# 2016 OU2 GROUNDWATER INVESTIGATION RE133D1, RE133D2 (VPB167) 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

April 2017

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

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CTO WE15

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## **List of Acronyms and Abbreviations**

AOC Area of Concern
bgs below ground surface
CSM 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] 167 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 RE133D1 and RE133D2, monitoring wells associated with VPB167. The purpose of this investigation was to ascertain subsurface conditions and contaminant levels upgradient of the Massapequa Water District. The locations of RE133D1 and RE133D2, 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 RE133 locations, the bottom of the Magothy (top of the Raritan Clay) is encountered at approximately 998 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 VPB167 between May 2016 and July 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 RE133D1 and RE133D2 were installed using mud rotary drilling techniques (Figure 2). Depths of monitoring wells RE133D1 and RE133D2 were 585 ft and 805 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 VPB167* (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 VPB167 along with the well screen intervals at RE133D1 and RE133D2 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 VPB167, 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 RE133D1 and RE133D2 were sampled by Resolution Consultants on September 20, 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.

Resolution Consultants, 2013b. UFP SAP Addendum, *Groundwater Sampling Using Low Stress (Low Flow) Purging and Sampling Protocol.* November 2013.

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

Resolution Consultants, 2017. 2016 OU2 Groundwater Investigation VPB167, Bethpage, NY. March 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)
RE133D1	7/8/2016	48.89	48.38	585	53.5	560 - 580	580 - 585	598
RE133D2	6/15/2016	48.91	48.72	805	53.5	780 - 800	800 - 805	818

MSL - mean sea level

ft bgs - feet below ground surface

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

	AIR DEVEL	OPMENT	PUM	IP DEVELOPME	APPROX. TOTAL	FINAL		
MONITORING WELL	DATE	APPROX. VOLUME (GAL)	DATE	FINAL PUMP DEPTH (FT BGS)	APPROX. VOLUME (GAL)	DEVELOPMENT VOLUME (GAL)	TURBIDITY (NTUs)	
RE133D1	7/14/2016	5,000	7/19/2016	560-580	4,300	9,300	0.87	
RE133D2	7/15/2016; 7/18/2016	9,000	7/20/2016 - 7/21/2016	780-800	9,000	18,000	48.3	

GAL - gallon

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

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

Location		RE133D1	RE133D2
Sample Date	NYSDEC	9/20/2016	9/20/2016
Sample ID	Groundwater Guidance or Standard Value	RE133D1-GW- 092016	RE133D2-GW- 092016
Sample type code	(Note 1)	Groundwater	Groundwater
VOC 8260C (ug/L)		O. Garianato.	Orounaudio.
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	0.16 J	<0.17 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	4.1 J	<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 UJ	<0.50 UJ
CARBON TETRACHLORIDE	5	<0.50 U	<0.50 U
CHLOROBENZENE	5	<0.50 U	<0.50 U
CHLOROETHANE	5 7	<1.0 UJ <0.50 U	<1.0 UJ
CHLOROFORM CHLOROMETHANE	5	<0.50 U	<0.50 U <1.0 U
CIS-1,2-DICHLOROETHENE	5	<0.50 U	<0.50 U
CIS-1,2-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 U	<1.0 U
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 UJ	<0.75 UJ
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)	рН	Specific Conductance (µS/cm)	DO (mg/L)	ORP (mV)	Turbidity (NTU)	Depth to water (ft bgs)	Flow rate (ml/min)
RE133D1	9/20/2016	15.60	4.84	0.132	0.32	105.9	26.3	25.86	650
RE133D2	9/20/2016	17.69	4.72	0.037	0.79	136.9	83.0	26.94	600

