November 13, 2015
103IP3406

Mr. Uriah Sowell
Rooney Engineering
115 Inverness Drive East, Suite 300,
Englewood, CO 80112

Subject: Infiltration Testing – Blainsport Station Valve Site
Sunoco Pennsylvania Pipeline Project
Lancaster County, West Cocalico Township

Dear Mr. Sowell:

Tetra Tech, Inc. (Tetra Tech) performed infiltration testing within proposed stormwater management feature areas at the proposed Blainsport Station Valve Site in West Cocalico Township, Commonwealth of Pennsylvania. This letter report summarizes results of the infiltration testing.

The intended method for infiltration testing was the double-ring constant head test; however, the field water truck used to supply water for testing could not access test locations within reasonable distance because of steep grades and fencing along the access route around the existing Blainsport Station. Therefore, the method used to conduct infiltration testing was the single-ring falling head test. This commonly accepted test method utilizes a considerable amount less water, and the water was reasonably hauled to the test locations with buckets. Two single-ring falling head infiltration tests were performed at the site on September 16, 2015, in accordance with ASTM International (ASTM) D5126; locations of the tests are shown in Attachment 1.

Prior to infiltration testing, a hand auger soil boring was advanced adjacent to each test location to log lithology, inspect for evidence of seasonal high water table, and collect representative soil samples. Soil borings were advanced by use of a hand-held auger, and subsurface conditions were logged. Boring logs (Attachment 2) include soil data obtained from the explorations. Soil borings could not be advanced to at least 2 feet below the infiltration test depths because of encounter with gravel and the very dense condition of the soils (believed to be fill material placed as part of construction of the adjacent Blainsport Station). However, Standard Penetration Test (SPT) borings were advanced at the existing Blainsport Station in April 2014. Bedrock was not encountered within the SPT borings at their termination depths of 20 and 25 feet below ground surface. The underlying geology is the Hammer Creek Formation, a reddish-brown Triassic coarse-grained sandstone with interbeds of red shale and quartz-pebble conglomerates. Groundwater was encountered within the SPT borings at depths ranging from 7 to 13 feet below ground surface. Soils within the infiltration test off-set borings did not exhibit mottling. Based on this, and depths to groundwater encountered in the SPT borings, groundwater is not anticipated to be present within two feet of the infiltration test depths.

A soil sample was collected at each of the two infiltration test depths. The samples were inspected and described visually in Tetra Tech's geotechnical laboratory. A Percent Finer than a No. 200 Sieve Test (ASTM D1140) was performed to measure the amount of silt and clay particulate in the soil samples. An Atterberg Limit Test (ASTM D4318) was conducted to aid in classification of the soils. Results of the grain-size analysis and Atterberg Limits testing were referenced to determine the Unified Soil Classification System (USCS) designation for the soils encountered at the infiltration test depth. A summary of the laboratory testing results is in Attachment 3.

Tetra Tech, Inc.
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Tel 302-738-7551 Fax 302-454-5988 www.tetratech.com

Infiltration testing via a single-ring, falling head testing method occurred at each test location; the procedure for this test method is described in Attachment 4. Results from the infiltration testing are summarized in the attached Infiltration Testing Tables (Attachment 5). Table 1 summarizes investigation and testing depths, results of the infiltration testing, and USCS classifications and descriptions of soils at the infiltration test depths.

TABLE 1
SUMMARY OF RESULTS FROM INFILTRATION INVESTIGATION

Infiltration Test Location	Infiltration Test Depth (inches)	Off-Set Soil Boring Depth (inches)	Infiltration Testing Results (inches/hour)	USCS Classification [(1)] at Test Depth	Generalized Description of Soils at Test Depth
IT-01	11	12	0.03 (0.00 final test hour)	CL	Reddish brown silty clay with a little fine sand, trace fine to coarse gravel.
IT-02	22	36	0.09 (0.00 final test hour)	CL	Reddish brown silty clay with a little fine sand, trace fine to coarse gravel.

Tetra Tech's services accorded with generally accepted engineering practice. No warranty, expressed or implied, is given. We appreciate the opportunity to provide our professional services to you. If you have any questions regarding the testing we performed, please contact me at (302) 283-2274, or via E-mail at ralph.boedeker@tetratech.com.

