TRANSCONTINENTAL GAS PIPE LINE COMPANY, LLC

APPENDIX J – HDD FEASIBILITY MEMOS – CHEESEQUAKE ROAD, LOCKWOOD MARINA, PARKWOOD VILLAGE

NORTHEAST SUPPLY ENHANCEMENT PROJECT

January 2020

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February 8, 2018

Subject: HDD Feasibility Memorandum – Updated 02.08.18
26-inch Northeast Supply Enhancement Project – Madison Loop
Cheesequake Road HDD

Attachment: Cheesequake Road HDD Plan, Profile and Stringing Drawing
Hydraulic Fracture and Inadvertent Drilling Fluid Returns Analysis
AECOM Boring Log and Laboratory Test Results

Laney Directional Drilling Co. (Laney) is pleased to present this Horizontal Directional Drill (HDD) feasibility memorandum for the proposed Cheesequake Road HDD summarizing the results of our constructability review based on information available to us as of the issuance of this memorandum. The proposed HDD is part of the Transcontinental Gas Pipe Line Company, LLC's Northeast Supply Enhancement Project 26-inch Madison Loop and is located in Middlesex County, New Jersey. The HDD method of construction is being considered by Williams E&C (Williams) to cross beneath a creek and Cheesequake Road approximately 2 miles southwest of South Amboy, New Jersey.

Surface Conditions:

Laney visited the Cheesequake Road site on June 23, 2016 and again on August 31, 2016 with representatives from Williams to assess the surface conditions along and near the proposed Cheesequake Road HDD. The Cheesequake Road HDD alignment is roughly orientated from east to west (entry and exit sides, respectively).The Cheesequake Road HDD, as currently proposed, is 1,900 feet in length measured along the centerline alignment. Please refer to the "NOT FOR CONSTRUCTION" plan, profile and stringing drawing Cheesequake Road HDD Revision J dated February 8, 2018 (plan, profile and stringing drawing) for reference.

The proposed entry point is located in a relatively flat densely wooded area at an elevation of approximately 83 feet North American Vertical Datum 88 (NAVD 88).). From entry, the HDD alignment trends along the existing pipeline right-of-way with the ground surface sloping down to a low lying area and a creek before undulating along the north creek bank to Cheesequake Road. To the west of the entry location, the HDD alignment trends adjacent to the existing pipeline right-of-way crossing it twice with the ground surface sloping up a hill before sloping back down to the proposed exit point at an elevation of approximately 72 feet NAVD 88.

The entry side workspace may be accessed from the east by Highway 9 and a temporary access road along the pipeline right-of-way (ROW). Note that an existing powerline corridor exists across the access to the entry workspace. Height restrictions of equipment may be required along this area. The exit side workspace may be accessed from the east by Cheesequake Road via the pipeline ROW and a temporary access road. The carrier pipe stringing area will be located on the exit side of the crossing and extend approximately 800 feet west of the proposed exit point. A minimum of two tie-in welds is required during pullback operations due to the limited carrier pipe stringing area length.

Subsurface Conditions:

Williams retained AECOM to perform a geotechnical exploration and laboratory testing program at the proposed HDD site. The geotechnical exploration program has completed three (3) geotechnical boring between September 15, 2016 and August 23, 2017 for the Cheesequake Road crossing. The borings were completed to depths ranging from 113-ft to 157-ft below ground surface (bgs). The location of the

geotechnical borings relative to the HDD alignment are depicted in the plan and profile drawing. The subsurface materials noted in the boring logs consisted predominately of clay with sand and sand with varying amounts of silts overlying silts, sands and clays. Refer to TABLE 1: Summary of Geotechnical Borings for further information.

TABLE 1: SUMMARY OF GEOTECHNICAL BORINGS

BORING #	DATE OF SAMPLE	SURFACE ELEVATION.	DEPTH (bgs)	DESCRIPTION OF RESULTS	CONSISTENCY
CB-1	08/14/17 - 08/15/17	71.8 ft.	113.4 ft.	SANDY CLAY / SAND / SILTY SAND	FIRM / MEDIUM / VERY DENSE
CB-2	08/23/17	69.1 ft.	115.0 ft.	SANDY SILT / CLAYEY SILT / SAND / CLAY	STIFF/ VERY STIFF / VERY DENSE / VERY STIFF
CB-3	09/15/16 - 09/20/16	66.3 ft.	157.0 ft.	SAND / SILT / SILTY SAND	MEDIUM / STIFF / VERY DENSE

Hydraulic Fracture Analysis:

Analysis of hydraulic fracture potential (fracture of the soil formation being drilled because of the annular pressure during drilling operation) consists of two steps: (i) estimation of annular drilling fluid pressure, and (ii) estimation of pressure at which shear failure of soil occurs (formation limit pressure). Typically, the maximum drilling fluid pressure occurs during pilot hole process. This is because frictional head loss is reduced in larger hole diameters. Also, in granular soil formations (angle of friction greater than zero), the shear failure pressure or limiting pressure increases with the increase in drilled hole diameter. For these reasons, the hydraulic fracture analysis is carried out for pilot hole process only. The factor of safety against hydraulic fracture is defined as the ratio between the estimated formation limit pressure and the estimated annular drilling fluid pressure. Similarly, factor of safety against inadvertent returns measures risk of inadvertent returns to the surface if the fracture of the formation being drilled occurs. This is calculated by dividing the limit pressures of the strongest soil layer above the drill path by the fluid pressure that layer is expected to be subject to.

Laney performed a hydraulic fracture and inadvertent returns analysis for the HDD pilot hole. As shown in the attachment, the factor of safety against hydraulic fracture under majority of the crossing, including the Cheesequake Road will be greater than 1.5 for the majority of the drill path. The exception to this occurs approximately at station 118+50 which is located approximately 50-ft from exit. Based on this analysis, we conclude that there is a low risk of inadvertent returns if the pilot hole is drilled as designed. This includes under critical areas along the drill path with exception of near the exit which can appropriately mitigated during construction.

Based on our evaluation of the proposed crossing, the anticipated drilling fluid properties and tooling used in our analysis are presented in Table 2 below.

TABLE 2: ANTICIPATED FLUID PROPERTIES AND TOOLING

Parameter	Unit
Drill Bit Diameter	10.625 Inch
Drill Pipe Diameter	5.5 Inch
Drilling Fluid Flow Rate	300 gpm[1]
Drilling Fluid Weight	9.5 ppg[2]

Notes:
[1] Gallons per minute.
[2] Pounds per gallon (drilling fluid anticipated to be mainly water with additional of minimal bentonite for this crossing).

Drilling fluid properties are dependent on construction practices of the HDD contractor, field conditions and interpretations of the drilling fluid engineer. Annular drilling fluid pressures can significantly change with changes in drilling fluid properties. Therefore, it is important to re-evaluate drilling fluid pressures based on fluid properties during HDD installations and compare them with estimated limiting pressures of the formation. Additionally, annular pressure measurement tools can be used to monitor annular pressure during the HDD installation.

The hydraulic fracture analysis performed by Laney does not account for pre-existing fractures in the formation. The inadvertent returns may occur through the pre-existing fractures in the formation.

Calculated factors of safety against hydraulic fracture are presented in the attachment. It should be noted that the analysis is based on the HDD contractor maintaining fluid returns to the entry pit; if drilling fluid returns are not maintained the analysis may no longer be valid. However, loss of drilling fluid returns does not automatically indicate that an inadvertent drilling fluid returns occurrence is imminent.

HDD Feasibility Considerations and Recommendations:

The Cheesequake Road HDD is currently proposed with a length of 1,900 feet and based on the current stringing area of approximately 800 feet, two (2) tie in welds will be required during pullback. We do not recommend extending the currently proposed length of the crossing beyond 1,900 feet because additional tie-in weld(s) will be required during pullback. Increasing the length of the crossing would create additional tie-in weld(s) during pullback and increase the risk of failure of the crossing especially when the HDD profile is located in overburden soils.

The risk of inadvertent drilling fluid returns along the HDD alignment near exit is generally low when the HDD profile is located in the medium dense to very dense sand. The highest risk of inadvertent returns is near the entry and exit points where the depth of cover is thin. We anticipate that the highest risk of inadvertent drilling fluid returns to be within approximately 75-50 feet of exit.

The HDD alignment crosses the existing 42-inch Lower Bay Loop “C” pipeline at approximate stations 5+60 and 16+80. We understand that the 42-inch Lower Bay Loop “C” pipeline was conventionally installed at stations 5+60 and 16+80 at depth of approximately 4 feet below ground surface (bgs). Based on the depth of the existing pipeline and the designed HDD profile depth there is over 40 feet of vertical separation at both crossing locations.

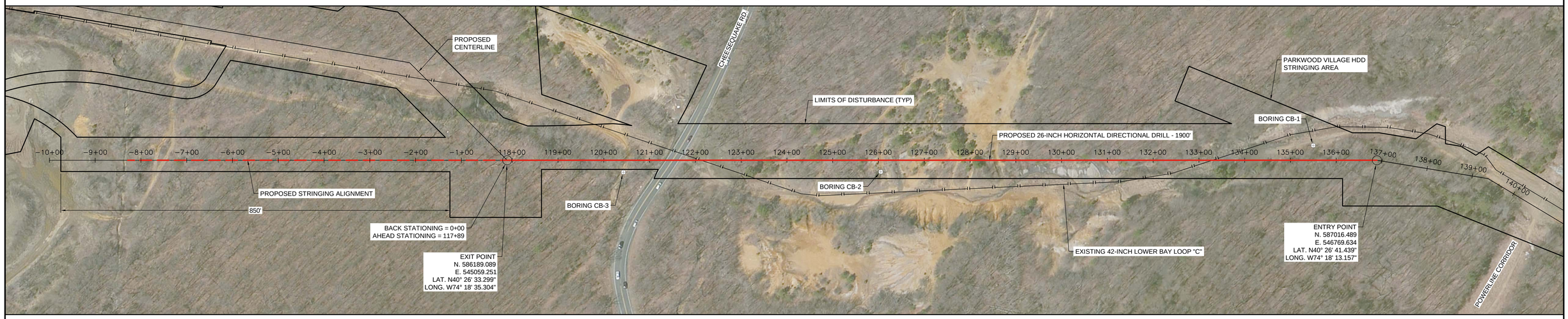
We anticipate that access to both the entry and exit sides of the proposed crossing from Highway 9 and Cheesequake Road will require traffic control for construction traffic ingress and egress to the workspaces. There is less than 3 feet of shoulder on Highway 9 with a high traffic density and will likely require closing the outside (west) lane during HDD construction. Cheesequake Road may require flaggers and traffic signs for construction traffic ingress and egress.

There is approximately 11 feet of elevation differential between the entry and exit sides of the crossing and we anticipate that challenges associated with elevation change should be minimal.

The entry and exit points are located within approximately 760 feet and 790 feet, respectively from noise sensitive areas (NSA) such that noise mitigation measures may be required during construction. Noise mitigation measures may include mufflers on diesel engines and/or noise abatement walls. Depending on local ordinances, the decibel level may not be able to exceed certain thresholds. In addition to noise mitigation measures, active monitoring of the construction sites decibel level output may be required.

Based on the results of our analysis, site visit and geotechnical data at the proposed Cheesequake Road HDD, we anticipate that this HDD is feasible from the currently available geotechnical data, geometrical, and surface conditions perspective.

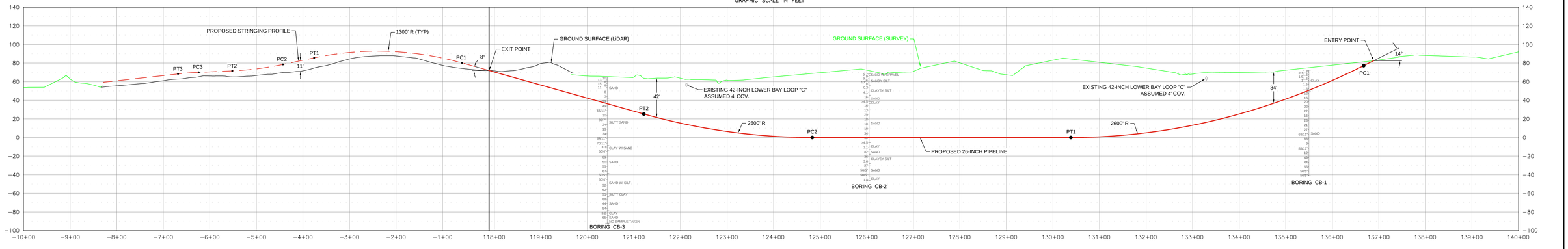
MIDDLESEX COUNTY, NEW JERSEY



PLAN VIEW

100 0 100 200

GRAPHIC SCALE IN FEET



PROFILE VIEW

BACK STATION = 0+00
AHEAD STATION = 117+89

100 0 100 200

GRAPHIC HORIZONTAL SCALE IN FEET

50 0 50 100

GRAPHIC VERTICAL SCALE IN FEET

BORING LEGEND

SPT (N/PP) — SOIL DESCRIPTION

BORING NAME

NOTES:

1. GROUND SURFACE DATA PROVIDED BY WILLIAMS.
2. THE PIPELINE INFORMATION SHOWN ON THIS DRAWING IS A COMPILATION OF DATA OBTAINED FROM VARIOUS SOURCES, LANEY DIRECTIONAL DRILLING DOES NOT GUARANTEE THE ACCURACY OF THE INFORMATION SHOWN

NOT FOR CONSTRUCTION

DRAWING COORDINATE SYSTEM
HORIZONTAL DATUM: SPCS – NEW JERSEY NAD83 AND GEOGRAPHIC NAD83
VERTICAL DATUM: NAVD 88

FOOTPRINT 03222018
Madison_Centerline_11062017
REFERENCE DRAWINGS

REV.	DATE	REVISION	APPVD.
K	04/04/18	ISSUED FOR REVIEW	BKP
J	02/08/18	ISSUED FOR REVIEW	BKP
I	11/09/17	REVISED STATIONING, ADDED OVERBEND LAYOUT	BKP
H	11/03/17	REVISED DESIGN	BKP
G	09/14/17	ADDED BORINGS CB-1 AND CB-2	BKP
F	07/25/17	UPDATED GROUND SURFACE DATA AND DESIGN	JET

THINK SAFETY FIRST

HORIZONTAL DIRECTIONAL DRILL DATA
CHEESEQUAKE ROAD

DESCRIPTION	STATION (ft)	ELEVATION (ft)
ENTRY @ 14°	136+88.96	82.59
PC1 = 2600° RADIUS	136+67.45	77.23
PT1 =	130+38.46	0.00
PC2 = 2600° RADIUS	124+83.08	0.00
PT2 =	121+21.23	25.30
EXIT @ 8°	117+88.96	72.00
HORIZONTAL DISTANCE (ft) = 1900.00		
DIRECTIONAL DRILL PIPE LENGTH (ft) = 1911.41		

WILLIAMS
NORTHEAST SUPPLY ENHANCEMENT

MIDDLESEX COUNTY — NEW JERSEY

TITLE: CHEESEQUAKE ROAD
HORIZONTAL DIRECTIONAL DRILL

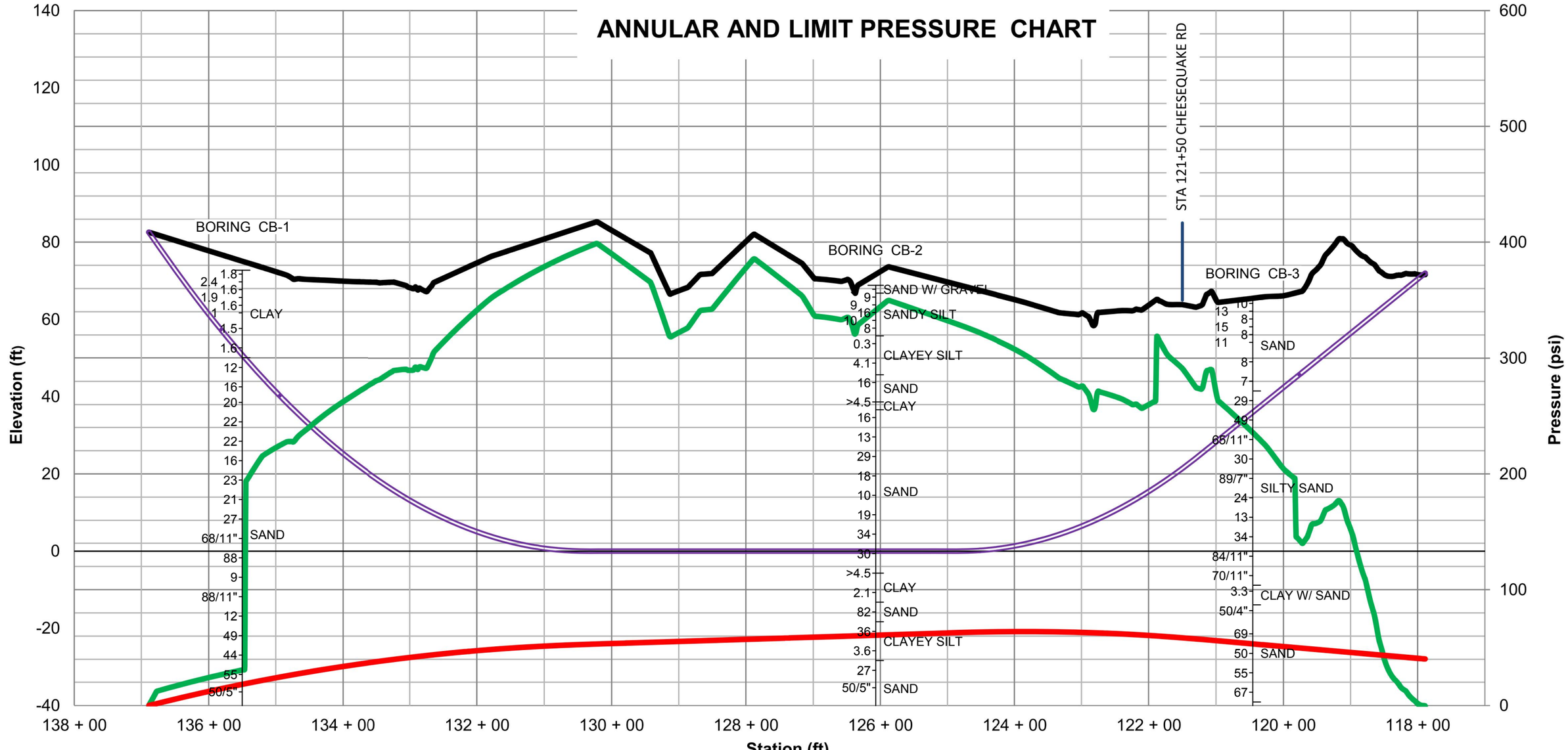
DESIGNED	DRAWN	CK'D.	PROJECT NO.	REV.
GEJ	GEJ	JET	10150	K
SCALE: AS NOTED	DATE: 08/25/16	DWG. NO. CHEESEQUAKE HDD.dwg SHT. 1 OF 1		

laney
"There is no substitute for experience"
831 Crossbridge Drive • Spring, Texas 77373
Tel: (281) 540-6615 • Fax: (281) 540-6727
www.laneydrilling.com

M:\ACTIVE PROJECTS\10150 - Williams - Northeast Supply Enhancement - Madison\Loop5\NV\Cheesequake Rd\Cheesequake RD_HDD_Rev'K_FERC.dwg\TAB-HDD modified on Apr 04, 2018 - 2:55pm - BLANE

Scale valid for 24" x 36" print

ANNULAR AND LIMIT PRESSURE CHART



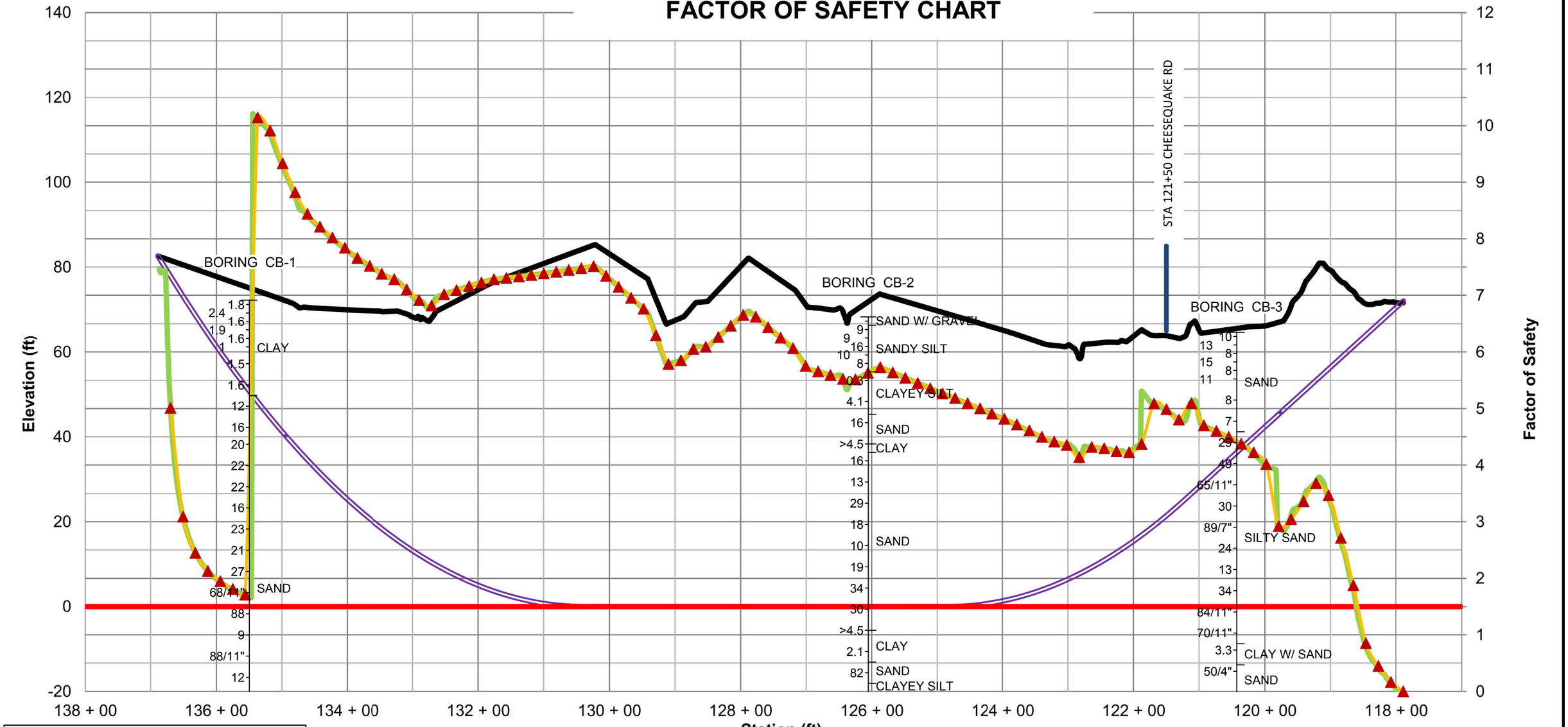
- Ground Elevations
- Borepath
- Cheesequake Road
- Limit Pressures
- Estimated Annular Pressure

