

## **APPENDIX C**

### **GEOTECHNICAL DATA**

## Geotechnical Considerations

### 1. General Description and History

The project area is in West Pittston, Pennsylvania located along the western bank of the Susquehanna River in northern Luzerne County. West Pittston is located in the northern section of the area known as the Wyoming Valley which extends from Duryea, on the Lackawanna River, southwestward to Nanticoke, on the North Branch of the Susquehanna River.

Existing flood control projects protect the more densely populated area of the valley, extending along portions of both banks of the Susquehanna River from the Borough of Exeter at the upstream limit to the downstream limits at the Borough of Plymouth. A broad, slightly rolling plain forms the greater part of the surface of the valley, which is flanked on both sides by moderately steep mountains. Elevations vary from about 500 feet above sea level along the Susquehanna River to about 2,150 feet above sea level at Penobscot Mountain on the southwest side of the valley. The ancestral Susquehanna River Valley was over-deepened by glaciation during the Pleistocene Epoch. When the glacier receded, the valley was filled with clay, silt, sand, gravel, and some cobbles and boulders. The depth to bedrock varies erratically, from as shallow as 40 feet, to more than 200 feet. The valley occupies the northern field of the Pennsylvania Anthracite Region, and extensive coal mining has been accomplished beneath the valley for more than 125 years. This mining has caused frequent and serious subsidences, which have caused damage to streets, railroads, and private property, as well as to existing flood protection systems. The longstanding problem of subsidence has abated since abandonment of mines in the early 1960's, when the termination of pumping operations resulted in the formation of vast underground mine water pools.

### 2. Geology

**A. General** - The Wyoming Valley lies within Luzerne and Lackawanna Counties, Pennsylvania. In geologic terminology, it is termed a structural trough, or synclinorium, which is the northern-most basin in northeastern Pennsylvania's anthracite region. This structural trough is approximately 17 miles in length, 8 miles across at its widest, and trends roughly N50°E. Maximum relief amounts to about 1600 feet. The Susquehanna River flows southwesterly through the trough, over a flat, densely populated flood plain, subparalleling the axial trend of the fold. The rock units in the core of the Wyoming synclinorium are of sedimentary origin and consist of interlaid coal, shale, and sandstone units ascribed to the Llewellyn formation of Pennsylvania age. Within the fold, the Llewellyn formation is approximately 2200 feet in stratigraphic thickness and is transected by numerous reverse and normal faults with displacements up to 500 feet. On the flanks of the fold, dips in strata range between 20 and 60 feet. In the lower elevations, bedrock is overlain by an unconsolidated glacio-fluvial deposit up to 300 feet thick of variable composition.

**B. Coal** - At least 26 beds of anthracite are represented in the Llewellyn formation. They range in thickness from of an inch to 27 feet. The lowest coal unit outcrops at elevation of 1000 feet, on both sides of the valley, and is at an approximate elevation of minus 530 feet in West Pittston and minus 700 feet in the Wilkes-Barre area, at its lowest point.

**C. Glaciation** - A hummocky bedrock surface with 300 feet of relief attests to the gouging of the Wyoming Valley by glacial ice, which moved through the area about 10,000 years ago. As the ice retreated, the deepened valley was filled with sediment carried by the glacial melt. This deposit of glacial sediment is referred to as the "buried valley." The stratigraphy of these sediments are complex, and change rapidly over short distances. Generally, there is a deep sand and gravel layer immediately overlying bedrock, an intermedia lacustrine zone of fine sediment, and an upper layer of sand gravel. The fine- grained soils are not present everywhere, but generally form impervious layers between the gravels, where found.

### **3. Prior Subsurface Explorations**

- A. General** – South of West Pittston along the Susquehanna River a substantial subsurface exploration program was performed by the US Army Corps Baltimore District between December 1985 and August 1988 for the Wyoming Valley Levee Raising Project. The data obtained were utilized in design calculations for the raised levees. Previous exploration data is contained in other reports: "Wyoming Valley, Pennsylvania, Comprehensive Study," 1978; "Phase I General Design Memorandum," 1981; and "Wyoming Valley Remedial Measures GDM," 1983.

Additional borings were performed for the Wyoming Valley Levee Raising Project and for other bridge, sanitary and storm projects. Those boring results are discussed below.

#### **B. Boring Summaries**

- a. **Wyoming Valley Levee Raising Project, 1995.** This project and the associated borings begin approximately 2.3 miles southwest of West Pittston along the Susquehanna River.

In 1995 the USACE performed a drilling program consisting of a total of 58 borings drilled to provide additional foundation information for the Levee Raising Project. Thirty-four borings were drilled adjacent to the landside or riverside levee toe to provide information for the under-seepage analysis. Thirteen of the borings were performed on the Cross Valley Expressway embankment to obtain samples of the embankment materials at the tie-outs. Three borings were drilled along the proposed levee alignment for the downstream end of Forty Fort to provide information for stability, settlement, and under-seepage analyses. Also, eight borings were performed in the Breslau ponding area in Hanover Township to evaluate the foundation materials as a potential source for impervious borrow.