Sincerely,

Ralph Boedeker

Ralph Boedeker, P.E.
Geotechnical Project Manager

cc: Karen Gleason (Tetra Tech – Pittsburgh)

Attachments
Attachment 1: Infiltration Test Locations
Attachment 2: Soil Boring Logs
Attachment 3: Laboratory Testing Summary
Attachment 4: Falling Head Singe Ring Infiltration Test Procedures
Attachment 5: Infiltration Testing Tables

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Attachment 1

Infiltration Test Locations

LEGEND:

Infiltration Test Locations (IT)

Standard Penetration Test Borings (GB)

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INFILTRATION TEST LOCATIONS
BLAINSPORT STATION VALVE SITE
LANCASTER COUNTY, WEST COCALICO TOWNSHIP, PA
SUNOCO PENNSYLVANIA PIPELINE PROJECT

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Attachment 2

Soil Boring Logs

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INFILTRATION TESTING SOIL LOG

Project: Sunoco PPP - Blainsport Valve Site
Project No.: 103IP3406
Boring/Pit No.: IT-01
Tested by: Tetra Tech/Hynes

Equipment Used: Infiltration Testing Equipment/Hand Auger
Weather: Sunny
Geology:
Land Use: N/A

Horizon	Upper Boundary	Lower Boundary	Soil Textural Class	Description	Soil Color	Color Patterns	Pores, Roots, Rock Structure	Depth to Bedrock	Depth to Water	Comments
	0''	3"	topsoil	topsoil	dark brown	Solid				
	3"	12"	CL	silty clay with a little fine sand, trace f-c gravel	reddish brown	solid		(see note 1)	Not Encountered	%<200: 85.6 at test depth

1) Could not penetrate deeper than 12" bgs with hand auger due to presense of gravel and dense compaction of fill. Hand auger refusal not suspected to be a result of bedrock. Many off-set attempts were made.

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INFILTRATION TESTING SOIL LOG

Project: Sunoco PPP - Blainsport Valve Site
Project No.: 103IP3406
Boring/Pit No.: IT-02
Tested by: Tetra Tech/Hynes

Equipment Used: Infiltration Testing Equipment/Hand Auger
Weather: Sunny
Geology:
Land Use: N/A

Horizon	Upper Boundary	Lower Boundary	Soil Textural Class	Description	Soil Color	Color Patterns	Pores, Roots, Rock Structure	Depth to Bedrock	Depth to Water	Comments
	0''	6"	topsoil	topsoil	brown	Solid				
	6"	36"	CL	silty clay with a little fine sand, trace f-c gravel	reddish brown	solid		(see note 1)	Not Encountered	%<200: 83.2 at test depth

1) Could not penetrate deeper than 36" bgs with hand auger due to presense of gravel and dense compaction of fill. Hand auger refusal not suspected to be a result of bedrock. Many off-set attempts were made.

TETRA TECH
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Newark, Delaware 19713
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TEST BORING LOG

Project Name: SUNOCO MARINER EAST			Project No.: 103IP2762
Project Location: BLAINSPORT STATION			Page 1 of 1
Test Boring No.: GB-01	Dates(s) Drilled: 04-18-14	Inspector: E. WATT	
Drilling Contractor: HYNES	Drilling Method: SPT - ASTM D1586	Driller: Justin	
Surface Elevation (ft): ~499.3	Groundwater Depth (ft): 7.0	Total Depth (ft): 20.0	

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *			N
			0.0	0.5			TOPSOIL (6")				
1	1.0	2.5	0.5		16	A	DR HIGHLY WEATHERED TO A REDDISH BROWN SANDY CLAY,	1	3	2	**5**
							TRACE FINE GRAVEL.				
2*	3.5	5.0			18		DR HIGHLY WEATHERED TO A REDDISH BROWN SANDY CLAY,	2	4	5	**9**
							TRACE FINE GRAVEL.				
3	6.0	7.5			16		DR HIGHLY WEATHERED TO A REDDISH BROWN SILTY CLAY	2	3	5	**8**
							WITH TRACE FINE SAND (USCS: CL).				
4	9.0	10.5			13		DR HIGHLY WEATHERED TO A REDDISH BROWN SILTY CLAY	1	4	5	**9**
				12.0			WITH TRACE FINE SAND.				
5	14.0	15.5	12.0		14	B	DR WEATHERED TO A REDDISH BROWN FINE SAND WITH SOME	2	6	10	**16**
				17.0			SILTY CLAY, TRACE FINE GRAVEL. (USCS: SC).				
6	19.0	19.8	17.0		7	C	DR. WEATHEED TO A REDDISH BROWN FINE TO MEDIUM SAND	15	50/3"		**>50**
				20.0			WITH SOME SILTY CLAY, AND A LITTLE F-C GRAVEL.				
							AUGER REFUSAL AT 20.0'. AUGER REFUSAL MATEIAL APPEARS				
							TO BE SANDSTONE.				
							WET ON SPOON AT 9'.				
							WATER LEVEL THROUGH AUGERS AT 7'.				
							CAVED AT 15', WATER LEVEL ON TOP OF CAVE AT 5'.				

