NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

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March 16, 2017

Mr. David D. Brayack, P.E.
Tetra Tech, Inc.
5700 Lake Wright Drive
Suite 309
Norfolk, VA 23502

Re: Letter Work Plan – Recharge Basin Evaluation for RE-108 Groundwater Hotspot Treatment System

David:

The New York State Department of Environmental Conservation (Department) has completed review of the Letter Work Plan – Recharge Basin Evaluation for RE-108 Groundwater Hotspot Treatment System for the Naval Weapons Industrial Reserve Plant site located in the Town of Oyster Bay, Nassau County, New York. Based on this review, the Department has no comments and the February 13, 2017 Recharge Basin Evaluation Work Plan is approved and considered final.

Thanks and please do not hesitate to contact me at (518) 402-9478 or Jason.pelton@dec.ny.gov with any questions.

Sincerely,

Jason M. Pelton
Project Manager
Remedial Section B, Remedial Bureau D
Division of Environmental Remediation

ec: D. Hesler
S. Karpinski, NYSDOH
Lora Fly, NAVFAC Mid-Atlantic
Joseph McCloud, NAVFAC Mid-Atlantic

TETRA TECH

NOR-02316

February 13, 2017

Mr. Jason Pelton
New York State Department of Environmental Conservation
Division of Environmental Remediation
Remedial Bureau D, Section B
625 Broadway
Albany, New York 12233-7015

Reference: CLEAN Contract No. N62470-16-D-9008
Contract Task Order WE09

Subject: Letter Work Plan – Recharge Basin Evaluation for
RE-108 Groundwater Hotspot Treatment System
Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage, New York

Dear Mr. Pelton:

On behalf of the Department of the Navy, Tetra Tech is submitting the subject document to the New York State Department of Environmental Conservation (NYSDEC) for information. This evaluation is being conducted to support the ongoing design for the RE-108 Groundwater Hotspot Treatment System. If you have any questions please contact Ms. Lora Fly, NAVFAC Mid-LANT, at lora.fly@navy.mil or (757) 341-2012.

Sincerely

David D. Brayack, P.E.
Project Manager

Enclosure: Letter Work Plan – Recharge Basin Evaluation for
RE-108 Groundwater Hotspot Treatment System
Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage, New York

Distribution:
NYSDEC, Don Hesler
NAVFAC Mid-Atlantic, Lora Fly
NAVFAC Mid-Atlantic, Joseph McCloud
Project File

Tetra Tech, Inc.
5700 Lake Wright Drive, Suite 309 Norfolk, VA 23502
Tel 757.461.3768 Fax 757.461.4148 www.tetratech.com

LETTER WORK PLAN
RECHARGE BASIN EVALUATION FOR
RE-108 GROUNDWATER HOTSPOT TREAMENT SYSTEM
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)
BETHPAGE, NEW YORK

This Letter Work Plan has been prepared by Tetra Tech, Inc. (Tetra Tech) for the Naval Facilities Engineering Command Mid-Atlantic under Contract Task Order (CTO) WE09 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract number N62470-16-D-9008. This work plan identifies field tasks to be conducted to determine the capacities of two storm water recharge basins that are being considered to infiltrate water from the RE-108 Groundwater Hotspot Treatment System (RE-108 System). Recharge basins are large open excavations in the ground surface, which infiltrate water. The basins being evaluated are 1.7 to 2.8 acres in size, 20 to 30 feet deep, and would be required to infiltrate 600 to 1,200 gallons per minute (GPM) of water on a continuous basis. The basins would also continue to be used for storm water retention and infiltration.

This evaluation is being conducted to support a Design Report for the RE-108 System. This report is scheduled to be submitted in December 2017. As discussed below, if necessary, the testing may extend beyond 2017 and then be used to support a subsequent 100 percent design package. The RE-108 System and recharge basins are located approximately 2.5 miles south of the former Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage, Long Island, New York (Figures 1 and 2).

Scope and Purpose

The Navy has identified two recharge basins (referred to as the RE-108 Recharge Basins) as potential locations to receive treated groundwater from the RE-108 System. These basins were selected because they are relatively close to the RE-108 Treatment System, but are far enough south (downgradient) that infiltration into these basins would not interfere with the extraction system capture zones. The basins are located approximately 2,800 feet (0.5 mile) downgradient (south) of the anticipated extraction wells and Treatment Plant Area for the RE-108 System (Figure 3). One basin is located near the intersection of Hicksville and Boundary Avenue (Figures 3 and 4) and the second basin is located on Seamans Neck Road (Figures 3 and 5).

In the NWIRP Bethpage Area, recharge basins are commonly used to manage storm water from roadways, parking lots, and roof drains. The nearest surface water bodies are located several miles further south (Figure 2). Discharge of treated groundwater from the RE-108 System to these bodies is also being evaluated under a separate action. Recharge basins in the area are sized as a reservoir to accumulate storm surges. The basin design then assumes that the accumulated water would infiltrate into the aquifer

before the next storm event. The absence of standing water and presence of established vegetation throughout these two basins indicates that both basins can handle the current storm water loads. The ability of the basins to handle additional flow is uncertain.

Recharge basins can also be used to infiltrate clean (non-contact) or treated water at production and remediation facilities (e.g., Navy's GM-38 Hotspot Treatment System). The GM-38 Hotspot Treatment System discharges approximately 1,000 GPM of treated groundwater into a 1.3-acre recharge basin. Based on a comparison of the size of the two RE-108 Recharge Basins with the GM-38-Hotspot Treatment System Basin, the RE-108 Recharge Basins should be able to handle the anticipated discharge rates.

The purpose of this evaluation is to determine whether one or either or both of the RE-108 Recharge Basins can be used to infiltrate 600 to 1,200 GPM of treated water on a continuous basis. This work plan identifies the field activities to be conducted and the approach for evaluating the data.

Background and History

The RE-108 Hotspot Area consists of groundwater containing over 1,000 micrograms per liter (µg/L) of volatile organic compounds (VOCs) that originated at least in part from the former NWIRP Bethpage facility. The definition of a hotspot and the need for action is identified in the Operable Unit (OU) 2 Record of Decision (ROD) (Navy, 2003). The RE-108 Hotspot Area currently extends from near the Northrop Grumman (NG) Onsite Containment System (ONCT) south to approximately Hempstead Turnpike (Figure 2). The primary VOC is trichloroethene (TCE) and represents approximately 98 percent of the total VOCs.

The Navy is currently conducting evaluations and studies to support the design of the RE-108 Treatment System. This work plan specifically addresses two recharge basins, which are being considered as a discharge option. Vertical profile boring (VPB) investigations have been conducted in area of the basins as part of the NWIRP Bethpage Off-Site Groundwater Program. VPB-44 was installed at the Hicksville/Boundary Ave recharge basin (see Figure 4) and VPB-128 was installed in the Seamans Neck Road recharge basin (see Figure 5). Field logs presenting the lithology from the upper portion of the VPBs are included in Attachment 1. Based on this information, the formation is classified as medium to coarse sand and gravel to depths of at least 80 feet below ground surface (bgs). This soil classification indicates that water should readily infiltrate into the soil. Groundwater is approximately 10 to 20 feet below the bottom of the basins.

Basin Evaluation Field Tests

The infiltration capacity of these basins will be assessed through two separate studies: (1) direct small-scale infiltration field tests and (2) long-term opportunistic recharge tests using storm water drainage. This section provides details and requirements for each study.

(1) Direct Small-Scale Infiltration Field Tests

Infiltration rates will be directly measured (inches per hour) at each recharge basin using a double ring infiltration test method as identified in the Tetra Tech standard operating procedure (SOP) (Attachment 2). Because of the limited volume of water used, this test method evaluates the infiltration rate for the near surface soil in the basin. Assuming uniform soil characteristics throughout the infiltration area and depth, these results in combination with the basin area can be used to calculate infiltration rates for the overall basin (GPM). One limit of this approach is that it will not identify potential interference from reduced permeability zones that may be present in deeper soil. The infiltration tests will be conducted at five points in each basin.

The Tetra Tech SOP outlines the requirements for conducting these tests and includes the following information:

- Field equipment required for the test.
- Site preparation procedures.
- Testing procedures.
- Data evaluation methods.
- Infiltration test data sheet.

During the infiltration tests, general surficial conditions (e.g., surface soil and vegetation) of the recharge basins will be observed and recorded in the field notes.