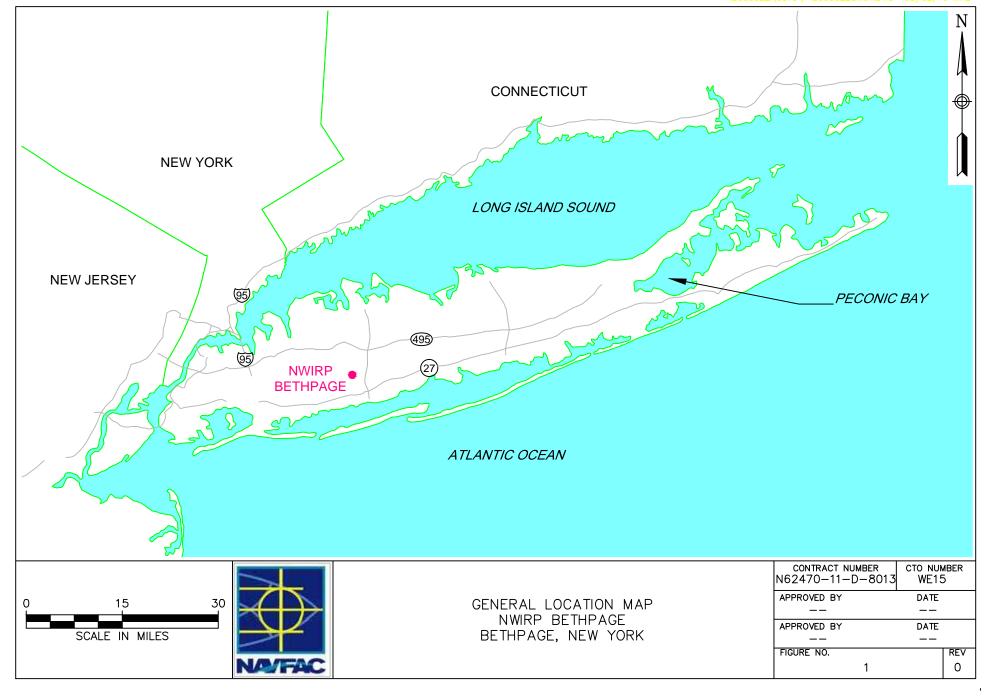
°C - degrees Celsius

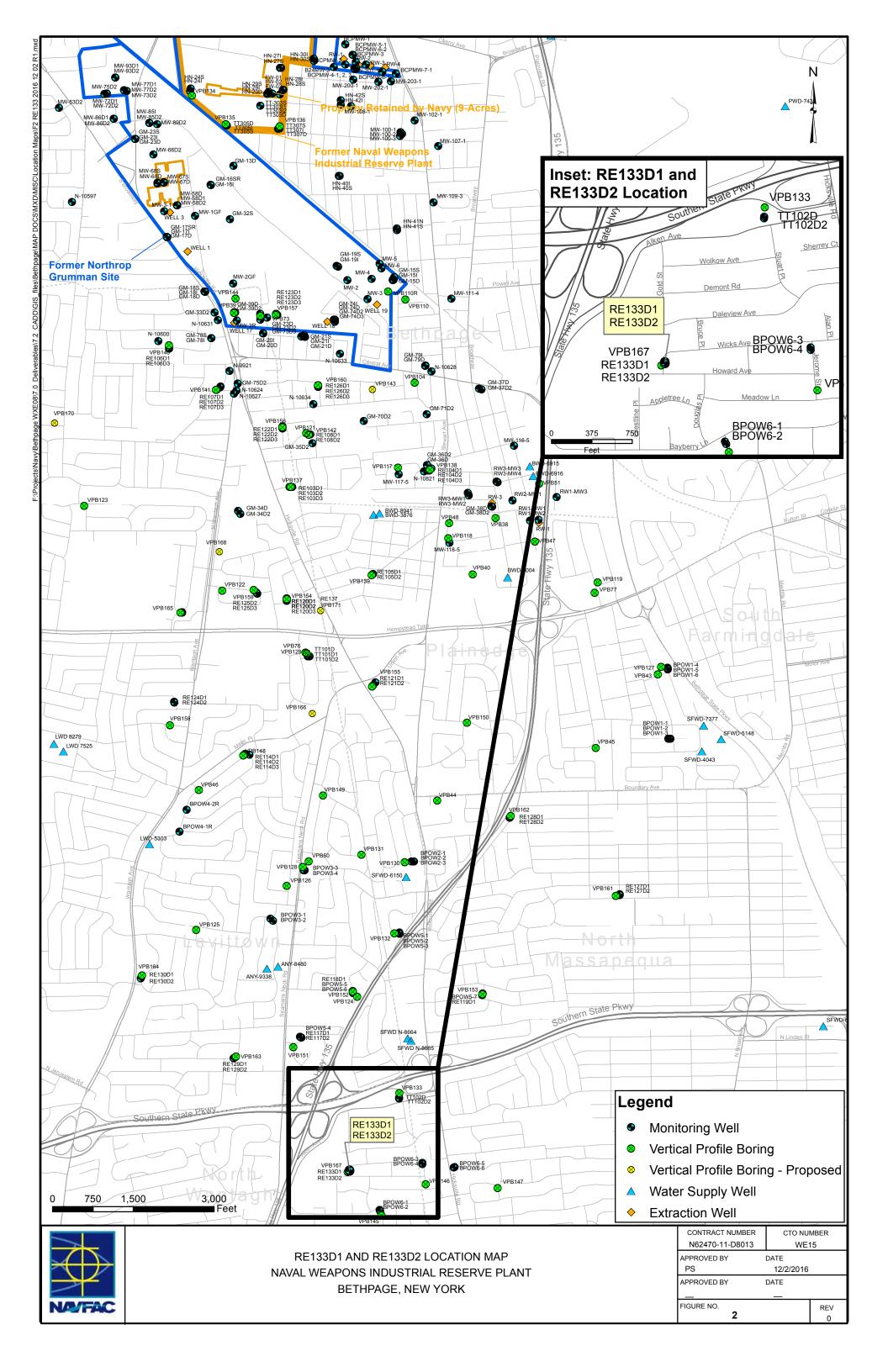
 $\mu S/cm$  - Microsiemens per Centimeter