Notes/Comments:

Pocket Pentrometer Testing

S1: 2.25 tsf S4: 3 TSF

S2: 3.0 tsf

S3: 2.0 tsf

DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
N: Number of blows to drive spoon from 6" to 18" interval.

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TEST BORING LOG

Project Name: SUNOCO MARINER EAST			Project No.: 103IP2762
Project Location: BLAINSPORT STATION			Page 1 of 1
Test Boring No.: GB-02	Dates(s) Drilled: 04-18-14	Inspector: E. WATT	
Drilling Contractor: HYNES	Drilling Method: SPT - ASTM D1586	Driller: Justin	
Surface Elevation (ft): ~497.0	Groundwater Depth (ft): 13.0	Total Depth (ft): 25.5	

Sample No.	Sample Depth (ft) From	Sample Depth (ft) To	Strata Depth (ft) From	Strata Depth (ft) To	Recov. (in)	Strata (USCS)	Description of Materials	6" Increment Blows *			N
			0.0	0.5			TOPSOIL (6")				
1	1.0	2.5	0.5		18	A	DR HIGHLY WEATHERED TO A REDDISH BROWN SILTY CLAY	2	2	3	**5**
							WITH TRACE FINE SAND, TRACE FINE GRAVEL.				
2*	3.5	5.0			18		DR HIGHLY WEATHERED TO A REDDISH BROWN SANDY CLAY,	2	4	6	**10**
				5.5			TRACE FINE GRAVEL.				
3	6.0	7.5	5.5		14	B	DR WEATHERED TO A REDDISH BROWN FINE SAND WITH A	2	5	6	**11**
							LITTLE SILTY CLAY, TRACE FINE GRAVEL.				
4	9.0	10.5			6		DR WEATHERED TO A REDDISH BROWN FINE TO MEDIUM SAND,	6	6	8	**14**
				12.0			WITH A LITTLE SILTY CLAY, TRACE FINE GRAVEL.				
5	14.0	15.5	12.0		11	C	DR WEATHERED TO A FINE TO MEDIUM SAND WITH SOME SILTY	14	18	21	**39**
							CLAY, TRACE TO LITTLE FINE GRAVEL. (USCS: SC).				
6	19.0	20.5			6		DR WEATHERED TO A FINE TO MEDIUM SAND WITH SOME SILTY	15	16	20	**36**
							CLAY, TRACE TO LITTLE FINE GRAVEL.				
7	24.0	25.5			12		DR WEATHERED TO A FINE TO MEDIUM SAND WITH SOME SILTY	15	18	22	**40**
				25.5			CLAY, TRACE TO LITTLE FINE TO COARSE GRAVEL.				
							WET ON SPOON AT 13.0' BGS.				
							WATER LEVEL THROUGH AUGERS AT 14' BGS.				
							CAVED AT 19', WATER LEVEL ON CAVE AT 18'.				

Notes/Comments:

Pocket Pentrometer Testing

S1: 2.25 tsf

S2: 3.0 tsf

DR: DECOMPOSED ROCK

Strata (USCS) Designations are approximated based on visual review, except where indicated in Description of Materials.

* Number of blows of 140 lb. Hammer dropped 30 in. required to drive 2 in. split-spoon sampler in 6 in. increments.
N: Number of blows to drive spoon from 6" to 18" interval.

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Attachment 3

Laboratory Testing Summary

GEOTECHNICAL LABORATORY TESTING SUMMARY
SUNOCO PENNSYLVANIA PIPELINE PROJECT
BLAINSPORT VALVE SITE

Valve Site	Soil Boring No.	Sample No.	Water Content, % (ASTM D2216)	Percent Silts/Clays, % (ASTM D1140)	Atterburg Limits (ASTM D4318)			USCS Classif. (ASTM D2487)
					Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	
Blainsport	IT-01	IT-01	7.2	85.6	43	20	23	CL
	IT-02	IT-02	9.6	83.2	44	21	23	CL

Notes:

