be minuscule rounding differences!

NOTE: Based on all tanks full and power off because of 100 year 24 hour Rainfall Event (tanks can't actually be filled completely ~90%).

See "Sheet With Areas"	AREA	L (ft)	W (ft)	H (ft)	Surface Area (ft^2)	Capacity (ft^3)	Capacity (GAL)	Capacity (BBL)
Weir Settling Tank Containment	W	119.25	24	3	2,862	8,586	64,228	1,529
Oil Tank Containment	X	24	24	3	576	1,728	12,926	308
Gun Barrel & Water Storage Tank Containment	Y	144	46	3	6,624	19,872	148,652	3,539
Unloading Pad with slope considered	U	59	53		3,127			
trough 'CuFt		(59x3x1.91)/2				169	1,260	30
Side 1 CuFt		(59x25x.667)/2				492	3,680	88
Side 2 CuFt		(59x25x.667)/2				492	3,680	88
Area above wall between containment W & X	(24x.667)	24	0.667	1	16	16	120	3
Area above wall between containment W + X and Y	(144x.667)	144	0.667	1	96	96	718	17
Area above wall between containment Y & Z	(46x.667)	46	0.667	1	31	31	232	6
Pump Area Containment with Roof	Z	48	46	3	2,208	6,624	49,551	1,180
Total Volume of ALL Containment Areas					15,540	38,106	285,048	6,787

Minus Housekeeping pads for 15 tanks on 13' diameter octagonal pads (15 pads x18.26 BBL = 274 BBL)		(274)
Note: No housekeeping pads under solids settling tanks- open 8" I-Beam support = no volume		-
	Subtotal	6,513

Pacode	§78a.64a.(d) Secondary Containment		
	Largest primary containment - 10 manifolded 400 BBl tanks (#3 thru #12)= 10 x400 BBL=		(4,000)
	plus an additional 10% of volume for precipitation	-	(400)
		Subtotal	2,113

Minus 'the footprint of remaining tanks not part of Largest group of 10 - 5ea 12' diameter tanks on pad = 5x2.33'x20 BBL/ft=	(233)
Minus the footprint of the four settling tanks - 8' "W"x2.33' "T"x 30' "L"= 559 ft^3 x .1781 BBL/CuFt=100 BBLx4 Tanks=	(400)
Remaining containment capacity calculated by Pennsylvania DEP rule= BBL	1,480

However the unroofed portion of the Penneco facility is 13,332 ft^2 (15540-2208) and PES has prepared for the very worst case:	
Less 100 year 24 hour Rainfall event 5"= (5"x144 in^2/ft^2)x13,332 ft^2= 9,599,040 in^3 / 1728 in^3/ft^3 = 5555 ft^3 x .1781 BBl/ft^3= 989 BBL	(989)
Remaining containment capacity by Penneco's environmental conscience = BBL	491

ATTACHMENT “Q”

Plugging and Abandonment Plan

Attachment Q
Plugging and Abandonment Plan
Sedat #4A Injection Well

Plugging and Abandonment Plan:

The company will plug the Sedat #4A in accordance with the Pennsylvania Bureau of Oil and Gas Management and the EPA regulations in place at the time of abandonment. The following actions will be taken:

* Move in service rig
* Set 4½" Cast Iron Bridge Plug at approximately 1,680'
* Run 2 7/8" tubing to 1,680'
* Spot solid plug from CIBP to Surface
* Retrieve and lay down tubing string
* Rig down and move out
* Haul tubing to storage or disposal
* Install monument with requisite detail

Form 7520-19 and cost estimate is attached.

OMB No. 2040-0042 Approval Expires 4/30/2022

United States Environmental Protection Agency

EPA

WELL REWORK RECORD, PLUGGING AND ABANDONMENT PLAN, OR PLUGGING AND ABANDONMENT AFFIDAVIT

Name and Address, Phone Number and/or Email of Permittee

Penneco Environmental Solutions, LLC
6608 Route 22
Delmont, PA 15626
724-468-8232
dmarcj@penneco.com

Permit or EPA ID Number	API Number	Full Well Name
	37-003-21644	Sedat #4A

State	County
Pennsylvania	Allegheny

Locate well in two directions from nearest lines of quarter section and drilling unit

Latitude: 40.526916

Longitude: -79.711027

Surface Location

[ ] 1/4 of [ ] 1/4 of Section [ ] Township [ ] Range [ ]

[ ] ft. from (N/S) [ ] Line of quarter section

[ ] ft. from (E/W) [ ] Line of quarter section.