Length of Drill:	1900 ft
Unit Weight of Drilling Fluid:	9.5 ppg
Effective Borehole Diameter:	10.625 in.
Drill Pipe Diameter:	5.500 in.
Plastic Viscocity of Drill Fluid:	13.0 cp
Yield Point of Drilling Fluid:	18 lb/100 sf
Drilling Fluid Discharge:	300 gpm

NORTHEAST SUPPLY ENHANCEMENT (NESE)
CHEESEQUAKE RD HDD
MIDDLESEX COUNTY, NEW JERSEY
Hydraulic Fracture and Inadvertent Returns Analysis

Laney
"There is no substitute for experience"

FACTOR OF SAFETY CHART



- Ground Elevations
- Borepath
- Factor of Safety = 1.5
- Factor of Safety - Hydraulic Fracture
- Inadvertent Returns

Length of Drill:	1900 ft
Unit Weight of Drilling Fluid:	9.5 ppg
Effective Borehole Diameter:	10.625 in.
Drill Pipe Diameter:	5.500 in.
Plastic Viscocity of Drill Fluid:	13.0 cp
Yield Point of Drilling Fluid:	18 lb/100 sf
Drilling Fluid Discharge:	300 gpm

NORTHEAST SUPPLY ENHANCEMENT (NESE)
CHEESEQUAKE RD HDD
MIDDLESEX COUNTY, NEW JERSEY
Hydraulic Fracture and Inadvertent Returns Analysis

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LOG of BORING No. CB-1

Sheet 1 of 3

DATE 8/14/2017-8/15/2017 SURFACE ELEVATION 71.8 LOCATION Northing: 40.444758 Easting: -74.304155

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		4	SS	Firm to very stiff dark gray to gray silty to sandy CLAY		1.8				
		8	SS			2.4				
5		4	SS			1.6				
		10	SS			1.9				
		7	SS			1.6				
10		12	SS			1.0				
15		6	SS			1.5				
20		6	SS			1.6				
					49.3					
25		12	SS	Medium dense gray to orange brown silty fine SAND to sandy SILT						
30		16	SS							
35		20	SS							
40		22	SS							
				(Undivided Magothy Unit)						
		22	SS	(Continued on Sheet 2 of 3)						

Completion Depth: 113.4 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger + Mud Rotary

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. CB-1

DATE 8/14/2017-8/15/2017 SURFACE ELEVATION 71.8 LOCATION Northing: 40.444758 Easting: -74.304155

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45				- Continuing medium dense to very dense gray to orange brown silty medium to fine SAND						
		16	SS							
50										
		23	SS							
55										
		21	SS							
60										
		27	SS							
65										
		68/11"	SS							
70										
		88	SS							
75										
		9	SS	- loose						
80										
		88/11"	SS							
85										
				(Undivided Magothy Unit)						
		12	SS	(Continued on Sheet 3 of 3)						

Completion Depth: 113.4 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger + Mud Rotary ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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LOG of BORING No. CB-1

Sheet 3 of 3

DATE 8/14/2017-8/15/2017 SURFACE ELEVATION 71.8 LOCATION Northing: 40.444758 Easting: -74.304155

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
90				- Continuing very dense light gray to orange brown silty fine SAND to sandy SILT						
95		49	SS							
		44	SS							
100										
		55	SS							
105										
		50/5"	SS							
110				(Old Bridge Sand)						
		50/5"	SS		-41.6					
115										
				Notes: 1. Ground surface elevation at the boring location was surveyed by Williams surveyors. 2. Groundwater level could not be measured due to the drilling method. 3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.						
120										
125										
130										

Completion Depth: 113.4 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger + Mud Rotary ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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LOG of BORING No. CB-2

Sheet 1 of 3

DATE 8/23/2017 SURFACE ELEVATION 69.1 LOCATION Northing: 40.443491 Easting: -74.307126

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		9	SS	Medium dense orange brown silty coarse to fine SAND with gravel	67.1					
		9	SS	(Pennsauken Formation)						
5		9	SS	Medium dense to dense light brown to orange brown medium to fine SAND with silt			5.6			M
		16	SS							
		10	SS							
10		8	SS							
					56.1					
15		5	SS	Soft to very stiff brownish gray to dark gray clayey SILT to silty CLAY, trace sand		0.3	25.3			M
20		22	SS			4.1				
					46.6					
25		16	SS	Medium dense gray to brown silty fine SAND			22.6			M
30		27	SS		39.1	>4.5	21.2			M
				Very stiff to hard dark gray silty CLAY	37.1					
35		16	SS	Medium dense to dense light brown silty medium to fine SAND to medium to fine SAND with silt						
		13	SS							
40				(Undivided Magothy Unit)						
		29	SS	(Continued on Sheet 2 of 3)						

Completion Depth: 115.0 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger + Mud Rotary ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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LOG of BORING No. CB-2

Sheet 2 of 3

DATE 8/23/2017 SURFACE ELEVATION 69.1 LOCATION Northing: 40.443491 Easting: -74.307126

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45				- Continuing medium dense to dense orange brown to light grayish brown silty medium to fine SAND to medium to fine SAND with silt						
		18	SS							
50										
		10	SS							
55										
		19	SS							
60										
		34	SS							
65										
		30	SS	- trace gravel			22.4			M
70										
		37	SS		-5.4	>4.5				
75				Very stiff brownish gray to light brown silty to sandy CLAY						
		27	SS			2.1	20.0			M
80					-12.4					
				Very dense gray silty medium to fine SAND, trace clay						
		82	SS							
85					-17.4					
				(Undivided Magothy Unit)						
		36	SS	(Continued on Sheet 3 of 3)						

Completion Depth: 115.0 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger + Mud Rotary ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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LOG of BORING No. CB-2

Sheet 3 of 3

DATE 8/23/2017 SURFACE ELEVATION 69.1 LOCATION Northing: 40.443491 Easting: -74.307126

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
90				Medium dense to dense gray to dark brownish gray sandy to clayey SILT						
		50	SS			3.6	28.5			M
95				(Undivided Magothy Unit)	-27.4					
		27	SS	Medium dense to very dense gray to brownish gray silty medium to fine SAND, trace gravel						
100										
		50/5"	SS							
105										
		50/5"	SS							
110					-41.9					
				Stiff to very stiff light brown silty CLAY						
		29	SS	(Old Bridge Sand)	-45.9	1.8				
115										
120				Notes: 1. Ground surface elevation at the boring location was surveyed by Williams surveyors. 2. Groundwater level was measured at approximately 12.9 ft below existing ground surface on completion of drilling. 3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.						
125										
130										

Completion Depth: 115.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger + Mud Rotary

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. CB-3

DATE 9/15/2016-9/20/2016 SURFACE ELEVATION 66.3 LOCATION Northing: 40.44282019 Easting: -74.30894441

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		10	SS	Loose to medium dense orange brown to light brown silty coarse to fine SAND, trace gravel						
		13	SS							
5		8	SS				16.5			M
		15	SS							
		8	SS							
10		11	SS							
15		8	SS							
20		7	SS				16.7			M
					42.8					
25		29	SS	Medium dense to very dense orange brown to light brown SILT with sand to silty medium to fine SAND						
30		49	SS				5.0			M
35		65/11"	SS				3.7			M
40		30	SS	(Undivided Magothy Unit)						

(Continued on Sheet 2 of 4)

Completion Depth: 157.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After ____ hrs.
ft., After ____ hrs.
ft., After ____ hrs.
ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. CB-3

DATE 9/15/2016-9/20/2016 SURFACE ELEVATION 66.3 LOCATION Northing: 40.44282019 Easting: -74.30894441

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		89/7"	SS	- Continuing medium dense to very dense orange brown to light brown SILT with sand to silty medium to fine SAND			20.2			M
50		24	SS							
55		13	SS	- trace gravel			19.1			M
60		34	SS							
65		84/11"	SS				23.0			M
70		70/11"	.ss.							
					-7.2					
75		50/3"	SS	Very stiff to hard light gray to orange brown CLAY with sand (Undivided Magothy Unit)		3.3	16.7	29	17	M
					-12.2					
80		50/4"	SS	Very dense light brown to light gray silty medium to fine SAND			22.4			M
85		69	SS	(Old Bridge Sand) (Continued on Sheet 3 of 4)						

Completion Depth: 157.0 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ft., After ____ hrs.

Project Name: Williams NESE Madison ft., After ____ hrs.

Drilling Method: Hollow Stem Auger ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. CB-3

Sheet 3 of 4

DATE 9/15/2016-9/20/2016 SURFACE ELEVATION 66.3 LOCATION Northing: 40.44282019 Easting: -74.30894441

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
90		50	SS	- Continuing very dense light brown to light gray silty medium to fine SAND			21.0			M
95		55	SS				22.8			M
100		67	SS							
					-37.2					
105		50/5"	SS	Medium dense to very dense light brown to orange brown medium to fine SAND with silt						
110		50/4"	SS				22.7			M
115		32	SS							
120		62	SS							
					-57.2					
125		51	SS	Dense light gray sandy SILT with clay						
					-62.2					
130		88	SS	Dense to very dense light gray to orange brown coarse to fine SAND (Old Bridge Sand)						

(Continued on Sheet 4 of 4)

Completion Depth: 157.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After ____ hrs.
ft., After ____ hrs.
ft., After ____ hrs.
ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. CB-3

DATE 9/15/2016-9/20/2016 SURFACE ELEVATION 66.3 LOCATION Northing: 40.44282019 Easting: -74.30894441

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
135		44	SS	- Continuing dense to very dense light gray to orange brown coarse to fine SAND						
140		54	SS		-77.2					
145		72	SS	Very stiff to hard light gray silty CLAY	-82.2	3.2				
150		65	SS	Dense to very dense dark gray to light brown silty fine SAND, trace clay	-87.2					
155				- no sample taken at 155 to 157 ft (Old Bridge Sand)	-90.7					
160										
165										
170										
175										

Notes:
1. Ground surface elevation at the boring location was surveyed by Williams surveyors.
2. Groundwater levels were measured as shown below:

Date & Time	GW Depth (ft)	GW Elev. (ft)
09/16/16 08:55	42.0	24.3
09/16/16 10:55	40.7	25.6
09/20/16 08:00	44.0	22.3

3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.

Completion Depth: 157.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

Project: Williams NESE - Madison
Project No.: 60515039

URS

SUMMARY OF LABORATORY TEST RESULTS

Boring and Sample Number	Depth (feet)	Classification	USCS Symbol	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		Specific Gravity	Organic Content (%)	Grain Size		Compaction	Consolidation	Unconfined Compression		Triaxial Compression		Permeability (cm/sec)	Special Tests
						Liquid Limit	Plastic Limit			<#200 (%)	<2µ (%)			Stress (psi)	Strain (%)	UU	CIU		
AB-1	8.0-10.0	Brown SILTY SAND	SM	11.7						15									
AB-1	24.0-26.0			28.4						87									
AB-1	48.0-50.0			27.5		38	23												
AB-1	58.0-60.0	Gray SANDY SILT	ML	18.7						57									
AB-2	50.0-52.0	Brown SILTY SAND	SM	23.9						17									
AB-2	55.0-57.0	Dark gray SILT	ML	26.8		42	26			86									
AB-2	60.0-62.0	Dark gray SILT with SAND	ML	22.6						71									
AB-2	70.0-72.0	Gray SILTY SAND	SM	24.4						33									
AB-2	75.0-77.0	Gray SANDY SILT	ML	21.4						54									
AB-2	80.0-82.0	Gray LEAN CLAY with SAND	CL	26.0		35	22			81									
AB-2	85.0-87.0	Gray SILT with SAND	ML	24.4						82									
AB-2	95.0-97.0	Gray SILTY SAND	SM	22.0						19									
AB-3	6.0-8.0	Brown SILTY SAND with GRAVEL	SM	18.8						24									
AB-3	10.0-12.0	Brown SANDY LEAN CLAY	CL	17.4		34	18			60									
AB-3	20.0-22.0	Brown gray SILTY SAND	SM	12.5						30									
AB-3	30.0-32.0	Brown gray SILTY SAND	SM	8.6						16									
AB-3	40.0-42.0	Brown gray SILTY SAND	SM	12.5						25									
AB-3	50.0-52.0	Brown gray SILTY SAND	SM	12.2						27									
AB-3	60.0-62.0	Brown POORLY GRADED SAND with SILT	SP-SM	8.7						11									

Note: The soil classification is based partially on visual classification unless both grain size and Atterberg limits are performed.

* Refer to Laboratory Test Curves

Project: Williams NESE - Madison
Project No.: 60515039

URS

SUMMARY OF LABORATORY TEST RESULTS

Boring and Sample Number	Depth (feet)	Classification	USCS Symbol	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		Specific Gravity	Organic Content (%)	Grain Size		Compaction	Consolidation	Unconfined Compression		Triaxial Compression		Permeability (cm/sec)	Special Tests
						Liquid Limit	Plastic Limit			<#200 (%)	<2µ (%)			Stress (psi)	Strain (%)	UU	CIU		
AB-3	70.0-72.0	Gray brown SILTY SAND	SM	23.8						19									
AB-3	75.0-77.0	Brown SILTY SAND	SM	12.1						25									
AB-3	80.0-82.0	Brown SILTY SAND	SM	12.0						16									
AB-3	90.0-92.0	Dark gray SILT	ML	30.3		45	29			91									
AB-3	95.0-97.0	Dark gray SANDY SILT	ML	37.9						69									
AB-4	8.0-10.0	Brown SILTY SAND	SM	12.8						17									
AB-4	29.0-31.0	Brown POORLY GRADED SAND with SILT	SP-SM	12.0						12									
AB-4	39.0-41.0			22.6		30	18												
AB-4	78.0-80.0			28.0		43	22												
AB-4	83.0-85.0	Light brown SILTY SAND	SM	17.5						31									
CB-2	4.0-6.0	Brown POORLY GRADED SAND with SILT	SP-SM	5.6						7									
CB-2	14.0-16.0			25.3						45									
CB-2	24.0-26.0	Gray SILTY SAND	SM	22.6						32									
CB-2	29.0-31.0			21.2						71									
CB-2	68.0-70.0	Light brown POORLY GRADED SAND with SILT	SP-SM	22.4						7									
CB-2	78.0-80.0			20.0						65									
CB-2	93.0-95.0			28.5						43									
CB-3	4.0-6.0	Brown gray SILTY SAND	SM	16.5						40									
CB-3	20.0-22.0	Brown SILTY SAND	SM	16.7						19									

Note: The soil classification is based partially on visual classification unless both grain size and Atterberg limits are performed.

* Refer to Laboratory Test Curves

Project: Williams NESE - Madison
Project No.: 60515039

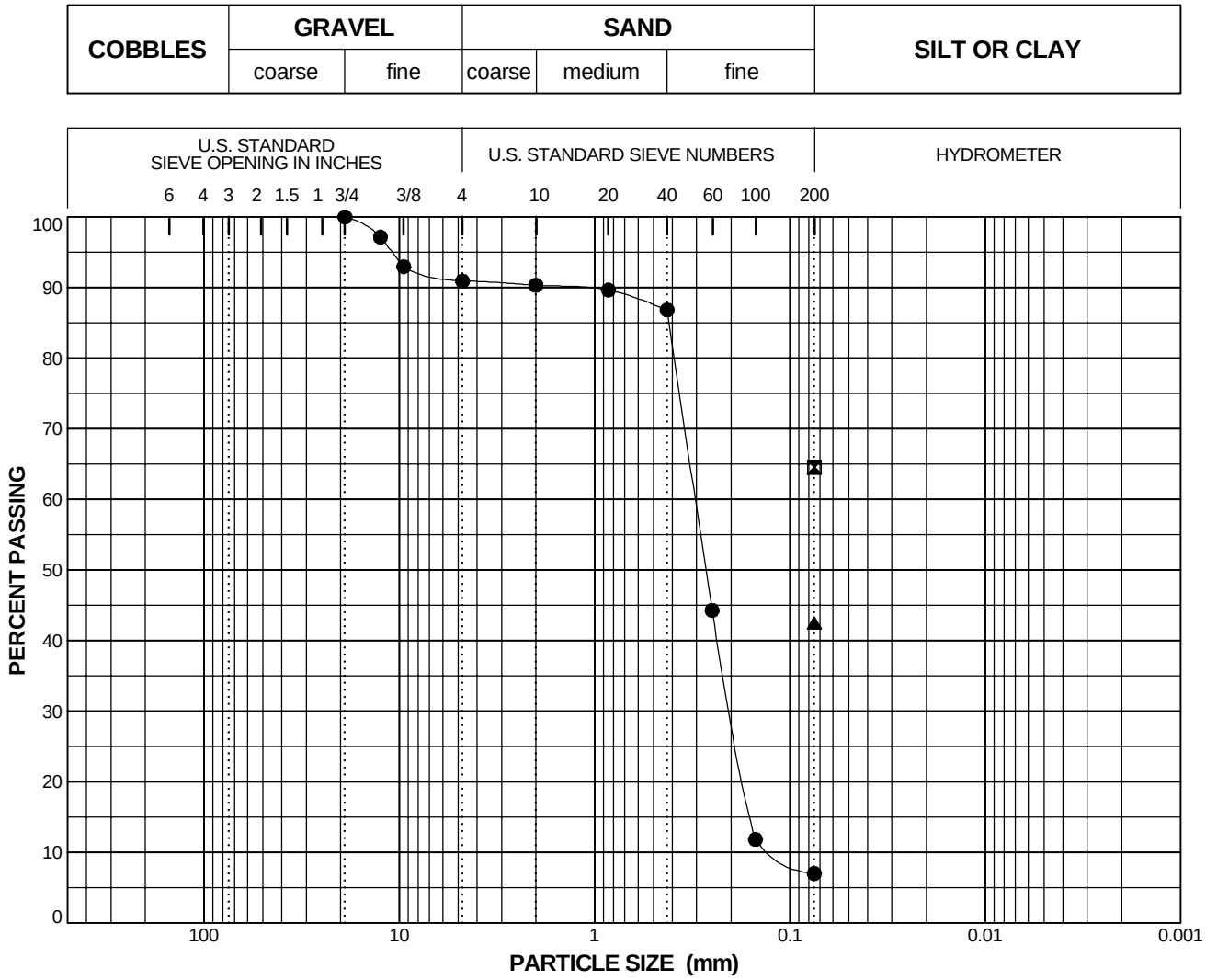
URS

SUMMARY OF LABORATORY TEST RESULTS

Boring and Sample Number	Depth (feet)	Classification	USCS Symbol	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		Specific Gravity	Organic Content (%)	Grain Size		Compaction	Consolidation	Unconfined Compression		Triaxial Compression		Permeability (cm/sec)	Special Tests
						Liquid Limit	Plastic Limit			<#200 (%)	<2µ (%)			Stress (psi)	Strain (%)	UU	CIU		
CB-3	30.0-32.0	Brown SILT with SAND	ML	5.0						77									
CB-3	35.0-37.0	Brown POORLY GRADED SAND with SILT	SP-SM	3.7						7									
CB-3	45.0-47.0	Brown SILTY SAND	SM	20.2						18									
CB-3	55.0-57.0	Brown SILTY SAND	SM	19.1						23									
CB-3	65.0-67.0	Brown POORLY GRADED SAND with SILT	SP-SM	23.0						9									
CB-3	75.0-77.0	Brown LEAN CLAY with SAND	CL	16.7		29	17			71									
CB-3	80.0-82.0	Brown SILTY SAND	SM	22.4						18									
CB-3	90.0-92.0	Brown POORLY GRADED SAND with SILT	SP-SM	21.0						9									
CB-3	95.0-97.0	Gray SILTY SAND	SM	22.8						48									
CB-3	110.0-112.0	Brown POORLY GRADED SAND with SILT	SP-SM	22.7						8									
MDB-1	10.0-12.0			18.8						55									
MDB-1	19.0-21.0	Brown gray SILTY SAND	SM	28.4						33									
MDB-1	34.0-36.0	Brown POORLY GRADED SAND with SILT	SP-SM	25.6						9									
MDB-1	48.0-50.0	Brown POORLY GRADED SAND with SILT	SP-SM	25.5						7									
MDB-1	63.0-65.0			19.6		33	16												

Note: The soil classification is based partially on visual classification unless both grain size and Atterberg limits are performed.