The subsurface exploration indicated the existence of three general foundation overburden zones along the levee alignment as shown below. See Map C-1 Church St. Edwardsville Plan and Geologic Profile.

Description of Stratum	Range of Thickness	Typical Thickness
Semi impervious blanket of silt and sand with gravel and occasional miscellaneous fill	10 to 40 feet	15 to 25 feet
Pervious layer of silty sandy gravel	7 to 50 feet	15 to 25 feet
Deposit of clayey and sandy silt	20 to 80 feet	40 feet
Intermittent pockets of dense sand and gravel		
Bedrock		60 to 100 feet below existing ground

**Table C.1 Summary Boring Results USACE WVLRP Final GDM PH II**

- b. **Hicks Creek Levee Borings** There is an existing levee in Exeter Borough at the confluence of Hick’s Creek and the Susquehanna River. The USACE drilled borings along the levee alignment and developed a geologic profile from Hick’s Creek south along the Susquehanna River banks in West Pittston for a length of approximately 4,200 feet. This geologic profile overlaps with the northern end of the West Pittston Levee Study area for approximately 1,900 feet. In the area of the Hick’s Creek levee there is a clayey silty stratum which lays over the top of rock with a thickness ranging from 8 to 20 feet. However, in the area of the proposed West Pittston levee to the south there is no clayey silt layer. The table below depicts the subsurface exploration results in the area of the proposed levee from Parke St. north approximately 1,900 feet to the cemetery. See Map C-2 Hicks Creek Plan and Geologic Profile.

Description of Stratum	Range of Thickness	Typical Depth (below ex. grade)
Silty sand gravel with slag and cinders	12 to 16 feet	
Silty sandy Gravel	15 to 45 feet	
Bedrock		33 to 60 feet

**Table C.2 Summary Boring Results USACE Hick’s Creek**

- c. **Eighth Street Bridge Borings** In 2009, the Pennsylvania Department of Transportation replaced the Eighth Street Bridge which crosses the Susquehanna River between Wyoming Borough and Jenkins Township, PA approximately 1.7 miles south of the West Pittston Levee project study area. Borings for the bridge project were drilled in 2007 on both banks of the Susquehanna River. The subsurface exploration indicated the existence soil materials and bedrock as shown below. See Map C-3 Eighth St. Bridge West Abutment Boring.

Description of Stratum	Range of Thickness
On the Embankments	
Sand, gravel and some silt, clay.	50 to 70 feet
Clay	20 to 40 feet
Sand, gravel some silt	20 to 80 feet
Intermittent pockets of dense sand and gravel	8 to 25 feet
Bedrock	100 to 120 feet deep
In the River Floodway	
Sand silt clay some gravel	90 to 110 feet
Bedrock	90 to 110 feet deep

**Table C.3 Summary Boring Results PennDOT 2007**

- d. **WVSA West Pittston Pump Stations** In 1966, the Wyoming Valley Sanitary Authority (WVSA) constructed interceptor sewer lines and Wastewater Pumping Stations along the Susquehanna River. In West Pittston Borough WVSA constructed WVSA-PS-3 (Susquehanna Ave) and WVSA-PS-1 (Wilkern St.). The Wilkern St. pump station is located along the existing Exeter Levee at the confluence of Hick’s Creek and the Susquehanna River, approximately 1,300 feet upstream of the northern end of the West Pittston levee study area. The Susquehanna Ave. pump station is located along the Susquehanna River, approximately 900 feet upstream of the southern end of the West Pittston levee study area. Borings were drilled at each pump station location. The subsurface exploration results are depicted below. See Map C-4 WVSA Pumping Station Borings.

Description of Stratum Wilkern St. (WVSA-PS-1)	Thickness	Typical Depth (below ex. grade)
Dry grey ash fill	25 feet	0 to 25 feet
Ash and gravel	8 feet	25 to 33 feet
Sand and gravel	4 feet	33 to 37 feet

Description of Stratum Susquehanna Ave. (WVSA-PS-3)	Thickness	Typical Depth (below ex. grade)
Silty sand	8 feet	0 to 8 feet
Silt, sand, gravel	6 feet	8 to 14 feet
Dense silt, sand, gravel, cobbles	11 feet	14 to 25 feet

**Table C.4 Boring Result WVSA Pumps Station Borings**

- e. **West Pittston Storm Project Boring** In 2010, West Pittston Borough constructed a storm water project in the southern area of the borough. In conjunction with that project borings were drilled. In particular, a boring was drilled in Susquehanna Avenue. This location is along the alignment of the West Pittston levee study in the area of the maximum height of the embankment levee. The subsurface exploration was 20 feet deep and the results are depicted below. See Map C-5 West Pittston Storm Water Project Boring at Susquehanna Ave.