Well Class	Timing of Action (pick one)	Type of Action (pick one)
[ ] Class I [✓] Class II [ ] Class III [ ] Class V	[✓] Notice Prior to Work Date Expected to Commence: Future Date [ ] Report After Work Date Work Ended:	[ ] Well Rework [✓] Plugging and Abandonment [ ] Conversion to a Non-Injection Well

Provide a narrative description of the work planned to be performed, or that was performed. Use additional pages as necessary. See instructions.

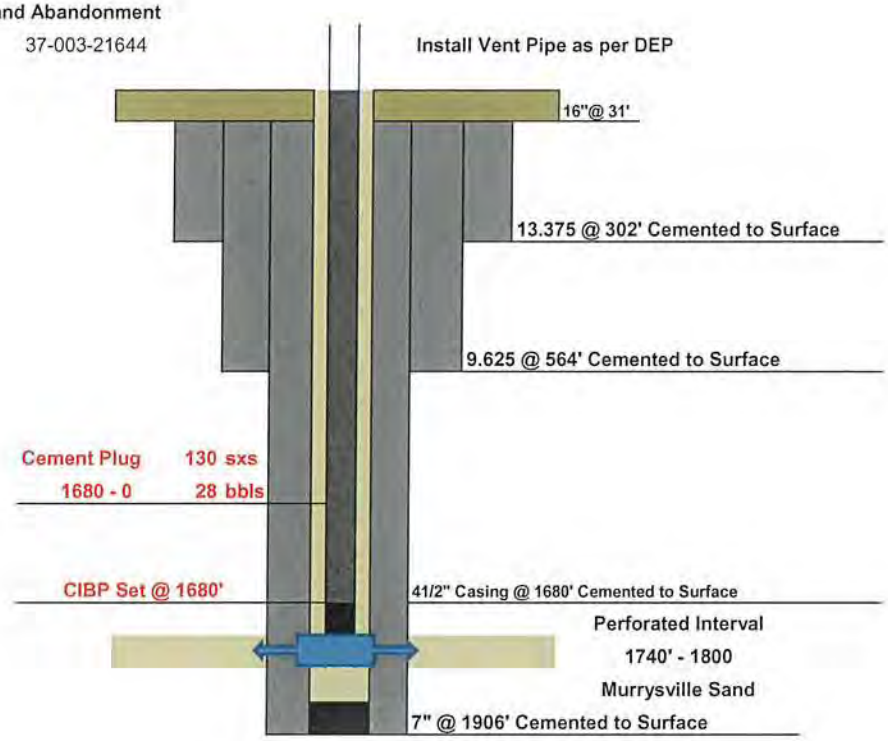
Upon the determination that the Sedat #4A well is no longer suitable for brine disposal, the well will be plugged starting with a 4½" Cast Iron Bridge Plug at approximately 1,680' (4½" casing seat depth) followed by 130 sks of Type 1 Cement from the CIBP to surface.

Certification

I certify under the penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. (Ref. 40 CFR § 144.32)

Name and Official Title *(Please type or print)*	Signature	Date Signed
D. Marc Jacobs, Jr. Senior Vice President		2/17/22

Penneco Oil Co
Sedat #4A
Plug and Abandonment
P/N 37-003-21644



ATTACHMENT “R”

Necessary Resources

STANDBY TRUST AGREEMENT

U.S. Environmental Protection Agency
Underground Injection Control
Financial Responsibility Requirement

THIS TRUST AGREEMENT (the "Agreement") is entered into as of the 23 day of March, 2016, by and between **PENNECO ENVIRONMENTAL SOLUTIONS, LLC**, owner or operator, a Pennsylvania limited liability company of 6608 State Route 22 Delmont, PA 15626 (the "Grantor"), and **FIRST COMMONWEALTH BANK**, of 600 Philadelphia Street, Indiana, Pennsylvania 15701, a Pennsylvania business corporation (the "Trustee").

WHEREAS, the United States Environmental Protection Agency ("EPA"), an agency of the United States Government, has established certain regulations applicable to the Grantor, requiring that an owner or operator of an injection well shall provide assurance that funds will be available when needed for plugging and abandonment of the injection well or wells; and

WHEREAS, the Grantor has elected to establish a trust to provide all of part of such financial assurance for the facility or facilities identified herein; and

WHEREAS, the Grantor, acting through its duly authorized officers, has selected the Trustee to be the trustee under this Agreement, and the Trustee is willing to act as trustee.