* Refer to Laboratory Test Curves



SYMBOL	●	⊠	▲
Boring	CB-2	CB-2	CB-2
Sample			
Spec			
Depth (ft)	68.0-70.0	78.0-80.0	93.0-95.0
% +3"	0.0	0.0	0.0
% Gravel	9.1	0.0	0.0
% Sand	83.9	0.0	0.0
% Fines	7.0	64.5	42.5
% -2µ			
Cc	1.14		
Cu	2.64		
LL			
PL			
PI			
USCS	SP-SM		
w (%)	22.4	20.0	28.5

Particle Size	PERCENT FINER		
(Sieve #)	●	⊠	▲
3"			
2"			
1"			
3/4"	100.0		
1/2"	97.1		
3/8"	92.9		
4	90.9		
10	90.3		
20	89.6		
40	86.8		
60	44.3		
100	11.8		
200	7.0	64.5	42.5

SYMBOL	DESCRIPTION AND REMARKS
●	Light brown POORLY GRADED SAND with SILT (SP-SM)
⊠	Light brown ()
▲	Gray ()

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-14

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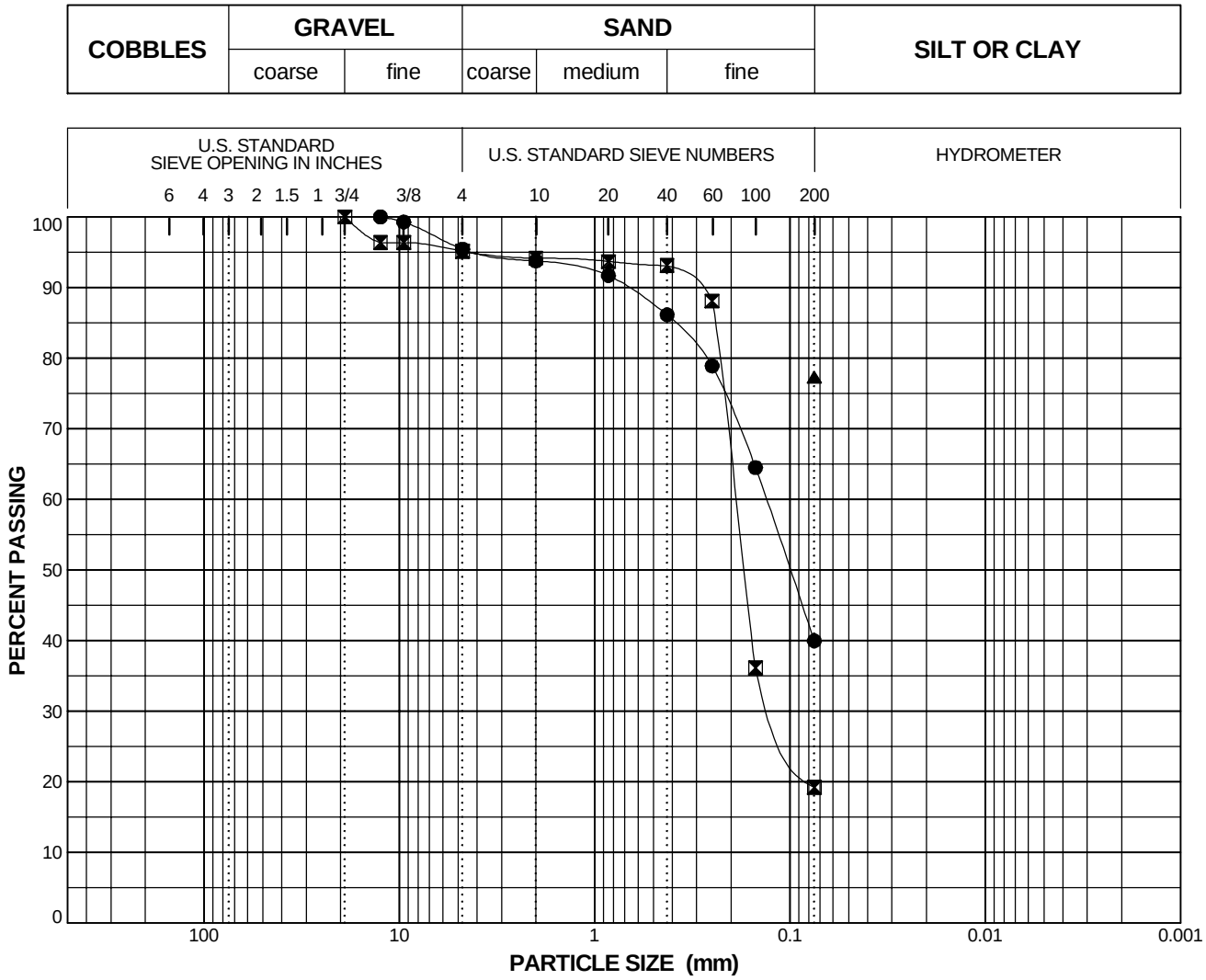

SYMBOL	●	⊠	▲
Boring	CB-3	CB-3	CB-3
Sample			
Spec			
Depth (ft)	4.0-6.0	20.0-22.0	30.0-32.0
% +3"	0.0	0.0	0.0
% Gravel	4.6	4.9	0.0
% Sand	55.5	75.9	0.0
% Fines	40.0	19.2	77.3
% -2µ			
Cc			
Cu			
LL			
PL			
PI			
USCS	SM	SM	ML
w (%)	16.5	16.7	5.0

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"		100.0	
1/2"	100.0	96.4	
3/8"	99.3	96.4	
4	95.4	95.1	
10	93.8	94.2	
20	91.7	93.7	
40	86.1	93.1	
60	78.9	88.1	
100	64.5	36.1	
200	40.0	19.2	77.3

SYMBOL	DESCRIPTION AND REMARKS
●	Brown gray SILTY SAND (SM)
⊠	Brown SILTY SAND (SM)
▲	Brown SILT with SAND (ML)

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-15

URS

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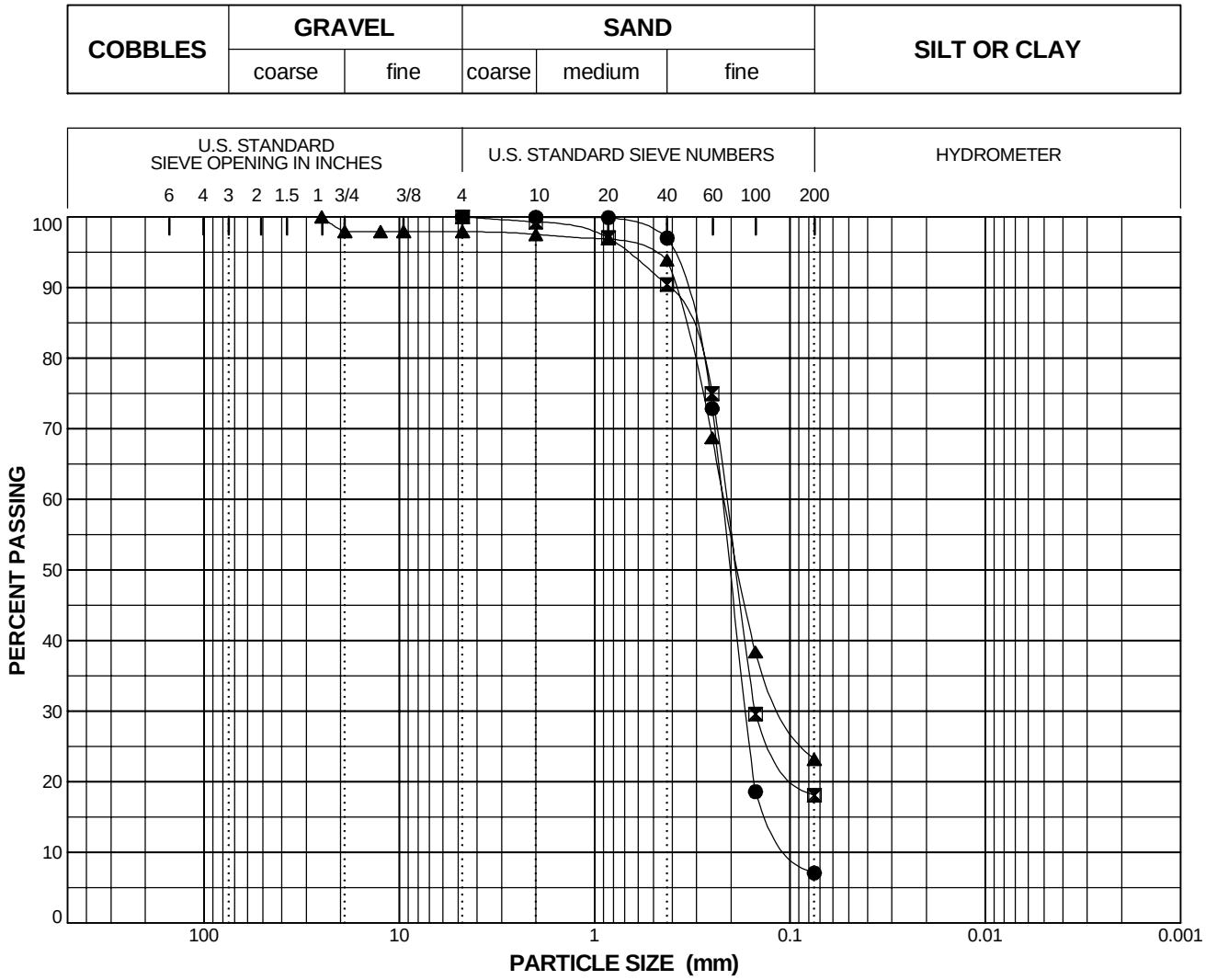

SYMBOL	●	⊠	▲
Boring	CB-3	CB-3	CB-3
Sample			
Spec			
Depth (ft)	35.0-37.0	45.0-47.0	55.0-57.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	2.1
% Sand	92.9	81.9	74.7
% Fines	7.1	18.1	23.2
% -2µ			
Cc	1.41		
Cu	2.48		
LL			
PL			
PI			
USCS	SP-SM	SM	SM
w (%)	3.7	20.2	19.1

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			100.0
3/4"			97.9
1/2"			97.9
3/8"			97.9
4	100.0	100.0	97.9
10	99.9	99.3	97.5
20	99.9	97.0	96.9
40	97.0	90.4	93.9
60	72.8	75.0	68.7
100	18.6	29.6	38.4
200	7.1	18.1	23.2

SYMBOL	DESCRIPTION AND REMARKS
●	Brown POORLY GRADED SAND with SILT (SP-SM)
⊠	Brown SILTY SAND (SM)
▲	Brown SILTY SAND (SM)

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-16

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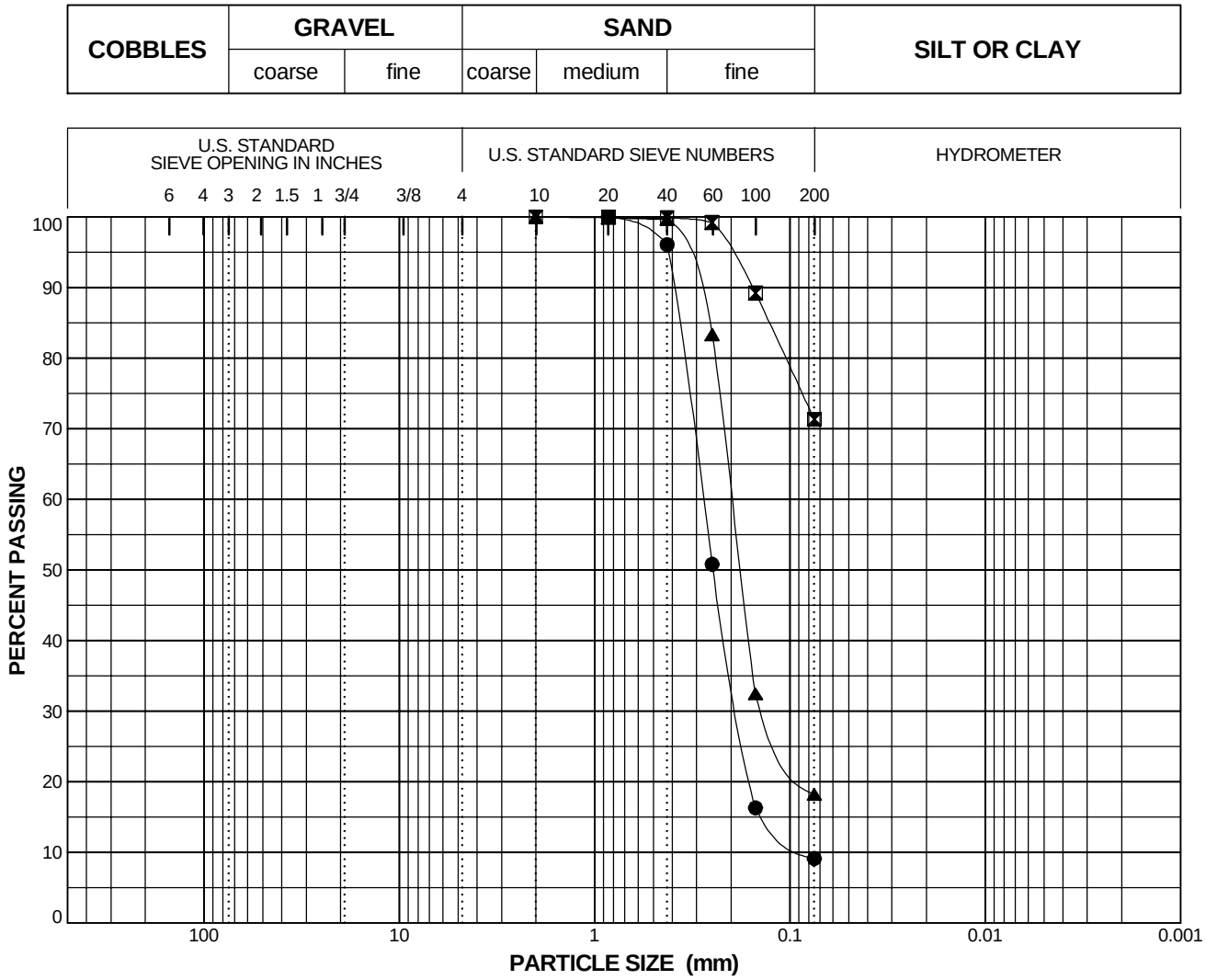

SYMBOL	●	⊠	▲
Boring	CB-3	CB-3	CB-3
Sample			
Spec			
Depth (ft)	65.0-67.0	75.0-77.0	80.0-82.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% Sand	90.9	28.7	81.8
% Fines	9.1	71.3	18.2
% -2µ			
Cc	1.48		
Cu	3.41		
LL		29	
PL		17	
PI		12	
USCS	SP-SM	CL	SM
w (%)	23.0	16.7	22.4

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"			
4			
10		100.0	100.0
20	100.0	99.9	99.9
40	96.1	99.9	99.6
60	50.8	99.2	83.3
100	16.3	89.2	32.4
200	9.1	71.3	18.2

SYMBOL	DESCRIPTION AND REMARKS
●	Brown POORLY GRADED SAND with SILT (SP-SM)
⊠	Brown LEAN CLAY with SAND (CL)
▲	Brown SILTY SAND (SM)

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-17

URS

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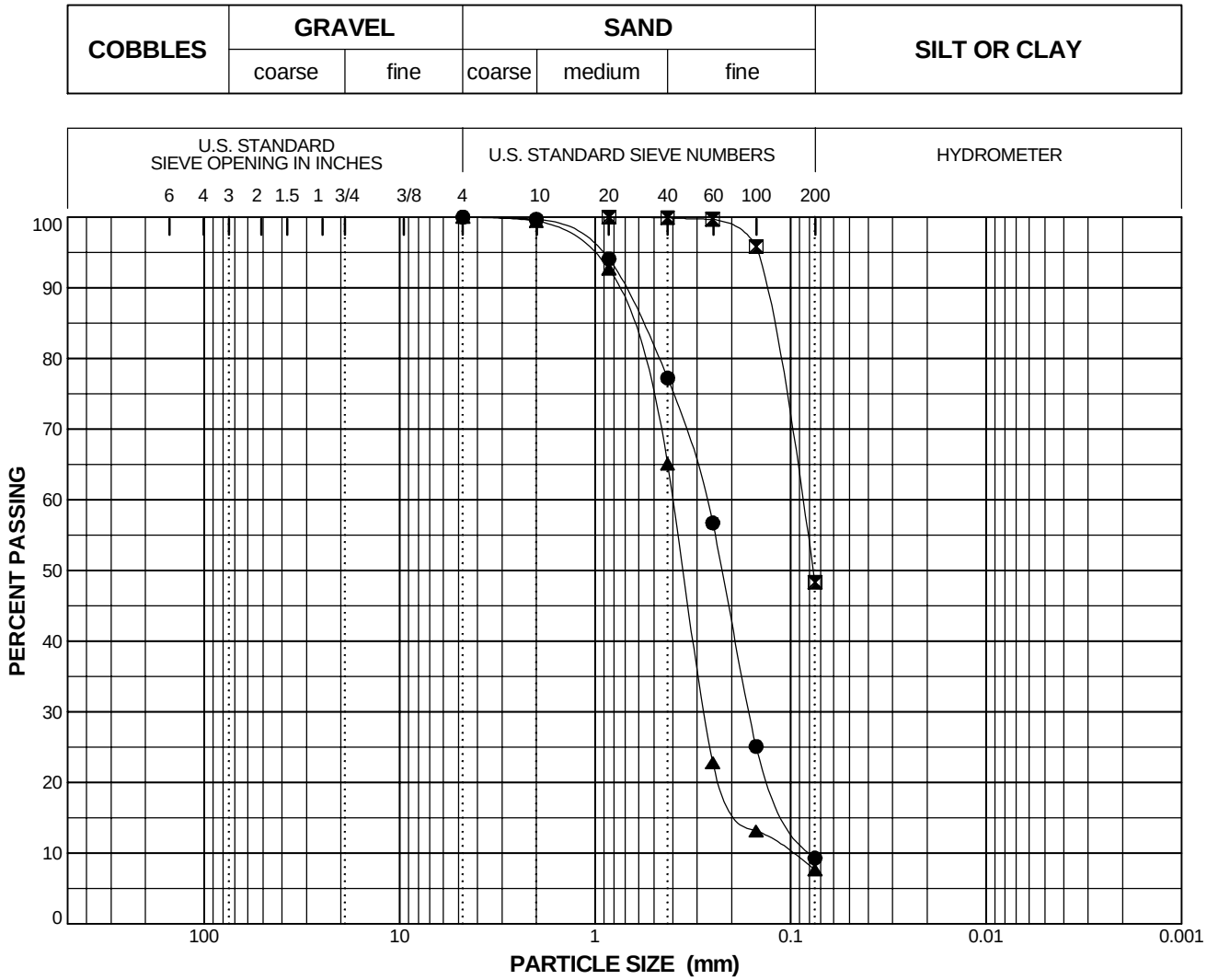

SYMBOL	●	⊠	▲
Boring	CB-3	CB-3	CB-3
Sample			
Spec			
Depth (ft)	90.0-92.0	95.0-97.0	110.0-112.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% Sand	90.7	51.7	92.4
% Fines	9.3	48.4	7.6
% -2µ			
Cc	1.25		1.86
Cu	3.52		3.94
LL			
PL			
PI			
USCS	SP-SM	SM	SP-SM
w (%)	21.0	22.8	22.7

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"			
4	100.0		100.0
10	99.7		99.4
20	94.1	100.0	92.7
40	77.2	99.9	65.1
60	56.7	99.7	22.8
100	25.1	95.9	13.1
200	9.3	48.4	7.6

SYMBOL	DESCRIPTION AND REMARKS
●	Brown POORLY GRADED SAND with SILT (SP-SM)
⊠	Gray SILTY SAND (SM)
▲	Brown POORLY GRADED SAND with SILT (SP-SM)

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-18

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GeoEngineers

Memorandum

3050 South Delaware Avenue, Springfield, Missouri 65804, Telephone: 417.831.9700, Fax: 417.831.9777 www.geoengineers.com

To:	Williams Pipeline
From:	GeoEngineers, Inc.
Date:	May 2, 2018
File:	8169-144-00
Subject:	26-inch Northeast Supply Enhancement Project, Madison Loop—Lockwood Marina HDD Feasibility Review

INTRODUCTION AND PROJECT UNDERSTANDING

GeoEngineers is pleased to present this Memorandum, describing our feasibility assessment for the proposed Lockwood Marina HDD from approximate Madison Loop milepost (MP) 11.49 to MP 11.84 in Middlesex County, New Jersey.

We understand that as part of the Northeast Supply Enhancement Project, Williams Pipeline (Williams) is proposing to construct the Madison Loop Pipeline which consists of approximately 3.4 miles of 26-inch-diameter steel pipeline in Middlesex County New Jersey. We further understand the proposed Lockwood Marina HDD is one of three proposed HDDs along the Madison Loop Pipeline route. The proposed Lockwood Marina HDD is located approximately 1.5 miles southeast of South Amboy, NJ and is proposed to be installed adjacent to an existing 42-inch pipeline, beneath Crossway Creek and portions of Lockwood Marina.

SURFACE CONDITIONS

The proposed Lockwood Marina HDD entry point is located immediately south of the existing 42-inch pipeline within a relatively flat, delineated wetland area at an elevation of approximately 4 feet North American Vertical Datum 88 (NAVD 88). From the entry point, the approximately 1,785-foot-long horizontal alignment trends roughly eastward, diverging away from the existing 42-inch pipeline, traversing Crossway Creek and portions of the Lockwood Marina, before exiting within a gently side sloping area adjacent to the existing pipeline right of way immediately east of Lockwood Marina. The topography along the alignment ranges from relatively flat to gently sloping and the approximate elevation at the exit point is approximately 17 feet NAVD 88. The HDD alignment, profile, workspace configurations, approximate boring locations and carrier pipe fabrication area are shown in the attached design drawing provided in Appendix A.

The proposed HDD entry workspace may be accessed directly from Gondek Drive southwest of the workspace. The proposed carrier pipe fabrication and stringing workspace is located on the exit side of the proposed HDD and extends from the exit point northeast, across Old Spye Road and 1st Street to State Highway 35 (Lorraine Ave). We anticipate the HDD exit side workspace will be accessed via the proposed pipeline fabrication workspace. Due to the limited horizontal distance between the exit point and State Highway 35, we anticipate the carrier pipe will be fabricated in three strings and two mid-welds will be required during carrier pipe installation (pullback). Additionally, we anticipate road closures will be required for both Old Spye Road and First Street. We understand Williams is coordinating with local entities and effected parties relative to alternate travel routes and parking areas.

Depending upon conditions at the time of construction, load-dispersing materials such as timber mats or quarry rock may be required to maintain stabilization of the equipment entering the locations and within the entry and exist side workspaces. We recommend the selected contractor visit the site prior to construction to evaluate the designated access routes and workspaces to determine what improvements might be necessary and what considerations may be needed prior to mobilization of equipment to the site.

SUBSURFACE CONDITIONS

Subsurface conditions were explored at the site by URS Corporation between June 15 and June 17, 2005 for the existing 42-inch pipeline (Borings B-1 through B-3) and by AECOM between August 16 and August 17, 2017 for the proposed HDD (Boring MDB-1). We utilized data from both exploration programs to evaluate feasibility of the proposed 26-inch Lockwood Marina HDD. In general, the subsurface conditions encountered in the borings consisted predominantly of medium dense to dense, fine to coarse sand with interbedded layers of stiff to hard silty clay, and soft to very soft clay, silts and isolated gravel pockets.

HYDRALUIC FRACTURE ANALYSIS

In order to evaluate the hydraulic fracture and inadvertent drilling fluid returns potential for a given HDD alignment, assumptions must be made when selecting the model input parameters. The assumptions used in the model include the extent and uniformity of soil layers, hydrostatic water pressures, drilling fluid properties, penetration rates and pump rates. The soil strength properties are estimated based on interpretations of the boring logs and laboratory test results. The drilling fluid properties, penetration rates and pump rates are estimated based on generally accepted best management practices (BMPs) of the HDD industry. Consequently, the results of the evaluation are only estimates of the potential for hydraulic fracture and inadvertent drilling fluid returns. In addition to the subsurface soil conditions, the drilling fluid properties influence the risk of hydraulic fracture and inadvertent returns and are dependent on the field conditions and the construction practices of the HDD contractor and "mud engineer." Changes in these properties can significantly affect the potential for hydraulic fracture and inadvertent drilling fluid returns.