mg/L - milligrams per liter

mV - Millivolts

NTU - Nephelometric Turbidity Unit ft bgs - feet below ground surface ml/min - mililiters per minute **Figures** 







# Appendix A

RE133D1, RE133D2

Section 1

**Boring Logs** 

# Boring Log

BORING #: **RE133D1**Sheet 1 of 2

Client: Department of the Navy, Naval Facilities	Logged By: V. Thayer	
Location: Howard & Wicks Ave., Town of Hemp	Drilling Company: Delta Well & Pump	
Project #: 60266526	Ground Elevation (msl): 48.89	Well Screen Interval (ft): 560-580
Start Date: 6/27/2016	Water Level (ft):	
Finish Date: 7/8/2016	Total Depth (ft): 598.0	

DEPTH (ft)	PID (ppm)	Formation	nscs	GRAPHIC LOG	MATERIAL DESCRIPTION	Well	Completion	Well Construction
U					0-563 ft bgs: See VPB167 for Descriptions			10" Diameter Steel Casing
100								
150							+	Bentonite Grout
200								Schlome Glou
250								
300								
350								
400							•	4" Diameter Schedule 80 PVC Riser
450						0.00		

# Boring Log

BORING #: **RE133D1**Sheet 2 of 2

Client: Department of the Navy, Naval Facilities	Logged By: V. Thayer							
Location: Howard & Wicks Ave., Town of Hemp	Drilling Company: Delta Well & Pump							
Project #: 60266526	Ground Elevation (msl): 48.89	Well Screen Interval (ft): 560-580						
Start Date: 6/27/2016	Water Level (ft):							
Finish Date: 7/8/2016	Total Depth (ft): 598.0							

SP-SM   Sp-S	DEPTH (ft)	PID (ppm)	Formation	SOSU	GRAPHIC LOG	MATERIAL DESCRIPTION	Well	Well Construction
SP-SM   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, little fine sand, silt (10-15%), trace coarse sand   SP-SM   SP-SM   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, little fine sand, silt (10-15%), trace coarse sand   SP-SM   SP-SM   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, interbedded with on 3/4" layer of dark gray microlaminated clayey silt   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, interbedded with on 14" layer of clayey silt   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, interbedded with on 14" layer of clayey silt   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, little fine sand, silt (10-15%), trace coarse sand   SP-SM   SP-SM   SP-SM   Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, little fine sand, silt (10-15%), trace coarse sand   SP-SM	502 504 506 508 510 512 514 516 518 520 522 524 526 528 530 532 534 536					0-563 ft bgs: See VPB167 for Descriptions (continued)		Schedule 80 PVC
#1 Filter Sand   #1 F	544 546 548 550 552							#00 Filter Sand
Sp-SM   Sp-S	556 558 560 562 564					Gray (10YR 5/1) poorly graded SAND with SILT; subangular medium sand, little fine sand, fines (silt 10%)		#1 Filter Sand
Sump	570 572 574 576			SP-SM		little medium sand, silty (15%) interbedded with on 3/4" layer of dark gray microlaminated clayey silt  Gray (10YR 5/1) poorly graded SAND with SILT, subangular medium Sand, interbedded with on 1/4" layer of clayey silt		Schedule 80 PVC, 10 Slot Well Screen
590 592 594 #1 Sand to Bottom	580 582 584 586	0 ,		SP-SM_	63.4534BB	medium sand, little fine sand, silt (10-15%), trace coarse		Sump
596 (2014) (2014	590 592 594 596							#1 Sand to Bottom