NOW THEREFORE, the Grantor and the Trustee agree as follows:

Section 1. Definitions. As used in this Agreement: (a) The term "Grantor" means the owner or operator who enters into this Agreement and any successors or assigns of the Grantor; (b) The term "Trustee" means the Trustee who enters into this Agreement and any successor Trustee; and (c) Facility or activity means any "underground injection well" or any other facility or activity that is subject to regulation under the Underground Injection Control Program.

Section 2. Identification of Facilities and Cost Estimates. This Agreement pertains to the facilities and cost estimates identified on attached Schedule A.

Section 3. Establishment of Fund. The Grantor and the Trustee hereby establish a trust fund (the "Fund") for the purpose of assuring compliance with the plugging and abandonment requirements established by EPA for the facilities identified on Schedule A. The Underground Injection Control regulations which govern the authorization to inject include a requirement for such financial assurance that the well or wells shall be plugged and abandoned at the time designated by EPA. The Grantor and the Trustee acknowledge that the Fund and all expenditures from the Fund shall be to fulfill the legal obligations of the Grantor under such regulations, and not any obligation of EPA. The Grantor and the Trustee intend that no third party have access to the Fund except as herein provided. The Fund is established initially as consisting of the property, which is acceptable to the Trustee, described in Schedule B attached hereto. Such property and any other property subsequently transferred to the Trustee is referred to as the Fund, together with all earnings and profits thereon, less any payments or distributions made by the Trustee pursuant to this Agreement. The Fund shall be held by the Trustee, IN TRUST, as hereinafter provided. The Trustee shall not be responsible, nor shall it undertake any responsibility, for the amount or adequacy of any additional payments necessary to discharge any liabilities of the Grantor established by EPA, nor shall the Trustee have any duty to collect such additional amounts from the Grantor.

Section 4. Payment for Plugging and Abandonment. The Trustee shall make payments from the Fund only for the costs of plugging and abandonment ("P&A") of the injection wells covered by this Agreement and the associated P&A Plan, only after EPA has advised the Trustee that work has been completed under the P&A Plan that complies with 40 C.F.R. § 144.28 and/or § 144.52. The Trustee shall not refund to the Grantor any amounts from the Fund unless and until EPA has advised the Trustee that the P&A Plan has been successfully completed. The Trustee shall not release any funds to the Grantor that are necessary to cover liability for any injection wells covered by this Agreement that remain unplugged.

Section 5. Payments Comprising the Fund. Payments made to the Trustee for the Fund shall consist of cash or securities acceptable to the Trustee.

Section 6. Trustee Management. The Trustee shall invest and reinvest the principal and income of the Fund and keep the Fund invested as a single fund, without distinction between principal and income, in accordance with general investment policies and guidelines which the Grantor may communicate in writing to the Trustee from time to time, subject, however, to the provisions of this Section. In investing, rein vesting, exchanging, selling, and managing the Fund, the Trustee shall discharge his duties with respect to the trust fund solely in the interest of the beneficiary and with the care, skill, prudence, and diligence under the circumstances then prevailing which persons of prudence, acting in a like capacity and familiar with such matters, would use in the conduct of an enterprise of a like character and with like aims; *except that:* (i) Securities or other obligations of the Grantor, or any other owner or operator of the facilities, or any of their affiliates as defined in the Investment Company Act of 1940, as amended, 15 U. S.C. 80a-2.(a), shall not be acquired or held, unless they are securities or other obligations of the Federal or a State government; (ii) The Trustee is authorized to invest the Fund in time or demand deposits of the Trustee, to the extent insured by an agency of the Federal or State government; and (iii) The Trustee is authorized to hold cash awaiting investment or distribution uninvested for a reasonable time and without liability for the payment of interest thereon.

Section 7. Commingling and Investment. The Trustee is expressly authorized in its discretion: (a) To transfer from time to time any or all of the assets of the Fund to any common, commingled, or collective trust fund created by the Trustee in which the Fund is eligible to participate, subject to all of the provisions thereof, to be commingled with the assets of other trusts participating therein; and (b) To purchase shares in any investment company registered under the Investment Company Act of 1940, 15 U.S. C. 80a-I *et seq.,* including one which may be created, managed, underwritten, or to which investment advice is rendered or the shares of which are sold by the Trustee. The Trustee may vote shares in its discretion.