The soil units encountered in the vicinity of the HDD are characterized by borings B-1 through B-3 and MDB-1. In general, the subsurface conditions encountered in the borings consisted predominantly of medium dense to dense, fine to coarse sand with interbedded layers of stiff to hard silty clay, and soft to very soft clay, silts and isolated gravel pockets.

We completed a hydraulic fracture and drilling fluid surface release analysis along the proposed HDD profile under the assumption that the pilot hole will be drilled from the entry side to the exit side. In general, the results of the analysis, presented in Appendix B, indicate the risk of inadvertent returns of drilling fluid to the ground surface is generally low to moderate along the majority of the alignment with factors of safety between 1.5 and 2.25. However, factors of safety are substantially lower near the end points, indicating a high risk of hydraulic fracture and surface release in those areas. In our design, we have specified the use of small diameter casing on the entry side during pilot hole operations and anticipate this will help mitigate the risk on entry side. Furthermore, in order to mitigate the risk of hydraulic fracture and surface release along the remainder of the alignment, we anticipate Williams requiring the following steps be taken during construction: 1) the utilization of annular pressure monitoring; and 2) the HDD contractor to manage pump and penetration rates, especially

through the final approximately 250 feet of the HDD (along and adjacent to the exit side tangent section) where surface release factors of safety are less than 1.0.

HDD FEASIBILITY CONSIDERATIONS & RECOMMENDATIONS

The proposed Lockwood Marina HDD has a directional drill length of approximately 1,793 feet. For design purposes, we utilized 2,600-foot design radii for the entry and exit vertical curves and have situated the horizontal bottom tangent at an elevation that takes advantage of the higher shear strength sand layer identified within the geotechnical exploration borings and provides reasonable horizontal and vertical separation from the existing 42-inch pipeline. Additionally, we have incorporated a horizontal curve with a 2,600-foot design radius near the exit point to help the HDD alignment line up with the carrier pipe fabrication workspace.

Currently we anticipate a stringing area with a horizontal length on the order of 820 feet. In order to maximize the length of the stringing area we have incorporated a horizontal curve with a 1,100-foot radius. We anticipate the addition of the horizontal curve may necessitate the need of additional pipe support and handling equipment during both fabrication and carrier pipe installation. Additionally, as described previously, we anticipate the carrier pipe pullback and fabrication workspace will require road closures for both Old Spye Road and 1st Street. However, we understand Williams is coordinating with local entities and effected parties relative to alternate travel routes and parking areas and do not anticipate either the horizontal curvature or the road closures to introduce complications that will affect feasibility.

Based on the information available at this time, the subsurface conditions observed in the previously completed geotechnical explorations and our detailed HDD constructability and feasibility review, it is our opinion that the proposed 26-inch Lockwood Marina HDD is feasible. There are, however, potential risks associated with the HDD method of construction at this crossing location that will require mitigation during construction. The primary risk for the proposed 26-inch Lockwood Marina HDD is related to hydraulic fracture and inadvertent returns potential, which as described above is considered to be low to moderate along the majority of the proposed alignment. As described above, we have specified the use of small diameter casing on the entry side during pilot hole operations and anticipate this will help mitigate the risk on entry side. Furthermore, we anticipate Williams will require the following additional mitigation measures during construction: 1) utilization of annular pressure monitoring; and 2) the HDD contractor to manage pump and penetration rates, especially through the final approximately 250 feet of the HDD alignment adjacent to the exit side where surface release factors of safety are less than 1.0. It is our opinion that these three measures are practical and effective means to manage potential risks associated with hydraulic fracture and drilling fluid surface release.

CLOSURE

We appreciate the opportunity to provide our feasibility review memorandum for the proposed 26-inch Lockwood Marina HDD. Please do not hesitate to contact us with questions or concerns.

Sincerely,
GeoEngineers, Inc.

Attachments:
Appendix A. Lockwood Marina HDD Conceptual Design Drawing
Appendix B. Lockwood Marina Hydraulic Fracture and Surface Release Analyses

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APPENDIX A
Conceptual Design Drawing

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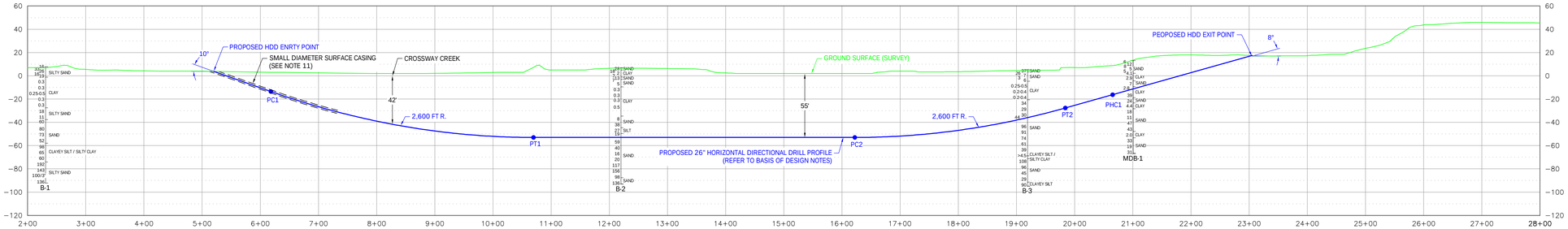
DATUM:
HORIZONTAL: NAD83 New Jersey State Plane, US Foot
VERTICAL: NAVD 88

PLAN

100 0 100
SCALE IN FEET



PROFILE

100 0 100
HORIZONTAL SCALE IN FEET

50 0 50
VERTICAL SCALE IN FEET

LEGEND

SPT (N) — TYPE OF SOIL

BORING LOCATION
MAJOR CONTOUR - 10' INTERVAL
MINOR CONTOUR - 2' INTERVAL

* THE STATIONING IS BASED ON AN ARBITRARY REFERENCE POINT

BASIS OF DESIGN:

1. PRODUCT PIPE WILL CONSIST OF 26" O.D. X 0.535" W.T., API-5L X-70 PIPE WITH 8-10 MILS OF FUSION BONDED EPOXY (FBE) AND A MINIMUM OF 40 MILS OF ABRASION RESISTANT OVERLAY (ARO).
2. THE MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP) =800 psi.
3. THE ASSUMED MAXIMUM OPERATING TEMPERATURE = 70° FAHRENHEIT.
4. THE MINIMUM ALLOWABLE THREE JOINT RADIUS SHALL NOT BE LESS THAN 2,250 FEET.

NOTES:

1. CONTRACTOR SHALL ADHERE TO THE SPECIFICATIONS AND REQUIREMENTS PER WILLIAMS PIPELINE COMPANY SPECIFICATIONS, CONTRACT DOCUMENTS AND SPECIAL PERMIT CONDITIONS, EXCEPT AS NOTED ON THIS DRAWING.
2. CONTRACTOR IS RESPONSIBLE FOR CALLING STATE ONE-CALL AND LOCATING ALL UNDERGROUND UTILITIES PRIOR TO BEGINNING CONSTRUCTION. IF ANY UTILITY IS LOCATED WITHIN 15 FEET OF THE DESIGNED HDD PROFILE AND ALIGNMENT, CONTRACTOR SHALL OBTAIN APPROVAL FROM WILLIAMS PIPELINE COMPANY PRIOR TO INITIATING HDD OPERATIONS.
3. IT IS THE CONTRACTOR'S RESPONSIBILITY TO IDENTIFY AND PROTECT ANY FOREIGN UTILITY THAT MAY BE AFFECTED BY THE HDD OPERATIONS.
4. PLACEMENT OF THE HDD RIG IS NOT FIXED BY THE DESIGNATION OF THE ENTRY AND EXIT POINTS. THE USE OF DUAL HDD RIGS DURING CONSTRUCTION MAY BE AT THE DISCRETION OF THE HDD CONTRACTOR, TO BE APPROVED BY THE PROJECT TEAM.
5. ALL EQUIPMENT MUST ACCESS THE SITE ALONG THE CONSTRUCTION RIGHT-OF-WAY OR FROM APPROVED ACCESS ROADS.
6. WORKSPACE: MAXIMUM WORKSPACE LIMITS ARE DEPICTED. RESTRICT CLEARING TO THE WORKSPACE INDICATED AT THE ENTRY AND EXIT POINTS AND PRODUCT PIPE STRINGING AND FABRICATION AREA ALONG THE CONSTRUCTION RIGHT-OF-WAY. CLEARING BETWEEN THE ENTRY AND EXIT POINTS REQUIRES PRIOR APPROVAL FROM THE ENVIRONMENTAL INSPECTOR AND IS LIMITED TO THE AMOUNT NECESSARY TO STRING SURVEY WIRES AND INSTALL PUMPS AND PIPING TO OBTAIN WATER (WHERE APPROVED).
7. WATER SOURCE: DRILL WATER AND HYDROSTATIC TEST WATER SHALL BE OBTAINED FROM AN APPROVED SOURCE.
8. HYDROSTATIC TEST: PRE-INSTALLATION AND POST-INSTALLATION HYDROSTATIC TESTS SHALL BE CONDUCTED IN ACCORDANCE WITH THE HYDROSTATIC TEST PLAN. TEST WATER SHALL BE SAMPLED AND TESTED IN ACCORDANCE WITH PERMIT REQUIREMENTS. THE TEST WATER SHALL BE DISCHARGED IN AN UPLAND AREA INTO AN EROSION CONTROL STRUCTURE OF STRAW BALES AND/OR SILT FENCES, GEOTEXTILE FILTER BAG, OR COLLECTED IN A TRUCK AND HAULED TO AN APPROVED DISPOSAL SITE. UPON COMPLETION OF DEWATERING AND DRYING, A CALIPER PIG SURVEY SHALL BE COMPLETED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.
9. SPILL-PREVENTION: REFUELING OF ALL EQUIPMENT SHALL BE COMPLETED IN ACCORDANCE WITH THE SPCC PLAN.
10. EROSION AND SEDIMENT CONTROL: CONTRACTOR SHALL SUPPLY, INSTALL AND MAINTAIN SEDIMENT CONTROL STRUCTURES IN ACCORDANCE WITH CONTRACT DOCUMENTS. CONTRACTOR SHALL INSTALL ADDITIONAL EROSION CONTROL STRUCTURES AS DIRECTED BY THE ENVIRONMENTAL INSPECTOR.
11. ENTRY SIDE: CONTRACTOR SHALL INSTALL A MINIMUM OF 215 FEET OF SMALL DIAMETER CASING
12. INSTALLATION: THE PIPE SECTION FOR THE DRILLED CROSSING SHALL BE MADE UP WITHIN THE APPROVED CONSTRUCTION RIGHT-OF-WAY AT THE DRILL EXIT POINT AS SHOWN. AFTER THE PILOT HOLE IS COMPLETE, CONTRACTOR'S ACTUAL DRILL PROFILE SHALL BE SUBMITTED TO WILLIAMS PIPELINE COMPANY FOR APPROVAL. CONTRACTOR SHALL ASSESS THE NEED FOR AND SUPPLY APPROPRIATE BALLAST DURING PULLBACK.
13. DRILLING FLUID DISPOSAL: CONTRACTOR SHALL DISPOSE OF EXCESS DRILLING FLUID AS DIRECTED BY THE WILLIAMS REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS. UNDER NO CIRCUMSTANCES SHALL DRILLING FLUID BE DISPOSED OF IN WATER BODIES OR WETLANDS. ANY DRILLING FLUID WHICH INADVERTENTLY SURFACES AT POINTS OTHER THAN THE ENTRY OR EXIT POINTS SHALL BE CONTAINED AND COLLECTED TO THE EXTENT PRACTICAL AND DISPOSED OF AS DIRECTED BY THE WILLIAMS REPRESENTATIVE IN ACCORDANCE WITH PERMIT CONDITIONS.
14. CLEANUP/STABILIZATION/RESTORATION: ALL DISTURBED AREAS SHALL BE RETURNED TO THE ORIGINAL CONTOURS. DISTURBED AREAS SHALL BE SEEDED AS SPECIFIED IN THE CLEAN-UP AND RESTORATION REQUIREMENTS. IF THE TERRAIN ALLOWS AND ACCESS IS PERMITTED, CONTRACTOR SHALL UTILIZE LOW GROUND PRESSURE EQUIPMENT OR OTHER EQUIPMENT APPROVED BY OWNER, TO FACILITATE CONTAINMENT AND CLEAN-UP OF ANY INADVERTENT RETURNS THAT OCCUR DURING THE HDD INSTALLATION PROCESS.
15. GEOTECHNICAL DATA: BORE HOLES ARE OFFSET FROM THE PIPELINE CENTERLINE AS SHOWN ON THE PLAN VIEW. THE GEOTECHNICAL INFORMATION PROVIDED ON THIS DRAWING IS A GENERAL SUMMARY. REFER TO THE APPLICABLE GEOTECHNICAL REPORT IN THE CONTRACT DOCUMENTS FOR MORE DETAILED INFORMATION.
16. BASE FILES, GROUND SURFACE SURVEY AND AERIAL IMAGE PROVIDED BY WILLIAMS PIPELINE COMPANY.

REFERENCES

DRAWING NUMBER	REFERENCE DRAWING TITLE
MADISON_MLLBD	SURVEY
MADISON_MLLBD	PROPERTY BOUNDARY

REVISIONS

NO.	DESCRIPTION	BY	DATE	CHK'D	APP'D
A	ISSUED AS DRAFT	RBM	04/30/18	GWC	

GWC — Design	03/09/18 — Date
RBM — Drawn	03/11/18 — Date
GWC — Checked	04/30/18 — Date
--- — Approved	00/00/17 — Date

GeoEngineers
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Springfield, MO 65804
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Fax (417) 831-9777

WILLIAMS PIPELINE - NORTHEAST SUPPLY ENHANCEMENT PROJECT SITE PLAN AND PROFILE

PROPOSED LOCKWOOD MARINA HDD MIDDLESEX COUNTY, NEW JERSEY

Project No. 8169-144-00
Drawing No.
Sheet 1 of 1

P:\8169144C\ADY\HDD\Crossing\Lockwood Marina HDD\Drawings\Lockwood Marina_Opt B HDD_Design.dwg\TAB SHEET 1 (Hiccuna) modified on May 02, 2018 - 9:08am

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APPENDIX B
Hydraulic Fracture and Surface Release Analyses

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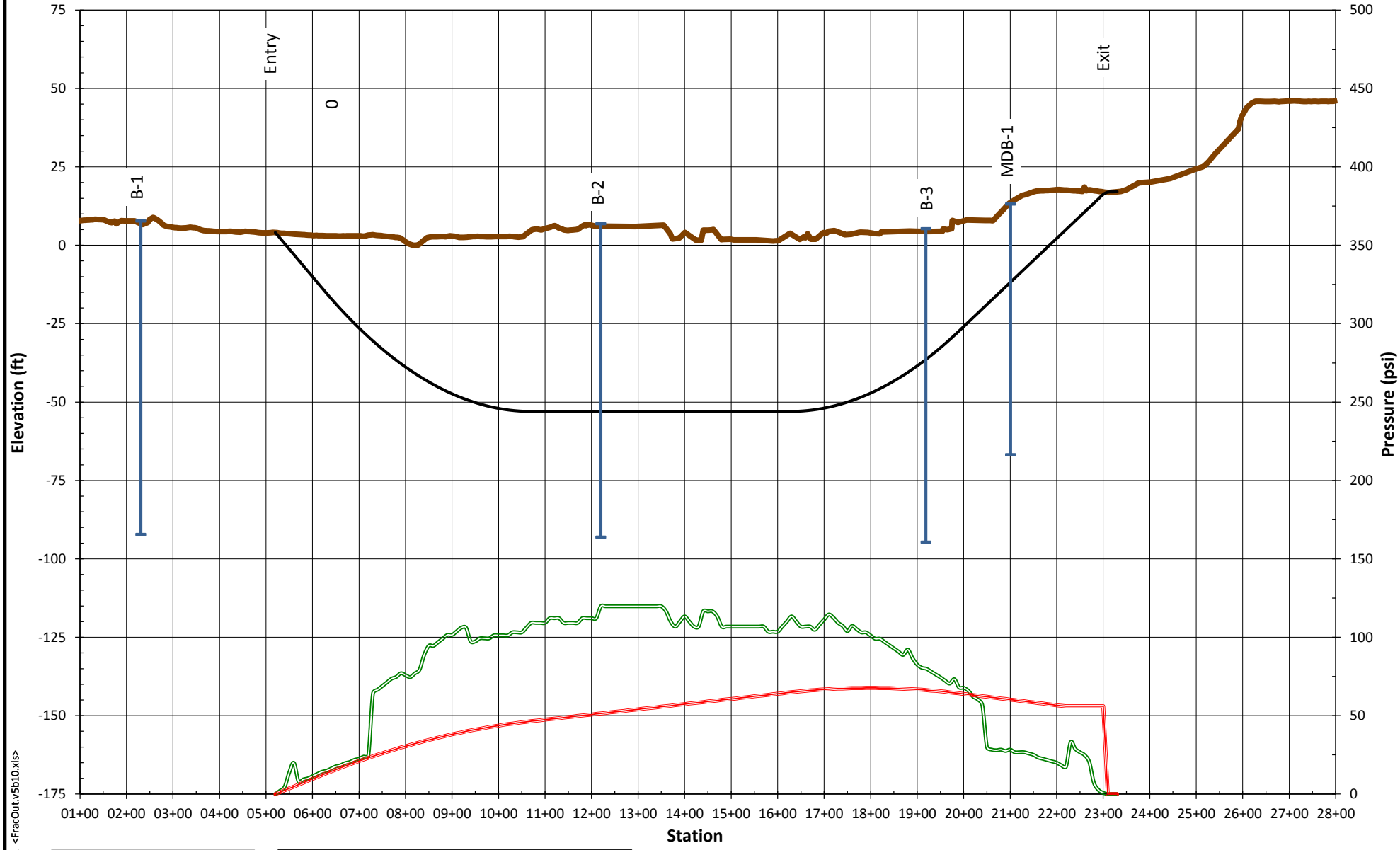
Williams - Lockwood Marina HDD



Crossing Length (ft)	1784
Hole Diameter (in)	9.875
Drill Pipe O.D. (in)	5.500
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (cP)	13
Yield Point (lb/100 sf)	28

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Formation Limit Pressure (psi)
- Estimated Annular Drilling Fluid Pressure (psi) for Pilot Hole

Williams - Lockwood Marina HDD

ESTIMATED ANNULAR DRILLING FLUID AND FORMATION LIMIT PRESSURES

GeoEngineers

APPENDIX B

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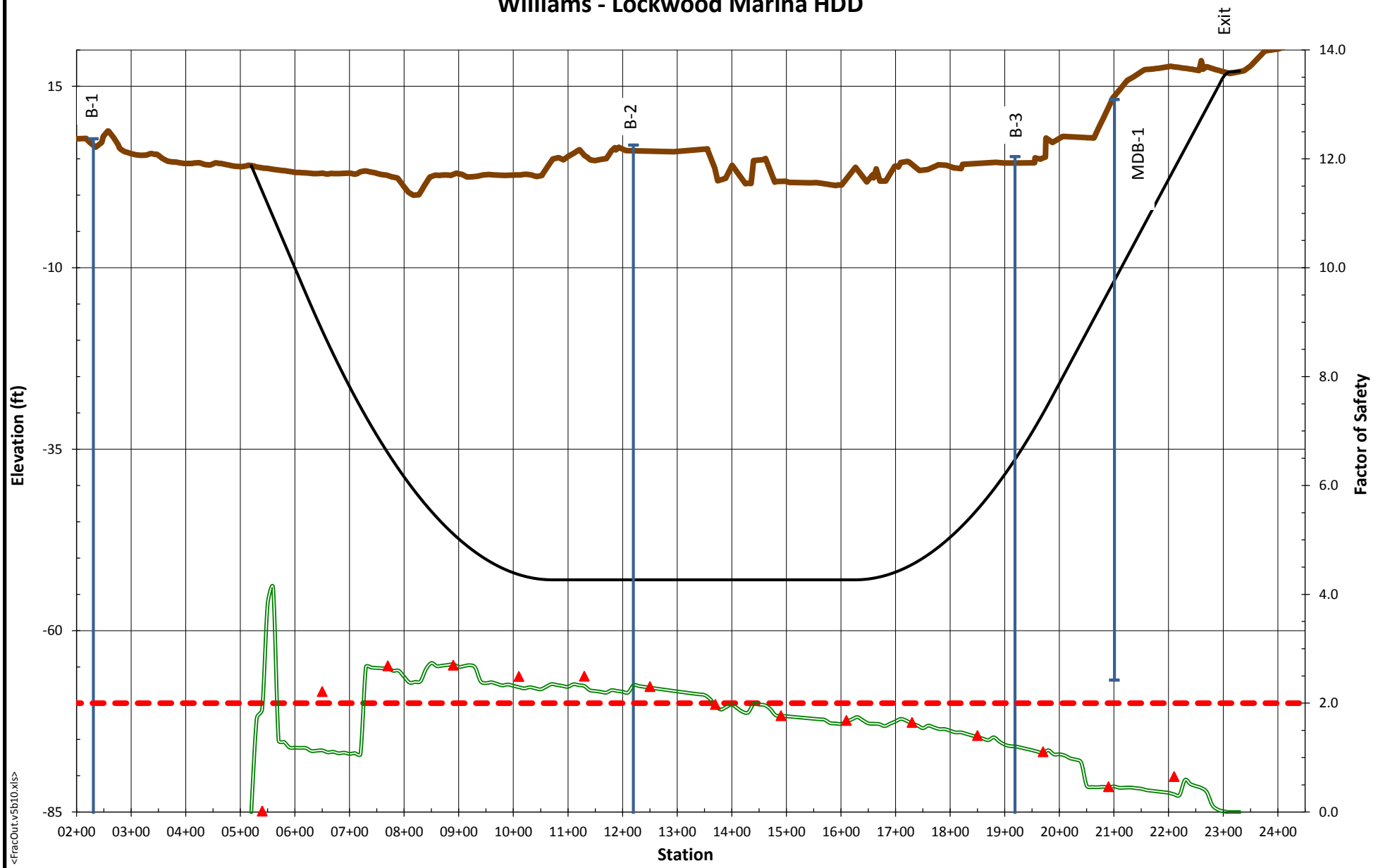
Williams - Lockwood Marina HDD



Crossing Length (ft)	1784
Hole Diameter (in)	9.875
Drill Pipe O.D. (in)	5.500
Drilling Fluid Weight (ppg)	9.5
Plastic Viscosity (cP)	13
Yield Point (lb/100 sf)	28

- Ground Surface Elevation (ft)
- HDD Profile (ft)
- Factor of Safety = 2
- Hydraulic Fracture Factor of Safety for Pilot Hole
- Drilling Fluid Surface Release Factor of Safety for Pilot Hole

Williams - Lockwood Marina HDD

HYDRAULIC FRACTURE AND DRILLING FLUID SURFACE RELEASE FACTORS OF SAFETY

GeoEngineers

APPENDIX B

00000-000-01 GWC 180221 <FracOut:v5b10.xls>

"There is no substitute for experience"

April 12, 2018

Subject: HDD Feasibility Memorandum – Updated 04.12.2018
26-inch Northeast Supply Enhancement Project – Madison Loop
Parkwood Village HDD

Attachment: Parkwood Village HDD Plan, Profile and Stringing Drawing
Hydraulic Fracture and Inadvertent Returns Analysis
AECOM Boring Logs and Laboratory Test Results

Laney Directional Drilling Co. (Laney) is pleased to present this Horizontal Directional Drill (HDD) feasibility memorandum for the proposed Parkwood Village HDD summarizing the results of our constructability review based on information available to us as of the issuance of this memorandum. The proposed HDD is part of the Transcontinental Gas Pipe Line Company, LLC's Northeast Supply Enhancement Project 26-inch Madison Loop and is located in Middlesex County, New Jersey. The HDD method of construction is being considered by Williams E&C (Williams) to cross beneath Westminster Boulevard, Parkwood Village and Highway 9 approximately 2 miles southwest of South Amboy, New Jersey.