# Boring Log

BORING #: **RE133D2**Sheet 1 of 2

Client: Department of the Navy, Naval Facilities	Logged By: V. Thayer							
Location: Howard & Wicks Ave., Town of Hemp	Drilling Company: Delta Well & Pump							
Project #: 60266526	Ground Elevation (msl): 48.91	Well Screen Interval (ft): 780-800						
Start Date: 6/1/2016	Drilling Method: Auger (0-50' bgs) Mud Rotary (>50' bgs)	Water Level (ft):						
Finish Date: 6/15/2016	Northing: 193991.82 Easting: 1126227.06	Total Depth (ft): 818.0						

ОЕРТН (ft)	PID (ppm)	Formation	SOSO	GRAPHIC LOG	MATERIAL DESCRIPTION	Well	Well Construction
0					0-783 ft bgs: See VPB167 for Descriptions		10" Diameter Steel Casing
50							Caomy
100							
150							
200						-	Bentonite Grout
250							
300							
350							
400							
450							
500							
550							4" Diameter Schedule 80 PVC Riser
600							501 VO 1(156)
650							
700							

# Boring Log

BORING #: **RE133D2**Sheet 2 of 2

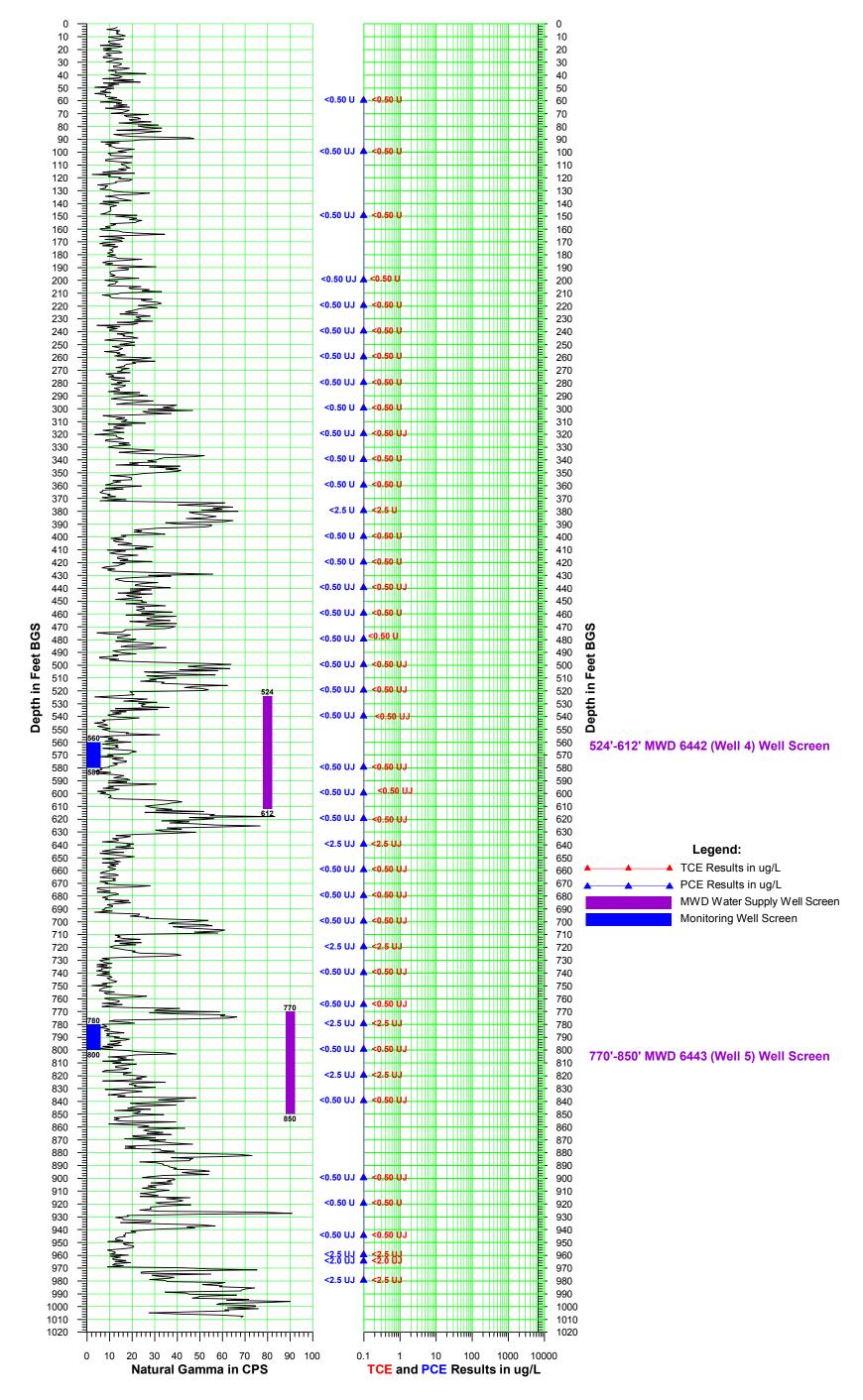
Client: Department of the Navy, Naval Facilities	Logged By: V. Thayer	
Location: Howard & Wicks Ave., Town of Hemp	Drilling Company: Delta Well & Pump	
Project #: 60266526	Ground Elevation (msl): 48.91	Well Screen Interval (ft): 780-800
Start Date: 6/1/2016	Water Level (ft):	
Finish Date: 6/15/2016	Northing: 193991.82 Easting: 1126227.06	Total Depth (ft): 818.0