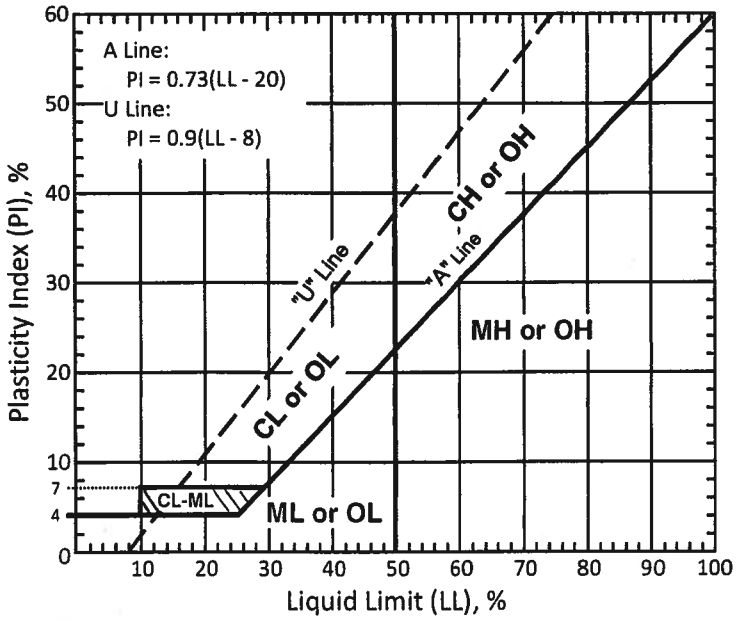
1) Sample depths based on feet below grade at time of exploration.

UNIFIED SOIL CLASSIFICATION SYSTEM [Casagrande (1948)]

Major Divisions			Group Symbols	Typical Descriptions	Laboratory Classifications		
Coarse Grained Soils (More than half of material is larger than No. 200 sieve)	Gravels More than half of coarse fraction is larger than No. 4 sieve	Clean gravel (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Determine Percentage of sand and gravel from grain size curve. Depending on Percentage of fines (fraction smaller than No. 200 sieve), coarse-grained soils are classified as follows: Less than 5 percent GW, GP, SW, SP; More than 12 percent GM, GC, SM, SC; 5 to 12 percent Borderline cases requiring dual symbols[1]	$C_u=\frac{D_{60}}{D_{10}}$ greater than 4: $C_c=\frac{(D_{30})2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting C_u or C_c requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above A line with I_p greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 Sieve)	Clean sands (Little or no fines)	SW	Well graded sands, gravely sands, little or no fines		$C_u=\frac{D_{60}}{D_{10}}$ greater than 6: $C_c=\frac{(D_{30})2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting C_u or C_c requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures		Atterberg limits below A Line or I_p less than 4	Limits Plotting in hatched zone with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above A line with I_p greater than 7	

Major Divisions		Group Symbols	Typical Descriptions
Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays , sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
	Highly organic soils	Pt	Peat and other highly organic soils

For soils plotting nearly on A line use dual symbols i.e ., I_p = 29.5, w_L=60 gives CH-MH. When w_L is near 50 use CL-CH or ML-MH. Take near as ± 2 percent.



(1) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC. well-graded gravel-sand mixture with clay binder.

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Attachment 4

Falling Head Singe Ring Infiltration Test Procedures

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Falling Head Singe Ring
Infiltration Test Procedure

- [ ] 15 gallons of clean water per test
- [ ] 4 inch diameter thin wall PVC pipe
- [ ] SledgeHammer
- [ ] 3- inch hand auger bucket
- [ ] Shovels Flat/Round
- [ ] Hand Auger 4-inch bucket (with extensions)
- [ ] Driving Block
- [ ] 5 gallon buckets Water
- [ ] level indicator Gator/ATV
- [ ] level indicator Gator/ATV (as necessary)

Procedure

A. Unless directed otherwise, advance one soil boring at each test location. The boring should extend to groundwater. Accurately measure depth to groundwater and depth of each soil change. Pay close attention to soils for mottling. Contact office to determine test depth. Note: This step can be omitted if test borings were advanced during a previous site visit.

B. Advance a 4-inch diameter soil boring to the specified test depth. Check boring log to ensure that soil at bottom of excavation is soil type to be tested.

C. Cut thin wall PVC to length (approximately 1 to 2' longer than desired test depth).

D. Push/drive PVC to bottom of soil boring.

E. Using 3-inch auger, clean out bottom of test hole to remove any soils that caved in during PVC placement. Drive PVC casing an additional 2 inches to ensure that bottom of test hole does not extend beyond the bottom of the PVC pipe.