Surface Conditions:

Laney visited the Parkwood Village site on June 23, 2016 and again on August 31, 2016 with representatives from Williams to assess the surface conditions along and near the proposed Parkwood Village HDD. The Parkwood Village HDD alignment is roughly orientated from east to west (entry and exit sides, respectively).The Parkwood Village HDD, as currently proposed, is 2,300 feet in length measured along the centerline alignment. Please refer to the "NOT FOR CONSTRUCTION" plan and profile drawing Parkwood Village HDD Revision M dated February 8, 2017 (plan and profile drawing) and the "NOT FOR CONSTRUCTION" stringing drawing Parkwood Village Stringing Revision M dated February 8 2018 (stringing drawing) for reference.

The proposed entry point is located in a relatively flat area at an elevation of approximately 119 feet North American Vertical Datum 88 (NAVD 88) in a cleared pipeline right-of way (ROW). From entry, the HDD alignment trends along the existing pipeline right-of-way with the ground surface sloping down to a low lying area before gently sloping up to an apartment parking lot. From the parking lot, the HDD alignment crosses Westminster Boulevard and additional apartment parking lots with the ground surface generally sloping down to Highway 9. To the west of Highway 9, the HDD alignment trends through the existing pipeline right-of-way adjacent to a densely vegetate area with the ground surface gently sloping up to the proposed exit point at an elevation of approximately 88 feet NAVD 88.

The entry side workspace may be accessed from the west by Westminster Road and a temporary access road. The exit side workspace may be accessed from the east by Highway 9 via the pipeline ROW and a temporary access road. The carrier pipe stringing area will be located on the exit side of the crossing and extend approximately 1,200 feet west of the proposed exit point. A minimum of one tie-in weld during pullback operations due to the limited carrier pipe stringing area length.

Design Considerations

A horizontal curve design radius of 3,030 feet was incorporated into the bottom tangent of the HDD design profile so that the HDD alignment maintained as much separation from the apartment complexes as possible with the current constraints and to assist in line-up of the stringing section for pullback operations. Additionally, the horizontal curve was used to attempt to stay as close as practical to the current right-of-way.

Subsurface Conditions:

Williams retained AECOM to perform a geotechnical exploration and laboratory testing program at the proposed HDD site. The geotechnical exploration program completed to date consisted of drilling four (4) geotechnical borings between September 21, 2016 and August 21, 2017. The borings were completed to depths of up to 112 feet below ground surface (bgs). The locations of the geotechnical borings relative to the HDD alignment are depicted in the plan and profile drawing. The subsurface materials noted in the boring logs consisted predominately of sand overlying silt and clay. Refer to TABLE 1: Summary of Geotechnical Borings for further information.

TABLE 1: SUMMARY OF GEOTECHNICAL BORINGS

BORING #	DATE OF SAMPLE	SURFACE ELEVATION.	DEPTH (bgs)	DESCRIPTION OF RESULTS	CONSISTENCY
AB-1	08/14/17	84.9 ft.	73.4 ft.	SAND / CLAY / SAND	LOOSE / VERY STIFF / DENSE
AB-2	9/21/2016-9/22/2016	105.2 ft.	112.0 ft.	SAND / SILT / SAND / CLAY/ SAND	DENSE / STIFF / VERY DENSE / HARD / DENSE
AB-3	09/22/16 - 09/23/16	118.9 ft.	112.0 ft.	SILT / SAND / CLAY / SILTY SAND	STIFF / DENSE / VERY STIFF / DENSE
AB-4	8/21/2017	120.2	105.0	SAND / CLAY / SAND	LOOSE / STIFF / DENSE

Hydraulic Fracture Analysis:

Analysis of hydraulic fracture potential (fracture of the soil formation being drilled because of the annular pressure during drilling operation) consists of two steps: (i) estimation of annular drilling fluid pressure, and (ii) estimation of pressure at which shear failure of soil occurs (formation limit pressure). Typically, the maximum drilling fluid pressure occurs during pilot hole process. This is because frictional head loss is reduced in a larger hole diameters. Also, in granular soil formations (angle of friction greater than zero), the shear failure pressure or limiting pressure increases with the increase in drilled hole diameter. For these reasons, the hydraulic fracture analysis is carried out for pilot hole process only. The factor of safety against hydraulic fracture is defined as the ratio between the estimated formation limit pressure and the estimated annular drilling fluid pressure. Similarly, factor of safety against inadvertent returns measures risk of inadvertent returns to the surface if the fracture of the soil layer being drilled occurs. This is calculated by dividing the limit pressures of the strongest soil layer above the drill path by the fluid pressure that layer is expected to be subjected to.

Laney performed a hydraulic fracture and inadvertent returns analysis for the pilot hole assuming the HDD contractor completed the pilot hole from east to west as designed and also from west to east as a potential mitigation measure for inadvertent return risk near Highway 9. When drilled from east to west, the risk of inadvertent drilling fluid returns along the majority of the HDD alignment is generally low when the HDD profile

is located in the medium dense sand layers. The risk of inadvertent returns is generally elevated near the entry and exit points where the depth of cover is thin. From approximate stations 155+00 to 165+00, the HDD alignment is within approximately 50 feet to 25 feet of several apartment complexes and dependent on if basements or foundations for the apartment complexes extend below the ground surface, the risk of inadvertent drilling fluid returns may be elevated at these locations. Our analysis indicates that an elevated risk of inadvertent returns is anticipated from approximate station 151+00 to exit due to the elevation differential along the HDD alignment, increased annular pressure as the pilot hole extends further away from the drill rig and the potential presence of a notable clay layer as observed in Boring AB-1. To mitigate this potential risk, the HDD contractor may elect to drill the pilot hole from the west side of the crossing. The hydraulic fracture and inadvertent returns potential based on each pilot hole completion direction is shown in the attached hydraulic fracture and inadvertent returns analysis. As shown in the attachment, the factor of safety against hydraulic fracture under majority of the crossing, including the Highway 9 will be greater than 1.5 if drilled from the west side.

Based on our evaluation of the proposed crossing, the anticipated drilling fluid properties and tooling used in our analysis are presented in Table 2 below.

TABLE 2: ANTICIPATED FLUID PROPERTIES AND TOOLING

Parameter	Unit
Drill Bit Diameter	10.625 Inch
Drill Pipe Diameter	5.5 Inch
Drilling Fluid Flow Rate	300 gpm[1]
Drilling Fluid Weight	9.5 ppg[2]

Notes:
[1] Gallons per minute.
[2] Pounds per gallon (drilling fluid anticipated to be mainly water with additional of minimal bentonite for this crossing).

Drilling fluid properties are dependent on construction practices of the HDD contractor, field conditions and interpretations of the drilling fluid engineer. Annular drilling fluid pressures can significantly change with changes in drilling fluid properties. Therefore, it is important to re-evaluate drilling fluid pressures based on fluid properties during HDD installations and compare them with estimated limiting pressures of the formation. Additionally, annular pressure measurement tools can be used to monitor annular pressure during the HDD installation and are recommended to be used on this crossing.

The hydraulic fracture analysis performed by Laney does not account for the pre-existing fractures or voids in the formation, which if present, may provide a preferential flow path for drilling fluid outside of the borehole.

Calculated factors of safety against hydraulic fracture are presented in the attachment. It should be noted that the analysis is based on the HDD contractor maintaining fluid returns to the entry pit; if drilling fluid returns are not maintained the analysis may no longer be valid. However, loss of drilling fluid returns does not automatically indicate that an inadvertent drilling fluid return occurrence is imminent.

"There is no substitute for experience"

HDD Feasibility Considerations and Recommendations:

There is approximately 30 feet of elevation differential between the entry and exit sides of the crossing which may cause approximately 180 feet of the entry tangent and portion of the entry curve to be in a “dry hole” condition, i.e. above the drilling fluid equilibrium point which in this case would be the exit elevation of 88 feet NAVD 88. The “dry hole” section may not have the benefit of being filled with fresh drilling fluid during construction after completion of the pilot hole. The risks associated with “dry hole” are hole collapse, a rapid and potentially significant release of drilling fluid to the low side in the event of a hole flush, and inability to maintain drilling fluid in the dry section of the hole. We anticipate that the risk of major hole collapse can be mitigated through the use of appropriate Best Management Practices (BMPs) including optimal penetration rates, drilling fluid flow rates and drilling fluid properties based on ground conditions encountered while conducting HDD operations. The HDD contractor may also elect to install large diameter casing to mitigate hole instability issues within the alluvial soils, if required. Additionally, our analysis indicates that an elevated risk of inadvertent returns is anticipated from approximate station 151+00 to exit due to the elevation differential along the HDD alignment, increased annular pressure as the pilot hole extends further away from the drill rig and the potential presence of a notable clay layer as observed in Boring AB-1. To mitigate this potential risk, the HDD contractor may elect to drill the pilot hole from the west side of the crossing.

The Parkwood Village HDD is currently proposed with a length of 2,300 feet and based on the current stringing area of approximately 1,205 feet, one (1) tie in weld will be required during pullback. We do not recommend extending the currently proposed length of the crossing beyond 2,300 feet because additional tie-in weld(s) will be required during pullback. Increasing the length of the crossing would create additional tie-in weld(s) during pullback and increase the risk of failure of the crossing especially when the HDD profile is located in alluvial soils. Although there is inherent risk in completing a tie-in weld during pullback operations, we anticipate that the subsurface conditions encountered at this site, as represented by the geotechnical borings, do not pose a significant risk of failure during pullback operations. However, the Pipeline Contractor will need to make all necessary preparations and plans to ensure that the downtime during pullback operations due to the tie-in weld are kept as minimal as possible.

The HDD alignment crosses the existing 42-inch Lower Bay Loop “C” pipeline at approximate stations 153+91 and 160+87. We understand that the 42-inch Lower Bay Loop “C” pipeline was conventionally installed at stations 153+91 and 160+87at depth of approximately 4 feet below ground surface (bgs). Based on the depth of the existing pipeline and the designed HDD profile depth there is over 50 feet of vertical separation at both crossing locations.

We anticipate that access to the exit side of the proposed crossing from Highway 9 will require traffic control for construction traffic ingress and egress to the exit workspace. There is less than 3 feet of shoulder on Highway 9 with a high traffic density and will likely require closing the outside (west) lane during HDD construction. Additionally, the mechanical contractor will be required to operate equipment below the existing power lines that cross the proposed pipe string. Height of equipment restrictions may be limited in this area.

The entry and exit points are located within approximately 140 feet and 450 feet, respectively, from noise sensitive areas (NSA) such that noise mitigation measures may be required during construction. Noise mitigation measures may include mufflers on diesel engines and/or noise abatement walls. Depending on local ordinances, the decibel level may not be able to exceed certain thresholds or work-hour limitations may be imposed. In addition to noise mitigation measures, active monitoring of the construction sites decibel level output may be required.

Based on the results of our analysis, site visit and geotechnical data at the proposed Parkwood Village HDD, we anticipate that this HDD is feasible from the geotechnical data, geometrical, and surface conditions perspective. We recommend that the potential risks noted in this memorandum be discussed by the project

team prior to mobilization to develop and agree on the anticipated level of risk and potential mitigation measures to be incorporated into the project.

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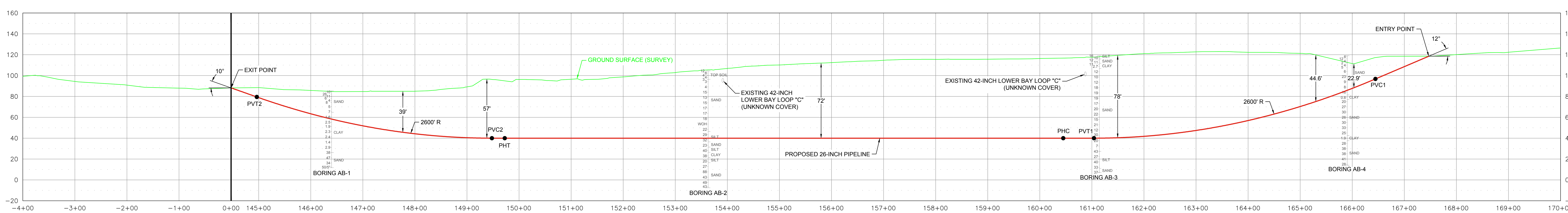
MIDDLESEX COUNTY, NEW JERSEY

PLAN VIEW

100 0 100 200
GRAPHIC SCALE IN FEET



BACK STATION = 0+00
AHEAD STATION = 144+47

PROFILE VIEW

100 0 100 200
GRAPHIC HORIZONTAL SCALE IN FEET

50 0 50 100
GRAPHIC VERTICAL SCALE IN FEET

HORIZONTAL DIRECTIONAL DRILL DATA PARKWOOD VILLAGE		
DESCRIPTION	STATION (ft)	ELEVATION (ft)
ENTRY @ 12°	167+47.00	118.58
PVC1 = 2600' RADIUS	166+44.62	96.82
PVT1 =	161+04.05	40.00
PHC = 20.28° 3030' RADIUS	160+44.70	40.00
PHT =	149+72.22	40.00
PVC2 = 2600' RADIUS	149+47.94	40.00
PVT2 =	144+96.45	79.50
EXIT @ 10°	144+47.00	88.22
HORIZONTAL DISTANCE (ft) = 2300.00		
DIRECTIONAL DRILL PIPE LENGTH (ft) = 2309.32		

THINK SAFETY FIRST

BORING LEGEND
SPT (N)/PP
SOIL DESCRIPTION
BORING NAME

NOT FOR CONSTRUCTION

DRAWING COORDINATE SYSTEM
HORIZONTAL DATUM: SPCS – NEW JERSEY NAD83 AND GEOGRAPHIC NAD83
VERTICAL DATUM: NAVD 88

REFERENCE DRAWINGS	REV.	DATE	REVISION	APPVD.
	N	04/05/18	ISSUED FOR REVIEW	BKP
	M	02/08/18	ISSUED FOR REVIEW	BKP
	L	11/08/17	UPDATED STATIONING	BKP
	K	10/10/17	ADDED SURVEY SURFACE	BKP
FOOTPRINT 03222018	J	06/21/17	PROPOSED BORING ADDED	JET
Madison_FERC_Supp_1.KMZ	I	03/20/17	PRELIMINARY LAYOUT	JET

WILLIAMS
NORTHEAST SUPPLY ENHANCEMENT

MIDDLESEX COUNTY NEW JERSEY

TITLE
PARKWOOD VILLAGE
HORIZONTAL DIRECTIONAL DRILL

DESIGNED	DRAWN	CK'D.	PROJECT NO.	REV.
JET	BTL	JET	10150	N
SCALE AS NOTED	DATE 05/04/16		DWG. NO. Apartment HDD.dwg SHT. 1 OF 2	

laney
"There is no substitute for experience"
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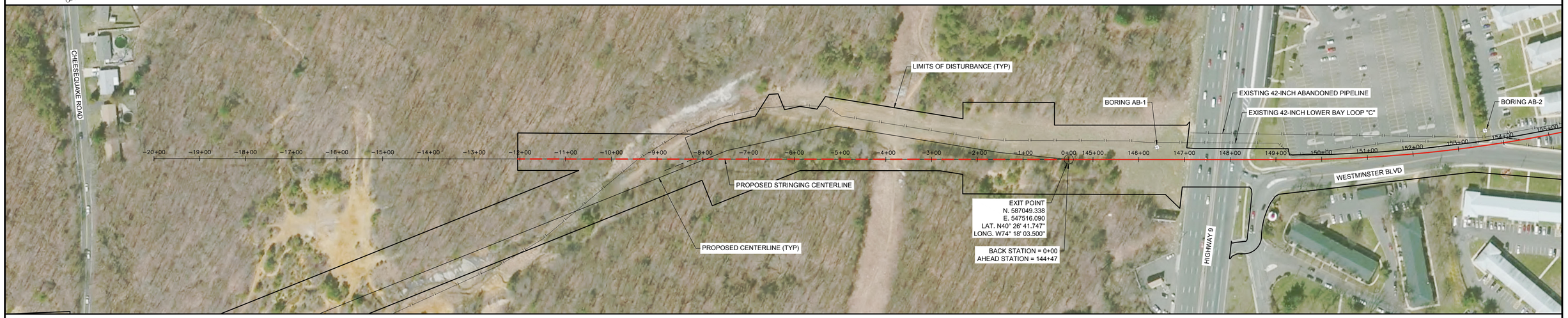
Tel: (281) 540-6615 • Fax: (281) 540-6727
www.laneydrilling.com

NOTES:
1. GROUND SURFACE DATA PROVIDED BY WILLIAMS.
2. THE PIPELINE INFORMATION SHOWN ON THIS DRAWING IS A COMPILATION OF DATA OBTAINED FROM VARIOUS SOURCES, LANEY DIRECTIONAL DRILLING DOES NOT GUARANTEE THE ACCURACY OF THE INFORMATION SHOWN.

Scale valid for 24" x 36" print

MIDDLESEX COUNTY, NEW JERSEY



PLAN VIEW

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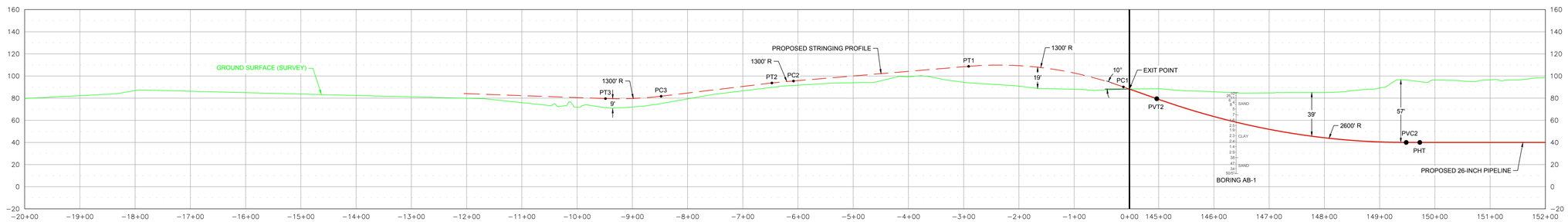
GRAPHIC SCALE IN FEET



PROFILE VIEW

100 0 100 200

GRAPHIC HORIZONTAL SCALE IN FEET

50 0 50 100

GRAPHIC VERTICAL SCALE IN FEET

BACK STATION = 0+00
AHEAD STATION = 144+47

BORING LEGEND

SPT (N)/PP

SOIL DESCRIPTION

BORING NAME

NOTES:

1. GROUND SURFACE DATA PROVIDED BY WILLIAMS.
2. THE PIPELINE INFORMATION SHOWN ON THIS DRAWING IS A COMPILATION OF DATA OBTAINED FROM VARIOUS SOURCES. LANEY DIRECTIONAL DRILLING DOES NOT GUARANTEE THE ACCURACY OF THE INFORMATION SHOWN.

NOT FOR CONSTRUCTION

DRAWING COORDINATE SYSTEM				
HORIZONTAL DATUM: SPCS – NEW JERSEY NAD83 AND GEOGRAPHIC NAD83				
VERTICAL DATUM: NAVD 88				
	N	04/05/18	ISSUED FOR REVIEW	BKP
	M	02/08/18	ISSUED FOR REVIEW	BKP
	L	11/08/17	UPDATED STATIONING	BKP
	K	10/10/17	ADDED SURVEY SURFACE	BKP
FOOTPRINT 03222018	J	06/21/17	PROPOSED BORING ADDED	JET
Madison_FERC_Supp_1.KMZ	I	03/20/17	PRELIMINARY LAYOUT	JET
REFERENCE DRAWINGS	REV.	DATE	REVISION	APPVD.