БЕРТН (ft)	PID (ppm)		Formation USCS GRAPHIC LOG		MATERIAL DESCRIPTION	Well	Well Construction	
740 742 744 746 748 750 752 754 756 758					0-783 ft bgs: See VPB167 for Descriptions (continued)		4" Diameter Schedule 80 PVC Riser (continued)	
762 764 766 768 770 772							#00 Filter Sand	
776 778 780 782 784 786	0		SM SM		White (10YR 8/1) silty SAND, micaceous fine Sand, 40% silt, trace coarse sand; think layer of subrounded gravel Pale brown (10YR 6/3) silty SAND, subangular fine to coarse Sand, 15% fines (silt and clay)		#1 Filter Sand	
788 790 792 794 796 796	0 0		GP-GM SP-SIM GP-GM SP-SIM SW-SM		Gray (10YR 6/2) poorly graded GRAVEL with SILT and SAND, subrounded fine gravel (pea size); little subangular medium sand, few silt  Gray (10YR 6/1) Poorly Graded SAND with SILT, subangular medium Sand, few coarse sand, silt (10%), trace subangular fine gravel  Gray (10YR 6/1) Poorly Graded GRAVEL with SILT and SAND, subrounded fine Gravel (pea size); little subangular medium sand, few silt  Gray (10YR 6/1) poorly graded SAND with SILT, subangular		4" Diameter Schedule 80 PVC, 10 Slot Well Screen (780-800 ft bgs)	
802 804 806 808 810			5		Gray (10YR 6/1) poorly graded SAND with SIL1, subangular medium Sand, silt (10%) Light gray (10YR 7/1) widely graded SAND with SILT, subangular medium Sand, little fine sand, subrounded coarse sand, little subrounded fine gravel, 10-15% fines White (7.5YR 8/1) SILTY SAND, fine sand, silt		Sump #1 Sand to Bottom	
814 816 818					End of boring at 818.0 ft. bgs.			

