2016 OU2 GROUNDWATER INVESTIGATION
RE127D1, RE127D2 (VPB161)
INSTALLATION REPORT

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)
SITE 1 OU2
BETHPAGE, NY

Prepared for:

Department of the Navy
Naval Facilities Engineering Command, Atlantic
9324 Virginia Avenue
Building Z-144
Norfolk, Virginia 23511

May 2017

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9324 Virginia Avenue
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Norfolk, Virginia 23511

Prepared by:

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Contract Number: N62470-11-D-8013
CTO WE15

May 2017

Brian Caldwell

Brian Caldwell
Contract Task Order Manager

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List of Acronyms and Abbreviations

AOC	Area of Concern
bgs	below ground surface
CCM	Conceptual Site Model
COR	Continuously Operating Reference
DOD	Department of Defense
EPA	Environmental Protection Agency, United States
ESS	Environmental Sequence Stratigraphy
ft	feet
GOCO	Government-Owned Contractor-Operated
GPS	Global Positioning System
IDW	Investigation Derived Waste
IR	Installation Restoration
Katahdin	Katahdin Analytical Services
NAD	North American Datum
NAVD	North American Vertical Datum
NAVFAC	Naval Facilities Engineering Command
NG	Northrop Grumman
NTU	nephelometric turbidity units
NWIRP	Naval Weapons Industrial Reserve Plant
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
OU	Operable Unit
PCBs	Polychlorinated Biphenyls
POTW	Publicly Owned Treatment Works
PPE	Personal Protective Equipment
PVC	Polyvinylchloride
SAP	Sampling and Analysis Plan
SVOC	Semivolatile Organic Compounds
TCE	Trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TOC	Total Organic Carbon
UFP	United Federal Programs
US	United States
VOC	Volatile Organic Compounds
VPB	Vertical Profile Boring

1.0 PROJECT BACKGROUND

Resolution Consultants has prepared this Data Summary Report for the Naval Facilities Engineering Command (NAVFAC), Mid-Atlantic under contract task order WE15 Contract N62470-11-D-8013. This report describes the installation of two monitoring wells and one initial groundwater monitoring event (specifically at the Vertical Profile Boring [VPB] 161 location) in 2016 for the Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage Operable Unit (OU) 2 Site 1 offsite plume. NWIRP Bethpage is located in east-central Nassau County, Long Island, New York, approximately 30 miles east of New York City (Figure 1).

1.1 Scope and Objectives

This report provides information on the installation of RE127D1 and RE127D2, monitoring wells associated with VPB161. The purpose of this investigation was to ascertain subsurface conditions and contaminant levels and the downgradient extent of the offsite plume southeast of Route 135. The locations of RE127D1 and RE127D2, as well as other VPBs and monitoring well locations, are shown in Figure 2.

The field investigation included completing two monitoring wells, well development, soil/groundwater analysis, groundwater grab samples, and surveying. Field tasks were conducted in 2016 in accordance with the *United Federal Programs Sampling and Analysis Plan (UFP SAP)*, Bethpage, New York (Resolution, 2013a). In addition, the work adhered to the following UFP SAP Addendums: *Groundwater Sampling Using Low Stress (Low Flow) Purging and Sampling Protocol* (Resolution Consultants, 2013b) and *Installation of Vertical Profile Borings and Monitoring Wells* (Resolution Consultants, 2013c).

Documentation of these activities is included in Appendix A of this report.

1.2 Site History

NWIRP Bethpage is in the Hamlet of Bethpage, Town of Oyster Bay, New York. Since its inception in 1941, the plant's primary mission was the research, prototyping, testing, design, engineering, fabrication, and primary assembly of military aircraft. The facilities at NWIRP included four plants used for assembly and prototype testing, a group of quality control laboratories, two warehouse complexes (north and south), a salvage storage area, water recharge basins, the Industrial Wastewater Treatment Plant, and several smaller support buildings.

The Navy's property originally totaled 109.5 acres and was formerly a Government-Owned Contractor-Operated (GOCO) facility that was operated by Northrop Grumman (NG) until September 1998. Prior to 2002, the NWIRP property was bordered on the north, west, and south by current or former NG facilities, and on the east by a residential neighborhood. By March 2008, approximately 100 acres of NWIRP property were transferred to Nassau County in three separate actions. The remaining 9 acres and access easements were retained by the Navy to continue remedial efforts at Installation Restoration (IR) Site 1 – Former Drum Marshalling Area and Site 4 – Former Underground Storage Tanks (Area of Concern [AOC] 22). A parcel of land connecting the two sites was also retained. Currently, the 9-acre parcel of NWIRP is bordered on the east by the residential neighborhood and on the north, south, and west by Steel Equities; however, a small portion is still owned by Nassau County. Access to the NWIRP is from South Oyster Bay Road.

1.3 Geology and Hydrogeology

Overburden at the site consists of well over 1,000 feet (ft) of unconsolidated deposits overlying crystalline bedrock of the Hartland Formation. Overburden is divided into four geologic units: the upper Pleistocene deposits, the Magothy Formation, the clay member of the Raritan Formation ("Raritan Clay") and the Lloyd Sand member of the Raritan Formation ("Lloyd Sand") (Geraghty and Miller, 1994).

The upper Pleistocene ranges in thickness from approximately 50 to 100 ft and consists of till and outwash deposits of medium to coarse sand and gravel with lenses of fine sand, silt and clay (Smolensky and Feldman, 1988); these deposits form the Upper Glacial Aquifer. Directly underlying this unit is the Magothy Formation with a thickness of 650 to 900 ft and lower extent of 700 to 1,000 ft below ground surface (bgs), as observed at the former NWIRP and extending southeast to areas south of Southern State Parkway. Locally at the RE127 locations, the bottom of the Magothy (top of the Raritan Clay) is encountered at approximately 988 feet bgs. The Magothy is characterized by fine to medium sands and silts interbedded with zones of clays, silty sands and sandy clays. Sand and gravel lenses are found in some areas between depths of 600 and 880 ft bgs; these deposits form the main producing zones of the Magothy Aquifer.

Investigations performed by the Navy since 2012 indicate that the bottom of the Magothy (top of the Raritan Clay) can extend to depths of 700 to greater than 1,000 ft bgs. The top of the Raritan Clay deepens to the south-southeast, as evidenced by clay depths of 1,000 ft bgs (or more) in borings installed offsite. The Raritan Clay Unit is of continental origin and consists of clay, silty clay, clayey silt, and fine silty sand. This member acts as a confining layer over the Lloyd Sand Unit. The Lloyd Sand Unit is also of continental origin, having been deposited in a large fresh water lacustrine environment. The material consists of fine to coarse-grained sands, gravel, inter-bedded clay, and silty sand. These deposits form the Lloyd Aquifer.

The Upper Glacial Aquifer and the Magothy Aquifer comprise the aquifers of interest at the NWIRP. Regionally, these formations are generally considered to form a common, interconnected aquifer as the coarse nature of each unit near their contact and the lack of any regionally confining clay unit allows for the unrestricted flow of groundwater between the formations.

The Magothy Aquifer is the major source of public water in Nassau County. The most productive water bearing zones are the discontinuous lenses of sand and gravel that occur within the siltier matrix. The major water-bearing zones are coarse sand and gravel lenses located in the lower portion of the Magothy. The Magothy Aquifer is commonly regarded to function overall as an unconfined aquifer at shallow depths and a confined aquifer at deeper depths. The drilling program at the NWIRP has revealed that clay zones beneath the facility are common but laterally discontinuous. No confining clay units of facility-wide extent have been encountered. This is also the case for borings installed offsite.

Groundwater is encountered at a depth of approximately 50 ft bgs at the facility. Historically, because of pumping and recharge at the facility, groundwater depths have been measured to range from 40 to 60 ft bgs. The groundwater flow in the area is to the south-southeast.

Resolution Consultants reviewed the geologic data and regional literature and developed four representative base-wide cross sections to support development of a Conceptual Site Model (CSM). A description of the application of Environmental Sequence Stratigraphy (ESS) and the results are provided in Appendix B.

2.0 FIELD PROGRAM

Two monitoring wells were installed in the vicinity of VPB161 between July 2016 and August 2016. Field investigation activities consisted of drilling, well installation, well development, sampling, soil/groundwater analysis, and surveying. Drilling during this investigation was performed by Delta Well and Pump Company of Ronkonkoma, New York. A description of these tasks is provided below.

2.1 Drilling and Well Construction

Monitoring wells RE127D1 and RE127D2 were installed using mud rotary drilling techniques (Figure 2). Depths of monitoring wells RE127D1 and RE127D2 were 685 ft and 780 ft respectively. Well construction details are summarized in Table 1. Boring logs with lithologic descriptions of the well screen interval are included in the Appendix A. *2016 OU2 Groundwater Investigation VPB161* (Resolution Consultants, 2017) documents the installation of this VPB including detailed lithologic descriptions, continuous gamma plot and multiple Volatile Organic Compounds (VOC) sample results over the entire boring length. The gamma and TCE/PCE plot for VPB161 along with the well screen intervals at RE127D1 and RE127D2 is included in Appendix A.

Prior to installing each monitoring well, the results of the groundwater samples, the geophysical logs, lithology and field data from the vertical profile borings were analyzed (*2016 OU2 Groundwater Investigation VPB161*, Resolution Consultants, 2017). Screen intervals were determined based on intervals with the highest VOC concentrations as measured in the hydropunch samples and coincident intervals with the highest apparent permeability based on the gamma logs. During the monitoring well installation, split spoon samples were collected every 5 ft in the screen interval. One soil sample per monitoring well was analyzed for Total Organic Carbon (TOC) via United States (US) Environmental Protection Agency (EPA) series SW-846 method 9060A by Katahdin Analytical Services (Katahdin). Data validation of TOC data was performed by Resolution Consultants. Data validation packages and analytical data tables are included in Appendix A.

Wells were constructed of 4-inch diameter, Schedule 80, National Sanitation Foundation-approved polyvinylchloride (PVC) riser pipe and .010-slot well screen. Wells were completed at the surface with a 12-inch diameter steel curb box. Well risers were set below grade and fit with lockable J plugs. Detailed monitoring well construction diagrams are included in Appendix A.

2.2 Well Development

Following installation, all monitoring wells were developed to evacuate silts and other fine-grained materials and to establish the filter pack to promote a hydraulic connection between the well and the surrounding aquifer. Well development was not initiated until at least 24 hours after well installation.

Monitoring well screens were developed using a combination of air lifting, manual surging, and pumping with a submersible pump. Turbidity was monitored during development to determine stabilization. In compliance with New York State Department of Environmental Conservation (NYSDEC) policy, wells were developed until turbidity was less than 50 nephelometric turbidity units (NTUs) if possible. Table 2 summarizes total pumped volume from air and pump development and final turbidity. Well development logs are included in Appendix A.

2.3 Sampling

Following development, wells were allowed to stabilize for at least 2 weeks prior to groundwater sampling in accordance with low flow sampling procedures. Wells were purged using a bladder pump with a drop tube intake placed at the approximate midpoint of the screened interval. The following water quality parameters were continuously measured: water temperature, pH, conductivity, oxidation-reduction potential, dissolved oxygen and turbidity. Groundwater analytical samples were collected when water quality parameters stabilized. Samples were analyzed for VOCs via method 8260C and 1,4-dioxane via Method 8270D SIM by Katahdin. All development and purge water was managed as investigation derived waste (IDW). Groundwater sample logs and data validation packages are included in Appendix A.

Monitoring wells RE127D1 and RE127D2 were sampled by Resolution Consultants on September 23, 2016. Analytical results and stabilized field parameters for these monitoring wells are summarized in Table 3 and 4, respectively. Data validation is documented in Appendix A. These monitoring wells will be included in quarterly sampling as part of the Navy’s ongoing Environmental Restoration Program.

2.4 Decontamination and Investigation Derived Waste

Resolution Consultants utilized dedicated and disposable sampling equipment when possible to avoid the potential for cross-contamination of samples. The sampling equipment included dedicated plastic scoops, disposable polyethylene tubing, disposable gloves, and laboratory supplied sample bottles. Hand held equipment and split spoons were decontaminated using Luminox and water wash, a potable water rinse, followed by a distilled water rinse. Water was collected in 5-gallon pails or 55-gallon drums. Non dedicated sampling equipment was decontaminated as outlined in the UFP SAP Addendum - *Groundwater Sampling Using Low Stress (Low Flow) Purging and Sampling Protocol* (Resolution Consultants, 2013b).

As part of the IDW management practices and in accordance with the SAP, the investigation waste (consisting of soil cuttings, drilling muds, IDW fluids, and personal protective equipment [PPE]) generated during the groundwater monitoring well installation and sampling was containerized and staged at NWIRP Bethpage.

IDW solids were containerized in roll offs. Representative samples from each roll off were submitted to Katahdin for analysis of:

- Target Compound List (TCL) VOCs
- TCL Semi-volatile Organic Compounds (SVOCs)
- Toxicity Characteristic Leaching Procedure (TCLP) Metals
- Polychlorinated Biphenyls (PCBs)
- Total petroleum hydrocarbons
- Corrosivity
- Ignitability
- Reactive Cyanide
- Reactive Sulfide
- Paint Filter

IDW fluid generated during well development and purging was containerized in frac tanks and stored at NWIRP Bethpage for characterization and ultimate disposal to the Publicly Owned Treatment Works (POTW), in accordance with the facilities existing discharge permit. A representative water sample was collected from each frac tank and submitted to Katahdin for analysis of VOCs via Method SW 624, pH via Method SW 9040B, PCBs via Method 8082 and Total Metals via Method SW 846. All analytical criteria were met for disposal of water.

2.5 Surveying

A survey of the monitoring well locations was conducted at the end of fieldwork by C. T. Male, Inc., of Latham, NY, under the direct supervision of Resolution Consultants. The locations were tied into the existing base map developed for this investigation. The survey elevation is referenced to the North American Vertical Datum (NAVD) 1988 and has a vertical accuracy of 0.01 foot. Vertical control is based on observations of the Continuously Operating Reference (COR) Stations Queens and Central Islip. The horizontal location is referenced to the North American Datum (NAD) 1983 (2011) NY. Long Island Zone 3104 and has an accuracy of 0.1 foot. Local horizontal and vertical control is based on Global Positioning System (GPS) observations using the NYSNet Real Time Network.