THINK SAFETY FIRST

WILLIAMS
NORTHEAST SUPPLY ENHANCEMENT

MIDDLESEX COUNTY — NEW JERSEY

TITLE
PARKWOOD VILLAGE
HORIZONTAL DIRECTIONAL DRILL STRINGING

DESIGNED	DRAWN	CK'D.	PROJECT NO.	REV.
JET	TTH	JET	10150	N
SCALE AS NOTED	DATE 05/05/16	DWG. NO. 2 SHT. 2 OF 2		

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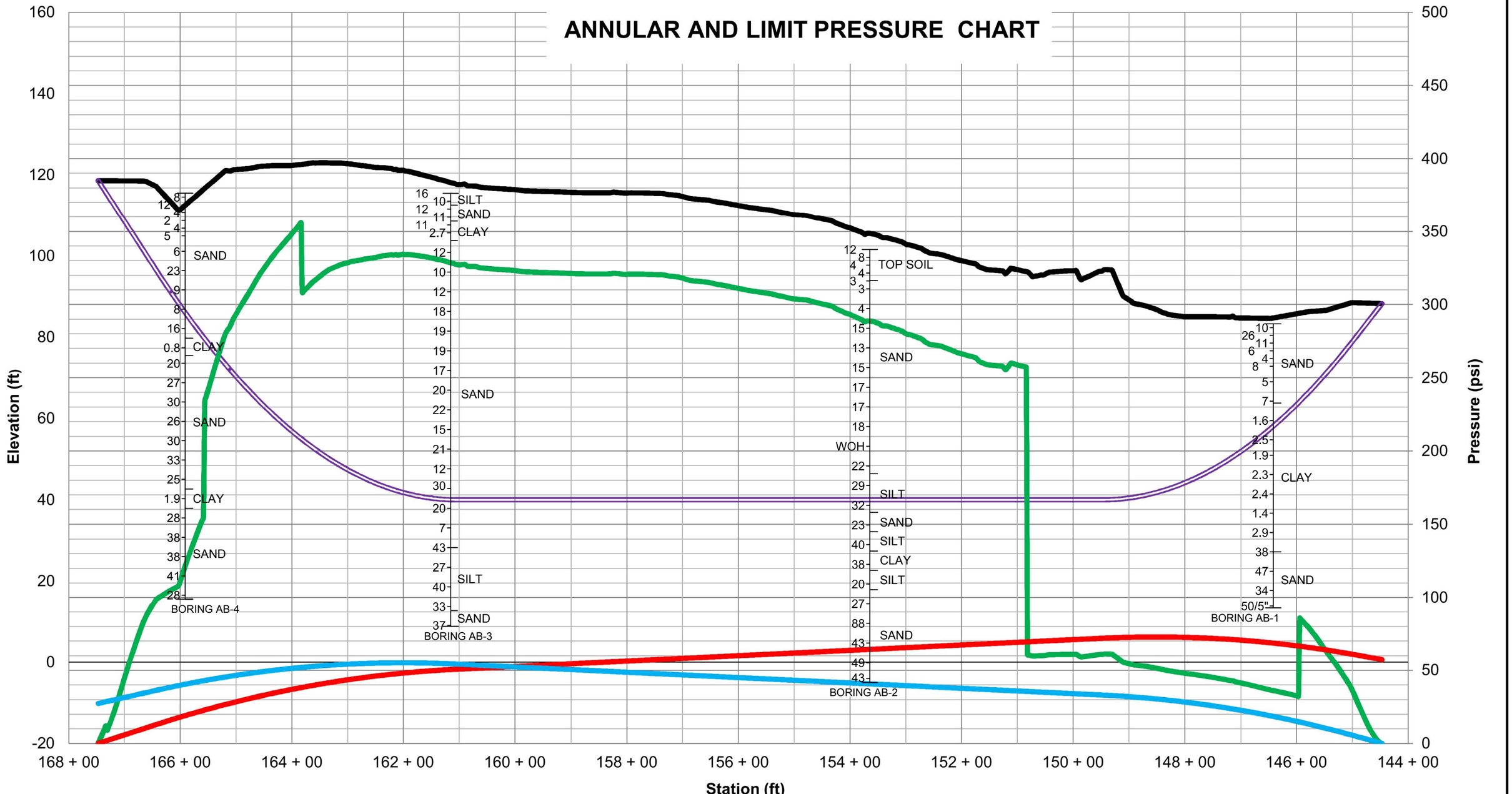
Scale valid for 24" x 36" print

ANNULAR AND LIMIT PRESSURE CHART



- Ground Elevations
- Borepath
- Cheesequake Road
- Limit Pressures
- Estimated Annular Pressure
- Estimated Annular Pressure-Reverse

Length of Drill:	2300 ft
Unit Weight of Drilling Fluid:	9.5 ppg
Effective Borehole Diameter:	10.625 in.
Drill Pipe Diameter:	5.500 in.
Plastic Viscocity of Drill Fluid:	13.0 cp
Yield Point of Drilling Fluid:	18 lb/100 sf
Drilling Fluid Discharge:	300 gpm

NORTHEAST SUPPLY ENHANCEMENT (NESE)
PARKWOOD VILLAGE
MIDDLESEX COUNTY, NEW JERSEY
Hydraulic Fracture and Inadvertent Returns Analysis

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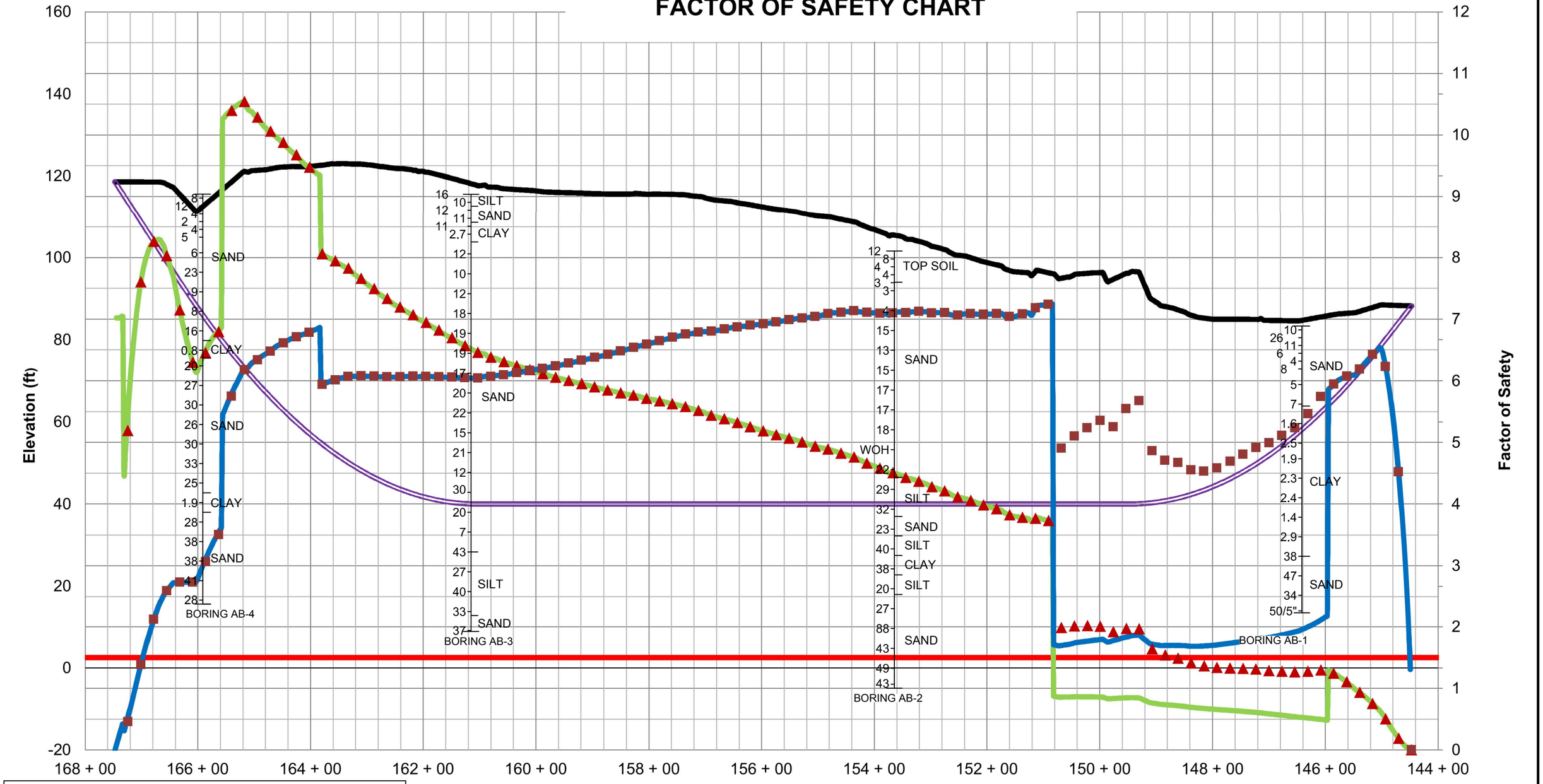
FACTOR OF SAFETY CHART



- Ground Elevations
- Borepath
- Factor of Safety = 1.5
- Factor of Safety - Hydraulic Fracture
- Factor of Safety-Reverse
- Inadvertent Returns
- Inadvertent Return-Reverse

Length of Drill:	2300 ft
Unit Weight of Drilling Fluid:	9.5 ppg
Effective Borehole Diameter:	10.625 in.
Drill Pipe Diameter:	5.500 in.
Plastic Viscocity of Drill Fluid:	13.0 cp
Yield Point of Drilling Fluid:	18 lb/100 sf
Drilling Fluid Discharge:	300 gpm

NORTHEAST SUPPLY ENHANCEMENT (NESE)
PARKWOOD VILLAGE
MIDDLESEX COUNTY, NEW JERSEY
Hydraulic Fracture and Inadvertent Returns Analysis

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LOG of BORING No. AB-1

DATE 8/14/2017 SURFACE ELEVATION 84.9 LOCATION Northing: 40.445039 Easting: -74.300287

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		10	SS	Loose to very dense brown to orange brown silty coarse to fine SAND, trace gravel						
		26	SS							
5		11	SS							
		6	SS							
		4	SS				11.7			M
10		8	SS							
15		5	SS							
20		7	SS		64.4	1.5				
				Stiff to very stiff dark gray silty CLAY, trace sand						
25		9	SS			1.6	28.4			M
30		9	SS			2.5				
		10	SS			1.9				
35										
		11	SS			2.3				
40										
				(Undivided Magothy Unit)						
		9	SS	(Continued on Sheet 2 of 2)		2.4				

Completion Depth: 73.4 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger + Mud Rotary ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. AB-1

Sheet 2 of 2

DATE 8/14/2017 SURFACE ELEVATION 84.9 LOCATION Northing: 40.445039 Easting: -74.300287

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45				- Continuing stiff to very stiff dark gray silty to sandy CLAY						
		5	SS			1.4	27.5	38	23	
50										
		19	SS			2.9				
55										
		38	SS		25.9	2.0	18.7			M
60				Dense to very dense gray to dark gray sandy SILT to silty medium to fine SAND, trace gravel						
		47	SS							
65										
		34	SS							
70				(Undivided Magothy Unit)						
		50/5"	SS		11.5					
75				Notes: 1. Ground surface elevation at the boring location was surveyed by Williams surveyors. 2. Groundwater level was measured at approximately 4.5 ft below existing ground surface on completion of drilling. 3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.						
80										
85										

Completion Depth: 73.4 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger + Mud Rotary

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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LOG of BORING No. AB-2

Sheet 1 of 3

DATE 9/21/2016-9/22/2016 SURFACE ELEVATION 105.2 LOCATION Northing: 40.44525521 Easting: -74.29773516

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		12	SS	TOPSOIL	104.2					
		8	SS	Loose to dense orange brown to brown silty medium to fine SAND with gravel						
5		4	SS		99.2					
		4	SS	Loose orange brown gravelly medium to fine SAND with silt						
		3	SS		95.2					
10		3	SS	Loose orange brown silty medium to fine SAND with gravel						
15		4	SS		86.7					
20		15	SS	Medium dense light brown to reddish brown medium to fine SAND						
25		13	SS		76.7					
30		15	SS	Medium dense orange brown coarse to fine SAND with gravel, trace silt						
35		17	SS	(Pennsauken Formation)	66.7					
40		17	SS	Medium dense orange brown to light gray medium to fine SAND (Undivided Magothy Unit)						

(Continued on Sheet 2 of 3)

Completion Depth: 112.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

AECOM

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

LOG of BORING No. AB-2

Sheet 2 of 3

DATE 9/21/2016-9/22/2016 SURFACE ELEVATION 105.2 LOCATION Northing: 40.44525521 Easting: -74.29773516

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		18	SS	- Continuing medium dense orange brown to light gray medium to fine SAND						
					56.7					
50		WOH	SS	Very loose orange brown to brown silty coarse to fine SAND, some gravel			23.9			M
					51.7					
55		22	SS	Very stiff gray to dark gray SILT with sand			26.8	42	26	M
60		29	SS			2.7	22.6			M
					41.7					
65		32	SS	Medium dense to dense light gray to dark gray silty medium to fine SAND						
70		23	SS				24.4			M
					31.7					
75		40	SS	Very dense gray sandy SILT			21.4			M
					26.7					
80		38	SS	Hard gray CLAY with sand			26.0	35	22	M
					21.7					
85		20	SS	Very stiff gray SILT with sand			24.4			M
				(Undivided Magothy Unit)	16.7					
				(Continued on Sheet 3 of 3)						

Completion Depth: 112.0 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. AB-2

DATE 9/21/2016-9/22/2016 SURFACE ELEVATION 105.2 LOCATION Northing: 40.44525521 Easting: -74.29773516

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
90		27	SS	Medium dense to very dense light gray to dark gray silty coarse to fine SAND						
95		88	SS				22.0			M
100		43	SS							
105		49	SS							
110		43	SS	(Undivided Magothy Unit)	-6.8					
115										
120										
125										
130										

Notes:
1. Ground surface elevation at the boring location was surveyed by Williams surveyors.
2. Groundwater levels were measured as shown below:

Date & Time	GW Depth (ft)	GW Elev. (ft)
09/21/16 10:30	45.0	60.2

3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.

Completion Depth: 112.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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LOG of BORING No. AB-3

Sheet 1 of 3

DATE 9/22/2016-9/23/2016 SURFACE ELEVATION 118.9 LOCATION Northing: 40.44596302 Easting: -74.29521804

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		16	SS	Dense to very dense brownish gray to orange brown sandy to clayey SILT						
		10	SS							
5		12	SS		113.9					
		11	SS	Medium dense light to reddish brown silty coarse to fine SAND with gravel (Pennsauken Formation)			18.8			M
		11	SS		109.9					
10		12	SS	Very stiff gray to orange brown sandy CLAY		2.7	17.4	34	18	M
					105.4					
15		12	SS	Medium dense light gray to orange brown silty medium to fine SAND						
20		10	SS				12.5			M
25		12	SS							
30		18	SS				8.6			M
35		19	SS							
40		19	SS				12.5			M
				(Undivided Magothy Unit)						

(Continued on Sheet 2 of 3)

Completion Depth: 112.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After hrs.

AECOM

LOG of BORING No. AB-3

DATE 9/22/2016-9/23/2016 SURFACE ELEVATION 118.9 LOCATION Northing: 40.44596302 Easting: -74.29521804

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45		17	SS	- Continuing medium dense light gray to orange brown silty medium to fine SAND						
50		20	SS				12.2			M
55		22	SS							
60		15	SS				8.7			M
65		21	SS							
70		12	SS				23.8			M
75		30	SS				12.1			M
80		20	SS				12.0			M
85		7	SS							
				(Undivided Magothy Unit)	30.4					
				(Continued on Sheet 3 of 3)						

Completion Depth: 112.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After hrs.
ft., After hrs.
ft., After hrs.
ft., After hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. AB-3

Sheet 3 of 3

DATE 9/22/2016-9/23/2016 SURFACE ELEVATION 118.9 LOCATION Northing: 40.44596302 Easting: -74.29521804

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
90		43	SS	Medium dense to dense dark gray to black SILT to sandy SILT			30.3	45	29	M
95		27	SS				37.9			M
100		40	SS							
105		33	SS							
					10.4					
110		37	SS	Medium dense gray silty fine SAND (Undivided Magothy Unit)	6.9					
115										
120										
125										
130										

Notes:
1. Ground surface elevation at the boring location was surveyed by Williams surveyors.
2. Groundwater levels were measured as shown below:

Date & Time	GW Depth (ft)	GW Elev. (ft)
09/22/16 13:20	71.0	47.9
09/23/16 09:45	55.0	63.9

3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.

Completion Depth: 112.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger

Water Depth: See Notes ft., After ____ hrs.
ft., After ____ hrs.
ft., After ____ hrs.
ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. AB-4

Sheet 1 of 3

DATE 8/21/2017 SURFACE ELEVATION 120.2 LOCATION Northing: 40.446484 Easting: -74.29365

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
0		8	SS	Loose to dense light gray to orange brown silty medium to fine SAND to medium to fine SAND with silt						
		12	SS							
5		4	SS							
		2	SS							
		4	SS				12.8			M
10		5	SS							
15		6	SS							
20		23	SS							
25		9	SS							
30		8	SS				12.0			M
35		16	SS							
					82.7					
40		12	SS	Firm to stiff light brown to orange brown sandy silty CLAY		0.8	22.6	30	18	
					78.2					
				(Undivided Magothy Unit)						
		20	SS	(Continued on Sheet 2 of 3)						

Completion Depth: 105.0 ft. Water Depth: See Notes ft., After ____ hrs.

Project No.: 60515039 ____ ft., After ____ hrs.

Project Name: Williams NESE Madison ____ ft., After ____ hrs.

Drilling Method: Hollow Stem Auger + Mud Rotary ____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. AB-4

DATE 8/21/2017 SURFACE ELEVATION 120.2 LOCATION Northing: 40.446484 Easting: -74.29365

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
45				Medium dense to dense orange brown to dark brown silty medium to fine SAND with clay						
		27	SS							
50										
		30	SS							
55										
		26	SS							
60										
		30	SS							
65										
		33	SS							
70										
		25	SS							
75					43.7					
		24	SS	Stiff to very stiff gray to brown silty sandy CLAY		1.9	28.0	43	22	
80					38.7					
		28	SS	Medium dense to dense grayish brown to orange brown silty medium to fine SAND			17.5			M
85				(Undivided Magothy Unit)						
		38	SS	(Continued on Sheet 3 of 3)						

Completion Depth: 105.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger + Mud Rotary

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

AECOM

LOG of BORING No. AB-4

Sheet 3 of 3

DATE 8/21/2017 SURFACE ELEVATION 120.2 LOCATION Northing: 40.446484 Easting: -74.29365

DEPTH, FT.	SAMPLES	SAMPLING RESISTANCE	SAMPLE TYPE	DESCRIPTION	STRATUM ELEVATION	POCKET PENETROMETER (TSF)	WATER CONTENT, %	LIQUID LIMIT, %	PLASTIC LIMIT, %	OTHER TESTS
90				- Continuing medium dense to dense brown to orange brown silty medium to fine SAND						
95		38	SS							
100		41	SS							
105		28	SS	(Undivided Magothy Unit)	15.2					
110				Notes: 1. Ground surface elevation at the boring location was surveyed by Williams surveyors. 2. Groundwater level was measured at approximately 9.6 ft below existing ground surface on completion of drilling. 3. Values under "Pocket Penetrometer" are pocket penetrometer resistance readings in tons per square foot, an indication of unconfined compressive strength of cohesive soils.						
115										
120										
125										
130										

Completion Depth: 105.0 ft.
Project No.: 60515039
Project Name: Williams NESE Madison
Drilling Method: Hollow Stem Auger + Mud Rotary

Water Depth: See Notes ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.
____ ft., After ____ hrs.

10/13/17 WILLIAMS NESE NESE MADISON.GPJ

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Project: Williams NESE - Madison
Project No.: 60515039

URS

SUMMARY OF LABORATORY TEST RESULTS

Boring and Sample Number	Depth (feet)	Classification	USCS Symbol	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		Specific Gravity	Organic Content (%)	Grain Size		Compaction	Consolidation	Unconfined Compression		Triaxial Compression		Permeability (cm/sec)	Special Tests
						Liquid Limit	Plastic Limit			<#200 (%)	<2µ (%)			Stress (psi)	Strain (%)	UU	CIU		
AB-1	8.0-10.0	Brown SILTY SAND	SM	11.7						15									
AB-1	24.0-26.0			28.4						87									
AB-1	48.0-50.0			27.5		38	23												
AB-1	58.0-60.0	Gray SANDY SILT	ML	18.7						57									
AB-2	50.0-52.0	Brown SILTY SAND	SM	23.9						17									
AB-2	55.0-57.0	Dark gray SILT	ML	26.8		42	26			86									
AB-2	60.0-62.0	Dark gray SILT with SAND	ML	22.6						71									
AB-2	70.0-72.0	Gray SILTY SAND	SM	24.4						33									
AB-2	75.0-77.0	Gray SANDY SILT	ML	21.4						54									
AB-2	80.0-82.0	Gray LEAN CLAY with SAND	CL	26.0		35	22			81									
AB-2	85.0-87.0	Gray SILT with SAND	ML	24.4						82									
AB-2	95.0-97.0	Gray SILTY SAND	SM	22.0						19									
AB-3	6.0-8.0	Brown SILTY SAND with GRAVEL	SM	18.8						24									
AB-3	10.0-12.0	Brown SANDY LEAN CLAY	CL	17.4		34	18			60									
AB-3	20.0-22.0	Brown gray SILTY SAND	SM	12.5						30									
AB-3	30.0-32.0	Brown gray SILTY SAND	SM	8.6						16									
AB-3	40.0-42.0	Brown gray SILTY SAND	SM	12.5						25									
AB-3	50.0-52.0	Brown gray SILTY SAND	SM	12.2						27									
AB-3	60.0-62.0	Brown POORLY GRADED SAND with SILT	SP-SM	8.7						11									

Note: The soil classification is based partially on visual classification unless both grain size and Atterberg limits are performed.

* Refer to Laboratory Test Curves

Project: Williams NESE - Madison
Project No.: 60515039

URS

SUMMARY OF LABORATORY TEST RESULTS

Boring and Sample Number	Depth (feet)	Classification	USCS Symbol	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		Specific Gravity	Organic Content (%)	Grain Size		Compaction	Consolidation	Unconfined Compression		Triaxial Compression		Permeability (cm/sec)	Special Tests
						Liquid Limit	Plastic Limit			<#200 (%)	<2µ (%)			Stress (psi)	Strain (%)	UU	CIU		
AB-3	70.0-72.0	Gray brown SILTY SAND	SM	23.8						19									
AB-3	75.0-77.0	Brown SILTY SAND	SM	12.1						25									
AB-3	80.0-82.0	Brown SILTY SAND	SM	12.0						16									
AB-3	90.0-92.0	Dark gray SILT	ML	30.3		45	29			91									
AB-3	95.0-97.0	Dark gray SANDY SILT	ML	37.9						69									
AB-4	8.0-10.0	Brown SILTY SAND	SM	12.8						17									
AB-4	29.0-31.0	Brown POORLY GRADED SAND with SILT	SP-SM	12.0						12									
AB-4	39.0-41.0			22.6		30	18												
AB-4	78.0-80.0			28.0		43	22												
AB-4	83.0-85.0	Light brown SILTY SAND	SM	17.5						31									
CB-2	4.0-6.0	Brown POORLY GRADED SAND with SILT	SP-SM	5.6						7									
CB-2	14.0-16.0			25.3						45									
CB-2	24.0-26.0	Gray SILTY SAND	SM	22.6						32									
CB-2	29.0-31.0			21.2						71									
CB-2	68.0-70.0	Light brown POORLY GRADED SAND with SILT	SP-SM	22.4						7									
CB-2	78.0-80.0			20.0						65									
CB-2	93.0-95.0			28.5						43									
CB-3	4.0-6.0	Brown gray SILTY SAND	SM	16.5						40									
CB-3	20.0-22.0	Brown SILTY SAND	SM	16.7						19									

Note: The soil classification is based partially on visual classification unless both grain size and Atterberg limits are performed.