Description of Stratum	Thickness	Typical Depth (below ex. grade)
Silty sand	10 feet	0 to 10 feet
Silty Gravel with sand	10 feet	10 to 20 feet

**Table C.5 Boring Result West Pittston Borough**

#### 4. Mining Considerations

##### A. General

Due to the extensive mining of the anthracite coal beds beneath West Pittston subsidence of the ground has occurred. Similarly, significant settlement had occurred on the Wyoming Valley levees from their initial construction in the 1930's through the 1960s. However, with the termination of mining operations, the probable completion of most caving, and the stabilization of mine pool levels, major subsidence due to past coal mining has abated since the late 1960's. Subsidence is not expected to be a significant factor in the West Pittston levee project.

### B. Knox Mine Disaster

On January 22, 1959 the tragic Knox Mine disaster occurred killing twelve miners. Mining was being performed beyond a safety stop line established to prevent excavation close to the Susquehanna River. The mining in the top Pittston vein had reached a point where there was only 5 to 10 feet of rock cover protecting the mine. The Susquehanna River bottom was only approximately 20 feet above the Pittston vein. Tunneling sharply upwards toward river bed without having drilled boreholes to gauge the rock thickness overhead, the miners came to a section with a thickness of about 5 feet. The insufficient "roof" cover caused the waters of the river to break into the mine. Due to the subsequent flooding of the connected mine workings, this event is often cited as the practical end of deep coal mining in the Wyoming Valley. The Knox mine opening was located approximately 3,500 downstream of the West Pittston levee study area. See Map C-6 Cross Section at Knox Mine Disaster

### C. West Pittston Mine Records

As discussed above, the Knox Mine Disaster was the result of a confluence of several factors. On the Pittston side (east side) of the Susquehanna River the bedrock rose to within 10 feet of the surface. Concurrently, in the same location a minable section of the Pittston vein also rose to less than 5 feet from the bedrock. Therefore, when the vein was mined, there was little rock roof above the mine. These conditions are not expected in West Pittston. The bedrock layer dips to the west, toward West Pittston. Examination of mine maps in the area of the West Pittston project (Philadelphia Avenue and Susquehanna Ave.) indicate that the depth to bedrock is approximately 90 feet below the surface. In addition, the top mines, the Bottom Check and the Pittston both peter out as they approach the river, indicating that they were not mined. The top most mined vein in this area is the Marcy which is approximately 190 feet below the ground surface. See Map C-7 Mine Cross-Section at Philadelphia Ave.

### D. Mining Effects Conclusions

There is expected to be substantial competent rock beneath the entire levee project and no adverse impacts from the prior mining operations are anticipated. However, the subsurface strata and the coal seams are highly variable. During the design phase a detailed mining investigation should be performed along the entire reach of the project. The mining investigation should be utilized to inform the boring program to confirm and quantify any pertinent existing mining conditions.

Since the upper mining units are at least 100 feet below top of rock, the load from the levee embankments, floodwalls and pump stations would have very minimal impact on stresses at the lower elevations. Although significant additional subsidence is not anticipated, the foundation conditions are such that the possibility that some localized subsidence may be experienced at times cannot be completely eliminated. There is no method of analysis available with which actual magnitudes or specific locations of subsidence can be predicted. Thus, the final design may include surface monuments

installed along the new levee crest throughout the entire project. Yearly surveys of the monuments would indicate if any subsidence has developed.

## **5. Future Geotechnical Investigation**

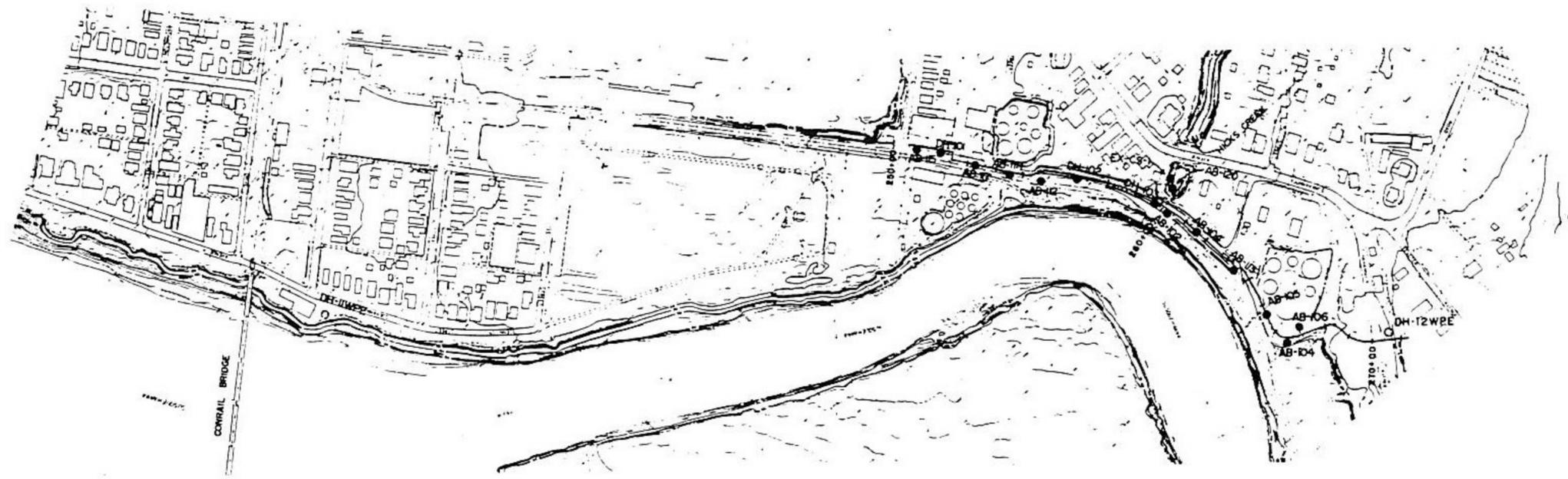
As a part of the detailed design effort for the flood protection project a geotechnical investigation will be required. This effort will involve drilling a series of borings along the proposed work area. The borings plan will be coordinated with the mining investigation as described above. In addition, borings and/or test pitting will be required offsite to locate and identify potential materials required for impervious embankment and random earth embankment. The random earth embankment may be a natural material or breaker refuse. The random earth embankment requirements are less restrictive than the impervious earth specifications.