A table of survey data (latitude/longitude, northing/easting, elevations of ground, rim and PVC) and a survey map is included in Appendix A.

3.0 REFERENCES

Geraghty and Miller, Inc., 1994. *Remedial Investigation Report, Grumman Aerospace Corporation, Bethpage, New York*. Revised September 1994.

Resolution Consultants, 2013a. *United Federal Programs Sampling and Analysis Plan*, *Site OU-2 Offsite Trichloroethene (TCE) Groundwater Plume Investigation, Bethpage, New York*. April 2013.

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Resolution Consultants, 2013c. UFP SAP Addendum*, Installation of Vertical Profile Borings and Monitoring Wells.* December 2013.

Resolution Consultants, 2017. *2016 OU2 Groundwater Investigation VPB161, Bethpage, NY.* May 2017.

Smolensky, D., and Feldman, S., 1988. *Geohydrology of the Bethpage-Hicksville-Levittown Area, Long Island, New York, U.S*. Geological Survey Water-Resourced Investigations Report 88-4135, 25 pp.

Tables

TABLE 1
MONITORING WELL CONSTRUCTION SUMMARY
2016 OU2 GROUNDWATER INVESTIGATION
NWIRP BETHPAGE, NY

MONITORING WELL	WELL COMPLETION DATE	GROUND ELEVATION (MSL)	PVC ELEVATION (INNER CASING) (MSL)	WELL DEPTH (ft bgs)	CASING DEPTH (ft bgs)	SCREEN INTERVAL (ft bgs)	SUMP DEPTH INTERVAL (ft bgs)	BORING DEPTH (ft bgs)
RE127D1	8/17/2016	61.58	61.13	685	53	660 - 680	680 - 685	698
RE127D2	7/20/2016	61.48	60.96	780	53	755 - 775	775 - 780	793

MSL - mean sea level
ft bgs - feet below ground surface

TABLE 2
MONITORING WELL DEVELOPMENT SUMMARY
2016 OU2 GROUNDWATER INVESTIGATION
NWIRP BETHPAGE, NY

MONITORING WELL	AIR DEVELOPMENT		PUMP DEVELOPMENT			APPROX. TOTAL DEVELOPMENT VOLUME (GAL)	FINAL TURBIDITY (NTUs)
	DATE	APPROX. VOLUME (GAL)	DATE	FINAL PUMP DEPTH (FT BGS)	APPROX. VOLUME (GAL)		
RE127D1	8/25/2016	5,500	8/30/2016	660-680	4,200	9,700	18.32
RE127D2	8/24/2016	6,000	8/26/2016; 8/29/2016	755-775	6,000	12,000	17.99

GAL - gallon
FT BGS - feet below ground surface
NTUs - Nephelometric Turbidity Units

TABLE 3. ANALYTICAL DATA SUMMARY
2016 OU2 GROUNDWATER INVESTIGATION
NWIRG BETHPAGE, NY

Location	NYSDEC Groundwater Guidance or Standard Value (Note 1)	RE127D1	RE127D2
Sample Date		9/23/2016	9/23/2016
Sample ID		RE127D1-GW-092316	RE127D2-GW-092316
Sample type code		Groundwater	Groundwater
VOC 8260C (ug/L)			
1,1,1-TRICHLOROETHANE	5	<0.50 U	<0.50 U
1,1,2,2-TETRACHLOROETHANE	5	<0.50 U	<0.50 U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	5	<0.50 U	<0.50 U
1,1,2-TRICHLOROETHANE	1	<0.50 U	<0.50 U
1,1-DICHLOROETHANE	5	<0.50 U	<0.50 U
1,1-DICHLOROETHENE	5	<0.50 U	<0.50 U
1,2,4-TRICHLOROBENZENE	5	<0.50 U	<0.50 U
1,2-DIBROMO-3-CHLOROPROPANE	0.04	***<0.75 U***	***<0.75 U***
1,2-DIBROMOETHANE	NL	<0.50 U	<0.50 U
1,2-DICHLOROBENZENE	3	<0.50 U	<0.50 U
1,2-DICHLOROETHANE	5	<0.50 U	<0.50 U
1,2-DICHLOROETHENE, TOTAL	5	<1.0 U	<1.0 U
1,2-DICHLOROPROPANE	1	<0.50 U	<0.50 U
1,3-DICHLOROBENZENE	3	<0.50 U	<0.50 U
1,4-DICHLOROBENZENE	3	<0.50 U	<0.50 U
1,4-DIOXANE (Method 8270D_SIM)	NL	<0.17 U	<0.18 U
2-BUTANONE	50	<2.5 U	<2.5 U
2-HEXANONE	50	<2.5 U	<2.5 U
4-METHYL-2-PENTANONE	NL	<2.5 U	<2.5 U
ACETONE	50	<2.5 UJ	<2.5 UJ
BENZENE	1	<0.50 U	<0.50 U
BROMODICHLOROMETHANE	50	<0.50 U	<0.50 U
BROMOFORM	50	<0.50 U	<0.50 U
BROMOMETHANE	5	<1.0 U	<1.0 U
CARBON DISULFIDE	60	<0.50 U	<0.50 U
CARBON TETRACHLORIDE	5	<0.50 U	<0.50 U
CHLOROBENZENE	5	<0.50 U	<0.50 U
CHLOROETHANE	5	<1.0 U	<1.0 U
CHLOROFORM	7	<0.50 U	<0.50 U
CHLOROMETHANE	5	<1.0 U	<1.0 U
CIS-1,2-DICHLOROETHENE	5	<0.50 U	<0.50 U
CIS-1,3-DICHLOROPROPENE	0.4	***<0.50 U***	***<0.50 U***
CYCLOHEXANE	NL	<0.50 U	<0.50 U
DIBROMOCHLOROMETHANE	5	<0.50 U	<0.50 U
DICHLORODIFLUOROMETHANE	5	<1.0 UJ	<1.0 UJ
ETHYLBENZENE	5	<0.50 U	<0.50 U
ISOPROPYLBENZENE	5	<0.50 U	<0.50 U
M- AND P-XYLENE	NL	<1.0 U	<1.0 U
METHYL ACETATE	NL	<0.75 U	<0.75 U
METHYL CYCLOHEXANE	NL	<0.50 U	<0.50 U
METHYL TERT-BUTYL ETHER	10	<0.50 U	<0.50 U
METHYLENE CHLORIDE	5	<2.5 U	<2.5 U
O-XYLENE	NL	<0.50 U	<0.50 U
STYRENE	5	<0.50 U	<0.50 U
TETRACHLOROETHENE	5	<0.50 U	<0.50 U
TOLUENE	5	<0.50 U	<0.50 U
TRANS-1,2-DICHLOROETHENE	5	<0.50 U	<0.50 U
TRANS-1,3-DICHLOROPROPENE	0.4	***<0.50 U***	***<0.50 U***
TRICHLOROETHENE	5	<0.50 U	<0.50 U
TRICHLOROFLUOROMETHANE	5	<1.0 U	<1.0 U
VINYL CHLORIDE	2	<1.0 U	<1.0 U
XYLENES, TOTAL	5	<1.5 U	<1.5 U
1,4-DIOXANE (Method 522)	NL	NA	NA

TABLE 3. ANALYTICAL DATA SUMMARY
2016 OU2 GROUNDWATER INVESTIGATION
NWIRP BETHPAGE, NY

Notes:

1 New York State Department of Environmental Conservation Division of Water Technical and Operation Guidance series
(6 NYCRR 700-706, Part 703.5 summarized in TOGS 1.1.1)
Ambient water quality standards and groundwater effluent limitations, class GA; NL = Not Listed

Bold = Detected; ***Bold and Italics*** =Not detected exceeds NYS Groundwater Standards or guidance value
Yellow highlighted values exceed Groundwater Standards or guidance value

Sample type codes: N - normal environmental sample, FD - field duplicate

U = Nondetected result. The analyte was analyzed for, but was not detected above the reported sample quantitation limit.
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte.
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
M = the matrix spike or matrix spike duplicate did not meet recovery or precision requirements.

TABLE 4
STABILIZED FIELD PARAMETERS
2016 OU2 GROUNDWATER INVESTIGATION
NWIRP BETHPAGE, NY

Well	Date	Temperature (°C)	pH	Specific Conductance (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Depth to water (ft bgs)	Flow rate (ml/min)
RE127D1	9/23/2016	17.58	4.80	0.026	0.31	7.400	41.0	28.68	600
RE127D2	9/23/2016	16.68	4.00	0.020	3.54	220.7	17.2	29.47	500

°C - degrees Celsius
µS/cm - Microsiemens per Centimeter
mg/L - milligrams per liter
mV - Millivolts
NTU - Nephelometric Turbidity Unit
ft bgs - feet below ground surface
ml/min - mililiters per minute

Figures

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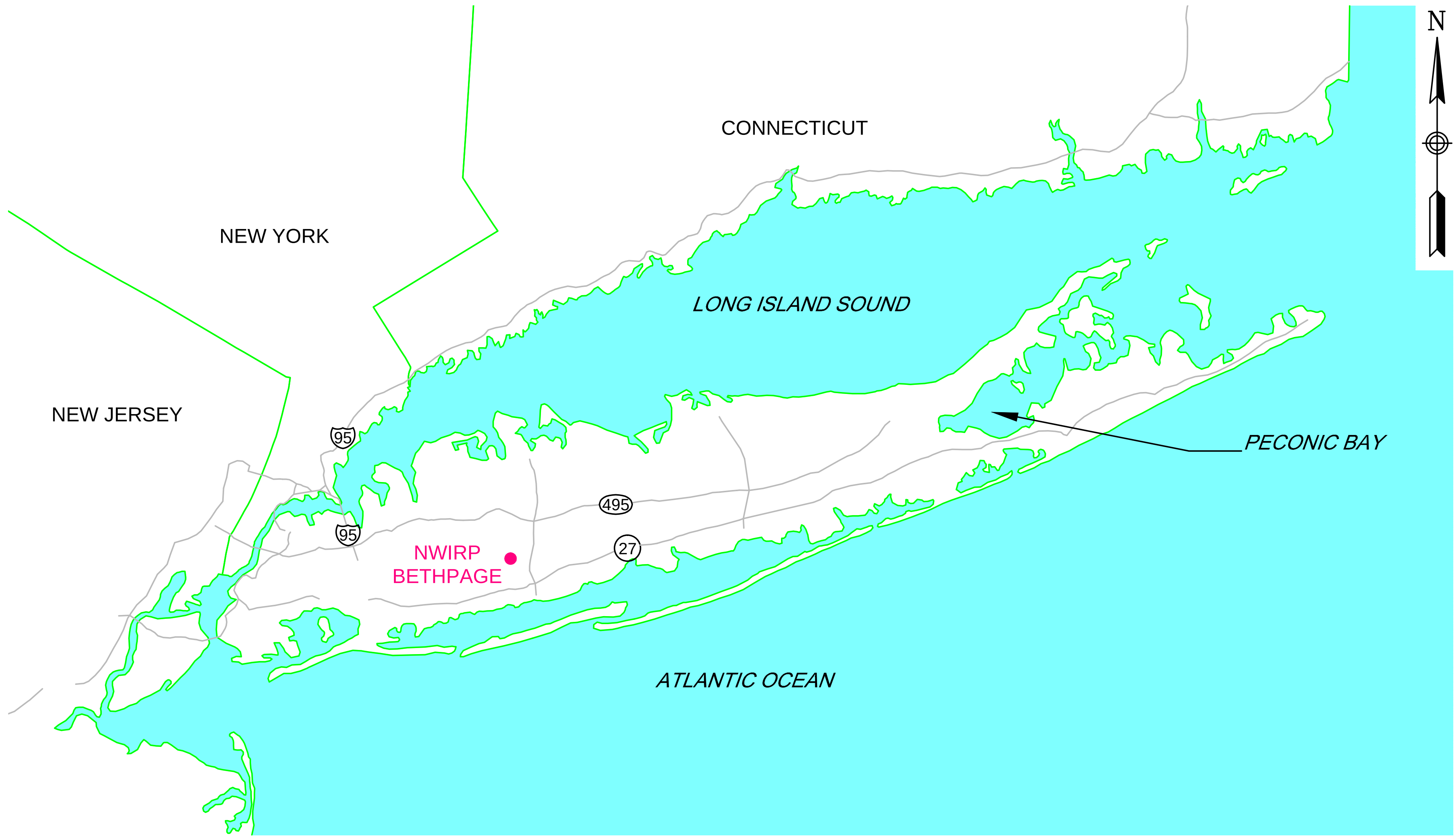