(2) Long-Term Opportunistic Recharge Tests

Initially, a large scale infiltration test using 600 to 1,200 gpm of water over several days was considered. However, a local source of this volume of water could not be identified and the approach was abandoned. Instead, the test will be conducted using storm water currently flowing into the basin. During heavy precipitation events, the recharge basins can receive a significant volume of storm water in a short period of time. The magnitude and timing of precipitation and the amount of water generated during these storm events cannot be predicated or calculated at this time. The window for this testing is currently planned for 6 months, but may be extended if a significant storm event does not occur during this period.

The testing will be conducted using water pressure transducers (Solinst® Levelogger Jr. Edge data logger [Attachment 3]) installed in the basins. Pressure transducers will be installed at the low point of each basin and near each storm water inlet (two inlets per basin). To secure the transducers, they will be installed within a screened section of polyvinyl chloride (PVC) pipe secured into the ground.

The pressure transducers installed in the low point of the basin will be used to directly measure the infiltration rate (inches per hour). This data coupled with the saturated basin area will be used to calculate the infiltration rate (GPM). The pressure transducers installed near the storm water inlet will be used to document the duration and magnitude of the precipitation events and to provide backup measurement for the low point transducers.

If storm events occur during the initial setup or during the subsequent monthly visits, the field crew will have additional equipment (e.g., a flow meter and a tape measure) to measure the basin inflows. A remote weather station will be set up in at NWIRP Bethpage (located approximately 3 miles north of the basins) to record precipitation data during the testing. In addition, precipitation data from the Long Island MacArthur Airport in Islip, New York will serve as a secondary weather station.

The basins will be visited once per month to ensure the operational status of the monitoring equipment and to download data.

Reporting

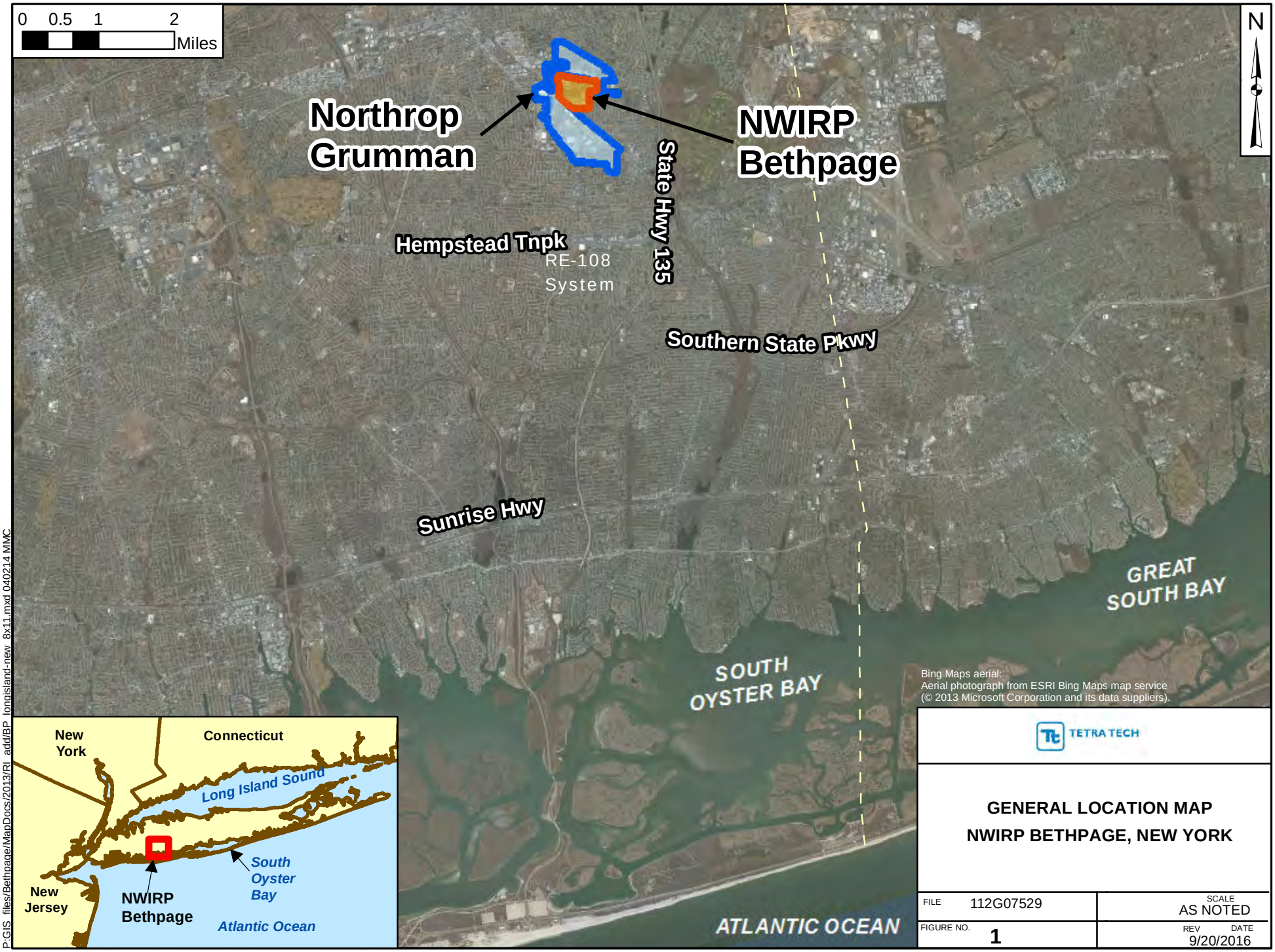
The data and findings from the field tests will presented in a data summary report. The report will document the manual and data logger field measurements and provide infiltration rate calculations for each of the locations and test methods.

References

NAVFAC, 2003. Record of Decision, Naval Weapons Industrial Reserve Plant, Bethpage, New York, Operable Unit 2 – Groundwater, NYS Registry: 1-30-003B. April.

Tetra Tech, Inc., 2016. Options Evaluation Report for the RE-108 Groundwater Hotspot System, Naval Weapons Industrial Reserve Plant, Bethpage, New York, October.

FIGURES



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TETRA TECH

GENERAL LOCATION MAP
NWIRP BETHPAGE, NEW YORK

FILE	112G07529	SCALE	AS NOTED
FIGURE NO.	1	REV / DATE	9/20/2016

N

RE-108
Hotspot
(2015)

Projected
RE-108 Hotspot
(2023)

Preliminary Discharge
Basin for
RE-108
Treatment Plant

Tpke
State Hwy 135
Fulton S
Boundary Ave
Seamans Neck Rd
Southern State Pkwy
Hicksville Rd
Bellmore Creek
Seamans Creek
Seaford Creek
Massapequa Creek
Massapequa
Pond
Sunrise Hwy

Legend

- Proposed Area for RE-108 Hotspot Treatment Plant
- RE-108 Hotspot Area Capture Zone
- Preliminary Discharge Basin for RE-108 Hotspot Treatment Plant
- General Recharge Basins
- Streams
- 1997 Northrop Grumman Property
- 1997 NWIRP Bethpage

TCE Iscoconcentraion Contour micrograms per liter (µg/L)

- 500 µg/L TCE Contour
- 2023 Projected 500 µg/L TCE Contour
- 1,000 µg/L TCE Contour
- 2023 Projected 1,000 µg/L TCE Contour

0 1,000 2,000 4,000 Feet

2013 ESRI Aerial Imagery

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TETRA TECH

GENERAL LOCATION MAP
RE-108 HOTSPOT
NWIRP BETHPAGE, NEW YORK

FILE	112G08005-WE09	SCALE	AS NOTED
FIGURE NO.	2	REV	DATE 11/22/2016

N

RE-108 Hotspot (2015)

Projected
RE-108 Hotspot (2023)

1,000 µg/L (2015)

1,000 µg/L (2023)

500 µg/L (2015)

500 µg/L (2023)

Hempstead Tpke

Seamans Neck Rd

Hicksville Rd

Boundary Ave

Hicksville/Boundary Ave
Recharge Basin

Seamans Neck Rd
Recharge Basin

Legend

- Proposed Area for RE-108 Hotspot Treatment Plant
- Preliminary Discharge Basin for RE-108 Hotspot Treatment Plant
- General Recharge Basins