### Section 2

**VPB167 Gamma and TCE/PCE Plot** 

## Vertical Profile Boring VPB-167 Downward Run - May 9, 2016 Validated Analytical Data



## Section 3

**Monitoring Well Construction Logs** 



Client:	NAVFAC	Project Number: 60266526	WELL ID: RE133D1				
Site Location	n: NWIRP BETHPAG	E, NY					
Well Location	on: Howard & Wicks A	Date Installed: 6/27/2016 - 7/8/2016*					
Method: MUD ROTARY Inspector: V. Thayer							
Coords:	Northing: 193975.82	Easting: 1126227.64	Contractor: DELTA WELL & PUMP				

## MONITORING WELL CONSTRUCTION DETAIL

Casing installed with Auger rig 5/2	23/16 - 5/24/16	Depth from G.S. (feet)	Elevation(feet) Datum
	Ground Surface (G.S.)	0.00	48.89
leasuring Point for	Top of 12 inch diameter Steel Curb Box		
measuring water levels	Top of Riser Pipe fit with locking j-plug	0.51	48.38
ement, Bentonite,	Riser Pipe:		
Bentonite Slurry Grout, or Native	Length		
Materials	Inside Diameter (ID) 4 inch		
% Cement	Type of Material PVC		
% Bentonite	Bottom of 10 inch diameter Steel Surface Casing	53.5	-4.6
% Native			
Materials			
	Bottom of Bentonite Grout	533.0	-484.1
	Bottom of #00 Filter Sand/Top of #1 Filter Sand	550	-501.1
	Top of Screen	560	-511.1
	Stabilized Water Level		
	Screen: Length 20		
	Inside Diameter (ID) 4 inch	_	
	Slot Size 10		
	Type of Material PVC		
	Type/Size of Sand #1		
	Type/Size of Sand #1 Sand Pack Thickness 48		
	<del>40</del>		
	Bottom of Screen	580	-531.1
	Bottom of Screen		-551.1
	Bottom of Sump:	585	-536.1
	Bottom of Borehole	598	-549.1
Borehole Diamete	r: 10 inch Approved:		
escribe Measuring Point:	Valerie Thayer	7/8/2016	
. <b>3</b>	Signature	Date	



Client:	NAVFAC	Project Number: 60266526	WELL ID: RE133D2
Site Location	n: NWIRP BETHPAG	E, NY	
Well Location	on: Howard & Wicks A	Date Installed: 6/1-6/15/2016 *	
Method:	MUD ROTARY	Inspector: V. Thayer	
Coords:	Northing: 193991.82	Easting: 1126227.06	Contractor: DELTA WELL & PUMP

## MONITORING WELL CONSTRUCTION DETAIL

Casing installed with Auger ri	g 5/19/16 - 5/20/16	Depth from G.S. (feet)	Elevation(feet) Datum
	Ground Surface (G.S.)	0.00	48.91
	Top of 12 inch diameter Steel Curb Box		
easuring Point for surveying & measuring water levels	Top of Riser Pipe fit with locking j-plug	0.19	48.72
ement, Bentonite,	Riser Pipe:		
Bentonite Slurry Brout, or Native	Length 780		
Materials	Inside Diameter (ID) 4 inch		
% Cement	Type of Material PVC		
% Bentonite	Bottom of 10 inch diameter Steel Surface Casing	53.5	-4.6
% Native			
Materials			
	Bottom of Bentonite Grout	755.0	-706.1
	Bottom of #00 Filter Sand/Top of #1 Filter Sand	770	-721.1
	Top of Screen	780	-731.1
	Stabilized Water Level		48.9
	Screen:		
	Length <u>20</u>	_	
	Inside Diameter (ID) 4 inch		
	Slot Size10		
	Type of Material PVC		
	Type/Size of Sand #1		
	Type/Size of Sand #1 Sand Pack Thickness 48		
	Bottom of Screen	800	-751.1
	Bottom of Sump:	805	-756.1
	Bottom of Borehole	818	-769.1
Borehole Diar	neter: 10 inch Approved:		
escribe Measuring Point:	Valerie Thayer	6/14/2016	
Ground Surface	Signature	Date	