0 15 30

SCALE IN MILES

GENERAL LOCATION MAP
NWIRP BETHPAGE
BETHPAGE, NEW YORK

CONTRACT NUMBER	CTO NUMBER
N62470–11–D–8013	WE15

APPROVED BY	DATE
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APPROVED BY	DATE
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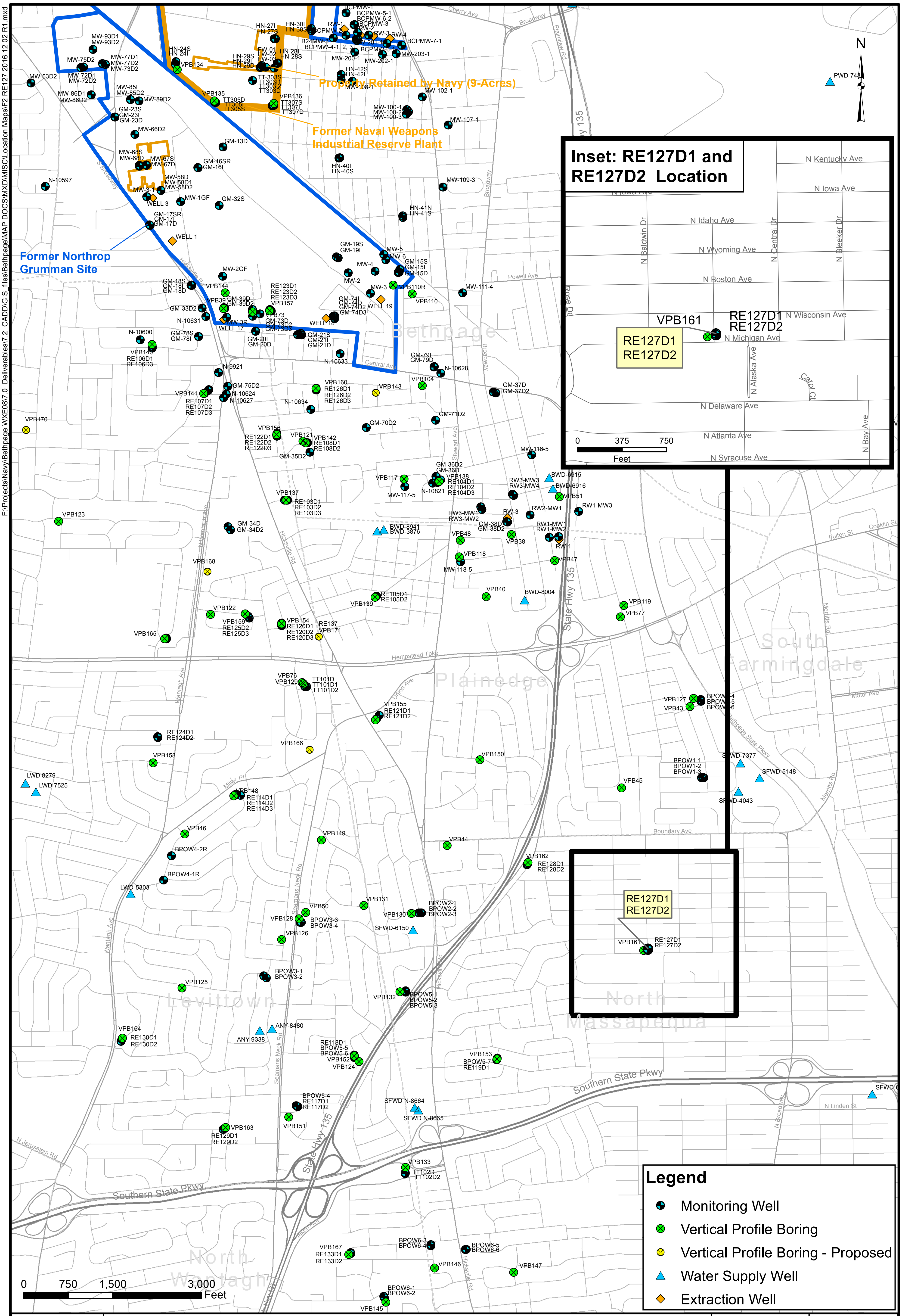
FIGURE NO.	REV
1	0



Legend

- ● Monitoring Well
- ⊗ Vertical Profile Boring
- ⊗ Vertical Profile Boring - Proposed
- ▲ Water Supply Well
- ◆ Extraction Well

NAVFAC	CONTRACT NUMBER N62470-11-D8013	CTO NUMBER WE15
RE127D1 AND RE127D2 LOCATION MAP NAVAL WEAPONS INDUSTRIAL RESERVE PLANT BETHPAGE, NEW YORK	APPROVED BY PS	DATE 12/2/2016
	APPROVED BY —	DATE —
	FIGURE NO. 2	REV 0

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Appendix A

RE127D1, RE127D2

Section 1

Boring Logs

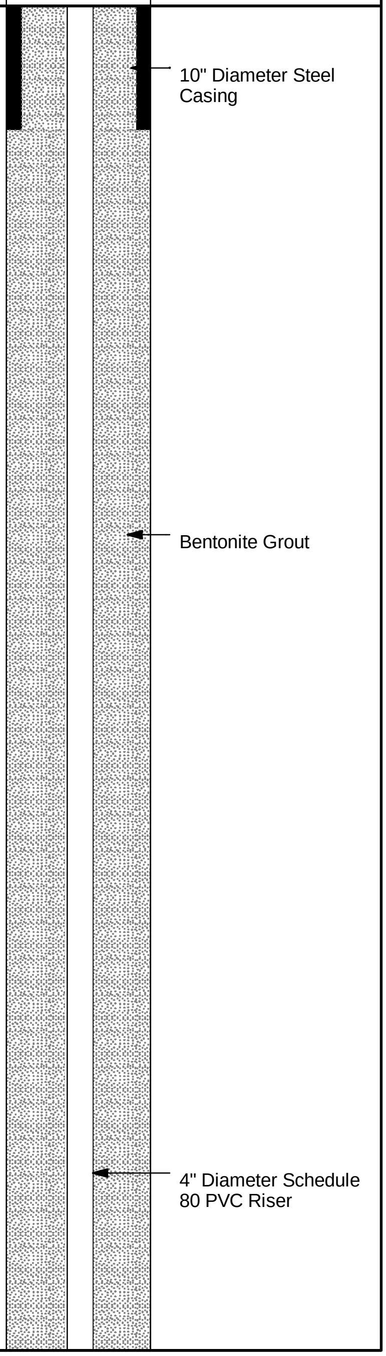
Resolution Consultants

Boring Log

BORING #: RE127D1
Sheet 1 of 2

Client: Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic
Logged By: G. Hicks
Location: N. Woodward Dr & N. Michigan Ave, Massapequa, NY
Drilling Company: Delta Well & Pump
Project #: 60266526
Ground Elevation (msl): 61.58
Well Screen Interval (ft): 660-680
Start Date: 8/8/2016
Drilling Method: Auger (0-50' bgs) Mud Rotary (>50' bgs)
Water Level (ft):
Finish Date: 8/17/2016
Northing: 199120.06 **Easting:** 1131245.10
Total Depth (ft): 698.0

DEPTH (ft)	PID (ppm)	Formation	USCS	GRAPHIC LOG	MATERIAL DESCRIPTION	Well Completion	Well Construction
0					0-663 ft bgs: See VPB161 for Descriptions		
50							
100							
150							
200							
250							
300							
350							
400							
450							
500							
550							

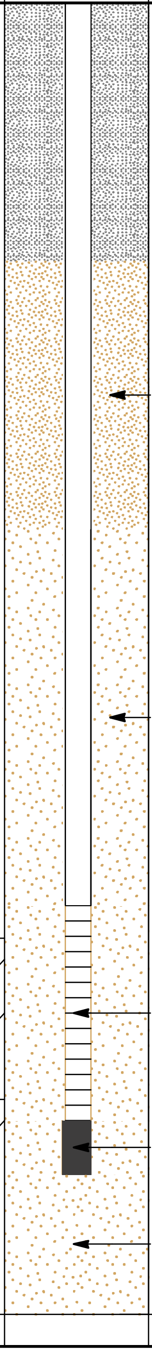


Resolution Consultants

Boring Log

BORING #: RE127D1
Sheet 2 of 2

Client: Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic		**Logged By:** G. Hicks
Location: N. Woodward Dr & N. Michigan Ave, Massapequa, NY		**Drilling Company:** Delta Well & Pump
Project #: 60266526	**Ground Elevation (msl):** 61.58	**Well Screen Interval (ft):** 660-680
Start Date: 8/8/2016	**Drilling Method:** Auger (0-50' bgs) Mud Rotary (>50' bgs)	**Water Level (ft):**
Finish Date: 8/17/2016	**Northing:** 199120.06 **Easting:** 1131245.10	**Total Depth (ft):** 698.0

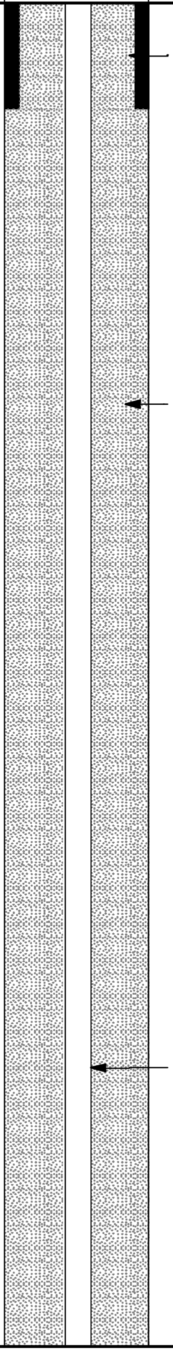
DEPTH (ft)	PID (ppm)	Formation	USCS	GRAPHIC LOG	MATERIAL DESCRIPTION	Well Completion	Well Construction
576 578 580 582 584 586 588 590 592 594 596 598 600 602 604 606 608 610 612 614 616 618 620 622 624 626 628 630 632 634 636 638 640 642 644 646 648 650 652 654 656 658 660 662					0-663 ft bgs: See VPB161 for Descriptions *(continued)*		4" Diameter Schedule 80 PVC Riser *(continued)* #00 Filter Sand #1 Filter Sand
664 666	0		SP		Light gray (GLEY1 7/N) poorly graded medium subrounded SAND, 1-cm-thick layer of Lignite, trace muscovite.		
668 670	0		SW		Light gray (GLEY1 7/N) well graded fine to coarse subrounded SAND, trace Silt, trace lignite, trace muscovite.		4" Diameter Schedule 80 PVC, 10 Slot Well Screen (660-680 ft bgs)
672 674 676	0		SP		Light gray (GLEY1 7/N) poorly graded fine subrounded SAND, trace Lignite, trace muscovite.		
678 680	0		SW		Light gray (GLEY1 7/N) well graded fine to medium subrounded SAND, trace Lignite, trace muscovite.		
682 684 686 688 690 692 694 696							Sump #1 Sand to Bottom
698					End of boring at 698.0 ft. bgs.		

Resolution Consultants

Boring Log

BORING #: **RE127D2**
Sheet 1 of 2

Client: Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic
Logged By: G. Hicks
Location: N. Woodward Dr & N. Michigan Ave, Massapequa, NY
Drilling Company: Delta Well & Pump
Project #: 60266526
Ground Elevation (msl): 61.48
Well Screen Interval (ft): 755-775
Start Date: 7/5/2016
Drilling Method: Auger (0-50' bgs) Mud Rotary (>50' bgs)
Water Level (ft):
Finish Date: 7/20/2016
Northing: 199105.31
Easting: 1131245.65
Total Depth (ft): 793.0

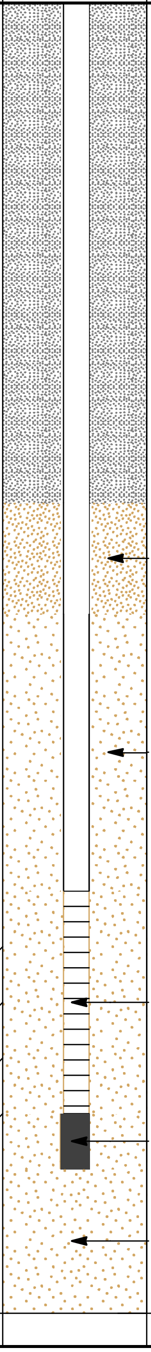
DEPTH (ft)	**PID (ppm)**	**Formation**	**USCS**	**GRAPHIC LOG**	**MATERIAL DESCRIPTION**	Well Completion	**Well Construction**
0					0-760 ft bgs: See VPB161 for Descriptions		10" Diameter Steel Casing
50							
100							
150							
200							Bentonite Grout
250							
300							
350							
400							
450							
500							
550							4" Diameter Schedule 80 PVC Riser
600							
650							

Resolution Consultants

Boring Log

BORING #: **RE127D2**
Sheet 2 of 2

Client: Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic
Logged By: G. Hicks
Location: N. Woodward Dr & N. Michigan Ave, Massapequa, NY
Drilling Company: Delta Well & Pump
Project #: 60266526
Ground Elevation (msl): 61.48
Well Screen Interval (ft): 755-775
Start Date: 7/5/2016
Drilling Method: Auger (0-50' bgs) Mud Rotary (>50' bgs)
Water Level (ft):
Finish Date: 7/20/2016
Northing: 199105.31 **Easting:** 1131245.65
Total Depth (ft): 793.0