TCE Iscoconcentraion Contours µg/L

- 500 µg/L TCE Contour
- 2023 Projected 500 µg/L TCE Contour
- 1,000 µg/L TCE Contour
- 2023 Projected 1,000 µg/L TCE Contour

0 250 500 1,000 Feet

2011 ESRI Aerial Imagery

P:\GIS files\Bethpage\MAP DOCS\MXD\BP_OU2_2016\BP_RE108_proposedarea.mxd

TETRA TECH

LAYOUT
RE-108 TREATMENT PLANT AREA
NWIRP BETHPAGE, NEW YORK

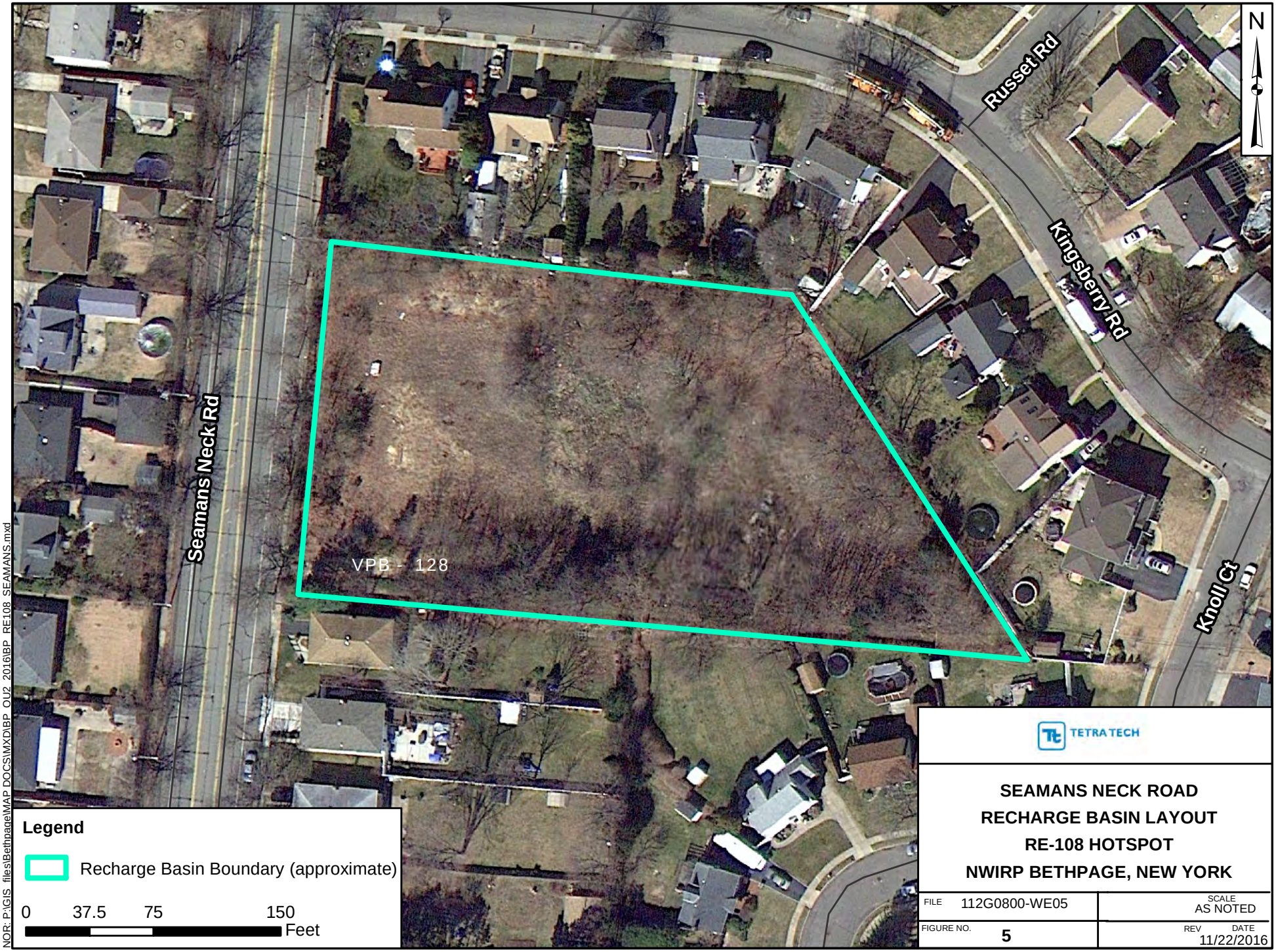
FILE	112G08005-WE09	SCALE	AS NOTED
FIGURE NO.	3	REV	DATE 11/22/2016

NOR: P:\GIS_files\Bethpage\MAP DOCS\MXD\BP_OU2_2016\BP_RE108_BOUNDARYAVE.mxd

TETRA TECH

BOUNDARY AVENUE
RECHARGE BASIN LAYOUT
RE-108 HOTSPOT
NWIRP BETHPAGE, NEW YORK

FILE	112G0800-WE05	SCALE	AS NOTED
FIGURE NO.	4	REV / DATE	11/22/2016



NOR: P:\GIS_files\Bethpage\MAP DOCS\MXD\BP_OU2_2016\BP_RE108_SEAMANS.mxd

TETRA TECH

SEAMANS NECK ROAD
RECHARGE BASIN LAYOUT
RE-108 HOTSPOT
NWIRP BETHPAGE, NEW YORK

FILE	112G0800-WE05	SCALE	AS NOTED
FIGURE NO.	5	REV DATE	11/22/2016

ATTACHMENT 1

VPB-44 and VPB-128 Boring Logs

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NWIRP Bethpage
PROJECT NUMBER: N4037-0500
DRILLING COMPANY: Unitech
DRILLING RIG: Failing 1500
BORING NUMBER: VPB-44
DATE: 4-18-01 / 4-19-01
GEOLOGIST: Vince Shickora
DRILLER: Jim Evans

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistancy or Rock Hardness	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1544	10					Brn Tan	Pebbly med to coarse Sand			0	0	0	0
1548	20					Brn Tan	Same as above with some gravel			0	0	0	0
4-18-01													
1200	30					Brn Grey Tan	Medium to Coarse Sand with quartz pebbles			0	0	0	0
4-19-01													
0935	40					Brn Tan	Fine to Med grain Sand Trace coarse Sand + Gravel			0	0	0	0
0936	50						Same as above			0	0	0	0

* When rock conng, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: 8" drag bit used

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NWIRP Bethpage
PROJECT NUMBER: N4037-03CC
DRILLING COMPANY: Unitech
DRILLING RIG: Failing 1500
BORING NUMBER: VPB-44
DATE: 4-19-01
GEOLOGIST: Vince Shickora
DRILLER: Tim Evans

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Drillers BZ**
S-1 CU	50												
1010	51	21/40	2"			Tan Brn	1/2" size gravel with Trace coarse Sand		HP-1 no recovery on first attempt	C	C	C	C
	52	40/43	24"						no second attempt due to gravel				
									(HP screen did not open)				
1145	60					Brn	med to coarse Sand with Trace gravel						
1148	70												
S-2 CU	71	35/100	3"			Brn Tan	1/4" to 1/2" gravel with Trace coarse Sand		HP-2 not collected unable to drive	0	0	0	0
1210	72	6	12"						Hydropunch due to gravel				
1344	80						Same as above						
1347	90						med to Course Sand and gravel						
							Same as above						
1403	100												

* When rock coring, enter rock brokeness.