* Refer to Laboratory Test Curves

Project: Williams NESE - Madison
Project No.: 60515039

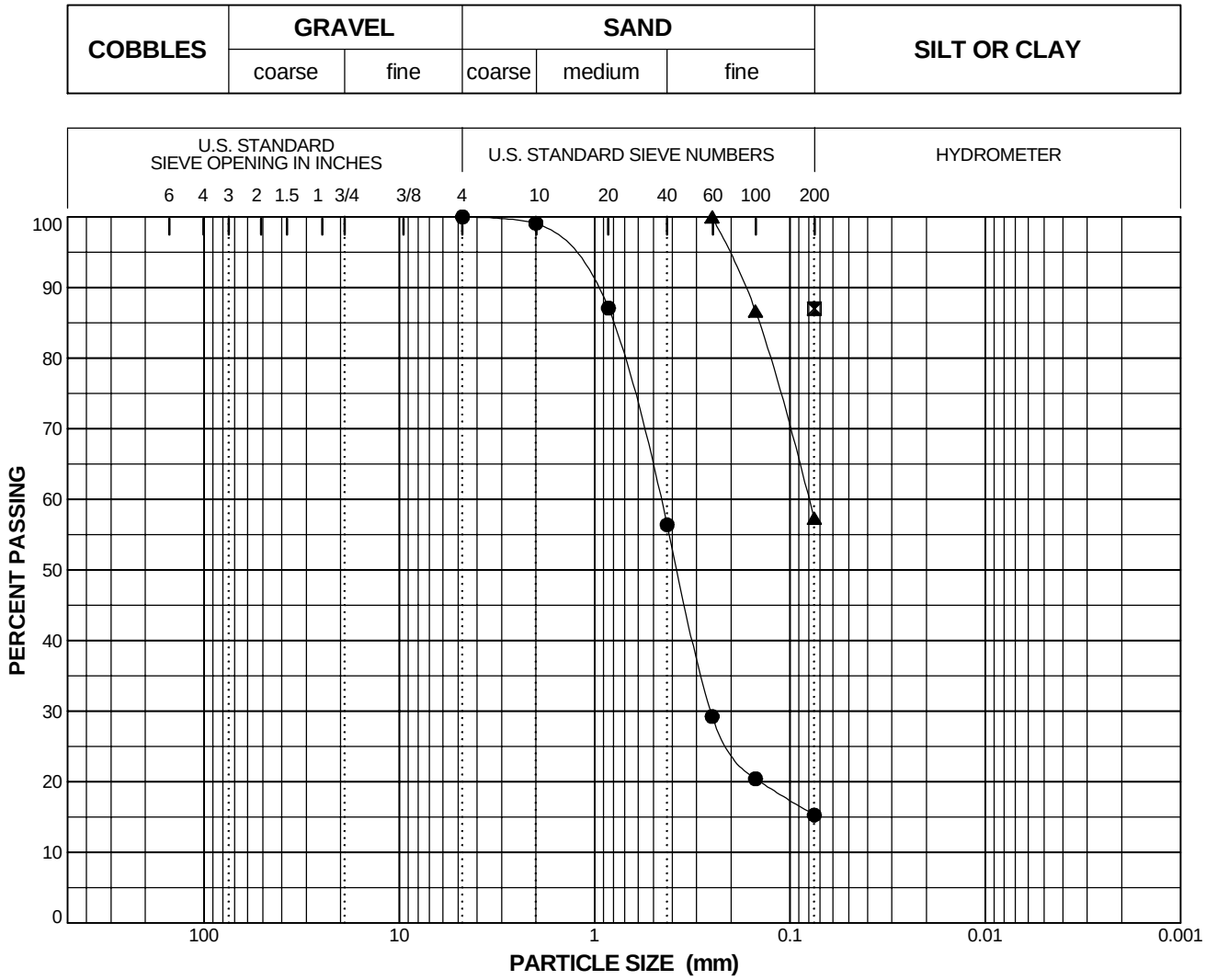
URS

SUMMARY OF LABORATORY TEST RESULTS

Boring and Sample Number	Depth (feet)	Classification	USCS Symbol	Water Content (%)	Dry Unit Weight (pcf)	Atterberg Limits		Specific Gravity	Organic Content (%)	Grain Size		Compaction	Consolidation	Unconfined Compression		Triaxial Compression		Permeability (cm/sec)	Special Tests
						Liquid Limit	Plastic Limit			<#200 (%)	<2µ (%)			Stress (psi)	Strain (%)	UU	CIU		
CB-3	30.0-32.0	Brown SILT with SAND	ML	5.0						77									
CB-3	35.0-37.0	Brown POORLY GRADED SAND with SILT	SP-SM	3.7						7									
CB-3	45.0-47.0	Brown SILTY SAND	SM	20.2						18									
CB-3	55.0-57.0	Brown SILTY SAND	SM	19.1						23									
CB-3	65.0-67.0	Brown POORLY GRADED SAND with SILT	SP-SM	23.0						9									
CB-3	75.0-77.0	Brown LEAN CLAY with SAND	CL	16.7		29	17			71									
CB-3	80.0-82.0	Brown SILTY SAND	SM	22.4						18									
CB-3	90.0-92.0	Brown POORLY GRADED SAND with SILT	SP-SM	21.0						9									
CB-3	95.0-97.0	Gray SILTY SAND	SM	22.8						48									
CB-3	110.0-112.0	Brown POORLY GRADED SAND with SILT	SP-SM	22.7						8									
MDB-1	10.0-12.0			18.8						55									
MDB-1	19.0-21.0	Brown gray SILTY SAND	SM	28.4						33									
MDB-1	34.0-36.0	Brown POORLY GRADED SAND with SILT	SP-SM	25.6						9									
MDB-1	48.0-50.0	Brown POORLY GRADED SAND with SILT	SP-SM	25.5						7									
MDB-1	63.0-65.0			19.6		33	16												

Note: The soil classification is based partially on visual classification unless both grain size and Atterberg limits are performed.

* Refer to Laboratory Test Curves



SYMBOL	●	⊠	▲
Boring	AB-1	AB-1	AB-1
Sample			
Spec			
Depth (ft)	8.0-10.0	24.0-26.0	58.0-60.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% Sand	84.7	0.0	42.7
% Fines	15.3	87.0	57.3
% -2µ			
Cc			
Cu			
LL			
PL			
PI			
USCS	SM		ML
w (%)	11.7	28.4	18.7

Particle Size	PERCENT FINER		
(Sieve #)	●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"			
4	100.0		
10	99.1		
20	87.1		
40	56.4		
60	29.2		100.0
100	20.4		86.7
200	15.3	87.0	57.3

SYMBOL	DESCRIPTION AND REMARKS
●	Brown SILTY SAND (SM)
⊠	Gray ()
▲	Gray SANDY SILT (ML)

PARTICLE SIZE DISTRIBUTION

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Project Number		
60515039	October 2017	Figure B-4

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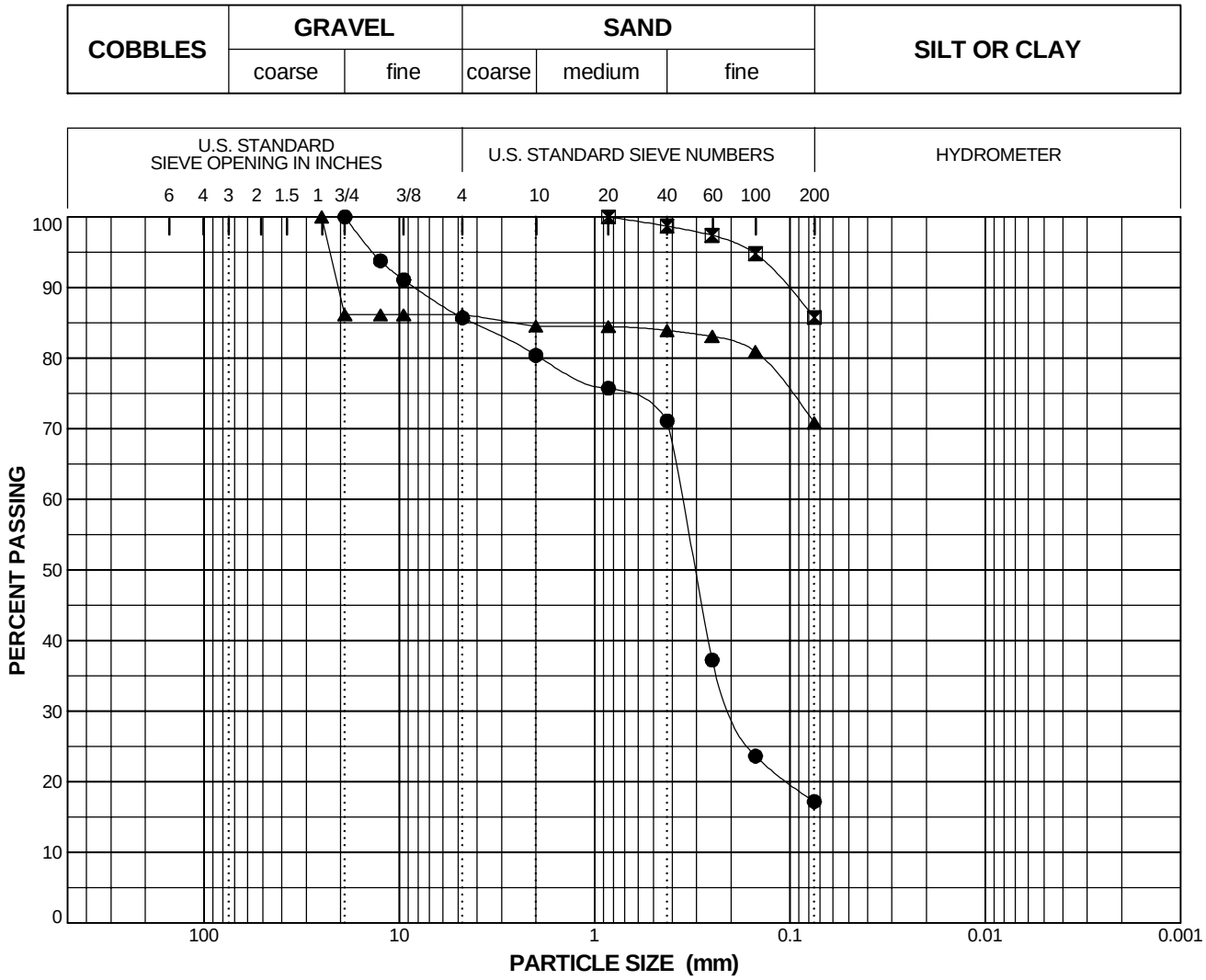

SYMBOL	●	⊠	▲
Boring	AB-2	AB-2	AB-2
Sample			
Spec			
Depth (ft)	50.0-52.0	55.0-57.0	60.0-62.0
% +3"	0.0	0.0	0.0
% Gravel	14.3	0.0	13.9
% Sand	68.5	14.3	15.3
% Fines	17.2	85.7	70.8
% -2µ			
Cc			
Cu			
LL		42	
PL		26	
PI		16	
USCS	SM	ML	ML
w (%)	23.9	26.8	22.6

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			100.0
3/4"	100.0		86.1
1/2"	93.8		86.1
3/8"	91.1		86.1
4	85.7		86.1
10	80.4		84.5
20	75.7	100.0	84.5
40	71.1	98.7	83.9
60	37.2	97.4	83.1
100	23.6	94.8	80.9
200	17.2	85.7	70.8

SYMBOL	DESCRIPTION AND REMARKS
●	Brown SILTY SAND (SM)
⊠	Dark gray SILT (ML)
▲	Dark gray SILT with SAND (ML)

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-5

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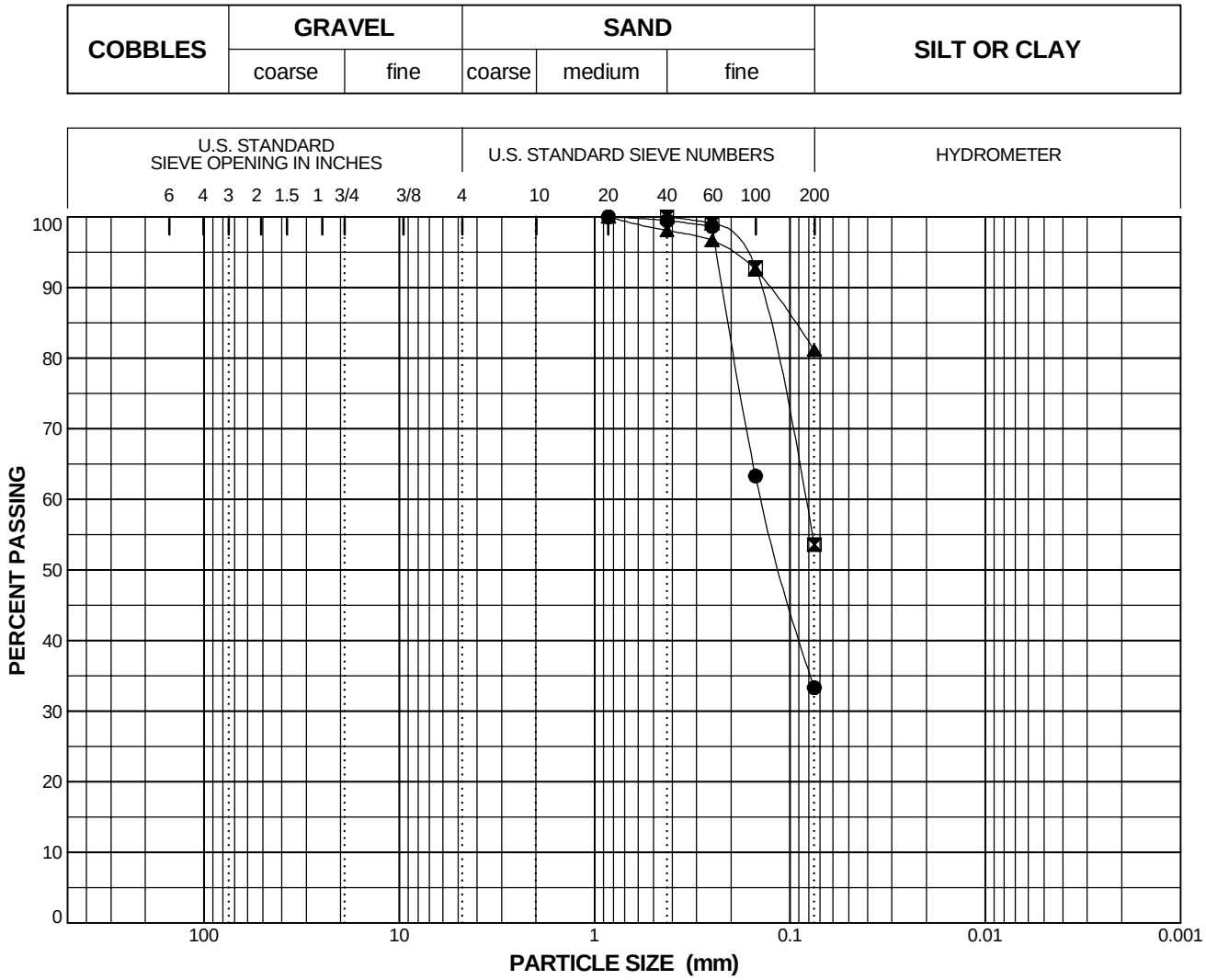

SYMBOL	●	⊠	▲
Boring	AB-2	AB-2	AB-2
Sample			
Spec			
Depth (ft)	70.0-72.0	75.0-77.0	80.0-82.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% Sand	66.7	46.4	18.9
% Fines	33.3	53.6	81.1
% -2µ			
Cc			
Cu			
LL			35
PL			22
PI			13
USCS	SM	ML	CL
w (%)	24.4	21.4	26.0

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"			
4			
10			
20	100.0		100.0
40	99.5	100.0	98.1
60	98.6	99.1	96.7
100	63.3	92.9	92.5
200	33.3	53.6	81.1

SYMBOL	DESCRIPTION AND REMARKS
●	Gray SILTY SAND (SM)
⊠	Gray SANDY SILT (ML)
▲	Gray LEAN CLAY with SAND (CL)

PARTICLE SIZE DISTRIBUTION

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Project Number		
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URS

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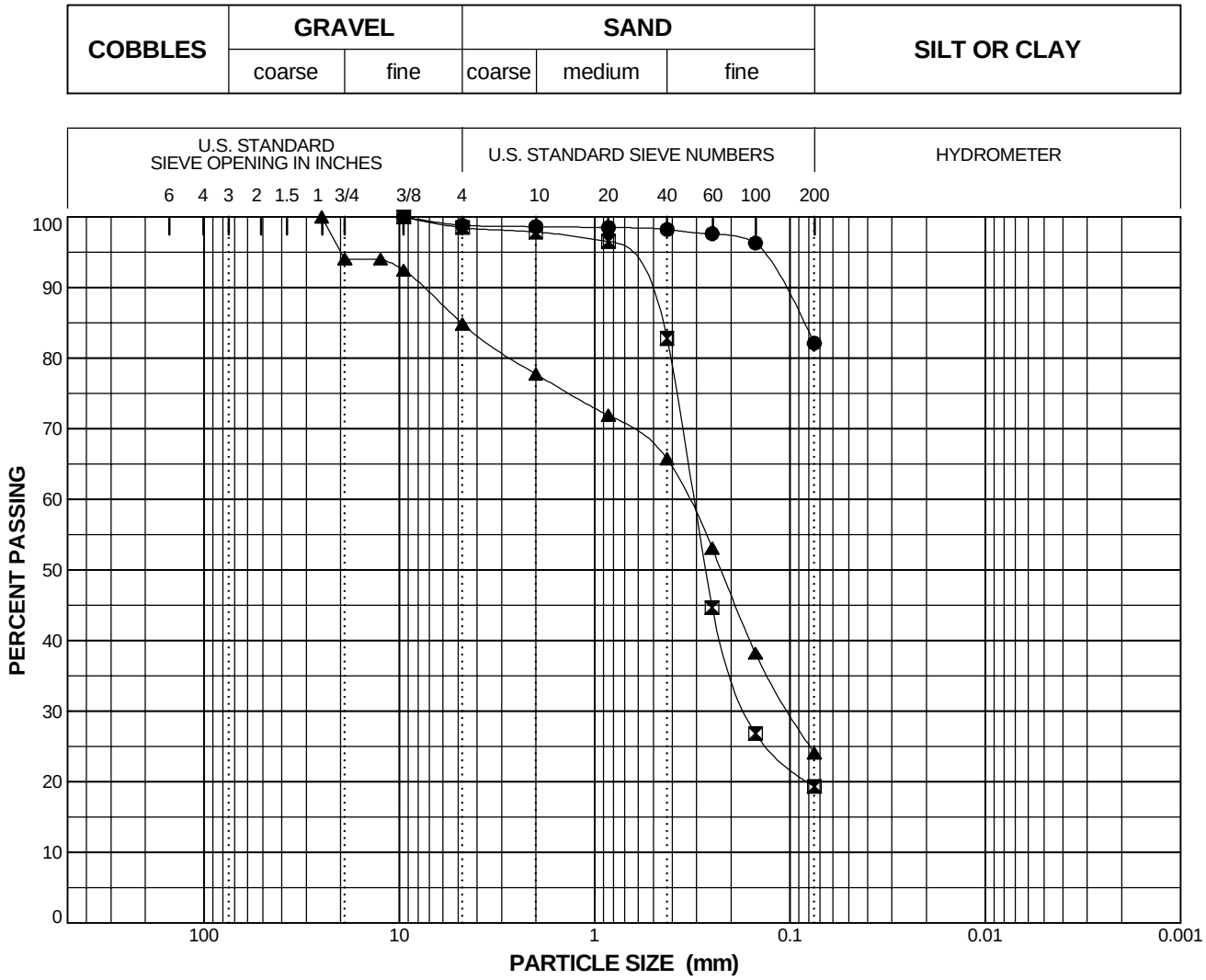

SYMBOL	●	⊠	▲
Boring	AB-2	AB-2	AB-3
Sample			
Spec			
Depth (ft)	85.0-87.0	95.0-97.0	6.0-8.0
% +3"	0.0	0.0	0.0
% Gravel	1.2	1.5	15.2
% Sand	16.7	79.2	60.7
% Fines	82.1	19.3	24.1
% -2µ			
Cc			
Cu			
LL			
PL			
PI			
USCS	ML	SM	SM
w (%)	24.4	22.0	18.8

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			100.0
3/4"			94.0
1/2"			94.0
3/8"	100.0	100.0	92.5
4	98.8	98.5	84.8
10	98.6	97.9	77.8
20	98.5	96.5	71.9
40	98.2	82.8	65.7
60	97.6	44.7	53.1
100	96.3	26.8	38.2
200	82.1	19.3	24.1

SYMBOL	DESCRIPTION AND REMARKS
●	Gray SILT with SAND (ML)
⊠	Gray SILTY SAND (SM)
▲	Brown SILTY SAND with GRAVEL (SM)