## Section 4

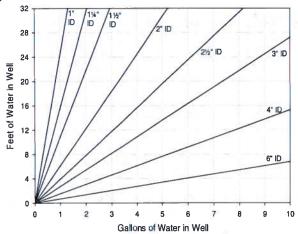
**Groundwater Sample Log Sheets** 



# **Low Flow Ground Water Sample Collection Record**

Client:	Nam N	WIRP Be	thnage			Date: 0	1201	16	Time: Start	will	am/pm
Project N		6026652		2 11		. Daie. <u>3</u>	<u>, –                                   </u>	10	Finish		am/pm
Site Loca Weather	ation:	Wide	1 4 10i			Coll	lector(s):	Paul 1			
1. WATI	ER LEVEL	DATA: (n	neasured t	from Top	of Casino	 a)					
	tal Well Ler			-			F. E	(a-b)	Casing Dia		aterial
b. Wa	ater Table [	Depth 25	1.87	d. Calcu	lated Syst	em Volum	ie (see back	) 13.1	gal. Zu		length (ft)
2. WELI	L PURGE [	DATA									
a. Pu	rge Method	l <u>:</u>	Geotech I	oladder pu	mp with d	rop tube a	ssembly				
- Te	ceptance C emperature - pH conductivity	± 3% ± 0.1 ur	1 1	eri eri loncac	Turbidity - ORP Tawdown			- D.O. Remove a	± 10% (val minimum 1		
c. Fie	ld Testing I	Equipmen	it used:	ATTA.	Make YSI	97.70	Model 556	R	Serial Num		100
				- 3	15 X X	1.1 Ag	E 3	6 80 a F	11.25	7 500 5	1 63 4
Time (24hr)	Volume Removed (gallons)	Temp.	Conduct. (mS/cm)	DO (mg/L)	pН	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Depth to water (ft)	Color	/Odor
930				*				650		OX	1
940		15.66	0.104	2.61	2.60	271.3	1.25		25.82	,	
945		15.50	0.121	1.42	3.51	190,5	92.3		25.83		11963
950											
955	5 Gal	15.64	0.130	0.69	4.37	137.4	35.2	650	25.84		
000	_	15.62	0.133	0.54	4.76	115.0					
Ha Ha	cceptance of as required as required ave parame	volume b turbidity b	een remov een reach lized		Yes	No	N/A			(continued or	n back)
3. SAMI	PLE COLL	ECTION:		Method:	Geotech	bladder p	ump with o	drop tube a	ssembly		
Sample I	D /3301		40-ml	er Type L vials	No. of Co	ontainers		ervation ICI		Cs	Time / 045
			1-L a	mber	2		ne	one	1,4-Di	oxane	1045
Commer	nts Liga	hit	bobbon	, stirr	ed up	the use	ter ea	lusan,	igh kurb	diky	
	,	-pirts	1 / WHA	Maria	paqua	WD				010000000000000000000000000000000000000	
Signatur	e <i>6</i>	and 1	vacet.	t)					_Date 4	9/20/	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:

RE 13301

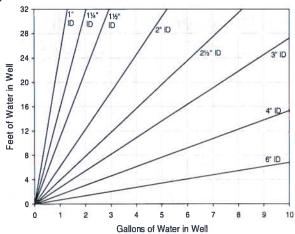
(continued from		/ \								
	Volume							Flow	1	
Time	Removed	Temp	pН	Conduct.	DO	ORP	Turbidity	Rate	Depth to	Color/Odor
(24 hr)	(Liters)	(°C)	<b>P</b>	(mS/cm)	(mg/L)	(mV)	(NTU)	(ml/min)	water (ft)	
1005		15.67	4.66	0.134	050	118.0				
1010	/	5,59	4.71	0.134	0:47	116.7	37.4	650	25.86	
1015	rogal	15.50	479	1.133	0.42	110.4	49 4			
1020	- Gyar		4.76	***	1.39	110.0	99.4 29.8			
1025				0.133	0.37	101.3				
1030		15.54	4.79	0.132	0.34	106.7	27.6			
1035	15ga		4.84		0.32	105.9	26.3			
7.5.0	390	7.00	7.00	<i>D</i> \$1 <i>J</i>		70011				
					3.0		20 1			
1045								200		Sample
7045							19			Je septe
		,								
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	- N - 3			-					<del>                                     </del>	
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L										