In addition to the borings, extensive laboratory analyses of the materials will be required. The structures for the flood protection project may include: earth levees, concrete levee walls, closure structures, pump stations, sheet piles, Mechanically Stabilized Earth walls (MSE walls) and or Mechanically Stabilized Earth embankment (MSE embankment).

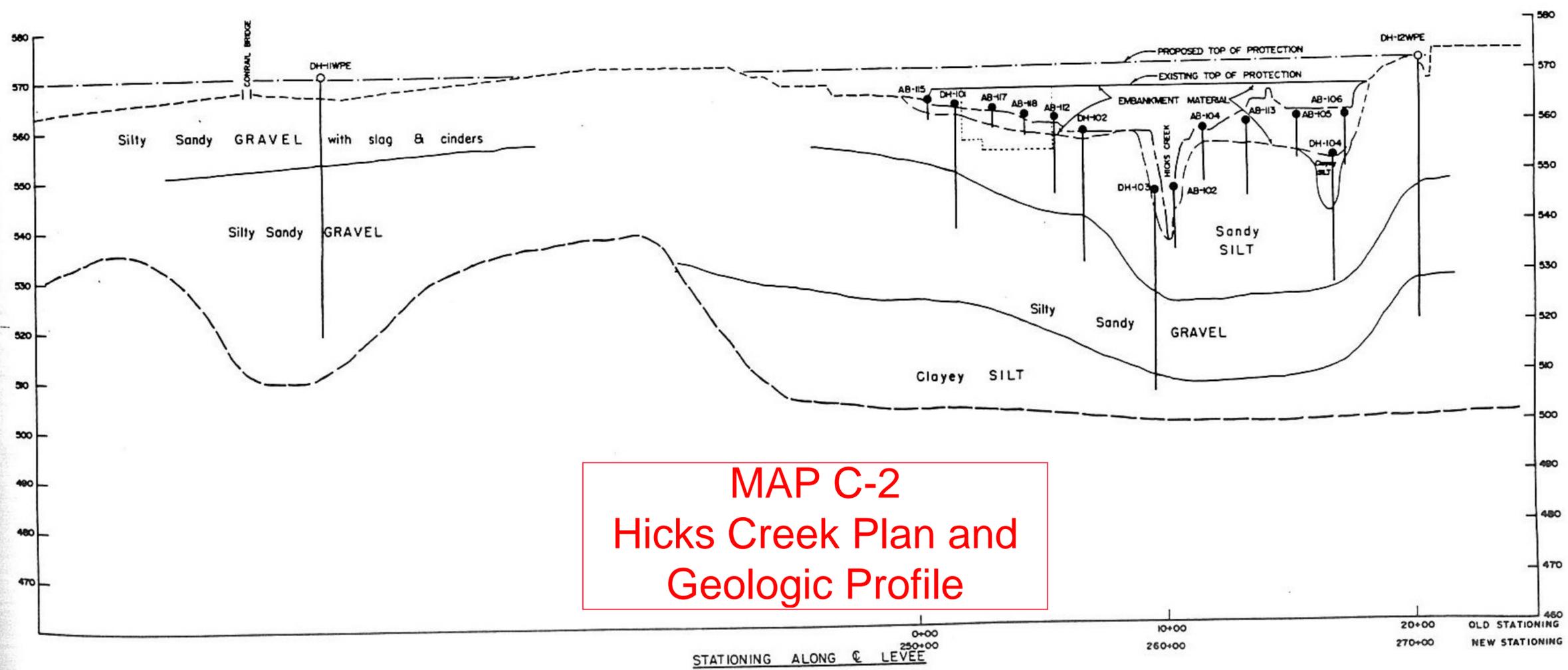
It is anticipated that the geotechnical investigation will address some or all of the following:

- develop foundation information
- develop information for the under-seepage analysis
- obtain samples of the embankment materials
- provide information for stability, settlement, and under-seepage analyses
- evaluate materials as a potential source for impervious borrow
- obtain undisturbed samples of fine-grained foundation silts and clays
- determine permeability values
- obtain standard penetration tests (SPT)
- classify of soils
- determine Atterberg limits
- perform unconfined compression tests
- perform unconsolidated-undrained (Q) triaxial tests
- perform consolidated-undrained (R) triaxial tests with
  - pore pressure measurements
- perform soil mechanical analyses, unit weight, moisture content
- determine shear strength parameters (cohesion, angle of internal friction)
- perform slope stability analyses
- perform analysis of through seepage, under-seepage.





**PLAN**  
SCALE IN FEET  
200 0 200 400



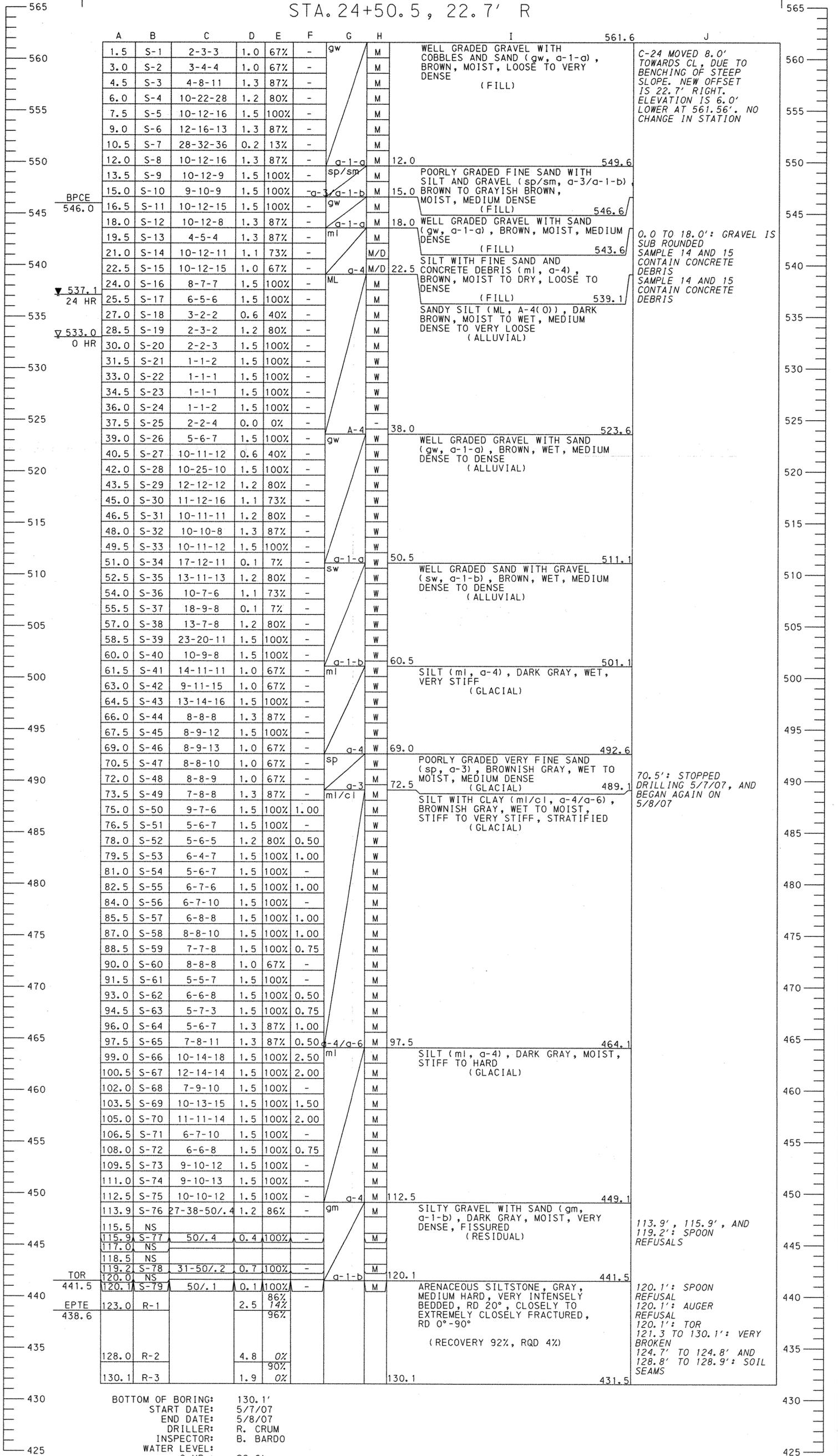
**MAP C-2**  
**Hicks Creek Plan and**  
**Geologic Profile**