PARTICLE SIZE DISTRIBUTION

Williams NESE - Madison

Project Number		
60515039	October 2017	Figure B-7

URS

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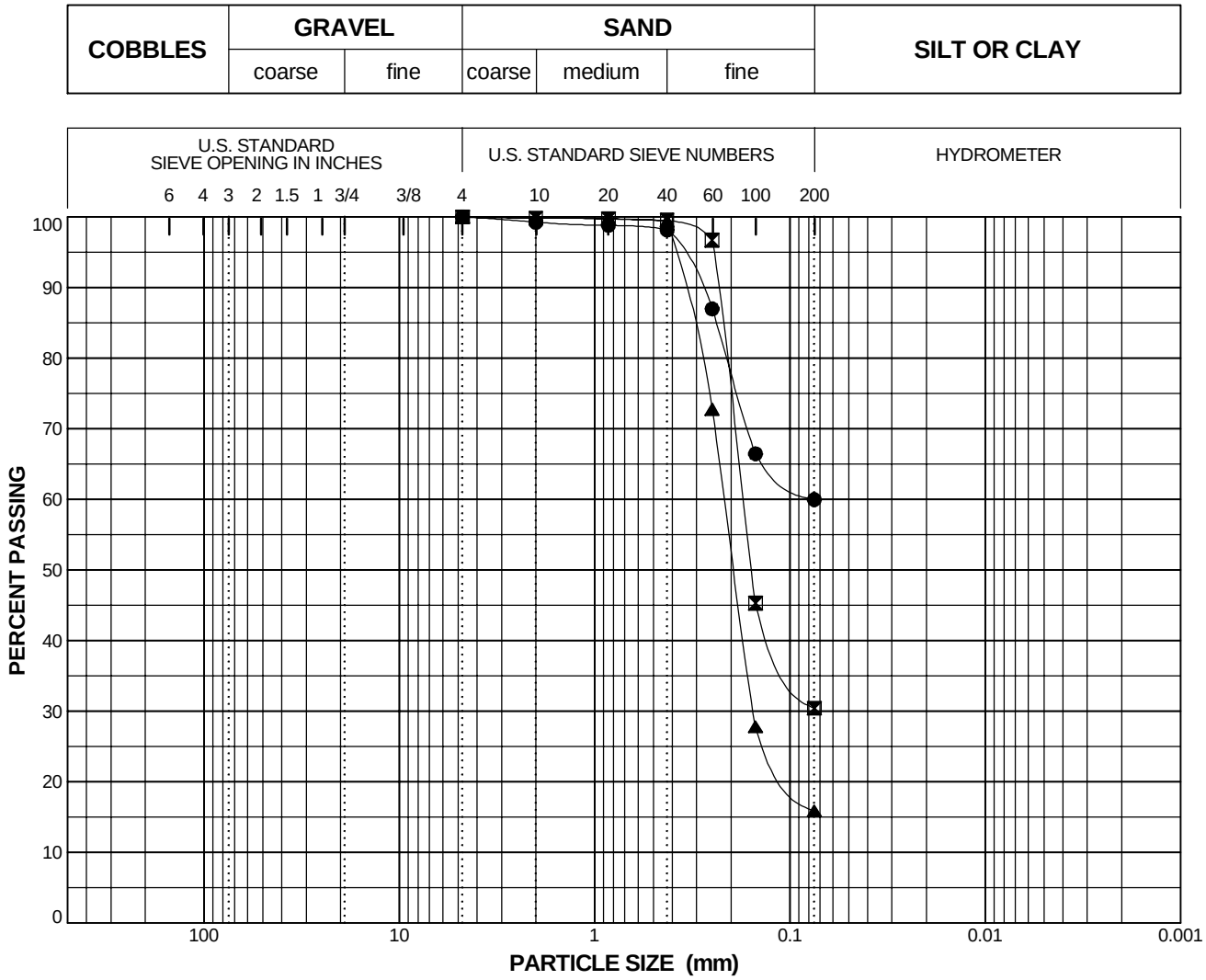

SYMBOL	●	⊠	▲
Boring	AB-3	AB-3	AB-3
Sample			
Spec			
Depth (ft)	10.0-12.0	20.0-22.0	30.0-32.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% Sand	40.0	69.6	84.1
% Fines	60.0	30.4	15.9
% -2µ			
Cc			
Cu			
LL	34		
PL	18		
PI	16		
USCS	CL	SM	SM
w (%)	17.4	12.5	8.6

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"			
4	100.0	100.0	100.0
10	99.2	99.8	99.8
20	98.8	99.7	99.7
40	98.2	99.5	99.5
60	87.0	96.7	72.8
100	66.4	45.3	27.8
200	60.0	30.4	15.9

SYMBOL	DESCRIPTION AND REMARKS
●	Brown SANDY LEAN CLAY (CL)
⊠	Brown gray SILTY SAND (SM)
▲	Brown gray SILTY SAND (SM)

PARTICLE SIZE DISTRIBUTION

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Project Number		
60515039	October 2017	Figure B-8

URS

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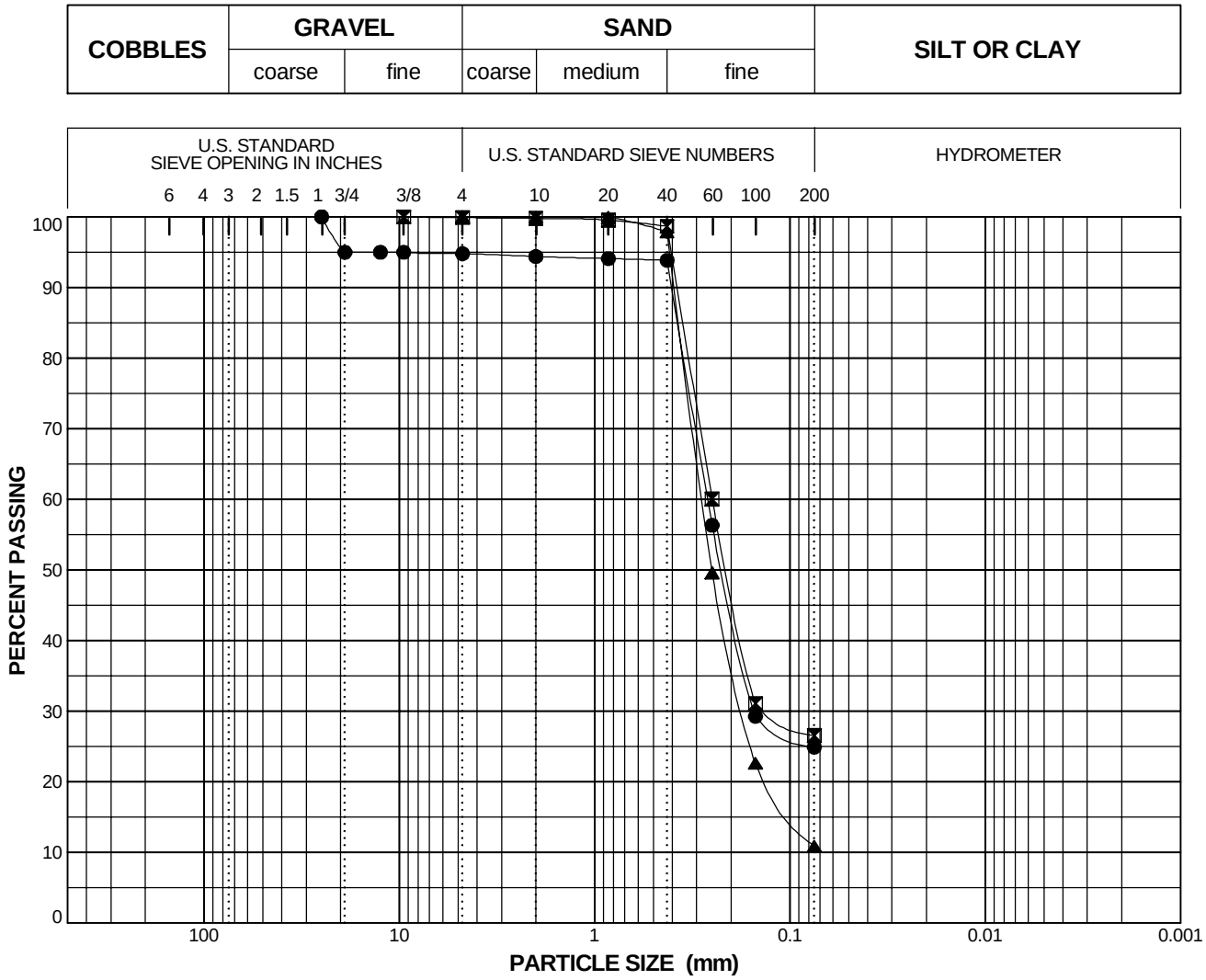

SYMBOL	●	⊠	▲
Boring	AB-3	AB-3	AB-3
Sample			
Spec			
Depth (ft)	40.0-42.0	50.0-52.0	60.0-62.0
% +3"	0.0	0.0	0.0
% Gravel	5.2	0.1	0.0
% Sand	69.9	73.3	89.1
% Fines	24.9	26.6	10.9
% -2µ			
Cc			1.49
Cu			3.94
LL			
PL			
PI			
USCS	SM	SM	SP-SM
w (%)	12.5	12.2	8.7

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"	100.0		
3/4"	95.0		
1/2"	95.0		
3/8"	95.0	100.0	
4	94.8	99.9	100.0
10	94.4	99.8	100.0
20	94.1	99.5	99.9
40	93.9	98.7	97.9
60	56.3	60.1	49.6
100	29.3	31.1	22.6
200	24.9	26.6	10.9

SYMBOL	DESCRIPTION AND REMARKS
●	Brown gray SILTY SAND (SM)
⊠	Brown gray SILTY SAND (SM)
▲	Brown POORLY GRADED SAND with SILT (SP-SM)

PARTICLE SIZE DISTRIBUTION

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Project Number		
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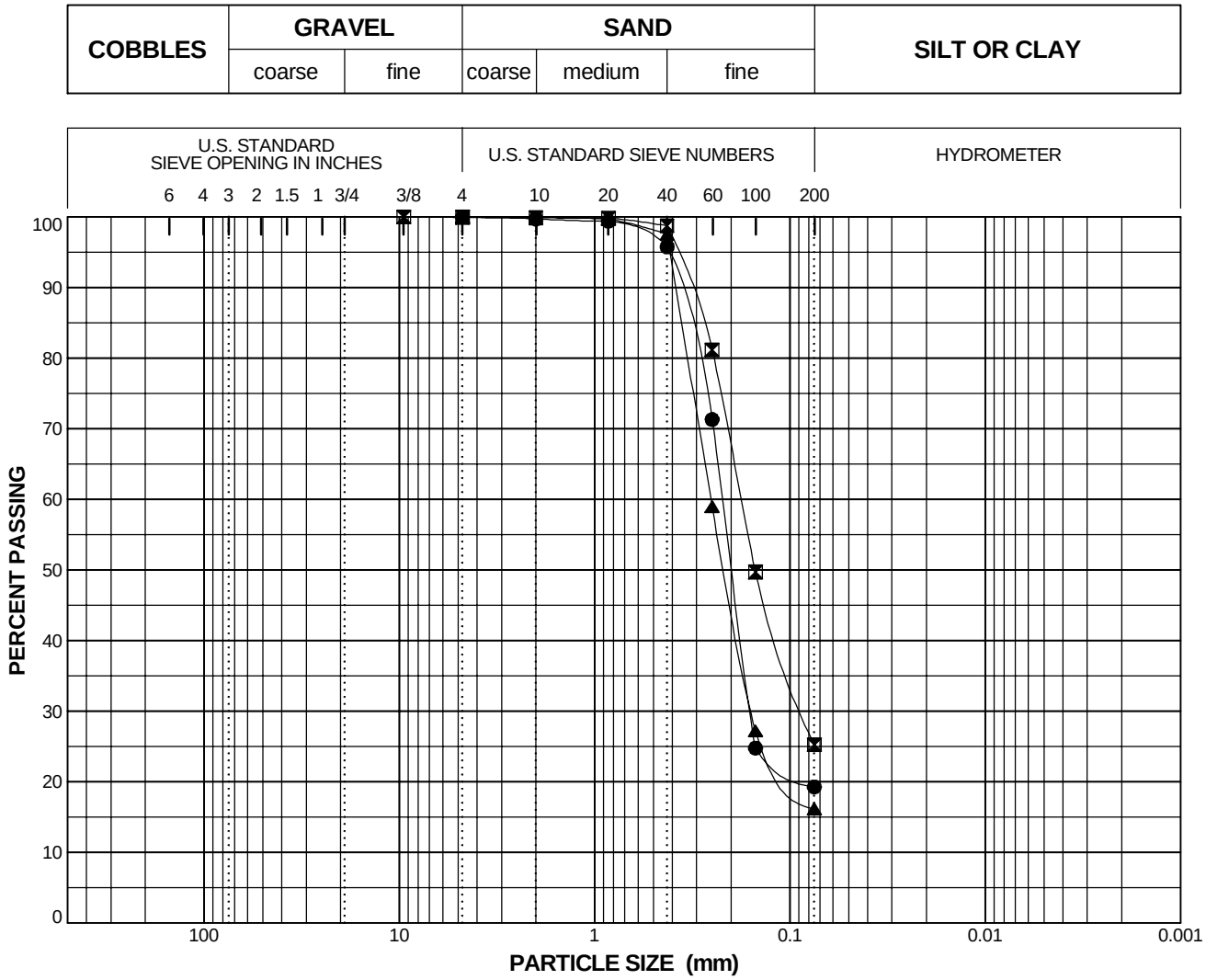

SYMBOL	●	⊠	▲
Boring	AB-3	AB-3	AB-3
Sample			
Spec			
Depth (ft)	70.0-72.0	75.0-77.0	80.0-82.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.1	0.0
% Sand	80.7	74.7	83.8
% Fines	19.3	25.3	16.2
% -2µ			
Cc			
Cu			
LL			
PL			
PI			
USCS	SM	SM	SM
w (%)	23.8	12.1	12.0

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"		100.0	
4	100.0	99.9	100.0
10	99.7	99.9	99.9
20	99.4	99.8	99.7
40	95.7	98.7	97.6
60	71.3	81.2	59.0
100	24.8	49.7	27.2
200	19.3	25.3	16.2

SYMBOL	DESCRIPTION AND REMARKS
●	Gray brown SILTY SAND (SM)
⊠	Brown SILTY SAND (SM)
▲	Brown SILTY SAND (SM)

PARTICLE SIZE DISTRIBUTION

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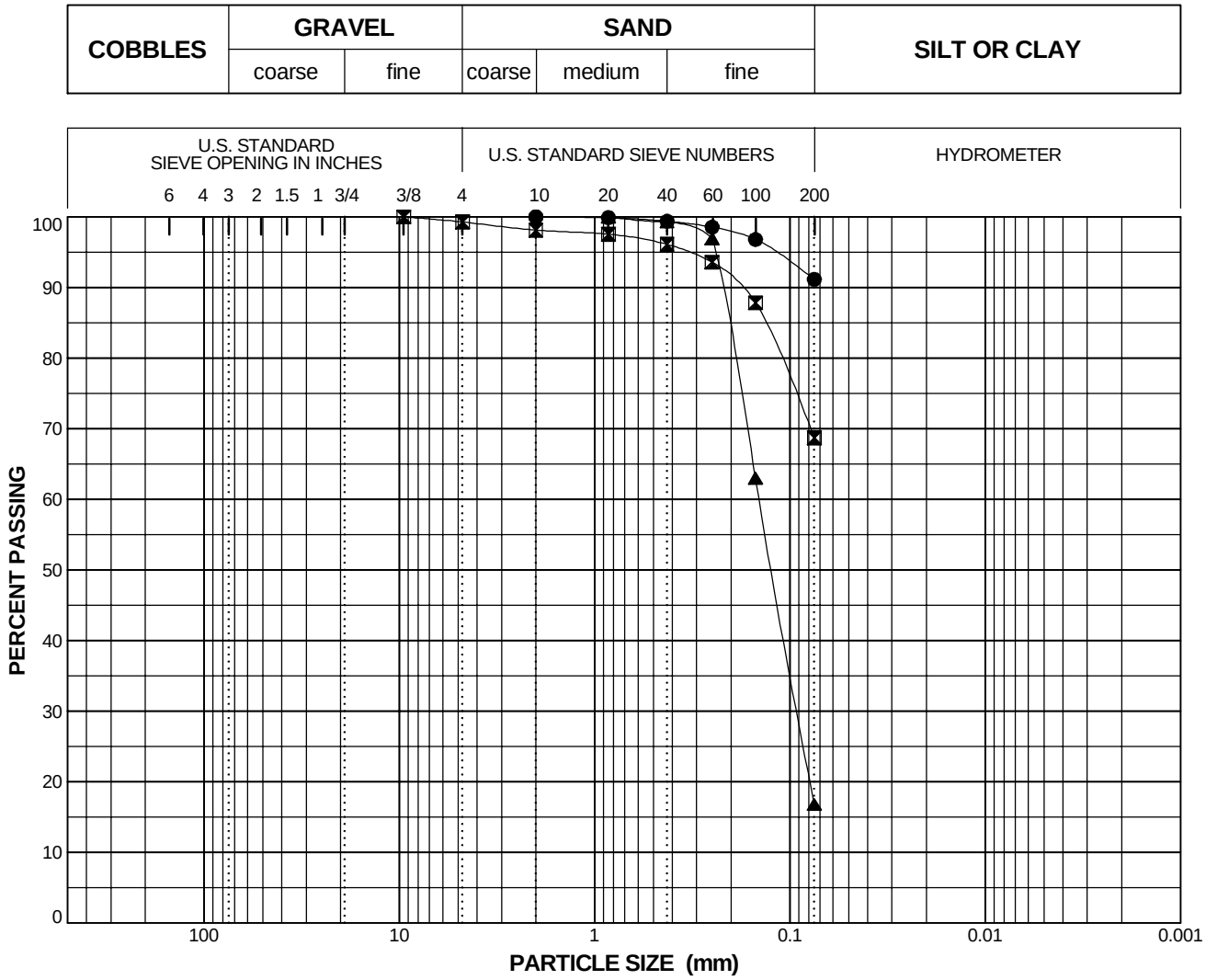

SYMBOL	●	⊠	▲
Boring	AB-3	AB-3	AB-4
Sample			
Spec			
Depth (ft)	90.0-92.0	95.0-97.0	8.0-10.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.7	0.0
% Sand	8.8	30.6	83.2
% Fines	91.2	68.7	16.8
% -2µ			
Cc			
Cu			
LL	45		
PL	29		
PI	16		
USCS	ML	ML	SM
w (%)	30.3	37.9	12.8

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"		100.0	
4		99.3	
10	100.0	98.1	
20	99.9	97.6	100.0
40	99.4	96.1	99.3
60	98.6	93.6	96.9
100	96.8	87.8	63.0
200	91.2	68.7	16.8

SYMBOL	DESCRIPTION AND REMARKS
●	Dark gray SILT (ML)
⊠	Dark gray SANDY SILT (ML)
▲	Brown SILTY SAND (SM)

PARTICLE SIZE DISTRIBUTION

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Project Number		
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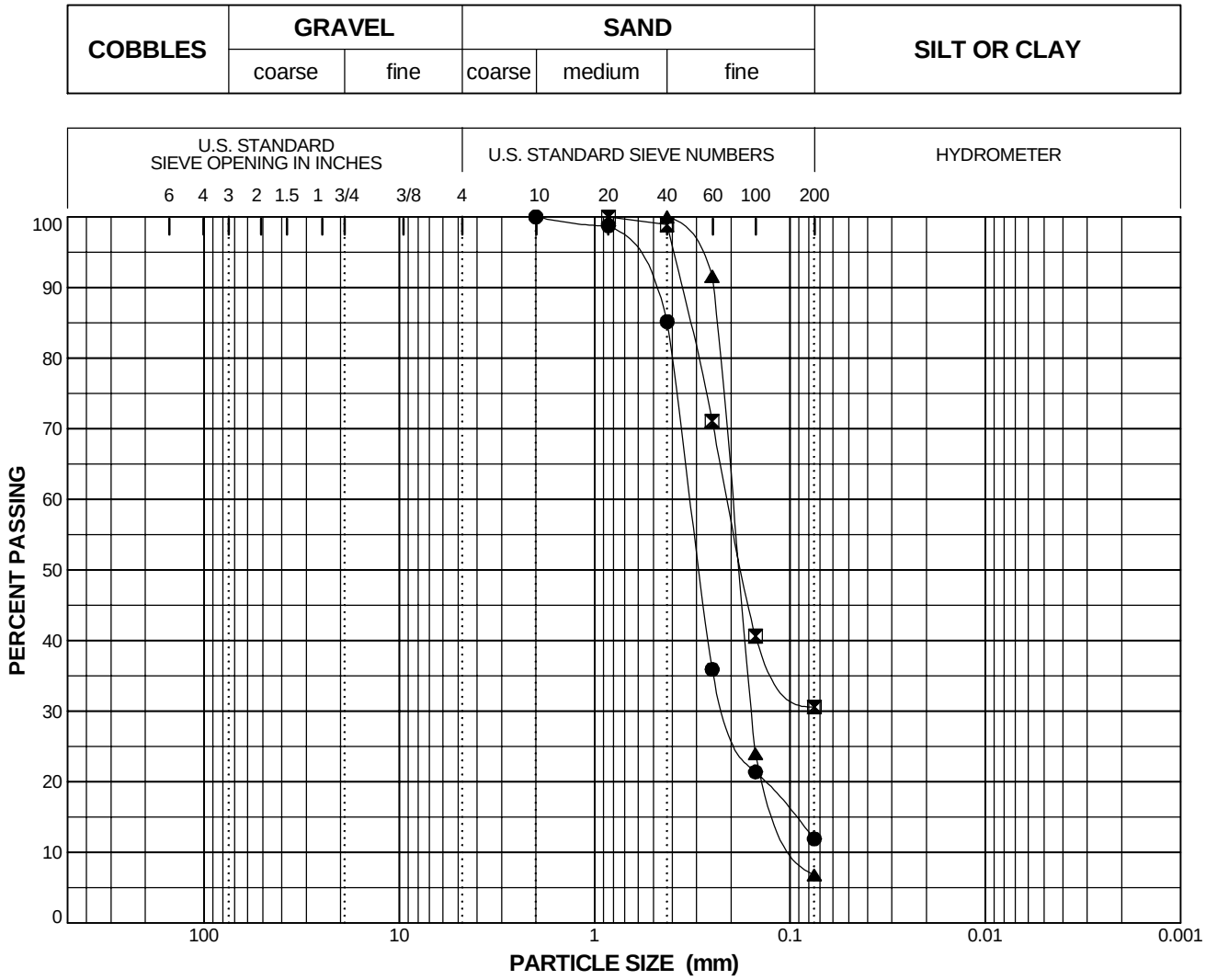

SYMBOL	●	⊠	▲
Boring	AB-4	AB-4	CB-2
Sample			
Spec			
Depth (ft)	29.0-31.0	83.0-85.0	4.0-6.0
% +3"	0.0	0.0	0.0
% Gravel	0.0	0.0	0.0
% Sand	88.1	69.4	93.2
% Fines	11.9	30.6	6.8
% -2µ			
Cc	1.95		1.47
Cu	4.97		2.31
LL			
PL			
PI			
USCS	SP-SM	SM	SP-SM
w (%)	12.0	17.5	5.6

Particle Size (Sieve #)	PERCENT FINER ●	⊠	▲
3"			
2"			
1"			
3/4"			
1/2"			
3/8"			
4			
10	100.0		
20	98.8	100.0	
40	85.2	98.9	100.0
60	35.9	71.1	91.6
100	21.4	40.6	24.0
200	11.9	30.6	6.8

SYMBOL	DESCRIPTION AND REMARKS
●	Brown POORLY GRADED SAND with SILT (SP-SM)
⊠	Light brown SILTY SAND (SM)
▲	Brown POORLY GRADED SAND with SILT (SP-SM)

PARTICLE SIZE DISTRIBUTION

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