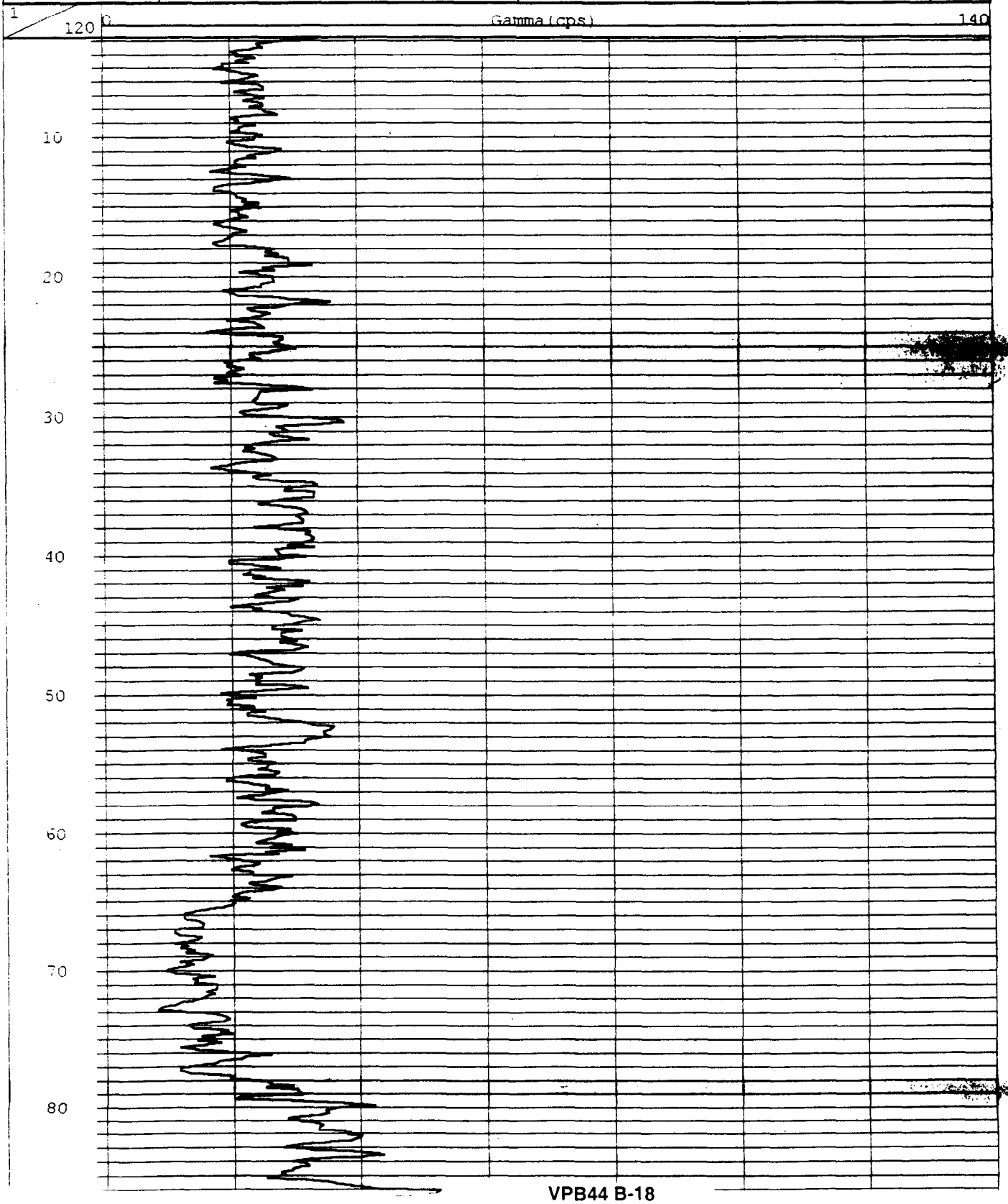
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

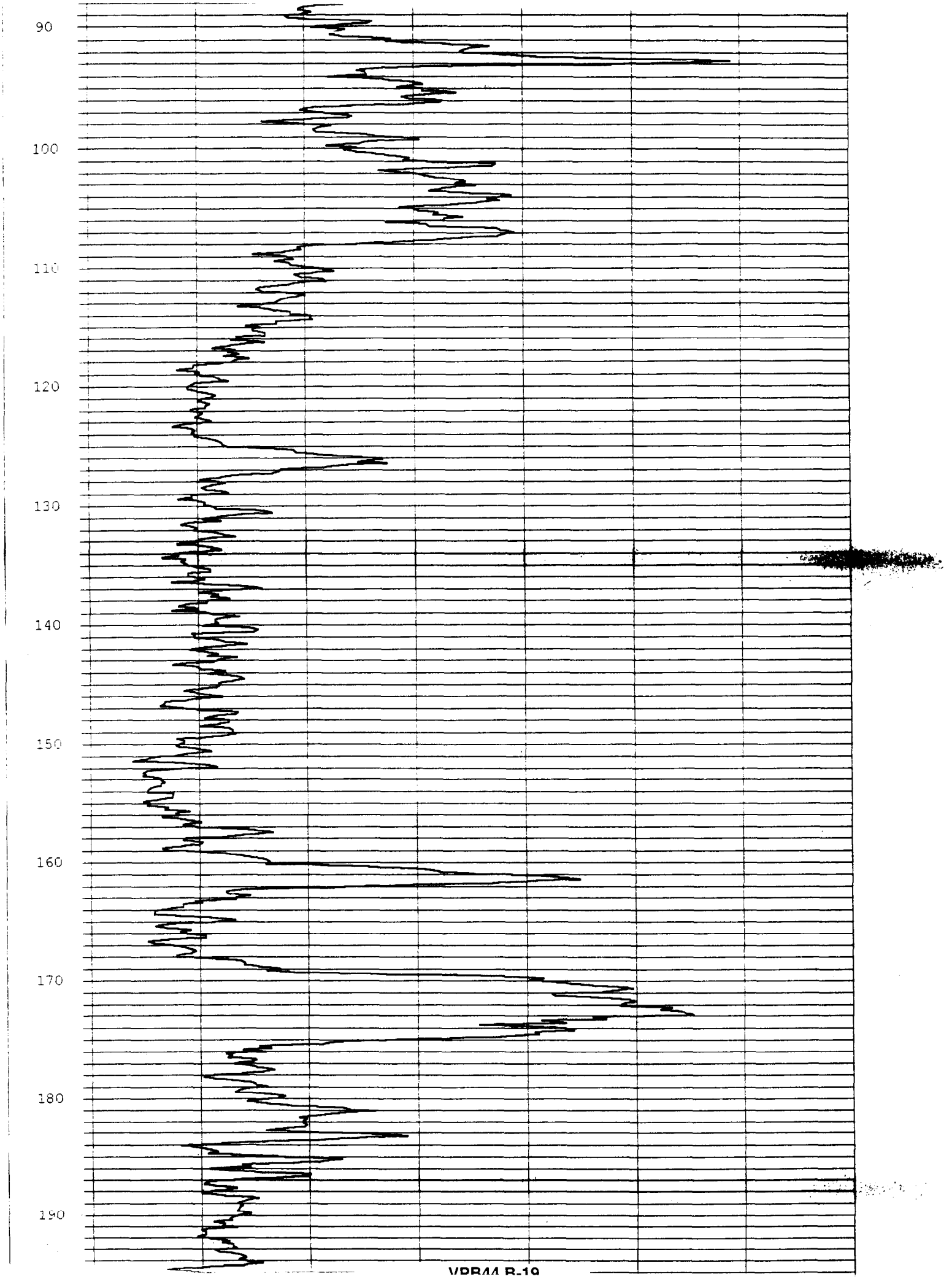
Drilling Area Background (ppm): 0

Remarks: 8" drag bit

Converted to Well: Yes ____ No X Well I.D. #: ____

	COMPANY: UNITECH DRILLING	Casing
	Location: BOUNDARY AVE. BETHPAGE	
Well: NWIRP BETHPAGE VPB-44	Depth Driller: 850 FEET Depth Logger: 849 FEET	150 FT. 6"
Date: MAY 9, 2001 BH Fluid:	Logged by: BENJAMIN RICE	
File Name:	Witness: VINCE SHIKORA	




90
100
110
120
130
140
150
160
170
180
190

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: BETHPAGE OU-2 OFFSITE GW
PROJECT NUMBER: 112G00622-PHASE II
DRILLING COMPANY: DELTA WELL & PUMP
DRILLING RIG: MUD ROTARY

BORING No.: VPB-128
DATE: 12/13/10
GEOLOGIST: Conti
DRILLER: B. Welischar

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				DENSE	YELLOW BRN	SAND AND GRAVEL	GW/SW	MOIST ½ TO 1" SUB ROUND GRAVEL (FROM CUTTINGS)	0			
	10						SAME			0			
	20						SAME			0			
				← 10" CAS			TO 40'						
	30						SAME			0			
									HIT H2O ~ 35 TO 40 PER DELTA				
	40						SAME		10" CASING DRIVEN USING CASING DRIVER	0			
	50						SAME						

1200 1300 1400

1/3/11

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks: DRIVE 10' CAS TO 40 USING CASING DRIVER AND 8" BIT TO ADVANCE AHEAD OF BORING.