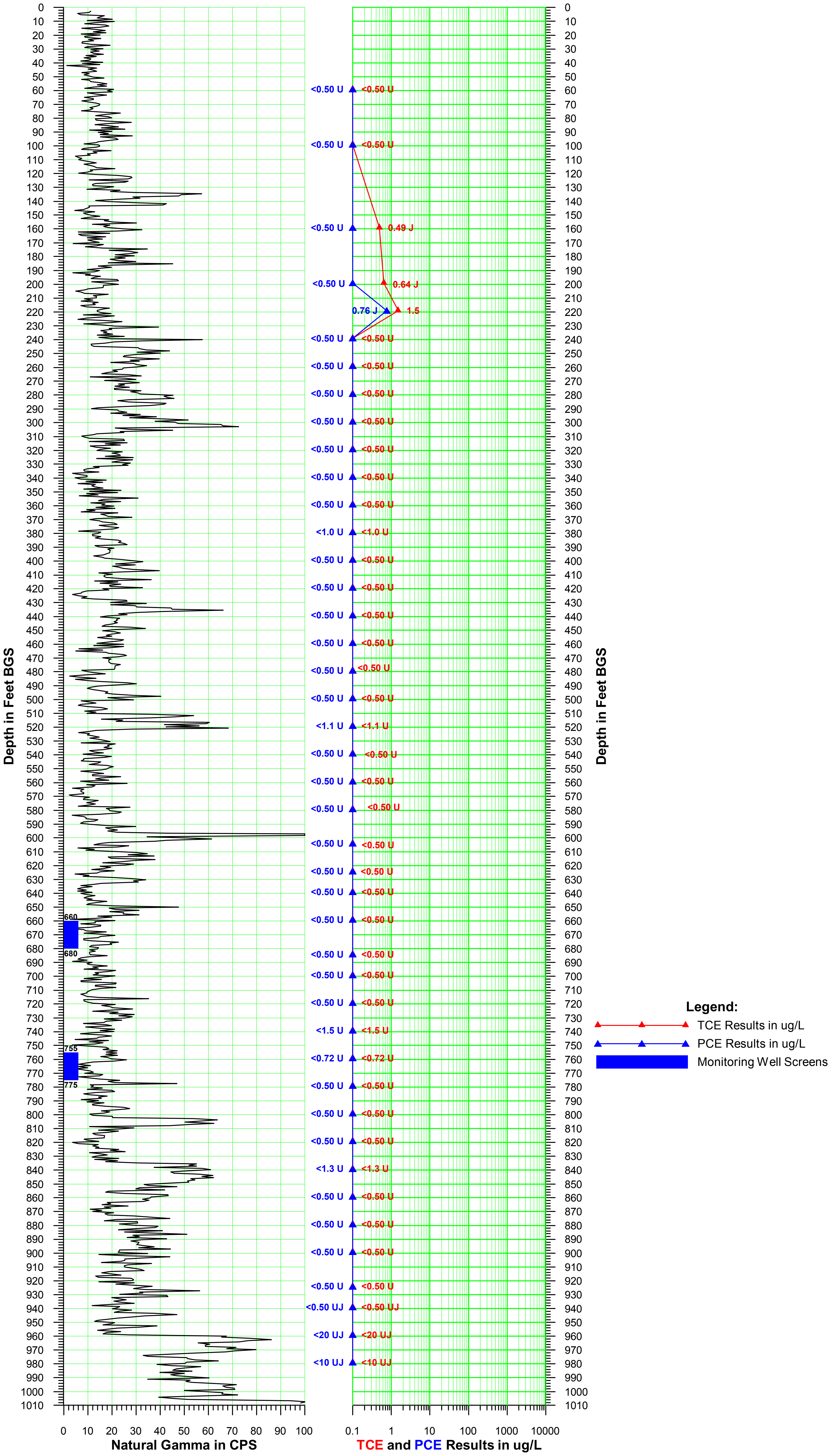


DEPTH (ft)	PID (ppm)	Formation	USCS	GRAPHIC LOG	MATERIAL DESCRIPTION	Well Completion	Well Construction
676					0-760 ft bgs: See VPB161 for Descriptions *(continued)*		4" Diameter Schedule 80 PVC Riser *(continued)*
678							
680							
682							
684							
686							
688							
690							
692							
694							
696							
698							
700							
702							
704							
706							
708							
710							
712							
714							
716							
718							
720							
722							
724							
726							#00 Filter Sand
728							
730							
732							
734							
736							
738							
740							
742							
744							#1 Filter Sand
746							
748							
750							
752							
754							
756							
758							
760	0		SP-SM		Pale brown (2.5Y 8/2) poorly graded fine SAND with Silt, trace iron		
762							
764	0		SP-SM		Pale brown (2.5Y 8/2) poorly graded fine SAND with Silt and fine subrounded gravel		
766							
768							4" Diameter Schedule 80 PVC, 10 Slot Well Screen (755-775 ft bgs)
770	0		SP-SC		Light gray (5Y 7/2) poorly graded fine SAND with soft fat Clay and fine subrounded gravel		
772							
774	0		SP		Light gray (5Y 7/2) poorly graded medium subangular SAND with fine to coarse subrounded Gravel		
776							
778							Sump
780							
782							
784							
786							#1 Sand to Bottom
788							
790							
792							
					End of boring at 793.0 ft. bgs.		

Section 2

VPB161 Gamma and TCE / PCE Plot

Vertical Profile Boring VPB-161
Downward Run - June 3, 2016
Validated Analytical Data



Section 3

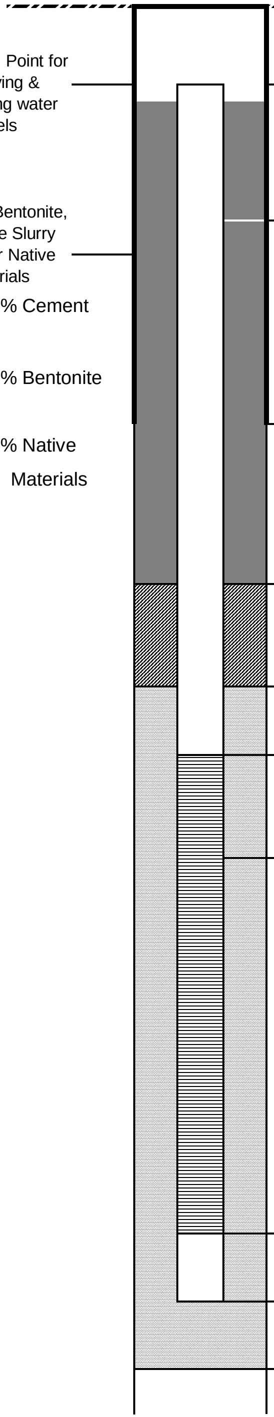
Monitoring Well Construction Logs

RESOLUTION CONSULTANTS

Client: NAVFAC	Project Number: 60266526	***WELL ID: RE127D1***	
Site Location: NWIRP BETHPAGE, NY			
Well Location: N. Woodward Dr & N. Michigan Ave, Massapequa, NY		Date Installed:	8/8/2016 - 8/17/2016*
Method: MUD ROTARY		Inspector:	G. Hicks
Coords: Northing: 199120.06 Easting: 1131245.10		Contractor:	DELTA WELL & PUMP

MONITORING WELL CONSTRUCTION DETAIL

* Casing installed with Auger rig 7/29/16 - 8/1/16



Measuring Point for surveying & measuring water levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

_____ % Cement

_____ % Bentonite

_____ % Native Materials

	Depth from G.S. (feet)	Elevation(feet) Datum
Ground Surface (G.S.)	0.00	61.58
Top of 12 inch diameter Steel Curb Box		
Top of Riser Pipe fit with locking j-plug	0.45	61.13
Bottom of 10 inch diameter Steel Surface Casing	53.0	8.6
Bottom of Bentonite Grout	600.0	-538.4
Bottom of #00 Filter Sand/Top of #1 Filter Sand	625	-563.4
Top of Screen	660	-598.4
▲ Stabilized Water Level		
Bottom of Screen	680	-618.4
Bottom of Sump:	685	-623.4
Bottom of Borehole	698	-636.4

Riser Pipe:

Length	660
Inside Diameter (ID)	4 inch
Type of Material	PVC

Screen:

Length	20
Inside Diameter (ID)	4 inch
Slot Size	10
Type of Material	PVC

Type/Size of Sand	#1
Sand Pack Thickness	73

Borehole Diameter: 10 inch

Approved:

Gordon Hicks
Signature

8/16/2016
Date

Describe Measuring Point:

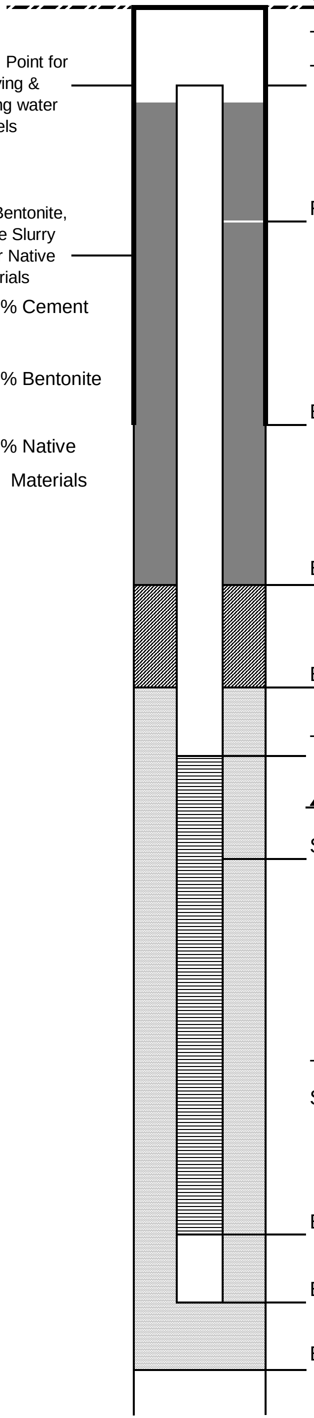
Ground Surface

RESOLUTION CONSULTANTS

Client: NAVFAC	Project Number: 60266526	***WELL ID: RE127D2***	
Site Location: NWIRP BETHPAGE, NY			
Well Location: N. Woodward Dr & N. Michigan Ave, Massapequa, NY		Date Installed:	7/5/2016 - 7/20/2016*
Method: MUD ROTARY		Inspector:	G. Hicks
Coords: Northing: 199105.31 Easting: 1131245.65		Contractor:	DELTA WELL & PUMP

MONITORING WELL CONSTRUCTION DETAIL

* Casing installed with Auger rig 6/21/16 - 6/22/16



Measuring Point for surveying & measuring water levels

Cement, Bentonite, Bentonite Slurry Grout, or Native Materials

______ % Cement

______ % Bentonite

______ % Native Materials

	Depth from G.S. (feet)	Elevation(feet) Datum
Ground Surface (G.S.)	0.00	61.48
Top of 12 inch diameter Steel Curb Box		
Top of Riser Pipe fit with locking j-plug	0.52	60.96
Bottom of 10 inch diameter Steel Surface Casing	53.0	8.5
Bottom of Bentonite Grout	720.0	-658.5
Bottom of #00 Filter Sand/Top of #1 Filter Sand	730	-668.5
Top of Screen	755	-693.5
▲ Stabilized Water Level		
Bottom of Screen	775	-713.5
Bottom of Sump:	780	-718.5
Bottom of Borehole	793	-731.5

Riser Pipe:

Length	755
Inside Diameter (ID)	4 inch
Type of Material	PVC

Screen:

Length	20
Inside Diameter (ID)	4 inch
Slot Size	10
Type of Material	PVC

Type/Size of Sand	#1
Sand Pack Thickness	63

Borehole Diameter: 10 inch

Approved:

Gordon Hicks
Signature

7/19/2016
Date

Describe Measuring Point:

Ground Surface

Section 4

Groundwater Sample Log Sheets

Well ID: RE127D1

RESOLUTION CONSULTANTS

Low Flow Ground Water Sample Collection Record

Client: Navy NWIRP Bethpage
Date: 9/ 23 /16
Time: Start 1120 am/pm
Project No: 60266526
Finish ______ am/pm
Site Location: Woodward & Michigan
Weather Conds: 80° sunny
Collector(s): ______

1. WATER LEVEL DATA: (measured from Top of Casing)

a. Total Well Length 698 ft
c. Length of Water Column ______ (a-b)
Casing Diameter/Material 4-inch PVC
b. Water Table Depth 29.92
d. Calculated System Volume (see back) 13.1 gal. 20 screen length (ft)

2. WELL PURGE DATA

a. Purge Method: Geotech bladder pump with drop tube assembly

b. Acceptance Criteria defined (see workplan)

- Temperature ± 3%
- pH ± 0.1 unit
- Conductivity ± 3%
- Turbidity ± 10%
- ORP ± 10mV
- Drawdown < 0.3'
- D.O. ± 10% (values >0.5 mg/L)

Remove a minimum 1 screen volume

c. Field Testing Equipment used:

	Make	Model	Serial Number
	YSI	556	22091
	LaMotte	2020	73189

Time (24hr)	Volume Removed (gallons)	Temp. (°C)	Conduct. (mS/cm)	DO (mg/L)	pH	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Depth to water (ft)	Color/Odor
1200										ON
1205		17.96	0.031	4.27	3.98	33.9		600		Cloudy
1210		17.61	0.031	1.72	2.05	58.7				
1215		17.77	0.030	1.25	2.81	54.3			28.28	
1220		18.09	0.029	0.98	4.34	41.3		600		
1225	5 gal	18.32	0.028	0.77	4.53	40.5	38.9			

(continued on back)

d. Acceptance criteria pass/fail

	Yes	No	N/A
Has required volume been removed	☑	☐	☐
Has required turbidity been reached	☑	☐	☐
Have parameters stabilized	☑	☐	☐

If no or N/A - Explain below.

3. SAMPLE COLLECTION:

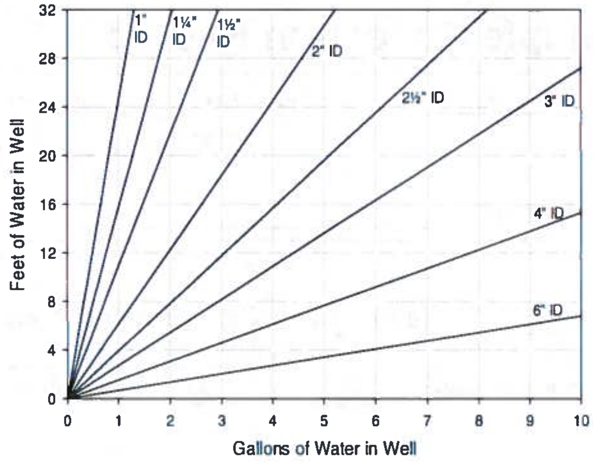
Method: Geotech bladder pump with drop tube assembly

Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time
	40-mL vials	3	HCl	VOCs	1325
	1-L amber	2	none	1,4-Dioxane	1325

Comments: hit bottom while installing new tubing

Signature: Paul Karetti
Date: 9/23/16

Purge Volume Calculation



Volume / Linear Ft. of Pipe		
ID (in)	Gallon	Liter
0.25	0.0025	0.0097
0.375	0.0057	0.0217
0.5	0.0102	0.0386
0.75	0.0229	0.0869
1	0.0408	0.1544
1.25	0.0637	0.2413
1.5	0.0918	0.3475
2	0.1632	0.6178
2.5	0.2550	0.9653
3	0.3672	1.3900
4	0.6528	2.4711
6	1.4688	5.5600

One screen volume
(4-inch well)

15 ft = 37.1 L / 9.8 G
20 ft = 49.4 L / 13.1 G
25 ft = 61.8 L / 16.3 G
30 ft = 74.3 L / 19.6 G
40 ft = 99.2 L / 26.1 G
50 ft = 123.6 L / 32.6 G

Well ID:

(continued from front)

Time (24 hr)	Volume Removed (Liters)	Temp (°C)	pH	Conduct. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Depth to water (ft)	Color/Odor
1230	~~6gal~~	17.84	4.68	0.027	0.43	36.		600	28.72	Cloudy
1235		17.91	4.68	0.026	0.42	33.6				
1240		17.95	4.70	0.027	0.42	32.1	34.4		28.72	
1245		17.84	4.71	0.026	0.40	26.0				
1250		17.71	4.64	0.026	0.35	18.6				
1255	10gal	17.33	4.55	0.026	~~0.026~~ 0.35	14.1	38.6			
1300		17.69	4.79	0.026	~~0.026~~ 0.35	10.0	36.4			
1305		17.68	4.77	0.026	0.31	8.7	38.8	600		
1310		17.52	4.76	0.026	0.30	7.9	40.1		28.68	
1315	13gal	17.58	4.80	0.026	0.31	7.4	41.0			
1325								200		Sample

Well ID: RE127D2

RESOLUTION CONSULTANTS

Low Flow Ground Water Sample Collection Record

Client: Navy NWIRP Bethpage
Date: 9/23/16
Time: Start 1120 am/pm
Project No: 60266526
Finish ______ am/pm
Site Location: N. Woodward Rd, RE127D2
Weather Conds: sunny 80°
Collector(s): F. Bell

1. WATER LEVEL DATA: (measured from Top of Casing)

a. Total Well Length 79.3
c. Length of Water Column ______ (a-b)
Casing Diameter/Material 4-inch PVC
b. Water Table Depth 29.55
d. Calculated System Volume (see back) 13.1 gal. 20 screen length (ft)

2. WELL PURGE DATA

a. Purge Method: Geotech bladder pump with drop tube assembly

b. Acceptance Criteria defined (see workplan)

- Temperature ± 3%
- pH ± 0.1 unit
- Conductivity ± 3%
- Turbidity ± 10%
- ORP ± 10mV
- Drawdown < 0.3'
- D.O. ± 10% (values >0.5 mg/L)

Remove a minimum 1 screen volume

c. Field Testing Equipment used:

Make	Model	Serial Number
YSI	556	RFW 24697
LaMotte	2020	73193

Time (24hr)	Volume Removed (gallons)	Temp. (°C)	Conduct. (mS/cm)	DO (mg/L)	pH	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Depth to water (ft)	Color/Odor
1205								600	29.54	0N
1210		18.69	0.028	7.66	5.71	79.4				
1215		12.73	0.024	10.06	3.09	200.9				
1220		17.86	0.024	10.05	3.43	197.5		600	29.52	
1225		18.17	0.023	8.72	3.55	199.2				
1230	Bladder fell off the pump + replaced it									

d. Acceptance criteria pass/fail — Yes / No / N/A (continued on back)

Has required volume been removed ☑ Yes ☐ No ☐ N/A
Has required turbidity been reached ☑ Yes ☐ No ☐ N/A
Have parameters stabilized ☑ Yes ☐ No ☐ N/A
If no or N/A - Explain below.