Section 8. Express Powers a/Trustee. Without in any way limiting the powers and discretions conferred upon the Trustee by the other provisions of this Agreement or by law, the Trustee is expressly authorized and empowered: (a) To sell, exchange, convey, transfer, or otherwise dispose of any property held by it, by public or private sale. No person dealing with the Trustee shall be bound to see to the application of the purchase money or to inquire into the validity or expediency of any such sale or other disposition; (b) To make, execute, acknowledge, and deliver any and all documents of transfer and conveyance and any and all other instruments that may be necessary or appropriate to carry out the powers herein granted; (c) To register any securities held in the Fund in its own name or in the name of a nominee and to hold any security in bearer form or in book entry, or to combine certificates representing such securities with certificates of the same issue held by the Trustee in other fiduciary capacities, or to deposit or arrange for the deposit of such securities in a qualified central depository even though, when so deposited, such securities may be merged and held in bulk in the name of the nominee of such depositary with other securities deposited therein by another person, or to deposit or arrange for the deposit of any securities issued by the United States Government, or any agency or instrumentality thereof, with a Federal Reserve bank, but the books and records of the Trustee shall at all times show that all such securities are part of

the Fund; (d) To deposit any cash in the Fund in interest-bearing accounts maintained or savings certificates issued by the Trustee, in its separate corporate capacity, or in any other banking institution affiliated with the Trustee, to the extent insured by an agency of the Federal or State government; and (e) To compromise or otherwise adjust all claims in favor of or against the Fund.

Section 9. Taxes and Expenses. All taxes of any kind that may be assessed or levied against or in respect of the Fund and all brokerage commissions incurred by the Fund shall be paid from the Fund. All other expenses incurred by the Trustee in connection with the administration of this Trust, including fees for legal services rendered to the Trustee, the compensation of the Trustee to the extent not paid directly by the Grantor, and all other proper charges and disbursements of the Trustee shall be paid from the Fund.

Section 10. Annual Valuation. The Trustee shall annually, at least 30 days prior to the anniversary date of establishment of the Fund, furnish to the Grantor and to the appropriate EPA Regional Administrator a statement confirming the value of the Trust. Any securities in the Fund shall be valued at market value as of no more than 60 days prior to the anniversary date of establishment of the Fund. The failure of the Grantor to object in writing to the Trustee within 90 days after the statement has been furnished to the Grantor and the EPA Regional Administrator shall constitute a conclusively binding assent by the Grantor, barring the Grantor from asserting any claim or liability against the Trustee with respect to matters disclosed in the statement.

Section 11. Advice of Counsel. The Trustee may from time to time consult with counsel, who may be counsel to the Grantor, with respect to any question arising as to the construction of this Agreement of any action to be taken hereunder. The Trustee shall be fully protected, to the extent permitted by law, in acting upon the advice of counsel.

Section 12. Trustee Compensation. The Trustee shall be entitled to reasonable compensation for its services as agreed upon in writing from time to time with the Grantor.

Section 13. Successor Trustee. The Trustee may resign or the Grantor may replace the Trustee, but such resignation or replacement shall not be effective until the Grantor has appointed a successor trustee and this successor accepts the appointment. The successor trustee shall have the same powers and duties as those conferred upon the Trustee hereunder. Upon the successor trustee's acceptance of the appointment, the Trustee shall assign, transfer, and pay over to the successor trustee the funds and properties then constituting the Fund. If for any reason the Grantor cannot or does not act in the event of the resignation of the Trustee, the Trustee may apply to a court of competent jurisdiction for the appointment of a successor trustee or for instructions. The successor trustee shall specify the date on which it assumes administration of the trust in a writing sent to the Grantor, the EPA Regional Administrator, and the present Trustee by certified mail 10 days before such change becomes effective. Any expenses incurred by the Trustee as a result of any of the acts contemplated by this Section shall be paid as provided in Section 9.

Section 14. Instructions to the Trustee. All orders, requests, and instructions by the Grantor to the Trustee shall be in writing, signed by such persons as are designated in the attached Exhibit A or such other designees as the Grantor may designate by amendment to Exhibit A. The Trustee shall be fully protected in acting without inquiry in accordance with the Grantor's orders, requests, and instructions. All orders, requests, and instructions by the EPA Regional Administrator to the Trustee shall be in writing, signed by the EPA Regional Administrators of the Regions in which the facilities are located, or their designees, and the Trustee shall act and shall be fully protected in acting in accordance with such orders, requests, and instructions. The Trustee shall have the right to assume, in the absence of written notice to the contrary, that no event constituting a change or a termination of the authority of any person to act on behalf of the

Grantor or EPA hereunder has occurred. The Trustee shall have no duty to act in the absence of such orders, requests, and instructions from the Grantor and/or EPA, except as provided for herein.