**GEOLOGIC PROFILE**  
HORIZ. 1 IN. = 200 FT.  
VERT. 1 IN. = 10 FT.

REV.	DATE	DESCRIPTION	BY
<b>U.S. ARMY ENGINEER DISTRICT, BALTIMORE</b> <b>CORPS OF ENGINEERS</b> <b>BALTIMORE, MARYLAND</b>			
SUSQUEHANNA RIVER FLOOD CONTROL PROJECTS WYOMING VALLEY, PENNSYLVANIA <b>PLAN AND GEOLOGIC PROFILE</b> SWOYERSVILLE - FORTY FORT HICKS CREEK SEGMENT STA 246+00 TO STA 272+00			

ABUTMENT 2

BORING NO. C-24  
 STA. 24+50.5, 22.7' R

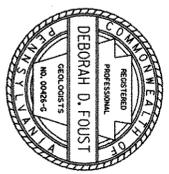


**LEGEND**

A - BOTTOM OF SAMPLE DEPTH  
 B - SAMPLE NUMBER AND TYPE  
 S = SPLIT SPOON, 2" O.D.  
 R = ROCK CORE, NX  
 C - BLOW COUNTS PER 6" OF SPOON PENETRATION  
 140 LB. HAMMER WEIGHT - 30" DROP  
 D - RECOVERY  
 E - PERCENTAGE OF RECOVERY - SPOON  
 F - PERCENTAGE OF RECOVERY - CORE  
 G - USCS/AASHTO CLASSIFICATION  
 H - MOISTURE  
 I - SOIL/ROCK DESCRIPTION  
 J - REMARKS

BPCE - BOTTOM OF PILE CAP ELEVATION  
 EPTC - ESTIMATED PILE TIP ELEVATION  
 TOR - TOP OF ROCK ELEVATION  
 W - WATER LEVEL (LONG TERM)  
 W - WATER LEVEL (0 HR)

THIS SHEET IS INCLUDED FOR THE CONVENIENCE OF THE DEPARTMENT AND SHALL NOT BE CONSIDERED AS A PART OF THE CONTRACT DRAWINGS. (SEE SECTION 102.05 OF PUB. 408).



THE CLASSIFICATION OF THE MATERIALS ENCOUNTERED HAVE BEEN VERIFIED

PREPARED BY  
 SOILS ENGINEER/GEOLOGIST  
 GTS TECHNOLOGIES, INC.  
 441 FRIENDSHIP RD  
 HARRISBURG, PA 17111

TEST BORINGS PERFORMED BY  
 TRC, INC.  
 APRIL - JUNE 2007  
 INSPECTION AND SUBSURFACE DATA PROVIDED BY  
 NAVARRO & WRIGHT

COMMONWEALTH OF PENNSYLVANIA  
 DEPARTMENT OF TRANSPORTATION

LUZERNE COUNTY  
 SECTION 370  
 S. R. 1021  
 SEGMENT 0010  
 OFFSET 0777  
 S. R. 1021-370 OVER SUSQUEHANNA RIVER  
 10-SPAN P/S CONCRETE I-BEAM BRIDGE  
 TEST BORINGS

RECOMMENDED  
 SHEET 32 OF 34  
 S - 26314A

BOTTOM OF BORING: 130.1'  
 START DATE: 5/7/07  
 END DATE: 5/8/07  
 DRILLER: R. CRUM  
 INSPECTOR: B. BARDO  
 WATER LEVEL:  
 0 HR : 28.6'  
 24 HR : 24.5'  
 CASING DEPTH: 120.1'  
 EQUIPMENT USED: ACKER XLS TRACK RIG

**MAP C-3**  
**Eighth St. Bridge West**  
**Abutment Boring**

18

550.08 ELEV.		1	2
549.08	DAMP SILT-SAND ASHES & GRAVEL	19	20
	DAMP BROWN	31	26
547.08	SANDY SILT		13
			17
	DAMP BROWN		14
	SILTY FINE	11	26
	SAND	17	31
542.08			29
			43
	DAMP BROWN		39
	SILT	68	45
	SAND	57	47
	GRAVEL		53
526.08			68
			155
		90	280
		75	260
			310
	DAMP HARD PACKED		295
	SILT		330
	SAND		185
	GRAVEL		205
	COBBLES (HARDPAN)		260
525.08			

REFUSAL ON SPOON # 15', 20' & 23'  
WHEN USING 140# HAMMER. CHANGED  
50 300# HAMMER WITH 18" DROP

WEST PITTSBURGH  
PUMPING STATION  
P.S. # II-34

19

559.70 ELEV.		1	2
558.7	MIXE FILL	5	2
		5	10
			32
			47
			52
	DRY HARD PACKED SANDY SILT	34	80
		41	57
			44
			47
550.7			42
	DAMP GRAY SILTY FINE SAND	41	46
	HARD PACKED	65	68
548.7			60
			58
			35
	DAMP GRAY SILT SAND GRAVEL	68	45
		42	42
			49
		70	46
529.7			