3. SAMPLE COLLECTION:

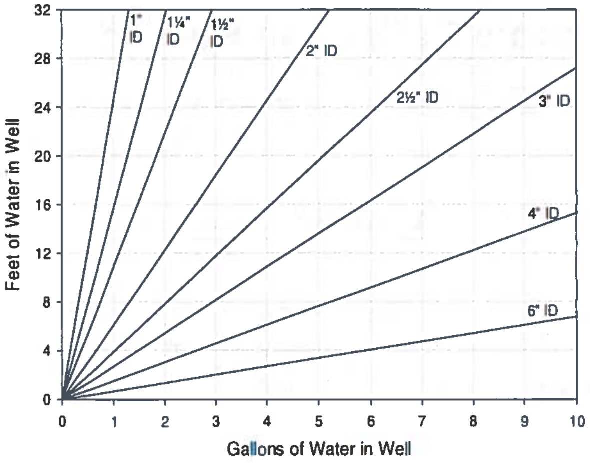
Method: Geotech bladder pump with drop tube assembly

Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time
RE127D2-GW-092316	40-mL vials	3	HCl	VOCs	1335
RE127D2-GW-092316	1-L amber	2	none	1,4-Dioxane	1335

Comments: hit bottom while installing new tubing

Signature
Date 9-23-16

Purge Volume Calculation



Volume / Linear Ft. of Pipe		
ID (in)	Gallon	Liter
0.25	0.0025	0.0097
0.375	0.0057	0.0217
0.5	0.0102	0.0386
0.75	0.0229	0.0869
1	0.0408	0.1544
1.25	0.0637	0.2413
1.5	0.0918	0.3475
2	0.1632	0.6178
2.5	0.2550	0.9653
3	0.3672	1.3900
4	0.6528	2.4711
6	1.4688	5.5600

One screen volume
(4-inch well)

15 ft = 37.1 L / 9.8 G
20 ft = 49.4 L / 13.1 G
25 ft = 61.8 L / 16.3 G
30 ft = 74.3 L / 19.6 G
40 ft = 99.2 L / 26.1 G
50 ft = 123.6 L / 32.6 G

Well ID:

(continued from front)

Time (24 hr)	Volume Removed (Liters)	Temp (°C)	pH	Conduct. (mS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Depth to water (ft)	Color/Odor
1240	—	—	—	—	—	—	—	—	—	—
1245	5Gal	17.81	4.72	0.021	3.76	158.9	~~700~~ 17.7	700	29.47	C
1250	—	17.32	2.70	0.021	3.52	261.9	—	700	29.48	
1255	—	17.47	2.95	0.021	3.45	218.4	—	700	29.48	
1300	—	17.37	3.70	0.021	3.38	215.6	—	700	29.49	
1305	10Gal	17.07	3.40	0.021	3.74	218.7	17.9	700	29.46	
1310	—	17.20	3.66	0.021	3.47	224.1	—	700	29.47	
1315	—	16.99	4.03	0.020	3.45	208.1	17.6	500	29.46	
1320	—	16.87	4.02	0.020	3.52	214.7	17.4	500	29.46	
1325	13.5	16.68	4.00	0.020	3.54	220.7	17.2	500	29.47	
Sampling time				1335				200		

Section 5

Analytical Data Validation

[The Data Validation report included here contains only result tables for RE127D1 and RE127D2; for the complete September-October 2016 Quarterly Sampling Data Validation report with all well results tables, see Sept-Oct (3Q) *2016 Groundwater Sampling Data Summary Report, Bethpage, NY*, Resolution Consultants, 2017.]

September 2016

Final Results after Data Review

NWIRP Bethpage OU 2 Regional Groundwater Investigation

			Sample Delivery Group	BETHPAGE-7		
			Lab ID	SJ7877-5		
			Sample ID	RE127D1-GW-092316		
			Sample Date	9/23/2016		
			Sample Type	Groundwater		
Method	**Analyte**	**CAS No**	**Units**	Result	Qual	RC
8260C	1,1,1-TRICHLOROETHANE	71-55-6	UG_L	0.5	U	
8260C	1,1,2,2-TETRACHLOROETHANE	79-34-5	UG_L	0.5	U	
8260C	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	76-13-1	UG_L	0.5	U	
8260C	1,1,2-TRICHLOROETHANE	79-00-5	UG_L	0.5	U	
8260C	1,1-DICHLOROETHANE	75-34-3	UG_L	0.5	U	
8260C	1,1-DICHLOROETHENE	75-35-4	UG_L	0.5	U	
8260C	1,2,4-TRICHLOROBENZENE	120-82-1	UG_L	0.5	U	
8260C	1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	UG_L	0.75	U	
8260C	1,2-DIBROMOETHANE	106-93-4	UG_L	0.5	U	
8260C	1,2-DICHLOROBENZENE	95-50-1	UG_L	0.5	U	
8260C	1,2-DICHLOROETHANE	107-06-2	UG_L	0.5	U	
8260C	1,2-DICHLOROETHENE, TOTAL	540-59-0	UG_L	1	U	
8260C	1,2-DICHLOROPROPANE	78-87-5	UG_L	0.5	U	
8260C	1,3-DICHLOROBENZENE	541-73-1	UG_L	0.5	U	
8260C	1,4-DICHLOROBENZENE	106-46-7	UG_L	0.5	U	
8260C	2-BUTANONE	78-93-3	UG_L	2.5	U	
8260C	2-HEXANONE	591-78-6	UG_L	2.5	U	
8260C	4-METHYL-2-PENTANONE	108-10-1	UG_L	2.5	U	
8260C	ACETONE	67-64-1	UG_L	2.5	UJ	c
8260C	BENZENE	71-43-2	UG_L	0.5	U	
8260C	BROMODICHLOROMETHANE	75-27-4	UG_L	0.5	U	
8260C	BROMOFORM	75-25-2	UG_L	0.5	U	
8260C	BROMOMETHANE	74-83-9	UG_L	1	U	
8260C	CARBON DISULFIDE	75-15-0	UG_L	0.5	U	
8260C	CARBON TETRACHLORIDE	56-23-5	UG_L	0.5	U	
8260C	CHLOROBENZENE	108-90-7	UG_L	0.5	U	
8260C	CHLOROETHANE	75-00-3	UG_L	1	U	
8260C	CHLOROFORM	67-66-3	UG_L	0.5	U	
8260C	CHLOROMETHANE	74-87-3	UG_L	1	U	
8260C	CIS-1,2-DICHLOROETHENE	156-59-2	UG_L	0.5	U	
8260C	CIS-1,3-DICHLOROPROPENE	10061-01-5	UG_L	0.5	U	
8260C	CYCLOHEXANE	110-82-7	UG_L	0.5	U	
8260C	DIBROMOCHLOROMETHANE	124-48-1	UG_L	0.5	U	
8260C	DICHLORODIFLUOROMETHANE	75-71-8	UG_L	1	UJ	c
8260C	ETHYLBENZENE	100-41-4	UG_L	0.5	U	
8260C	ISOPROPYLBENZENE	98-82-8	UG_L	0.5	U	
8260C	M- AND P-XYLENE	108-38-3/106-42	UG_L	1	U	
8260C	METHYL ACETATE	79-20-9	UG_L	0.75	U	
8260C	METHYL CYCLOHEXANE	108-87-2	UG_L	0.5	U	
8260C	METHYL TERT-BUTYL ETHER	1634-04-4	UG_L	0.5	U	
8260C	METHYLENE CHLORIDE	75-09-2	UG_L	2.5	U	
8260C	O-XYLENE	95-47-6	UG_L	0.5	U	
8260C	STYRENE	100-42-5	UG_L	0.5	U	
8260C	TETRACHLOROETHENE	127-18-4	UG_L	0.5	U	
8260C	TOLUENE	108-88-3	UG_L	0.5	U	
8260C	TRANS-1,2-DICHLOROETHENE	156-60-5	UG_L	0.5	U	
8260C	TRANS-1,3-DICHLOROPROPENE	10061-02-6	UG_L	0.5	U	
8260C	TRICHLOROETHENE	79-01-6	UG_L	0.5	U	
8260C	TRICHLOROFLUOROMETHANE	75-69-4	UG_L	1	U	
8260C	VINYL CHLORIDE	75-01-4	UG_L	1	U	
8260C	XYLENES, TOTAL	1330-20-7	UG_L	1.5	U	
8270D_SIM	1,4-DIOXANE	123-91-1	UG_L	0.17	U	

Notes:

UG_L	= Micrograms per liter
NA	= Not applicable
Qual	= Final qualifiers (See Attachment B)
RC	= Reason codes (See Attachment C)

September 2016
Final Results after Data Review
NWIRP Bethpage OU 2 Regional Groundwater Investigation

			Sample Delivery Group	BETHPAGE-7		
			Lab ID	SJ7877-6		
			Sample ID	RE127D2-GW-092316		
			Sample Date	9/23/2016		
			Sample Type	Groundwater		
Method	**Analyte**	**CAS No**	**Units**	Result	Qual	RC
8260C	1,1,1-TRICHLOROETHANE	71-55-6	UG_L	0.5	U	
8260C	1,1,2,2-TETRACHLOROETHANE	79-34-5	UG_L	0.5	U	
8260C	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	76-13-1	UG_L	0.5	U	
8260C	1,1,2-TRICHLOROETHANE	79-00-5	UG_L	0.5	U	
8260C	1,1-DICHLOROETHANE	75-34-3	UG_L	0.5	U	
8260C	1,1-DICHLOROETHENE	75-35-4	UG_L	0.5	U	
8260C	1,2,4-TRICHLOROBENZENE	120-82-1	UG_L	0.5	U	
8260C	1,2-DIBROMO-3-CHLOROPROPANE	96-12-8	UG_L	0.75	U	
8260C	1,2-DIBROMOETHANE	106-93-4	UG_L	0.5	U	
8260C	1,2-DICHLOROBENZENE	95-50-1	UG_L	0.5	U	
8260C	1,2-DICHLOROETHANE	107-06-2	UG_L	0.5	U	
8260C	1,2-DICHLOROETHENE, TOTAL	540-59-0	UG_L	1	U	
8260C	1,2-DICHLOROPROPANE	78-87-5	UG_L	0.5	U	
8260C	1,3-DICHLOROBENZENE	541-73-1	UG_L	0.5	U	
8260C	1,4-DICHLOROBENZENE	106-46-7	UG_L	0.5	U	
8260C	2-BUTANONE	78-93-3	UG_L	2.5	U	
8260C	2-HEXANONE	591-78-6	UG_L	2.5	U	
8260C	4-METHYL-2-PENTANONE	108-10-1	UG_L	2.5	U	
8260C	ACETONE	67-64-1	UG_L	2.5	UJ	c
8260C	BENZENE	71-43-2	UG_L	0.5	U	
8260C	BROMODICHLOROMETHANE	75-27-4	UG_L	0.5	U	
8260C	BROMOFORM	75-25-2	UG_L	0.5	U	
8260C	BROMOMETHANE	74-83-9	UG_L	1	U	
8260C	CARBON DISULFIDE	75-15-0	UG_L	0.5	U	
8260C	CARBON TETRACHLORIDE	56-23-5	UG_L	0.5	U	
8260C	CHLOROBENZENE	108-90-7	UG_L	0.5	U	
8260C	CHLOROETHANE	75-00-3	UG_L	1	U	
8260C	CHLOROFORM	67-66-3	UG_L	0.5	U	
8260C	CHLOROMETHANE	74-87-3	UG_L	1	U	
8260C	CIS-1,2-DICHLOROETHENE	156-59-2	UG_L	0.5	U	
8260C	CIS-1,3-DICHLOROPROPENE	10061-01-5	UG_L	0.5	U	
8260C	CYCLOHEXANE	110-82-7	UG_L	0.5	U	
8260C	DIBROMOCHLOROMETHANE	124-48-1	UG_L	0.5	U	
8260C	DICHLORODIFLUOROMETHANE	75-71-8	UG_L	1	UJ	c
8260C	ETHYLBENZENE	100-41-4	UG_L	0.5	U	
8260C	ISOPROPYLBENZENE	98-82-8	UG_L	0.5	U	
8260C	M- AND P-XYLENE	108-38-3/106-42	UG_L	1	U	
8260C	METHYL ACETATE	79-20-9	UG_L	0.75	U	
8260C	METHYL CYCLOHEXANE	108-87-2	UG_L	0.5	U	
8260C	METHYL TERT-BUTYL ETHER	1634-04-4	UG_L	0.5	U	
8260C	METHYLENE CHLORIDE	75-09-2	UG_L	2.5	U	
8260C	O-XYLENE	95-47-6	UG_L	0.5	U	
8260C	STYRENE	100-42-5	UG_L	0.5	U	
8260C	TETRACHLOROETHENE	127-18-4	UG_L	0.5	U	
8260C	TOLUENE	108-88-3	UG_L	0.5	U	
8260C	TRANS-1,2-DICHLOROETHENE	156-60-5	UG_L	0.5	U	
8260C	TRANS-1,3-DICHLOROPROPENE	10061-02-6	UG_L	0.5	U	
8260C	TRICHLOROETHENE	79-01-6	UG_L	0.5	U	
8260C	TRICHLOROFLUOROMETHANE	75-69-4	UG_L	1	U	
8260C	VINYL CHLORIDE	75-01-4	UG_L	1	U	
8260C	XYLENES, TOTAL	1330-20-7	UG_L	1.5	U	
8270D_SIM	1,4-DIOXANE	123-91-1	UG_L	0.18	U	