Section 15. Notice of Nonpayment. The Trustee shall notify the Grantor and the appropriate EPA Regional Administrator, by certified mail within 10 days following the expiration of the 30-day period after the anniversary of the establishment of the Trust, if no payment is received from the Grantor during that period. After the pay-in period is completed, the Trustee shall not be required to send a notice of nonpayment.

Section 16. Amendment of Agreement. This Agreement may be amended by an instrument in writing executed by the Grantor, the Trustee, and the appropriate EPA Regional Administrator, or by the Trustee and the appropriate EPA Regional Administrator if the Grantor ceases to exist.

Section 17. Irrevocability and Termination. Subject to the right of the parties to amend this Agreement as provided in Section 16, this Trust shall be irrevocable and shall continue until terminated at the written agreement of the Grantor, the Trustee, and the EPA Regional Administrator, or by the Trustee and the EPA Regional Administrator if the Grantor ceases to exist. Upon termination of the Trust, all remaining trust property, less final trust administration expenses, shall be delivered to the Grantor.

Section 18. Immunity and Indemnification. The Trustee shall not incur personal liability of any nature in connection with any act or omission, made in good faith, in the administration of this Trust, or in carrying out any directions by the Grantor or the EPA Regional Administrator issued in accordance with this Agreement. The Trustee shall be indemnified and saved harmless by the Grantor or from the Trust Fund, or both, from and against any personal liability to which the Trustee may be subjected by reason of any act or conduct in its official capacity, including all expenses reasonably incurred in its defense in the event the Grantor fails to provide such defense.

Section 19. Choice of Law. This Agreement shall be administered, construed, and enforced according to the laws of the Commonwealth of Pennsylvania.

Section 20. Interpretation. As used in this Agreement, words in the singular include the plural and words in the plural include the singular. The descriptive headings for each Section of this Agreement shall not affect the interpretation or the legal efficacy of this Agreement.

[The remainder of this page is intentionally left blank. Signatures follow.]

SCHEDULE A

Identification of Facilities and Cost Estimates

Schedule A is referenced in the standby trust agreement dated March 23, 2016 by and between PENNECO ENVIRONMENTAL SOLUTIONS, LLC, the Grantor and
(Name of owner or operator)
FIRST COMMONWEALTH BANK, the Trustee.
(Name of trustee)

EPA identification number	PAS2D701BALL
Name of facility	Sedat 3A Injection Well
Address of facility	1800 Old Leechburg Road Pittsburgh, PA 15239
Current plugging and abandonment cost estimate	$13,397.10
Date of estimate	02/17/2022
EPA identification number	PAS2D702BALL
Name of facility	Sedat 4A Injection Well
Address of facility	1800 Old Leechburg Road Pittsburgh, PA 15239
Current plugging and abandonment cost estimate	$13,397.10
Date of estimate	02/17/2022

SCHEDULE B

Description of Property / Financial Instrument

[Surety, Letter of Credit, etc.]

Schedule B is referenced in the Standby Trust Agreement (Section 3) dated 02/22/2022

by and between PENNECO ENVIRONMENTAL SOLUTIONS, LLC , the "Grantor,"
(name of owner or operator)

and FIRST COMMONWEALTH BANK , the "Trustee."
(name of the trustee)

The fund consists of: (Check one and provide identification number)

- (●) Irrevocable Letter of Credit No. 491R1397 (Sedat 3A)
- ( ) Surety Performance Bond No. _____
- ( ) Other (Describe) _____

SCHEDULE B

Description of Property / Financial Instrument

[Surety, Letter of Credit, etc.]

Schedule B is referenced in the Standby Trust Agreement (Section 3) dated 02/22/2022

by and between PENNECO ENVIRONMENTAL SOLUTIONS, LLC , the "Grantor,"
(name of owner or operator)

and FIRST COMMONWEALTH BANK , the "Trustee."
(name of the trustee)

The fund consists of: (Check one and provide identification number)

- (●) Irrevocable Letter of Credit No. 491R1398 (Sedat 4A)
- ( ) Surety Performance Bond No. _____
- ( ) Other (Describe) _____

IN WITNESS WHEREOF the parties below have caused this Agreement to be executed by their respective representatives duly authorized and their seals to be hereunto affixed and attested as of the date first above written.