F. Collect initial test information using water level indicator

    1. Determine the total depth to the bottom of the hole from top of pipe and record.
    2. Determine riser height above ground and .record.
    3. Subtract 2 feet from total depth (See F.1.) and record.

G. Start Test\

    1. Set up water level indicator at depth determined in F.3.
    2. Fill tube with water until water level indicator alarms. To minimize soil scouring, slowly pour water down the inside of the casing wall.
    3. Record exact depth to water with level indicator

H. Run Test:

    1. Pre-soak (1 hour or less).
        a. Record depth to water every 15 minutes for first hour (pre-soak).
        b. At the end of first hour refill pipe with water to level determined Step F.3.

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Falling Head Singe Ring
Infiltration Test Procedure

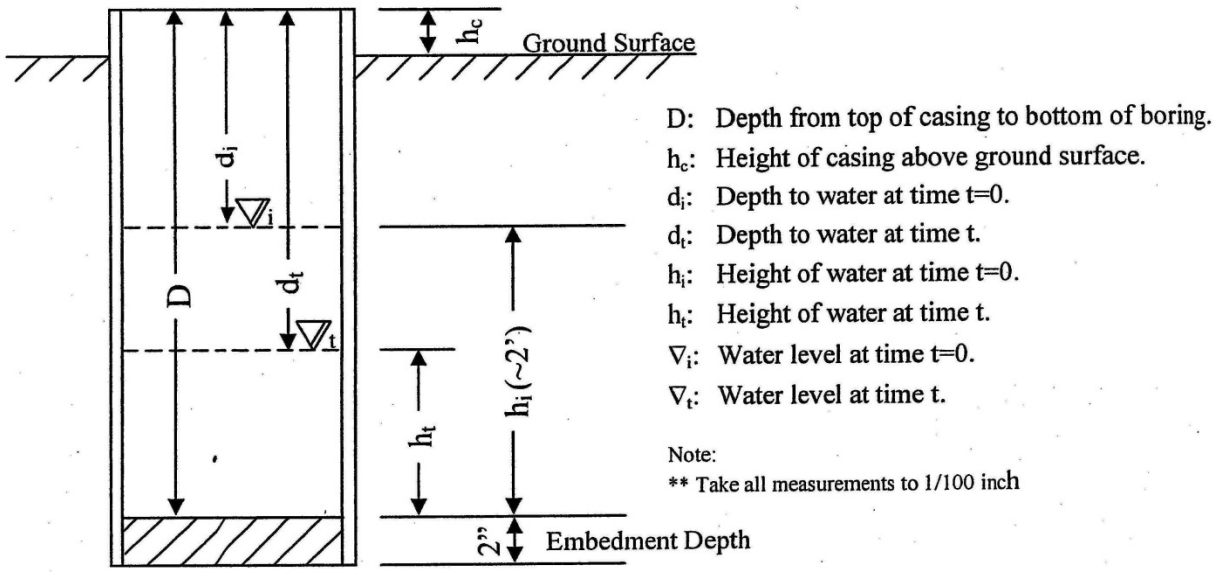
2. Infiltration testing (four, one Hour tests)
   a. Tests starts after completing Step H.1.b
   b. Record depth of water every 15 minutes (or more frequently) for one hour or until water drains from pipe.
   c. Refill pipe with water to level determined in Step F.3
   d. Repeat Step H.2.b. and c. three additional times (four test runs)
   e. Testing concludes after pre-soak and four test runs are completed

I. Calculations

Infiltration rate is calculated as inches per hour.

Determine the water level drop recorded during each one hour test (note that the water level indicator is marked in tenths of a foot. A conversion to inches is required). Multiply the water level drop recorded in tenths of a foot by 1.2 to get water level drop in inches.

All data should be recorded on pre-made forms.