Converted to Well: Yes ✓ No ✗ Well I.D. #: BPOW 3-9

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: BETHPAGE OU-2 OFFSITE GW
PROJECT NUMBER: 112G00622-PHASE II
DRILLING COMPANY: DELTA WELL & PUMP
DRILLING RIG: MUD ROTARY
BORING No.: VPB-128
DATE: 1/3/11
GEOLOGIST: Conti
DRILLER: B. Welischar

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth/Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	50				DENSE	TAN BRN	SAND - SOME GRAVEL	SW	WET	0			
1/3	57								TOOK				
S-1 1500	58								[BP-VPB128-GW-058]				
1/4	60									0			
							SAME.						
	70						SAME			0			
	80						SAME			0			
	90						SAME - NOT AS MUCH GRAVEL			0			
	100									0			

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

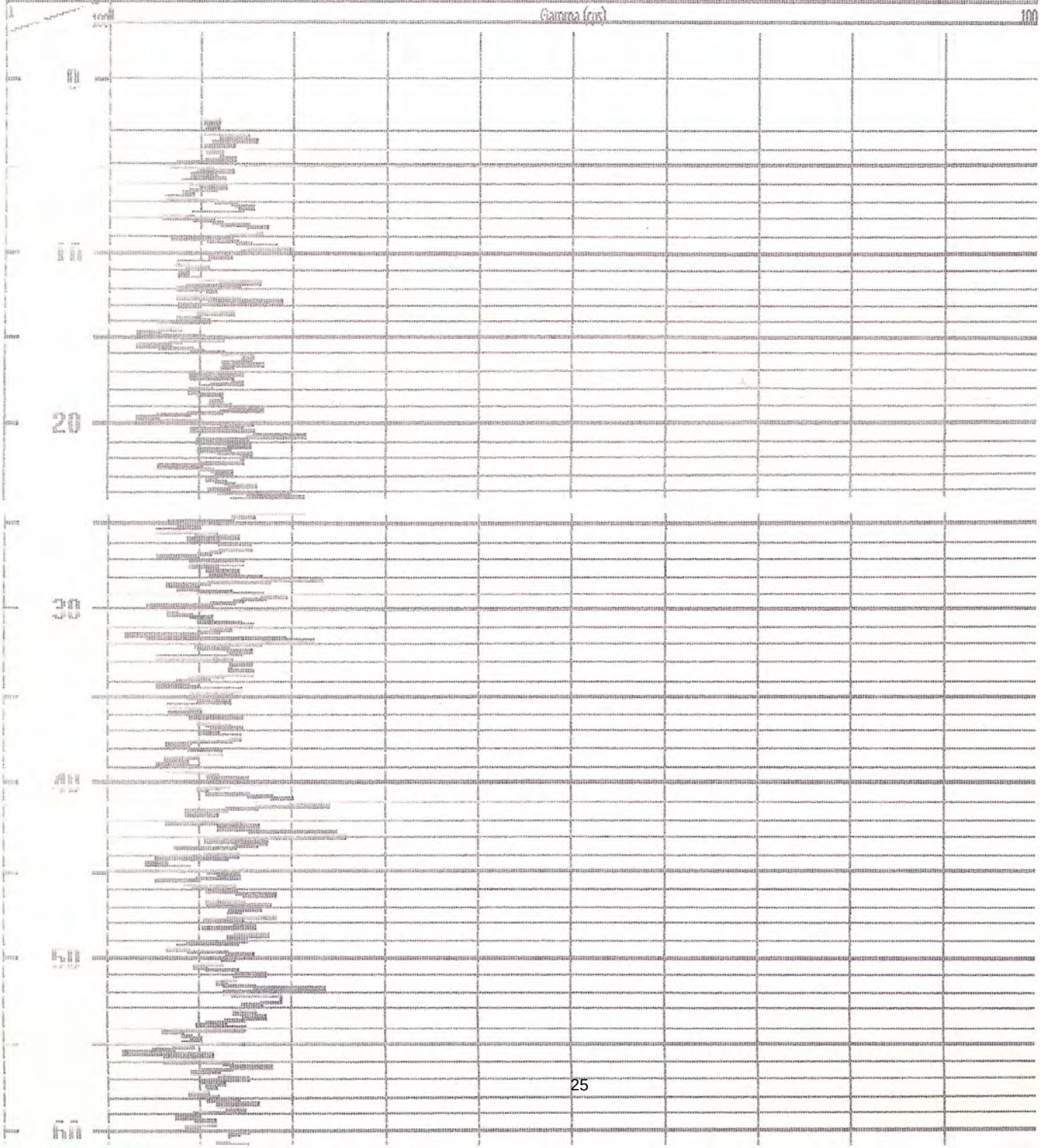
Remarks:

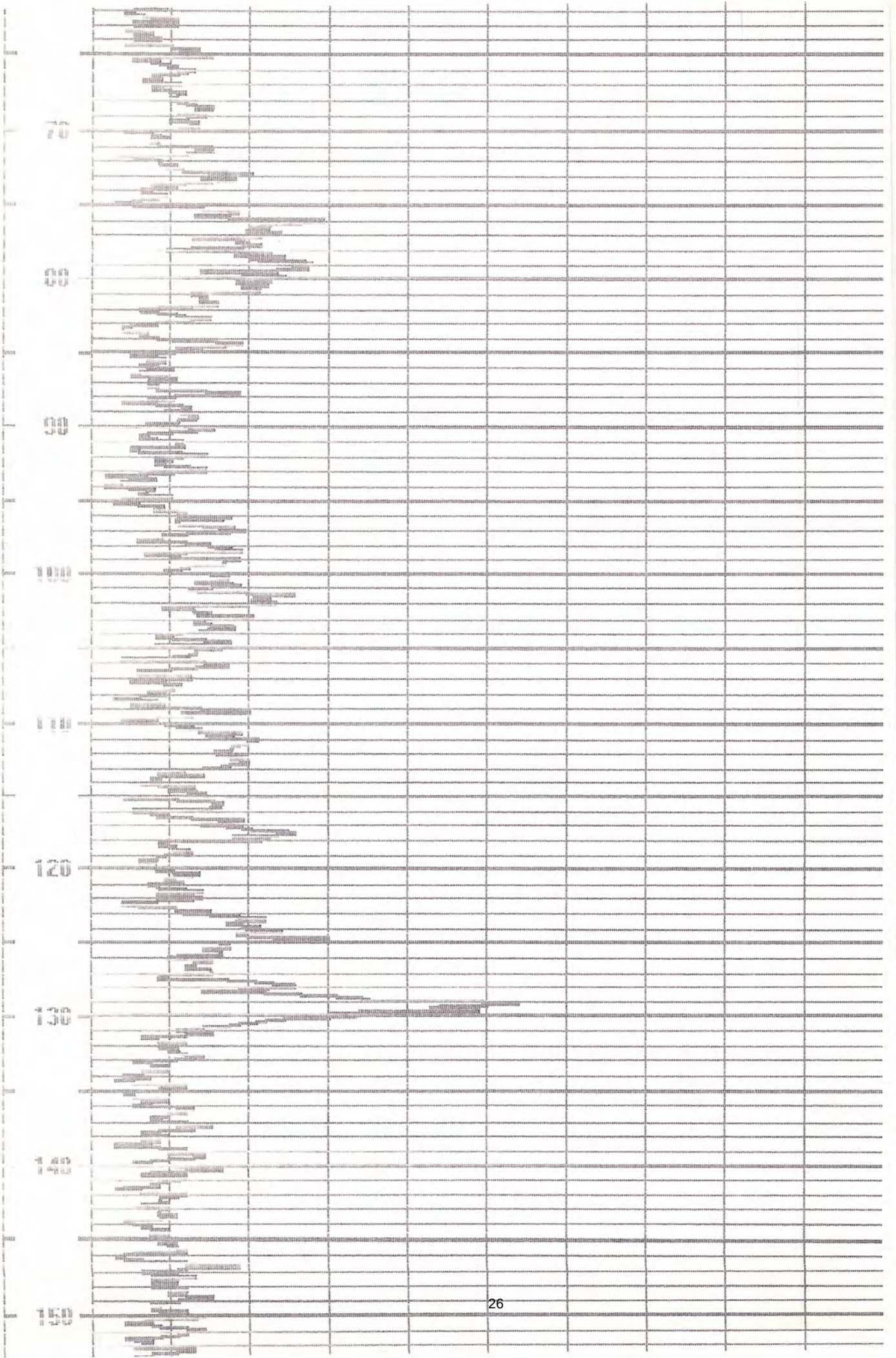
Drilling Area Background (ppm): 0

Converted to Well: Yes ✓ No ✗ Well I.D. #: BPOW 3-4

Date: Friday, February 17, 1999 Time: 05:33 File: C:\My Documents\V17\VPB-128.ld

	COMPANY: DELTA WELL & PUMP CO INC		Casing
	Location: NWIRP BETHPAGE		
Well: VPB-128		Depth Driller:	
		Depth Logger:	
Date: 02/02/2011	BH Fluid:	Logged by: CMO	
File Name: 717		Witness: STAN	