GRANTOR:
PENNECO ENVIRONMENTAL SOLUTIONS, LLC

By: _____

Name: Terrence S Jacobs

Title: President

Before me came the individual whose identity I confirmed as Terrence S. Jacobs and whose true signature is set forth above; wherefore have I set my hand and seal this 18th day of March, 2016.

Eileen M. Staub
Notary Public

[Seal]

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Eileen M. Staub, Notary Public
Salem Twp., Westmoreland County
My Commission Expires May 15, 2017
MEMBER, PENNSYLVANIA ASSOCIATION OF NOTARIES

TRUSTEE:
FIRST COMMONWEALTH BANK

By: _____

Name: Douglas I. Sako

Title: Senior Vice President

Before me came the individual whose identity I confirmed as Douglas I Sako and whose true signature is set forth above; wherefore have I set my hand and seal this 23rd day of March, 2016.

Heidi M Holt
Notary Public

[Seal]

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
HEIDI M. HOLT, NOTARY PUBLIC
BROCKWAY BORO, JEFFERSON COUNTY
MY COMMISSION EXPIRES APRIL 24, 2019

( ) This bank/institution has the authority to act as trustee and its trust activities are examined and regulated by a State or Federal agency.

CERTIFICATE OF ACKNOWLEDGMENT
FOR
STANDBY TRUST FUND AGREEMENT

STATE OF Pennsylvania)
) SS:
COUNTY OF Jefferson)

On this, the 23rd day of March, 2016, before me personally came Douglas I Sako, to me known, who, being by me duly sworn, did depose and say that he/she resides at 654 Philadelphia St. Indiana, PA 15701 (Address) that he/she is the Senior Vice President (Title) of FIRST COMMONWEALTH BANK (Corporation) the corporation described in and which executed the above instrument; that he/she knows the seal of said corporation; that the seal affixed to such instrument in such corporate seal; that it was so affixed by order of the Board of Directors of said corporation, and that he/she signed his/her name thereto by like order.

Heidi M Holt
(Notary Public)

(Seal)

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
HEIDI M. HOLT, NOTARY PUBLIC
BROCKWAY BORO, JEFFERSON COUNTY
MY COMMISSION EXPIRES APRIL 24, 2019

IN WITNESS WHEREOF the parties below have caused this Agreement to be executed by their respective representatives duly authorized and their seals to be hereunto affixed and attested as of the date first above written.

GRANTOR:
PENNECO ENVIRONMENTAL SOLUTIONS, LLC

By:_____

Name:_____

Title:_____

Before me came the individual whose identity I confirmed as _____ and whose true signature is set forth above; wherefore have I set my hand and seal this _____ day of _____, 2016.

_____
Notary Public

[Seal]

TRUSTEE:
FIRST COMMONWEALTH BANK

By: [signature]

Name: Danny Diveley

Title: Trust Officer

Before me came the individual whose identity I confirmed as Danny Diveley and whose true signature is set forth above; wherefore have I set my hand and seal this 24th day of March, 2016.

[signature]
Notary Public

[Seal]

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
KELLY PERNEY, NOTARY PUBLIC
CITY OF GREENSBURG, WESTMORELAND CO.
MY COMMISSION EXPIRES NOV. 25, 2018

(X) This bank/institution has the authority to act as trustee and its trust activities are examined and regulated by a State or Federal agency.

CERTIFICATE OF ACKNOWLEDGMENT
FOR
STANDBY TRUST FUND AGREEMENT

STATE OF Pennsylvania)
) SS:
COUNTY OF Westmoreland)

On this, the 24th day of March, 2016, before me personally came Danny Diveley, to me known, who, being by me duly sworn, did depose and say that he/she resides at 654 Philadelphia Street, Indiana, PA 15601 (Address) that he/she is the Trust Officer (Title) of FIRST COMMONWEALTH BANK (Corporation) the corporation described in and which executed the above instrument; that he/she knows the seal of said corporation; that the seal affixed to such instrument in such corporate seal; that it was so affixed by order of the Board of Directors of said corporation, and that he/she signed his/her name thereto by like order.