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Falling Head Singe Ring
Infiltration Test Procedure

Date: ____________________ Test Location: __________________________

Depth from top of Casing to Bottom of Boring (D): ___________________________

Height of Casing above Ground Surface (h_c): _______________________________

Tester/ Technician Performing Test: _________________________________

Time (t)	Time Elapsed	Depth to Water (d_t) Measured from top of casing to water to nearest 1/100 foot	Change

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Attachment 5

Infiltration Testing Tables

INFILTRATION TEST DATA SHEET

JOB NAME: PPP - Blainsport Station Valve Site

PROJECT NUMBER: 103IP3406 **TEST LOCATION:** IT-01

TEST DATE: September 16, 2015 **TEST DEPTH:** 0.90 ft

	TIME	DEPTH TO WATER BELOW GROUND SURFACE	HYDRAULIC HEAD	Δ HYDRAULIC HEAD	PERMEABILITY ($K_{m)}$		COMMENTS
24 Hour Pre-soak	15:30	-1.23 ft	2.13 ft				Presoaked on 9/15
	7:00	-1.16 ft	2.06 ft	0.07 ft	0.07 ft/hr	0.84 in/hr	
Test Hour 2	7:15	-1.16 ft	2.06 ft	0.00 ft			
	7:30	-1.16 ft	2.06 ft	0.00 ft			
	7:45	-1.16 ft	2.06 ft	0.00 ft			
	8:00	-1.16 ft	2.06 ft	0.00 ft	0.00 ft/hr	0.00 in/hr	
Test Hour 3	8:15	-1.16 ft	2.06 ft	0.00 ft			
	8:30	-1.16 ft	2.06 ft	0.00 ft			
	8:45	-1.15 ft	2.05 ft	0.01 ft			
	9:00	-1.15 ft	2.05 ft	0.00 ft	0.01 ft/hr	0.12 in/hr	
Test Hour 4	9:15	-1.15 ft	2.05 ft	0.00 ft			
	9:30	-1.15 ft	2.05 ft	0.00 ft			
	9:45	-1.15 ft	2.05 ft	0.00 ft			
	10:00	-1.15 ft	2.05 ft	0.00 ft	0.00 ft/hr	0.00 in/hr	
Test Hour 5	10:15	-1.15 ft	2.05 ft	0.00 ft			
	10:30	-1.15 ft	2.05 ft	0.00 ft			
	10:45	-1.15 ft	2.05 ft	0.00 ft			
	11:00	-1.15 ft	2.05 ft	0.00 ft	0.00 ft/hr	0.00 in/hr	

There are generally two acceptable methods to calculate steady state infiltration rates:
1. Time Weighted Average: 0.03 in/hr
2. Final Test Hour Reading: 0.00 in/hr

INFILTRATION TEST DATA SHEET

JOB NAME: PPP - Blainsport Station Valve Site

PROJECT NUMBER: 103IP3406 **TEST LOCATION:** IT-02

TEST DATE: September 16, 2015 **TEST DEPTH:** 1.82 ft

	TIME	DEPTH TO WATER BELOW GROUND SURFACE	HYDRAULIC HEAD	Δ HYDRAULIC HEAD	PERMEABILITY ($K_{m)}$		COMMENTS
24 Hour Pre-soak	15:30	-0.20 ft	2.02 ft				Presoaked on 9/15
	7:00	0.48 ft	1.34 ft	0.68 ft	0.68 ft/hr	8.16 in/hr	
Test Hour 2	7:15	0.48 ft	1.34 ft	0.00 ft			
	7:30	0.48 ft	1.34 ft	0.00 ft			
	7:45	0.48 ft	1.34 ft	0.00 ft			
	8:00	0.49 ft	1.33 ft	0.01 ft	0.01 ft/hr	0.12 in/hr	
Test Hour 3	8:15	0.49 ft	1.33 ft	0.00 ft			
	8:30	0.49 ft	1.33 ft	0.00 ft			
	8:45	0.50 ft	1.32 ft	0.01 ft			
	9:00	0.50 ft	1.32 ft	0.00 ft	0.01 ft/hr	0.12 in/hr	
Test Hour 4	9:15	0.50 ft	1.32 ft	0.00 ft			
	9:30	0.51 ft	1.31 ft	0.01 ft			
	9:45	0.51 ft	1.31 ft	0.00 ft			
	10:00	0.51 ft	1.31 ft	0.00 ft	0.01 ft/hr	0.12 in/hr	
Test Hour 5	10:15	0.51 ft	1.31 ft	0.00 ft			
	10:30	0.51 ft	1.31 ft	0.00 ft			
	10:45	0.51 ft	1.31 ft	0.00 ft			
	11:00	0.51 ft	1.31 ft	0.00 ft	0.00 ft/hr	0.00 in/hr	

There are generally two acceptable methods to calculate steady state infiltration rates:
1. Time Weighted Average: 0.09 in/hr
2. Final Test Hour Reading: 0.00 in/hr