ATTACHMENT 2

Tetra Tech Infiltration Testing Standard Procedure

INFILTRATION TESTING STANDARD PROCEDURE
DOUBLE RING INFILTROMETER
Tetra Tech NUS Pittsburgh Earth Sciences Department
October 2016 Revision

Purpose: This test is used to determine the infiltration capacity of site soils, typically for the design of an infiltration basin or similar stormwater/runoff infiltration structure.

Notes:

- This test should not be done in the rain, within 24 hours following a significant rainfall event (>0.5 inches), or when the ambient temperature is below freezing.
- The tests are to be performed by qualified professionals who have appropriate experience and qualifications.
- At least two tests for a planned infiltration structure are recommended, and more are desirable, especially if the results of the first two tests are substantially different.

Equipment:

- Two concentric rings 6 to 12 inches in height. The Inner ring diameter should be equal to 50% to 70% of the outer ring. PVC or metal pipe or equivalent, i.e. 8-inch and 12-inch, 6- and 10-inch, or 4- and 8-inch. Minimum inner ring diameter is 4 inches, with larger ring diameters preferred.
- Water Supply - 5-gallon buckets, 6 gallon water buffalos, or other
- Portable folding table
- Measuring cup(s)
- Stop watch or timer
- Scale or metal tape measure
- Carpenters Level
- Flat wood board for driving the cylinders uniformly into soil
- Rubber mallet/heavy duty hammer
- Field note book
- Log sheets for recording data
- Flat shovel (for scraping surface material at test areas)
- GPS (to locate test areas)

Site Preparation:

1) Prepare a level testing area, and remove approximately 2 to 4 inches of soil, including all topsoil and loose soil. Be careful not to compact soils in the test area.

2) Measure and record outer ring and inner ring lengths. Use rings of the same length (minimum of 8 inches); recommend using 10-12 inch (or longer) rings. Make a mark 2 inches from one end on the outside of the outer ring, this mark will be used to estimate depth the ring is driven into the soil.

3) Set outer ring in place and drive ring a minimum of 2 inches into the soil (to the mark made in Step 2) – the ring must be seated firmly to prevent lateral leakage.

4) Set inner ring in the center of outer ring and drive to a minimum depth of 2 inches (the bottoms and tops of the rings should be at the same level) – seat firmly to prevent leakage.

5) With the rings in place measure up 4 inches from the prepared test ground surface and make an indicator mark on the inside of the inner and outer ring at this point (this will be the minimum water column height for testing; but a higher water column is acceptable/preferred).

Testing Procedure:

Presoak: Should be conducted immediately prior to testing and will take 1 hour. All water level drop measurements are made relative to the top of the rings or a mark slightly below the top, whichever is used as the fill point (the top of the rings is recommended).

1) Fill both rings with water to the top of the rings/fill point, after 30 minutes measure the drop in water. **Refill both rings** with more water as needed to reach the fill point, and wait another 30 minutes and measure the water level drop in the inner ring. Use shorter time intervals if necessary to maintain at least 4 inches of water in the rings at all times.
2) The drop in the water level during the last 30-minutes of presoaking will be used to determine the time interval between readings during the actual testing:
    - If the water level drop is 2 inches or more, use 10-minute measurement intervals.
    - If the water level drops less than 2 inches, use 30-minute measurement intervals.
    - Note that the water level in the inner and outer rings should be at approximately the same height for each refill.

Test: Obtain and record the drop in water level in the inner ring at the appropriate time intervals as determined during the presoak step (10 or 30 minutes, or as otherwise needed to **maintain at least a four-inch water column**).

1) Refill both rings to the fill point (at the beginning of the test and at the predetermined time intervals), and measure the drop in water level over each predetermined time period for 8 consecutive fill/drop measurement cycles or until a stabilized rate is achieved. **Refill both rings to the fill point after each reading**. A stabilized rate means a difference of 1/4 inch or less of a drop between the lowest and the highest change in water level across four consecutive readings.
2) Record each set of readings (time, elapsed time, drop in water level within the inner ring, amount of water refilled within the inner ring) on the test log sheet, along with other pertinent project info.
3) The water level drop measured in the inner ring during the final cycle or the stabilized rate, measured in inches per unit time, is the infiltration rate for the test area.

An infiltration test data sheet is attached for recording the test measurements.

Evaluation:

1) The infiltration rate (inches/hr) is a direct conversion of the test data into inches per hour, i.e., 2.5 inches/30 minutes = 5 inches/hr).
2) For two tests of an area, the higher infiltration rate is discarded for design consideration.
3) For more than two tests of an area, the geometric mean result is used for design purposes.
4) The **desired infiltration rate range is from 0.1 to 10 inches/hour**. If your infiltration tests fall outside this range, contact the project manager/design engineer ASAP for direction r.e. contingency testing in other nearby areas.

Notes:

A percolation test is another type of infiltration test performed using a dug, open circular hole of uniform diameter, at least 12 inches deep. Presoak and testing procedures are similar to the double-ring infiltration test, except that a minimum 6-inch water column should be used for presoak and testing activities, adjusted as necessary throughout the test for seepage. The measured percolation rate will need to be adjusted by a reduction factor (Rf) to account for lateral seepage as well as vertical seepage to get an infiltration rate as follows:

$Rf = [(2H-\Delta H)/D] + 1,$

where H = initial water column height, ΔH = average/final drop in water level over unit time, and D = borehole diameter. The observed percolation rate is divided by the calculated reduction factor to get the vertical infiltration rate.

Soil Characterization:

Typically the soils at an infiltration testing site should be characterized to obtain information regarding the soil types, depth to the seasonal high water table, and depth to bedrock. Test pits are the preferred method to obtain this information, however site-specific field conditions may dictate other methods (soil borings, hand digs, etc.). The excavation should be separate from but close to the infiltration test location, advanced to at least 2 feet below the depth of infiltration testing, and a **detailed soil log** prepared (see attached soil log) describing the subsurface materials encountered. If bedrock or evidence of the seasonal high water table is encountered within 2 feet of the infiltration testing depth, note on log and notify the project manager/project engineer to determine whether infiltration testing should be completed, terminated, or modified at that location.

References:

Pennsylvania Stormwater, Best Management Practices Manual, Appendix C – Site Evaluation and Soil Testing, 363-0300-002/December 30, 2006.

Attachments:

Infiltration Test Data Sheet
Soil Log Sheet
USDA Soil Textural Classification Info

INFILTRATION TEST DATA SHEET

Tetra Tech, Inc.