Notes:

UG_L	= Micrograms per liter
NA	= Not applicable
Qual	= Final qualifiers (See Attachment B)
RC	= Reason codes (See Attachment C)

DATA VALIDATION REPORT

Project:	Regional Groundwater Investigation — NWIRP Bethpage		
Laboratory:	Katahdin Analytical		
Sample Delivery Groups:	SJ5406		
Analyses/Method:	Total Organic Carbon (TOC) by U.S. EPA SW-846 Method 9060A		
Validation Level:	2		
Project Number:	0888812477.SA.DV		
Prepared by:	Dana Miller/Resolution Consultants	Completed on:	09/12/2016
Reviewed by:	Tina Cantwell/Resolution Consultants	File Name:	SJ5406_ 9060A

SUMMARY

This report summarizes data review findings for samples listed below, collected by Resolution Consultants from the Regional Groundwater Investigation — NWIRP Bethpage site on 15 July 2016 in accordance with the following Sampling and Analysis Plans:

- *Sampling and Analysis Plan, Bethpage, New York.* (Resolution Consultants April 2013).
- *UFP SAP Addendum, Installation of Vertical Profile Borings and Monitoring Wells, Operable Unit 2, NWIRP Bethpage, New York.* (Resolution Consultants November 2013).
- *UFP SAP Addendum, Inclusion of Additional Target Analytes for Volatile Organics Analyses, NWIRP Bethpage OU2, Bethpage, New York*. (Resolution Consultants August 2014).

Sample ID	Lab ID	Matrix/Sample Type	Analysis
RE127D2-SOIL-071516-768-770	SJ5406-1	Soil	9060A, 2540G
RE127D2-EB-071516	SJ5406-2	Equipment Blank	9060A

Data validation activities were conducted using the following guidance documents: *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, specifically Method 9060A, Total Organic Carbon* (U.S. EPA, 1996), and Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories, Version 4.2 (October 2010). In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody)/sample integrity
✓	Holding times and sample preservation
NA	Gas chromatography/Mass spectrometer performance checks
NA	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks/field blanks/trip blanks
NA	Surrogate spike recoveries
NA	Matrix spike and/or matrix spike duplicate results
✓	Laboratory control sample / laboratory control sample duplicate results
NA	Field duplicates
NA	Internal standards
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. Acceptable data parameters for which all criteria were met and no qualification was performed, and non-conformance or other issues that were noted during validation, but did not result in qualification of data are not discussed further.

Qualifications Actions

The data was reviewed independently from the laboratory to assess data quality. TOC was detected in the equipment blank but professional judgement was used not to qualify the associated sample as undetected. No results were qualified during this review and are considered usable by the project for their intended purpose, according to U.S. Environmental Protection Agency and Department of Defense guidelines. Attachment A, Table A-1 provides final results after data review.

ATTACHMENTS

Attachment A: Table A-1, Final Results after Data Review

Attachment A
Final Results after Data Review

Table A-1
Final Results after Data Review
Regional Groundwater Investigation NWIRP Bethpage

			Sample Delivery Group	SJ5406	SJ5406
			Lab ID	SJ5406-1	SJ5406-2
			Sample ID	RE127D2-SOIL-071516-768-770	RE127D2-EB-071516
			Sample Date	7/15/2016	7/15/2016
			Sample Type	Soil	Equipment Blank
Method	**Analyte**	**CAS No**	**Units**	Result	Result
2540G	TOTAL SOLIDS	-29	PCT	79	NA
5310B	TOTAL ORGANIC CARBON	-28	MG_L	NA	0.24
9060A	TOTAL ORGANIC CARBON	-28	UG_G	1000	NA

Notes:

ID = Identification
PCT = Percent
MG_L = Milligrams per liter
UG_G = Micrograms per gram
NA = Not analyzed

DATA VALIDATION REPORT

Project:	Regional Groundwater Investigation — NWIRP Bethpage		
Laboratory:	Katahdin Analytical		
Sample Delivery Groups:	SJ6337		
Analyses/Method:	Total Organic Carbon (TOC) by U.S. EPA SW-846 Method 9060A		
Validation Level:	2		
Project Number:	0888812477.SA.DV		
Prepared by:	Dana Miller/Resolution Consultants	Completed on:	09/12/2016
Reviewed by:	Tina Cantwell/Resolution Consultants	File Name:	SJ6337_ 9060A

SUMMARY

This report summarizes data review findings for samples listed below, collected by Resolution Consultants from the Regional Groundwater Investigation — NWIRP Bethpage site on 12 July 2016 in accordance with the following Sampling and Analysis Plans:

- *Sampling and Analysis Plan, Bethpage, New York.* (Resolution Consultants April 2013).
- *UFP SAP Addendum, Installation of Vertical Profile Borings and Monitoring Wells, Operable Unit 2, NWIRP Bethpage, New York.* (Resolution Consultants November 2013).
- *UFP SAP Addendum, Inclusion of Additional Target Analytes for Volatile Organics Analyses, NWIRP Bethpage OU2, Bethpage, New York*. (Resolution Consultants August 2014).

Sample ID	Lab ID	Matrix/Sample Type	Analysis
RE127D1-SOIL-081216-678-680	SJ6337-1	Soil	9060A, 2540G
RE127D1-EB-081216	SJ6337-2	Equipment Blank	9060A

Data validation activities were conducted using the following guidance documents: *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, specifically Method 9060A, Total Organic Carbon* (U.S. EPA, 1996), and Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories, Version 4.2 (October 2010). In the absence of method-specific information, laboratory quality control (QC) limits, project-specific requirements and/or professional judgment were used as appropriate.

REVIEW ELEMENTS

The data were evaluated based on the following parameters (where applicable to the method):

✓	Data completeness (chain-of-custody)/sample integrity
✓	Holding times and sample preservation
NA	Gas chromatography/Mass spectrometer performance checks
NA	Initial calibration/continuing calibration verification
✓	Laboratory blanks/equipment blanks/field blanks/trip blanks
NA	Surrogate spike recoveries
NA	Matrix spike and/or matrix spike duplicate results
✓	Laboratory control sample / laboratory control sample duplicate results
NA	Field duplicates
NA	Internal standards
✓	Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. NA indicates that the parameter was not included as part of this data set or was not applicable to this validation and therefore not reviewed. Acceptable data parameters for which all criteria were met and no qualification was performed, and non-conformance or other issues that were noted during validation, but did not result in qualification of data are not discussed further.

Qualifications Actions

The data was reviewed independently from the laboratory to assess data quality. TOC was detected in the equipment blank but professional judgement was used not to qualify the associated sample as undetected. No results were qualified during this review and are considered usable by the project for their intended purpose, according to U.S. Environmental Protection Agency and Department of Defense guidelines. Attachment A, Table A-1 provides final results after data review.

ATTACHMENTS

Attachment A: Table A-1, Final Results after Data Review

Attachment A
Final Results after Data Review

Table A-1
Final Results after Data Review
Regional Groundwater Investigation NWIRP Bethpage

Sample Delivery Group				SJ6337	SJ6337
Lab ID				SJ6337-1	SJ6337-2
Sample ID				RE127D1-SOIL-081216-678-680	RE127D1-EB-081216
Sample Date				8/12/2016	8/12/2016
Sample Type				Soil	Equipment Blank
Method	**Analyte**	**CAS No**	**Units**	Result	Result
2540G	TOTAL SOLIDS	-29	PCT	84	NA
5310B	TOTAL ORGANIC CARBON	-28	MG_L	NA	0.52
9060A	TOTAL ORGANIC CARBON	-28	UG_G	1900	NA

Notes:

ID = Identification
PCT = Percent
MG_L = Milligrams per liter
UG_G = Micrograms per gram
NA = Not analyzed

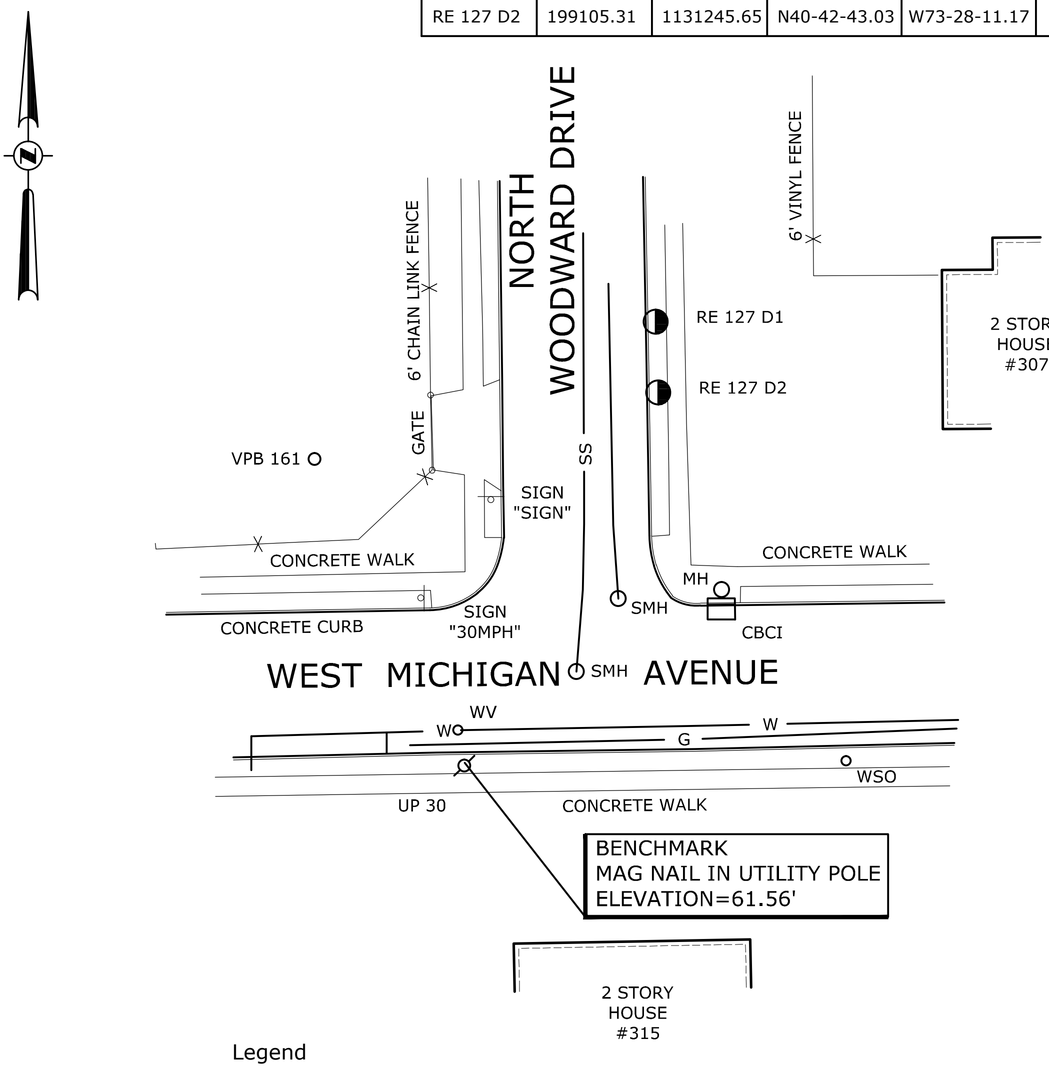
Section 6

Survey

NONE :XREFS

UNAUTHORIZED ALTERATION OR ADDITION TO THIS DOCUMENT IS A VIOLATION OF SECTION 7209 SUBDIVISION 2 OF THE NEW YORK STATE EDUCATION LAW.

Description	Northing	Easting	Latitude	Longitude	Ground	Rim	PVC
VPB 161	199091.46	1131174.08	N40-42-42.90	W73-28-12.10	62.00	NA	NA
RE 127 D1	199120.06	1131245.10	N40-42-43.18	W73-28-11.17	61.58	61.57	61.13
RE 127 D2	199105.31	1131245.65	N40-42-43.03	W73-28-11.17	61.48	61.49	60.96

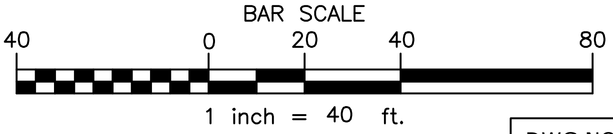


Legend

▭	CBCI	Catch Basin Curb Inlet
◐	MW	Monitoring Well
○	MH	Manhole
○	SMH	Sanitary Manhole
⌀	UP	Utility Pole
○	VPB 161	Vertical Profile Boring
○	WSO	Water Shut-off
○	WV	Water Valve
——— G ———		Gas Line Markout
——— W ———		Water Line Markout
——— SS ———		Sanitary Sewer Markout

Map Notes

1. Information shown hereon was compiled from an actual field survey conducted on October 11, 2016.
2. North orientation is Grid North based on the New York State Plane Coordinate System, Long Island Zone, NAD 83 as obtained from GPS observations.
3. Vertical datum shown hereon is NAVD 88 as obtained from GPS observations.



DWG NO. 16-579

Date	RECORD OF WORK	Appr.