WEST PITTSBURGH &  
EXETER R.R.  
P.S. # II-41

20

566.88 ELEV.		1	2
			13
			22
			18
			8
			5
			5
			8
		1	8
		3	7
			11
			11
			8
		7	12
		8	13
			12
	DRY GRAY ASH FILL		12
			11
			11
		70	12
		13	14
			12
			11
			13
		9	13
		8	17
			16
			15
541.88			15
			11
			17
			8
			12
			13
	DAMP GRAY & RED ASH FILL SOME GRAVEL w 33"		9
		16	8
		11	14
			16
533.88			21
	LOOSE MOIST BROWN SAND GRAVEL		36
		53	
		68	
529.88			

WILKERN STREET  
PUMPING STATION  
P.S. # II-41

MAP C-4  
WVSA Pumping Station  
Borings



# TEST BORING LOG

Project: West Pittston Sewer System Improv. Project  
West Pittston, PA

Test Loc. No.: **B-1**  
Contract No.: **09125**

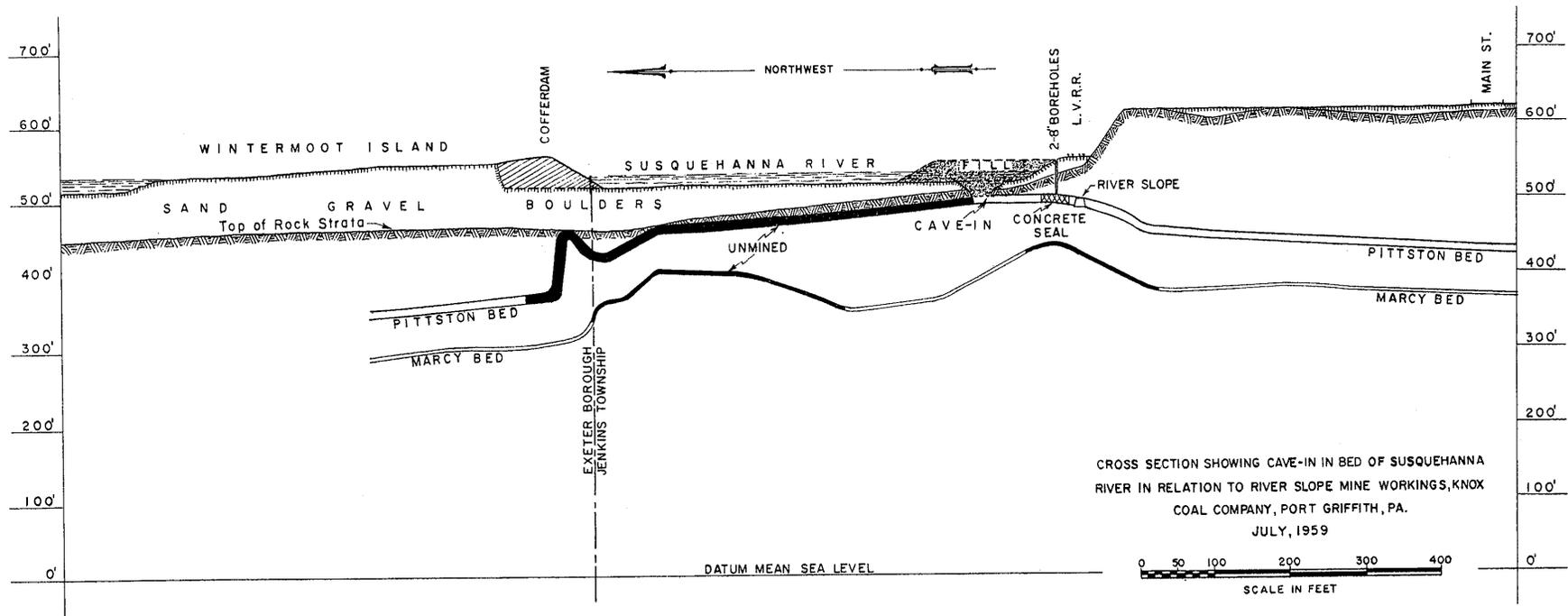
ME, Inc. Rep.: MS  
Date Drilled: 06/08/09  
Equip. Used: Diedrich D-50  
Surface Elev.: 550.0+/-

Groundwater Observations		
Date	Time	Depth
Encountered: 06/08/09		18.5'
Completion: 06/08/09		dry