PROJECT NAME: _____ TEST AREA ID: _____

PROJECT NUMBER: _____ PERSONNEL: _____

TEST METHOD: Double Ring Infiltrometer Percolation
Single Ring Infiltrometer

Location Coordinates or Description:

INNER RING INSIDE DIAMETER/HEIGHT: _____

OUTER RING INSIDE DIAMETER/HEIGHT: _____

PERCOLATION HOLE DIAMETER: _____ (If performing an open hole perc test)

DATE(s): _____

Distance from the bottom of the inner ring/hole to measuring point (minimum water column of 6-8 inches): _____

MEASURING POINT: Ring Rim Indicator Mark

DEPTH OF TEST:_____

TIME	ELAPSED TIME SINCE START OF TEST (minutes)	WATER LEVEL DROP, INNER RING OR PERCOLATION HOLE (inches)	VOLUME OF WATER ADDED AT EACH CYCLE, INNER RING (liters)	REMARKS
PRESOAK DATA				

TEST DATA				

TETRA TECH

Soil Log

Tested By: _____ ***Project:*** _____ ***Project No.:*** _____

Test Pit: _____ ***Date:*** _____ ***Elevation:*** _____ ***Equipment Used:*** _____

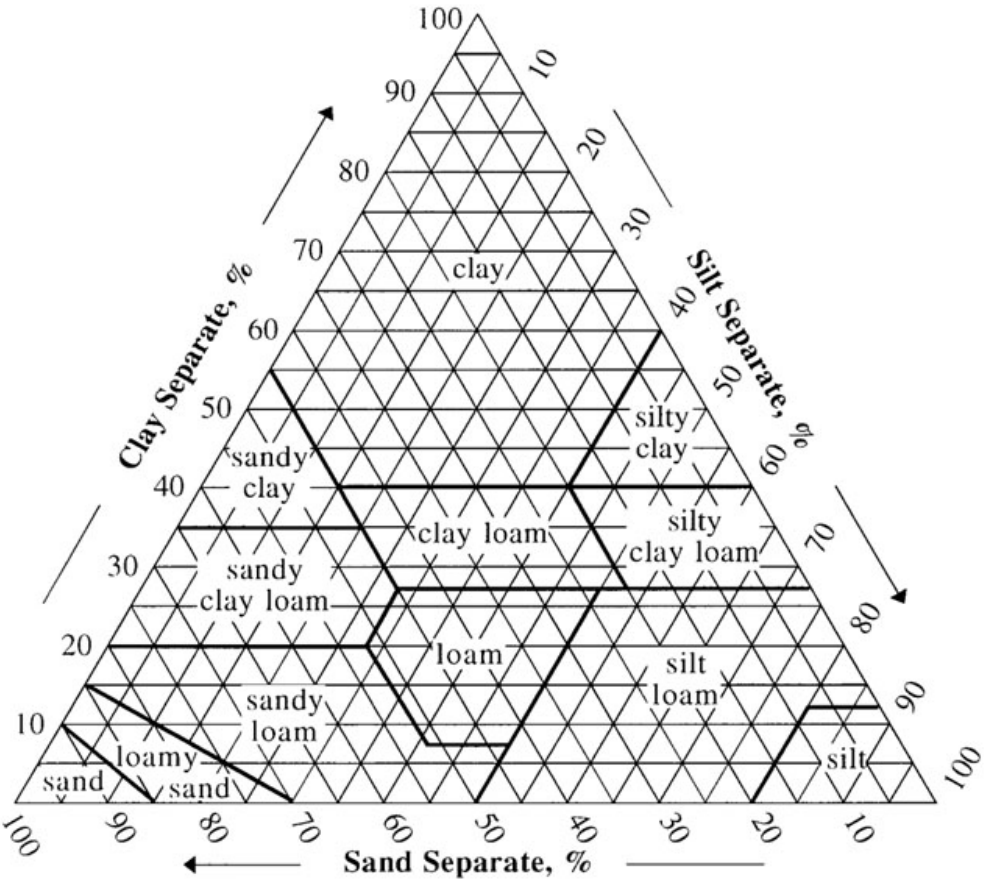
Geology: _____ ***Soil Type:*** _____ ***Land Use:*** _____ ***Weather:*** _____

Additional Comments _____

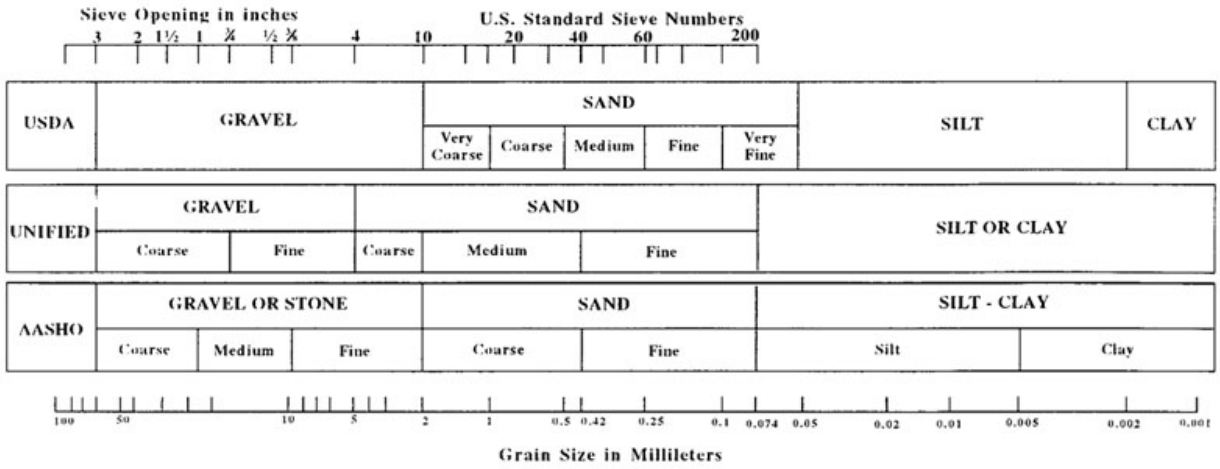
Horizon	***Upper Boundary***	***Lower Boundary***	***Soil Textural Class***	***Type, Size, Coarse Fragments, etc.***	***Soil Color***	***Color Patterns***	***Pores, Roots, Rock Structure***	***Depth to Bedrock***	***Depth to Water***	***Comments***

Horizon:	*USDA Definition*	*Soil Textural Class*	*Boundary*	*Notes:*
O	Organic debris	Use ternary diagram from US Department of Agriculture Soil Conservation Service	Use depth and classification Classification as Follows: Abrupt	
A	Dark colored, mixed mineral organic matter			
B	Maximum accumulation of silicate clay minerals		Clear	
C	Weathered parent material		Gradual	
R	Layer of consolidated rock beneath the soil		Diffuse	

Table based on: Sample soil log located on page 12 of the Pennsylvania Stormwater Best Management Practices Manual
USDA Definitions located from: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054308