Drafter: GLB

Checker: JFC

Appr. by: JFC

Proj. No. 14.4121

VERTICAL PROFILE BORING 161 SURVEY LOCATION
WEST MICHIGAN AVENUE/NORTH WOODWARD DRIVE

TOWN OF BETHPAGE

NASSAU COUNTY, NEW YORK

C.T. MALE ASSOCIATES
Engineering, Surveying, Architecture & Landscape Architecture, D.P.C.
50 CENTURY HILL DRIVE, LATHAM, NY 12110
518.786.7400 * FAX 518.786.7299

SCALE: 1"=40'

DATE:OCT. 11, 2016

CAD DWG. FILE NAME: K:\Projects\144121\Survey\Drawings and Maps\VPB 161.dwg

Appendix B

Geologic Cross Sections derived from Environmental Sequence Stratigraphy (ESS)

Appendix B. Geologic Cross Sections derived from Environmental Sequence Stratigraphy

Resolution Consultants reviewed the geologic data and regional literature at the Naval Weapons Industrial Reserve Plant at Bethpage, New York and developed four representative base-wide cross sections to support development of a CSM. The cross sections are presented in Figure 1 - Figure 4. The cross sections provide geologic context for groundwater and analytical data and can be used as the framework upon which new and existing datasets (groundwater, analytical chemistry, geophysical data, etc.) can be analyzed to better understand groundwater flow-paths and contaminant transport and storage zones. As such, these sections are an integral component of an effective CSM.

The cross sections were developed using ESS. The ESS approach examines subsurface data in the context of the depositional environments and petroleum industry best practices of sequence stratigraphy and facies models. Shown for each boring included in the stratigraphic analysis are a vertical series of colored blocks which correspond to boring log lithology and a continuous data curve (in red or as a scan of a paper document, which corresponds to the gamma log). These colored blocks represent vertical grain size distribution and are the basis for the correlations between the data points.

The color coded blocks correspond to the graphic grainsize scale as shown in the cross-sections' keys. The width of the block increases with relative grainsize. Block color indicates the textural classification of the sediment (e.g., yellow for sand, green for silt, blue for clay) as written in the field notes of the core logging geologist (see the cross section keys for further definition).

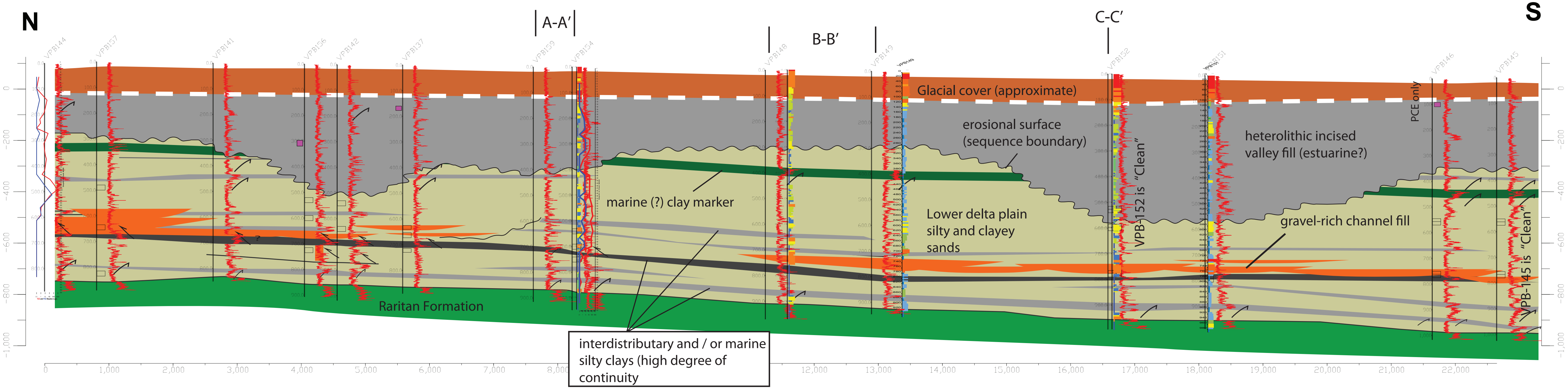
Logs of natural gamma emissions are a common proxy for grainsize. They typically are used as a correlation aide because repetitive spatially extensive trends in grainsize are easily identified visually when curves are examined along a given section. In non-granitic aquifer material, the chemistry of minerals found in clays result in higher concentrations of gamma emitting anions as opposed to the quartz, heavy minerals, and lithic fragments that generally predominate the coarser size fractions. Thus, peaks in the gamma logs can be indicative of clay layers and in general as gamma count per second increases, the grainsize decreases. Gamma logs should always be "calibrated" by comparing side by side with a lithologic log at representative locations. Good agreement between gamma logs and lithology logs were noted in the data points used for the ESS sections at Bethpage.

The previously established general hydrostratigraphy at Bethpage consists of the basal Raritan confining unit, the Magothy aquifer, and the shallow glacial aquifer. The stratigraphy shown in the sections presented in this technical memo is consistent with this general model but additionally shows the Magothy to consist of basal zone gravel-rich channel fills (orange in sections); extensive, planar marine clays (thin units shown in grey and dark green); and silty sands of inter-distributary and delta front origins (shown in tan). Additionally, an erosional incision into the lower delta plain sediments is observed throughout the site (portrayed in sections as a wavy solid black line). Above this, the Magothy sediments are more likely estuarine "incised valley fill" as indicated by the more heterogeneous gamma ray character. In some locations, such as VPB139 on section A-A', there appears to be clear lithologic control on contaminant distribution within the estuarine facies where the higher TCE and PCE concentrations occur in the coarser lithologic zones.

The depositional axis of the incised valley fill likely trends north-south/southeast. The incision is clearly indicated on all sections via the correlation of a prominent clay layer shown in sections in dark green. Where this clay is missing in the gamma logs, it is likely that it was eroded during a lowstand of sea level. Additionally, while relatively planar in their geometry, the major units dip gently south-south east. This is an important geologic characteristic to consider when comparing analytical results because hydrologic zones separated by thin confining layers within the Magothy may be accessed by screens of similar depth.

One of the most important benefits of the ESS approach is to develop and refine the CSM. ESS facilitates an understanding of the geology governing groundwater occurrence and movement, and provides an element for refining the approaches for assessment and remediation. The ESS results from this effort suggest that a modern analog (a modern geological setting that allows an understanding of the ancient environment) for the Magothy depositional environments is the Mackenzie River Delta, shown in Figure 5. Basal gravel zones are represented by the braided river deposits of the Toklat River, Alaska, in Figure 6.

Environmental Sequence Stratigraphy Cross Section



GRAIN SIZE LOG INDEX*

* not all grainsize categories shown in the comprehensive key are present at the site.
Site sediments are predominatly fine (clays, sandy clays, silts,and fine to medium sand)

- 🟦 Clay
- 🟦 Clay with 10% Sand
- 🟦 Clay with 20% Sand
- 🟦 Clay with 30% Sand
- 🟦 Clay with 40% Sand
- 🟧 Clay with Fine Gravel
- 🟧 Clay with Medium Gravel
- 🟥 Clay with Coarse Gravel
- 🟩 Silt
- 🟩 Silt with 10% Sand
- 🟩 Silt with 20% Sand
- 🟩 Sandy Silt
- 🟩 Silty Sand
- 🟦 Clayey Sand
- 🟩 Silty Sand (Fine Sand with 40% Fines)
- 🟦 Clayey Sand (Fine Sand with 40% Fines)
- 🟩 Silty Sand (Fine Sand with 30% Fines)
- 🟦 Clayey Sand (Fine Sand with 30% Fines)
- 🟩 Silty Sand (Fine Sand with 10-20% Fines)
- 🟦 Clayey Sand (Fine Sand with 10-20% Fines)
- 🟧 Gravelly Silt (Silt with Fine Gravel)
- 🟧 Gravelly Silt (Silt with Medium Gravel)
- 🟥 Gravelly Silt (Silt with Coarse Gravel)
- 🟨 Fine Sand
- 🟩 Silty Sand (Medium Sand with 50% Fines)
- 🟦 Clayey Sand (Medium Sand with 50% Fines)
- 🟩 Silty Sand (Medium Sand with 40% Fines)
- 🟦 Clayey Sand (Medium Sand with 40% Fines)
- 🟩 Silty Sand (Medium Sand with 30% Fines)
- 🟦 Clayey Sand (Medium Sand with 30% Fines)
- 🟩 Silty Sand (Medium Sand with 10-20% Fines)
- 🟦 Clayey Sand (Medium Sand with 10-20% Fines)
- 🟧 Fine Sand with Fine Gravel
- 🟧 Fine Sand with Medium Gravel
- 🟥 Fine Sand with Coarse Gravel
- 🟨 Medium Sand
- 🟩 Silty Sand (Coarse Sand with 50% Fines)
- 🟦 Clayey Sand (Coarse Sand with 50% Fines)
- 🟩 Silty Sand (Coarse Sand with 40% Fines)
- 🟦 Clayey Sand (Coarse Sand with 40% Fines)
- 🟩 Silty Sand (Coarse Sand with 30% Fines)
- 🟦 Clayey Sand (Coarse Sand with 30% Fines)
- 🟩 Silty Sand (Coarse Sand with 10-20% Fines)
- 🟦 Clayey Sand (Coarse Sand with 10-20% Fines)
- 🟧 Medium Sand with Fine Gravel
- 🟧 Medium Sand with Medium Gravel
- 🟥 Medium Sand with Coarse Gravel
- 🟨 Coarse Sand
- 🟧 Coarse Sand with Fine Gravel
- 🟧 Coarse Sand with Medium Gravel
- 🟥 Coarse Sand with Coarse Gravel
- 🟧 Clayey/Silty Gravel (Fine gravel with clay/silt)
- 🟧 Clayey/Silty Gravel (Medium gravel with clay/silt)
- 🟥 Clayey/Silty Gravel (Coarse gravel with clay/silt)
- 🟧 Sandy Gravel (Fine Gravel with Sand)
- 🟧 Sandy Gravel (Medium Gravel with Sand)
- 🟥 Sandy Gravel (Coarse Gravel with Sand)
- 🟧 Fine Gravel
- 🟧 Medium Gravel
- 🟥 Coarse Gravel

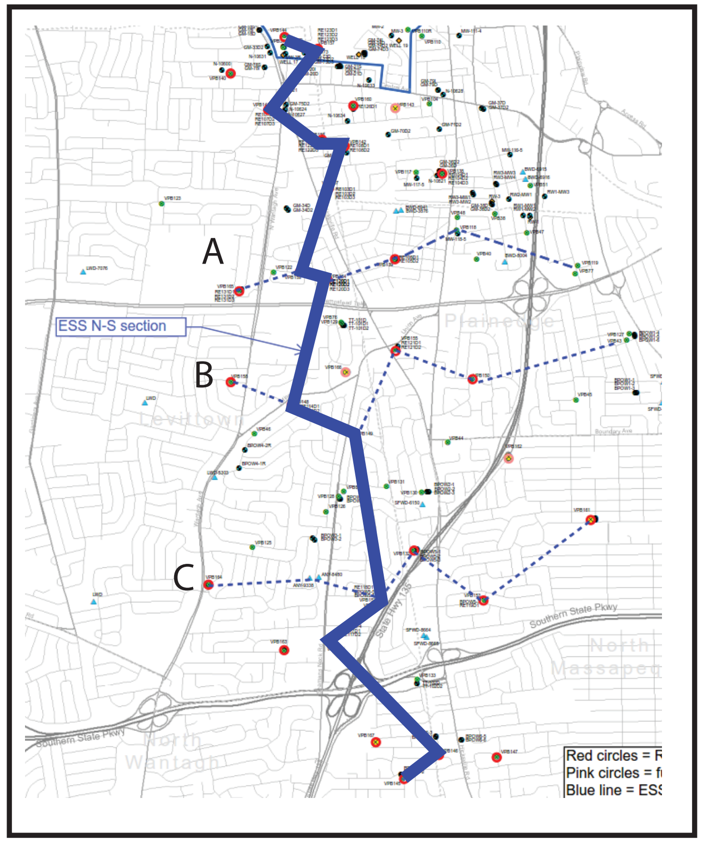


Figure 1. Cross Section N-S

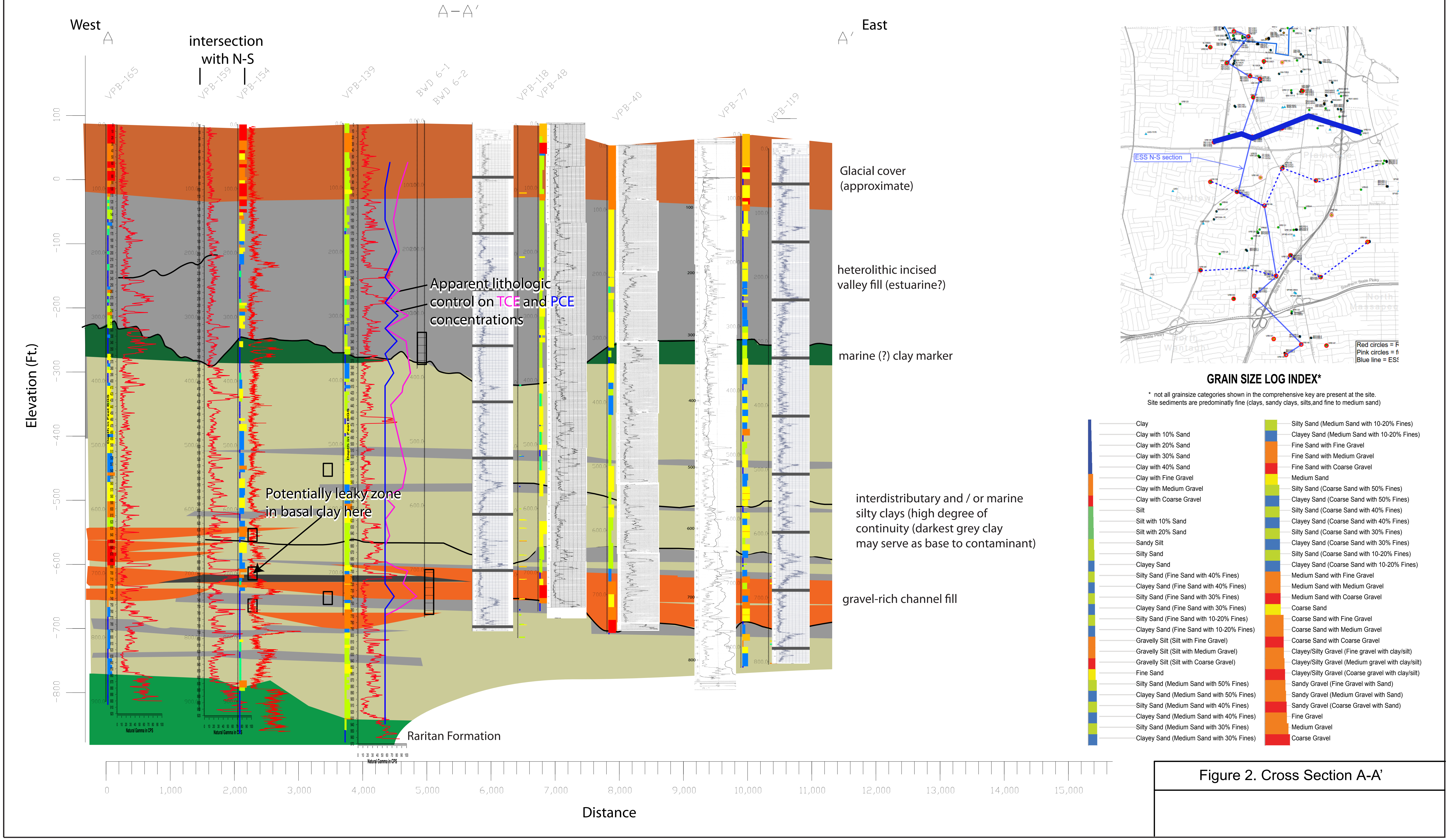


Figure 2. Cross Section A-A’