COMMONWEALTH OF PENNSYLVANIA
NOTARIAL SEAL
KELLY PERNEY, NOTARY PUBLIC
CITY OF GREENSBURG, WESTMORELAND CTY.
MY COMMISSION EXPIRES NOV. 25, 2018

Kelly Perney
(Notary Public)

(Seal)

First Commonwealth Bank
Central Offices:
Philadelphia and Sixth Streets
P.O. Box 400
Indiana, PA 15701-0400
800.711.2265
fcbanking.com

IRREVOCABLE STANDBY LETTER OF CREDIT # 491R1398

Issue Date: February 23, 2022

Beneficiary:
Department of Environmental Protection Agency
Regional Administration, Region III
1650 Arch Street
Philadelphia, PA 19103

Applicant:
Penneco Environmental Solutions LLC
6608 State Route 66
Delmont, PA 15626

Dear Beneficiary:

We hereby establish our Irrevocable Standby Letter of Credit No. 491R1398 in your favor as Beneficiary, at the request and for the account of the Applicant, Penneco Environmental Solutions LLC, for drawings up to Thirteen Thousand Four Hundred U.S. Dollars (13,400.00). We hereby authorize you to draw at sight, on First Commonwealth Bank at our office located at 654 Philadelphia Street, P.O. Box 400, Indiana, PA 15701 and expires with our close of business on February 23, 2023.

Funds under this credit are available to you against presentation of your sight draft(s) marked "Drawn under Irrevocable Standby Letter of Credit # 491R1398 dated February 23, 2022" and accompanied by:

1. your statement purportedly signed by an authorized representative of Department of Environmental Protection Agency, stating that "Penneco Environmental Solutions LLC have not performed their obligations required by Department of Environmental Protection Agency and are hereby responsible for payment of 13,400.00

AND

2. this original letter of credit and any amendments hereafter.

Partial draws are permitted.

It is a condition of this letter of credit that it shall be automatically renewable for additional terms of one year from the present or each future expiration date unless we give you and Penneco Environmental Solutions LLC at least ninety (90) days prior to said expiration date written notice by certified mail, return receipt requested, that we elect to terminate this credit at the end of its then current term.

FIRST Commonwealth Bank
Time to be first.

This Letter of Credit is subject to and shall be governed in accordance with the terms of the Uniform Commercial Code, Article 5, Letters of Credit, 13 Pa.C.S.A. § 5101 *et seq.* ("Article 5"); and shall not be subject to or governed by the provisions of the Uniform Customs and Practice for Documentary Credit (2007 Revision) International Chamber of Commerce Publication No. 600 (the "UCP 600") or International Standby Practices Publication No. 590 (1998 Edition) (the "ISP 98"), except that where Article 5 is silent as to any issue which is addressed by the UCP 600, then the UCP 600 shall govern as to that issue only.

Sincerely,
First Commonwealth Bank

By: _____

Name: Jason Colinet
Title: Vice President

First Commonwealth Bank.
Time to be first.

LETTER OF CREDIT AGREEMENT

ISSUE DATE: February 23, 2022
LETTER OF CREDIT NO.: 491R1398
AMOUNT: 13,400.00

ISSUING BANK ("BANK")
FIRST COMMONWEALTH BANK
P. O. BOX 400
INDIANA, PA 15701

NAME OF CUSTOMER ("ACCOUNT PARTY")
Penneco Environmental Solutions LLC
6608 State Route 66
Delmont, PA 15626

Account Party hereby directs Bank to fund drafts issued under this letter of credit by drawing against 8900020823 dated February 23, 2022 for the amount of said drafts.

In consideration of the issuance by Bank of the Letter, Account Party hereby:

1. Agrees to reimburse Bank for any charges or commissions incurred by Bank for processing of any drafts presented for payment under the Letter, and authorizes Bank to charge any of Account Party's deposit accounts for payment of said charges.

2. Authorizes Bank to honor any request for payment which is made under and in compliance with the terms of the Letter without regard to, and without any duty on Bank's part to inquire into the existence of any disputes or controversies between Account Party, the beneficiary of the Letter, or any other person, firm, or corporation, or the respective rights, duties or liabilities of any of term or whether any facts or occurrences represented in any of the documents presented under the Letter are true or correct.

3. Affirms that Bank's sole obligation shall be limited to honoring requests for payment under and in compliance with the terms of the Letter, and that this obligation shall remain limited even if Bank has assisted in the wording or preparation of the Letter and any associated documents or may be otherwise aware of the underlying transaction giving rise to the request for the Letter.