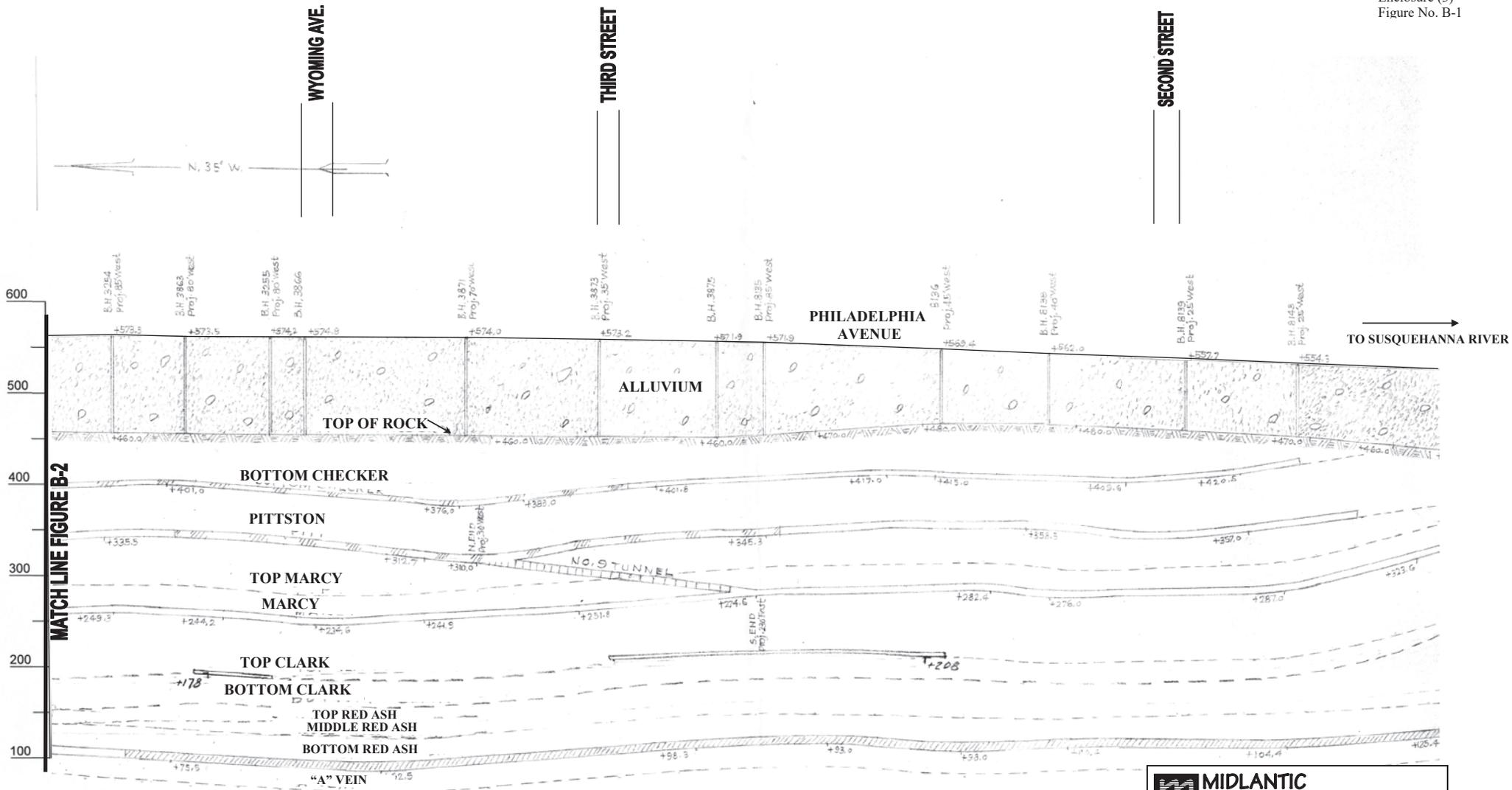
Depth (ft.)	Strata Description	Class.	Str'm	Elev.	InSitu Testing		M (%)	Remarks
					Depth	Test Data		
0	8" asphalt							
5	brown silty SAND (fine)	SM	A		5	7+6+ 4+4		
10	brown poorly graded SAND with gravel	SP-SM	B	540.0	10	10+17+ 14+12		
15	brown poorly graded silty GRAVEL with sand	GP-GM			15	6+19+ 15+16		
20	brown, coarse poorly graded silty GRAVEL with sand				20	6+10+ 7+5		
20	Bottom of Boring at 20.0 feet			530.0	20			
25					25			
30					30			

Comments: Test Location – Susquehanna Avenue @ #3064  
Backfilled upon completion.

**MAP C-5**  
**West Pittston Storm Water Project**  
**Boring at Susquehanna Ave**



**MAP C-6**  
**Cross Section at**  
**Knox Mine Disaster**



EXETER COLLIERY  
LEHIGH VALLEY COAL CO.

CROSS-SECTION  
**PHILADELPHIA AVENUE**  
(Looking Upstream)

**MAP C-7**  
**Mine Cross-Section at Philadelphia Ave**

<b>MIDLANTIC ENGINEERING</b>		
<b>Mining Cross-Section</b> West Pittston Sewer System Improvements Project West Pittston, PA		
Project: 09125	Date: 06/19/09	Scale: 1" = 100'