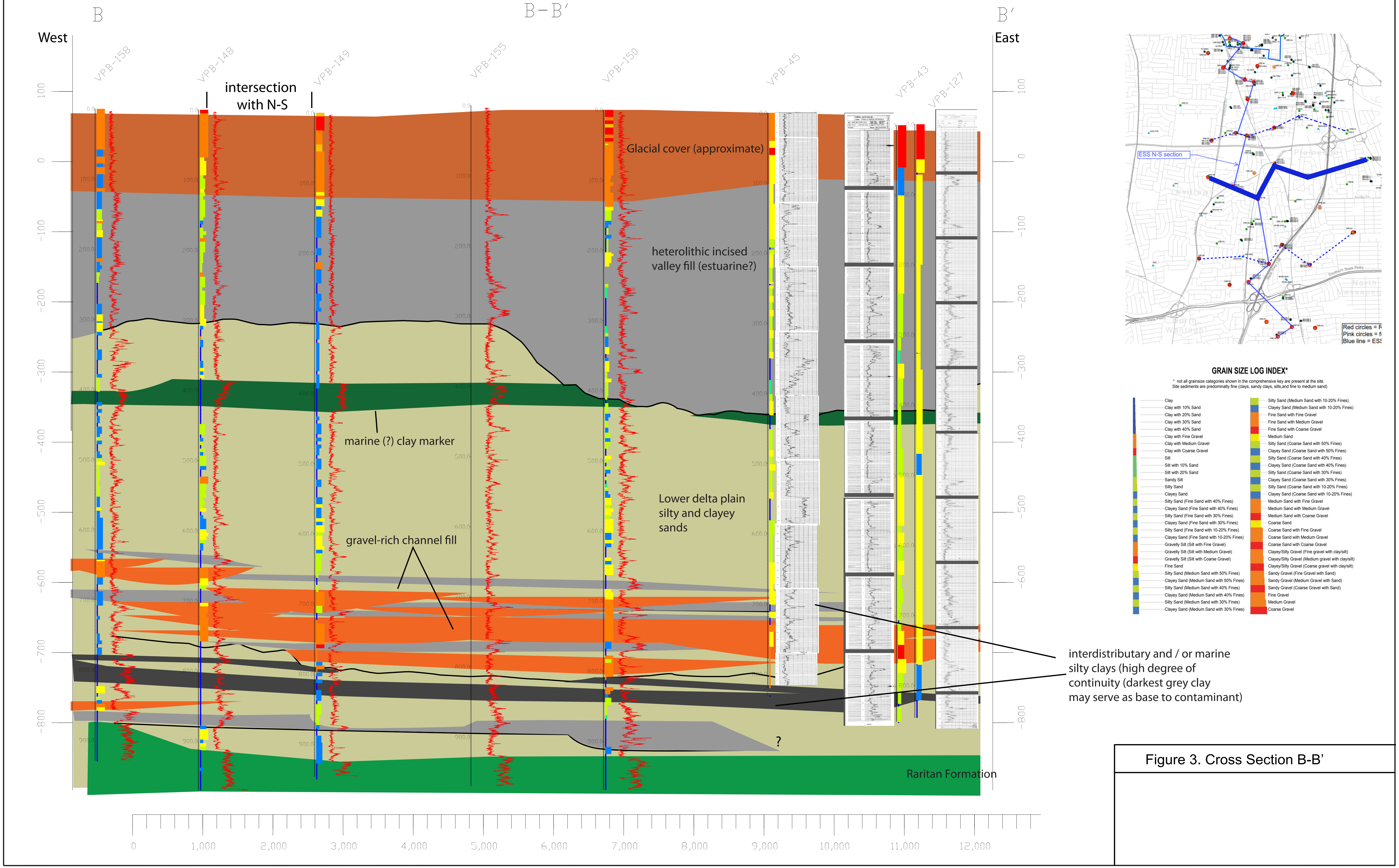
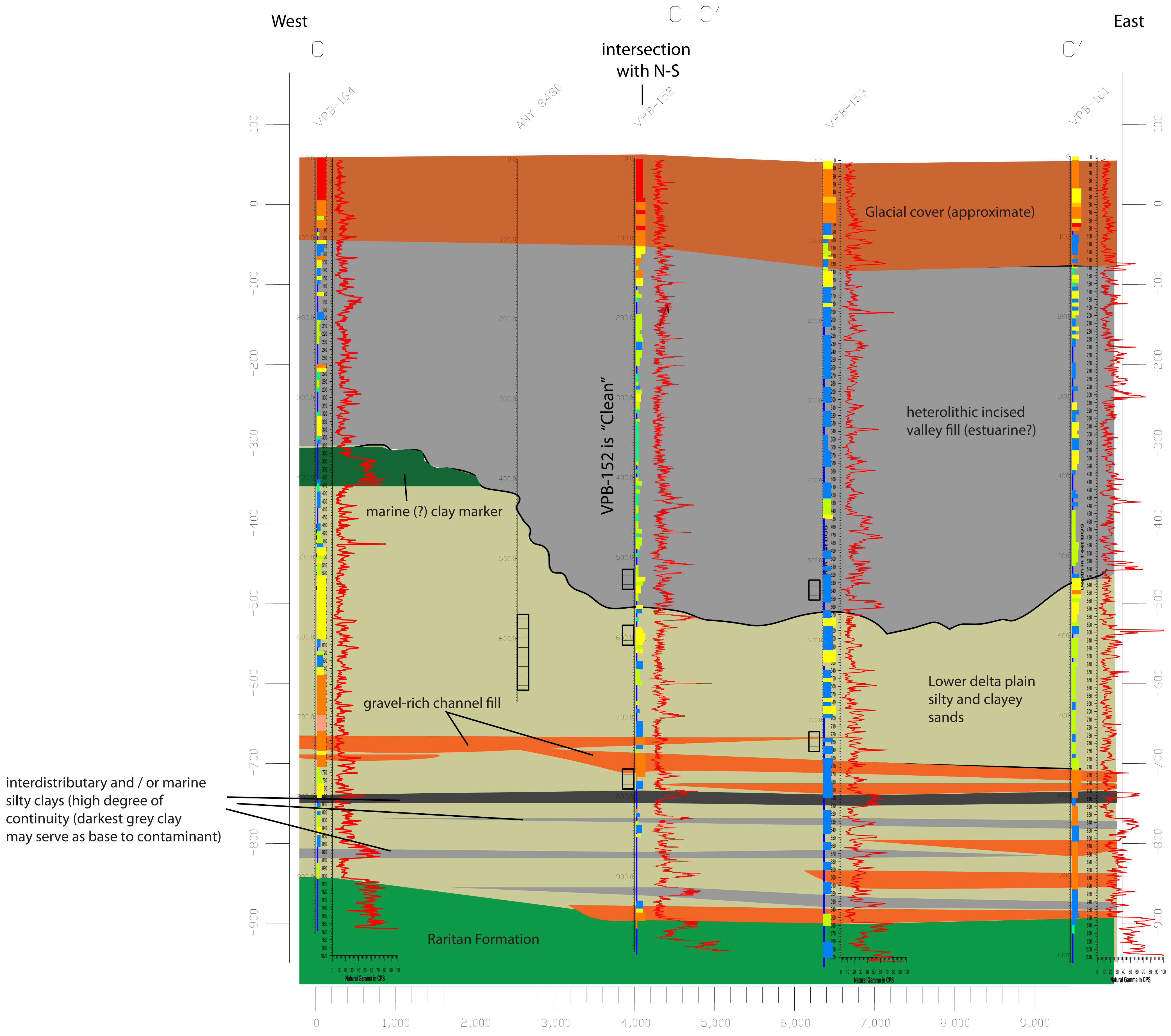
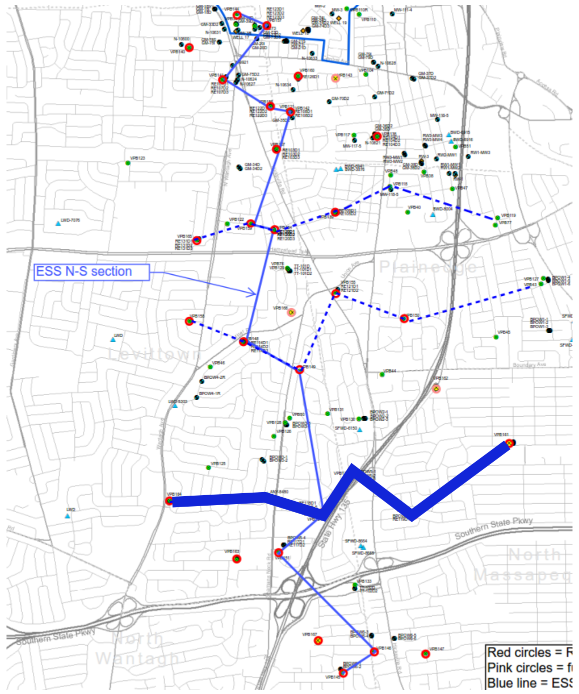


Figure 3. Cross Section B-B'





GRAIN SIZE LOG INDEX*

* not all grainsize categories shown in the comprehensive key are present at the site.
Site sediments are predominatly fine (clays, sandy clays, silts,and fine to medium sand)

- 🟦 Clay
- 🟦 Clay with 10% Sand
- 🟦 Clay with 20% Sand
- 🟦 Clay with 30% Sand
- 🟦 Clay with 40% Sand
- 🟧 Clay with Fine Gravel
- 🟧 Clay with Medium Gravel
- 🟥 Clay with Coarse Gravel
- 🟩 Silt
- 🟩 Silt with 10% Sand
- 🟩 Silt with 20% Sand
- 🟩 Sandy Silt
- 🟩 Silty Sand
- 🟦 Clayey Sand
- 🟩 Silty Sand (Fine Sand with 40% Fines)
- 🟦 Clayey Sand (Fine Sand with 40% Fines)
- 🟩 Silty Sand (Fine Sand with 30% Fines)
- 🟦 Clayey Sand (Fine Sand with 30% Fines)
- 🟩 Silty Sand (Fine Sand with 10-20% Fines)
- 🟦 Clayey Sand (Fine Sand with 10-20% Fines)
- 🟧 Gravelly Silt (Silt with Fine Gravel)
- 🟧 Gravelly Silt (Silt with Medium Gravel)
- 🟥 Gravelly Silt (Silt with Coarse Gravel)
- 🟨 Fine Sand
- 🟩 Silty Sand (Medium Sand with 50% Fines)
- 🟦 Clayey Sand (Medium Sand with 50% Fines)
- 🟩 Silty Sand (Medium Sand with 40% Fines)
- 🟦 Clayey Sand (Medium Sand with 40% Fines)
- 🟩 Silty Sand (Medium Sand with 30% Fines)
- 🟦 Clayey Sand (Medium Sand with 30% Fines)
- 🟩 Silty Sand (Medium Sand with 10-20% Fines)
- 🟦 Clayey Sand (Medium Sand with 10-20% Fines)
- 🟧 Fine Sand with Fine Gravel
- 🟧 Fine Sand with Medium Gravel
- 🟥 Fine Sand with Coarse Gravel
- 🟨 Medium Sand
- 🟩 Silty Sand (Coarse Sand with 50% Fines)
- 🟦 Clayey Sand (Coarse Sand with 50% Fines)
- 🟩 Silty Sand (Coarse Sand with 40% Fines)
- 🟦 Clayey Sand (Coarse Sand with 40% Fines)
- 🟩 Silty Sand (Coarse Sand with 30% Fines)
- 🟦 Clayey Sand (Coarse Sand with 30% Fines)
- 🟩 Silty Sand (Coarse Sand with 10-20% Fines)
- 🟦 Clayey Sand (Coarse Sand with 10-20% Fines)
- 🟧 Medium Sand with Fine Gravel
- 🟧 Medium Sand with Medium Gravel
- 🟥 Medium Sand with Coarse Gravel
- 🟨 Coarse Sand
- 🟧 Coarse Sand with Fine Gravel
- 🟧 Coarse Sand with Medium Gravel
- 🟥 Coarse Sand with Coarse Gravel
- 🟧 Clayey/Silty Gravel (Fine gravel with clay/silt)
- 🟧 Clayey/Silty Gravel (Medium gravel with clay/silt)
- 🟥 Clayey/Silty Gravel (Coarse gravel with clay/silt)
- 🟧 Sandy Gravel (Fine Gravel with Sand)
- 🟧 Sandy Gravel (Medium Gravel with Sand)
- 🟥 Sandy Gravel (Coarse Gravel with Sand)
- 🟧 Fine Gravel
- 🟧 Medium Gravel
- 🟥 Coarse Gravel

Figure 4. Cross Section C-C’

Figure 5. Mackenzie River Delta Depositional Environment

Source: Thermal Emission and Reflection Radiometer image from NASA's TERRA satellite, August 4, 2005, Mackenzie River, Canada. Image from GSFC/METI/ERSDAC/JAROS and the US/Japan ASTER Science Team. http://earthobservatory.nasa.gov/IOTD/view.php?id=8320

Figure 6. Braided River Depositional Environment

Source: East Fork Toklat River, Alaska Range, Denali National Park https://pubs.usgs.gov/of/2004/1216/b/b.html