4. Assumes all risks of the acts or omissions of the users of the Letter, and releases Bank or responsibility for the validity, sufficiency, genuineness or effect of any documents associated with the Letter, even if such documents should in fact prove to be in any or all respects invalid, insufficient, fraudulent, or forged.

5. Agrees that any extension or modification of the original Letter will be subject to the terms of this Agreement.

Penneco Environmental Solutions LLC

BY: _____
Terrence S Jacobs, President

BY: _____
Darryl M Jacobs, Executive Vice President

HB Cementing LLC

Cost Estimate

Date:	17-Feb-22
Customer:	Penneco Oil Co.
Lease Name:	Sedat #4A
API #	37-003-21644
County:	Allegheny
Mileage:	30
Cement Blend:	Type 1

Tub/Cas Size	1.9
Tub/Cas TD	1680
Hole Size	4
Hole TD	1680
Total Sacks	130

Ticket # 0

HB Cementing Services, LLC
(724) 297-3456

Item Desription		QTY	U/M	Unit Cost	Net	Net Total
Pumping Chrg		1501-3500	FT	$1,475.00	$1,475.00	$4,254.10
Type 1		130	Sack	$16.95	$2,203.50	
Mileage Chrg		30	Unit Mi	$3.25	$97.50	
Mileage Chrg (PU)		30	Unit Mi	$2.80	$84.00	
Bulk Delivery		183.3	T/M	$2.15	$394.10	

Comments:

X

Customer Representatve Signature

Thanks For Using H B Cementing

SUREFIRE WIRELINE, LLC.

PRICE ESTIMATE

Customer/Operator: Penneco Oil Company
Representative: Marc Jacobs
Well/Lease/Project Name: Sedat #4A (P&A)
Prepared By: Gary Violi
Date: Thursday, February 17, 2022
Job Type: CIBP Set - 4.5"

GENERAL PRICING		Unit Price	Quantity	Total Price
Mileage Heavy Vehicle	per mile , one way from service point.	6.10	30	183.00
Mobilization / Service Charge				
Service Charge	per job (6 hours on location).....	1,440.00	1	1,440.00
Wireline Bridge Plugs / Frac Plugs				
Plug Setting				
Depth Charge	minimum.....	520.00	1	520.00
4 1/2" Cast Iron	each.....	760.00	1	760.00
Powder Charge/Igniter	each.....	220.00	1	220.00
	Gross Price Subtotal			**3,123.00**
	Discount			**0.00**
	Net Price Subtotal			**3,123.00**
Miscellaneous Charges				
	Total Net Price			**3,123.00**

Note: The above is an estimate only. Actual charges may differ as job parameters and exact services are requested or necessary at the time the work is performed. The Discount and consequently the Net Price are applicable only if payment is made within 30 days of the receipt of the invoice. After 30 days the full Gross Price and any Miscellaneous Charges will apply. Any invoices unpaid after 60 days will be subject to a Finance Charge and any and all Expenses to collect such unpaid invoices will be paid by the customer.

150 North Avenue, PO Box 235
Yatesboro, PA 16263

Phone: 724-783-5035
Fax: 724-783-5168

BID

2/17/2022 Company Name: Sedat #4Aand *#3A*

Contact Name: Ed Rosenbeger

Contact email: edrosenberger70@gmail.com

Day	Description	Hours	Unit Price	Price
Day 1	Move in rig up T.D hole			
	Set CIBP			$ -
	Run tubing to CIBP			$ -
	Break cirrculation Start on setting cement plugs			$ -
	Cement well back to surface			$ -
	Clean up	12	$ 230.00	$ 2,760.00
Day 2	Come back next day check cement top			$ -
	Rig down move out	6	$ 230.00	$ 1,380.00
				$ -
	Water truck (2days)	12	$ 85.00	$ 1,020.00
	Winch truck hauling tubing (in and out)	4	$ 100.00	$ 400.00
	Travel (2 days)	4	$ 115.00	$ 460.00
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
				$ -
			Total	$ 6,020.00

Comments:

ATTACHMENT “U”

Description of Business

Attachment U
Description of Business
Sedat #4A Injection Well

Business Description for Sedat #4A Injection Well

The Company's business is the treatment and disposal of oil and gas well produced fluids by injection of the fluid into an underground formation via an injection well constructed by the company for this purpose.