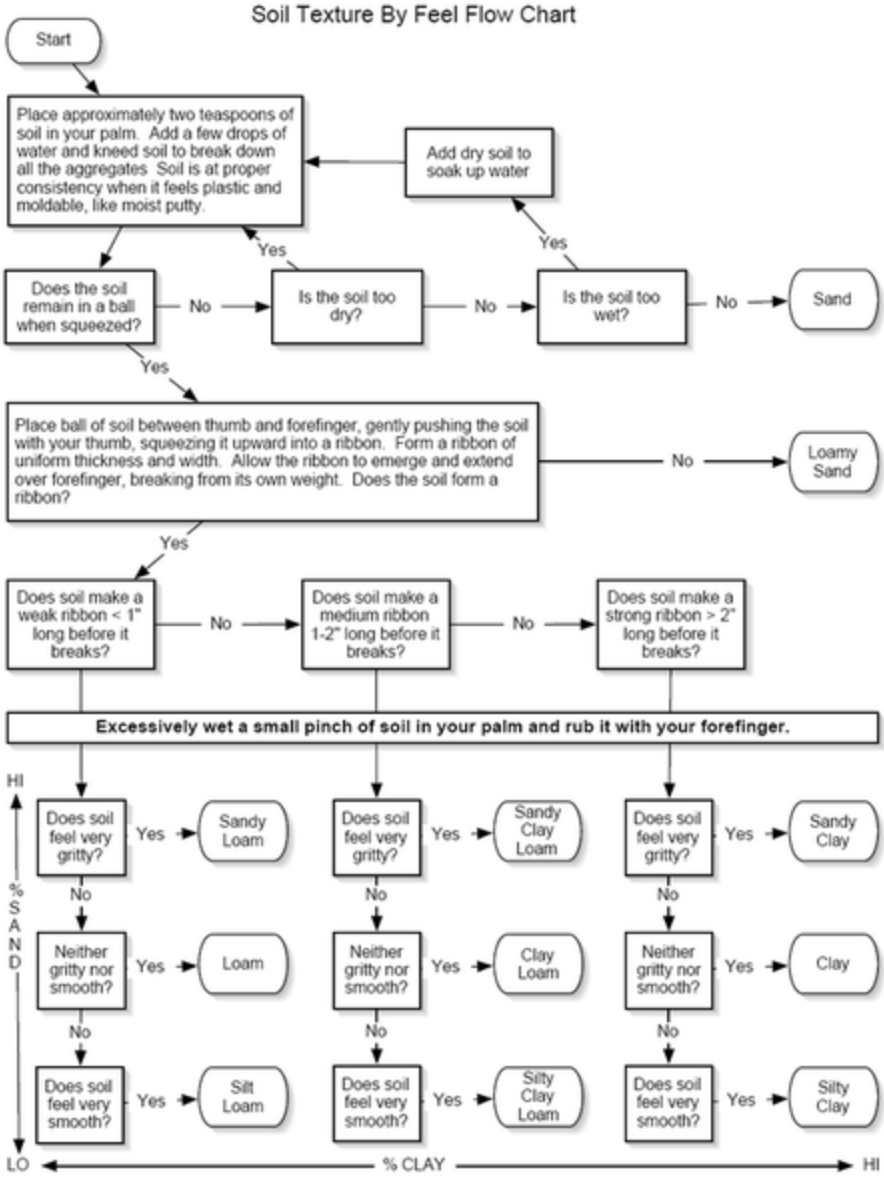


COMPARISON OF PARTICLE SIZE SCALES



USDA Soil Textural Triangle

Soil Texture By Feel Flow Chart



ATTACHMENT 3

Solinst® Levelogger Jr. Edge Technical Specifications

Levelogger Junior Edge

Model 3001

The Levelogger Junior Edge provides an inexpensive alternative for measuring groundwater and surface water levels and temperature. The Levelogger Junior Edge combines pressure and temperature sensors, a datalogger, and 5-year battery in one compact 7/8" x 5.6" (22 mm x 142 mm) stainless steel housing.

The Levelogger Junior Edge records absolute pressure using the same durable Hastelloy pressure sensor as the Levelogger Edge. The Hastelloy sensor has excellent performance in harsh environments with better temperature compensation and thermal response time, and can withstand 2 times overpressure without permanent damage.

The Levelogger Junior Edge features FRAM memory, with an increased capacity of 40,000 sets of temperature and water level data points. Readings are linear at a user-defined interval between 0.5 second to 99 hours. Accuracy is 0.1% FS, with 20 bit resolution and lifetime factory calibration.

If greater accuracy, more sampling options, or wider depth ranges are required, the Solinst Levelogger Edge has the functionality to suit your application (see Model 3001 Data Sheet). For conductivity datalogging, Solinst also offers the LTC Levelogger Junior (see Model 3001 LTC Levelogger Junior Data Sheet).

Technical Specifications	
Level Sensor:	Piezoresistive Silicon with Hastelloy Sensor
Ranges:	F15/M5, F30/M10
Accuracy (typical):	0.1% FS
Units of Measure:	cm, m, ft, psi, kPa, mBar, ºC, ºF
Resolution:	20 Bit Resolution
Normalization:	Automatic Temp Compensation
Temp Compensation Range:	0ºC to 40ºC
Temperature Sensor:	Platinum RTD
Accuracy:	± 0.1ºC
Resolution:	0.1ºC
Battery Life:	5 Years
Operating Temperature:	- 20ºC to 80ºC
Clock Accuracy:	± 1 minute/year (- 20ºC to 80ºC)
Memory:	FRAM
Maximum Readings:	40,000 sets of readings
Communication:	Optical Infrared to USB, RS232, or SDI-12
Size:	7/8" x 5.6" (22 mm x 142 mm)
Weight:	4.2 oz. (119 grams)
Wetted Materials:	316 Stainless Steel, Delrin®, Viton®, Hastelloy
Sampling Mode:	Linear and Real Time View
Measurement Rates:	0.5 sec to 99 hours
Barometric Compensation:	Software Wizard and Barologger Edge

Features

Get Quote | More Info

- Low cost
- 5 year battery life
- Accuracy of 0.1% FS
- Increased memory to 40,000 data points
- New robust Hastelloy pressure sensor
- Compatible with Solinst Telemetry Systems and SDI-12

Operation

Programming the Levelogger Junior Edge is the same as with the Levelogger Edge. An Optical Reader or PC Interface Cable connects the Levelogger to a laptop or desktop PC. The intuitive Levelogger Software automatically detects the type of Levelogger that is connected. Programming, downloading, data management and export are intuitive tasks. The Real Time View option allows immediate viewing of live water level and temperature readings, independent of the scheduled programming intervals.

The Levelogger Junior Edge outputs temperature and temperature compensated water level readings. Using the Data Compensation Wizard in the Levelogger Software, you can barometrically compensation multiple Levelogger Junior Edge files simultaneously, with just one Barologger Edge file.

The Levelogger Junior Edge is compatible with Levelogger Series accessories, including the Leveloader Gold data transfer device, SDI-12 Interface Cable, and Solinst Telemetry Systems (see Model 9100/9200 Data Sheet).

These compact dataloggers are straightforward to deploy. Installation can be with direct read cables, by stainless steel wireline or Kevlar® cord suspension, with the option of using Solinst 2" Locking Well Caps.

Applications

- Monitoring water levels in wells and surface water
- Pump and slug tests
- Reservoir and stormwater runoff management
- Watershed and drainage basin monitoring
- Stream gauging, lake and wetland monitoring
- Tank level measurement

Levelogger Edge Comparison

Model 3001	 CE WEEE	 CE WEEE
	Levelogger Edge	Levelogger Junior Edge
Backwards Compatible	YES (with limitations) See http://www.solinst.com/Downloads/	YES (with limitations) See http://www.solinst.com/Downloads/
Warranty	3 Years	1 Year
Pressure Transducer	Piezoresistive Silicon with Hastelloy Sensor	Piezoresistive Silicon with Hastelloy Sensor
Calibrated Ranges:	15, 30, 65, 100, 300 ft, Atmospheric Barologger 5, 10, 20, 30, 100 m, Atmospheric Barologger	15, 30 ft 5, 10 m
Accuracy (typical)	± 0.05% FS (Barologger Edge ±0.05 kPa)	± 0.1% FS
Resolution	24 Bit Resolution	20 Bit Resolution
Normalization	Automatic Temperature Compensation	Automatic Temperature Compensation
Calibration	Factory – Lifetime calibration	Factory – Lifetime calibration
Response Time (90% Thermal Δ)	1 minute/10ºC change	1 minute/1ºC change
Temp Comp Range	0 to +50°C (Barologger Edge -10 to +50ºC)	0 to +40°C
Over-pressure Range	2 X	2 X
Temperature Sensor	Platinum RTD	Platinum RTD
Temperature Accuracy	± 0.05°C	± 0.1°C
Temperature Resolution	0.003°C	0.1°C
Operating Temp Range	-20 to +80°C	-20 to +80°C
Clock Accuracy	± 1 minute / year (-20ºC - +80ºC)	± 1 minute / year (-20ºC - +80ºC)
Battery Life	10 Years (based on 1 reading/minute)	5 Years (based on 1 reading/minute)
Size	7/8" x 6.25" (22 mm x 159 mm)	7/8" x 5.6" (22 mm x 142 mm)
Weight	4.6 oz. (129 grams)	4.2 oz. (119 grams)
Memory	40,000 readings in FRAM memory, or up to 120,000 readings using data compression option	40,000 readings in FRAM memory, no data compression option
Communication Speed	9600 bps, 38,400 bps with HS USB Optical Reader	9600 bps
Com Interface	Optical infra-red: USB, RS232, SDI-12	Optical infra-red: USB, RS232, SDI-12
Memory Modes	Continuous or Slate	Slate
Logging Rates	0.125 sec to 99 hours	0.5 sec to 99 hours
Logging Modes	Linear, Event & User-Selectable Schedules with Repeat Mode, Future Start, Future Stop, Real Time View	Linear, Real Time View
Barometric Compensation	Barologger Edge	Barologger Edge
Corrosion Resistance	Titanium based PVD coating and Hastelloy Sensor	316 L Stainless Steel and Hastelloy Sensor
Other Wetted Materials	Delrin, Viton, Hastelloy, 316L Stainless Steel	Delrin, Viton, Hastelloy, 316L Stainless Steel
Direct Read Capability	Yes	Yes
Leveloader Compatible	Yes (ensure the latest firmware is installed)	Yes (ensure the latest firmware is installed)

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