Well ID:	RE133	pz
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Client:	Noun	IWIRP Pa	thnage			Date: 9	1/201	16	Time: Start	840 am/pr
Client: Navy NWIRP Bethpage Project No: 60266526					_ Dale. <u>-s</u>	11 20 1	10	Finish		
Site Loca	ation:	-	s & How	ard		-				111111111
Weather	Conds:	clo	ady 70	10		_ Col	llector(s):	F. Bell	Pacelk. 8	Saby C.
1. WAT	ER LEVEL	DATA: (n	neasured t	rom Top	of Casin	g)				
	tal Well Ler								4-inch PV	
b. W	ater Table [	Depth 4	7.25	d. Calcu	lated Sys	tem Volun	∩e (see bac⊦	131	gal. <u>20</u>	screen length (f
	L PURGE Durge Method		Geotech b	oladder pu	ump with c	irop tube a	assembly		= =	
- Te	ceptance C emperature - pH Conductivity	± 3% ± 0.1 ur	1 60	Fynt				- D.O. Remove a	22.	lues >0.5 mg/L) screen volume
c. Fie	eld Testing l	Equipmen	t used:	9 -	Make YSI	16 J. A.	Model 556	1 2	Serial Nun	
			500		a Mot	te. a	2020 OW	3 17 18 18	674-	3817
	Volume			- 55			12	- 6		
Time (24hr)	Removed (gallons)	Temp. (°C)	Conduct. (mS/cm)	DO (mg/L)	pН	ORP (mV)	Turbidity (NTU)	Flow Rate (ml/min)	Depth to water (ft)	Color/Odor
1000		manufact of	Ale I ma	3 1	3	er are-c		600	26.46	OX
1005		17.34	0.043	2.12	4.83	126.7	1 220	1 0 1 2	26.49	Cloudy
1010	L	17.33	0.042	2.07	454	141.7	499	1.019	12 x10 = 1	- Day
1015		17.09	0.041	1-66	4.26	152.2		2600	26.51	
1020		17.02	0.041	1.17	4.31	148.4	867	1-1-4	1	
1025	56	16.97	0.037	0.96	4.30	139.4		600	26.52	
H:	cceptance of as required as required ave parame If no or N	volume b turbidity b	een remov een reach lized		Yes	No	N/A			(continued on back)
3. SAM	PLE COLL	ECTION:		Method:	Geotech	bladder p	ump with	drop tube a	ssembly	
Sample ZF/33	ID Da-GN-	09261	Contain	_ vials	3			ervation HCI	VC	is Req. Time
	N3-GW			mber	2		n	one	1,4-D	oxane /33()
Comme	nts									
Signatur				)		4			_Date	09-20-16

# 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 fro	m front)									
1	Volume							Flow		
	Removed		рН	Conduct.	DO	ORP	Turbidity		Depth to	
(24 hr)	(Liters)	(°C)		(mS/cm)			(NTU)		water (ft)	
1030		17-07	4.32	0.037	0.96.	139.4	840	450	26.49	Cloudy
1035	-51:	16.98	4.35	0.036	0.93	138.6	795	700	26.52	Clouck
10-10	_	17.83	4.44	0.037	0.86	134.4		400	26.51	Cloudy
1045		17.93	4.49	0.037	0.84	135.8		600	26.82	Cleanedout flow
1050	_	19.11	4,98	0.039	6.33	114.5	BOF	600	26.84	
1055	_	17.45	4.76	0.038	0.89	125.3	66		26.93	
1100	10Gal	17.57	4.73	0.037	0.88	130.5		600	26.96	
1105	746	1778	11.73	0.037	08. <b>3</b>	136.7	78	600	26.94	
11.10	-mare	17.80	11. FM	0.037	1.15	133.3	77	600	26.95	•
1115	-	17.69	4.72	0.037	0.79	136.9	83	600	26 921	
			- 0		-	4_				
37		٠								
11.30	Dan	ale.	tin	10				100		
	4									
				-						,
8										
			,							
		4								
No.										
									L	

#### Section 5

# **Analytical Data Validation**

[The Data Validation report included here contains only result tables for RE133D1 and RE133D2; for the complete September 2016 Quarterly Sampling Data Validation report with all well results tables, see September 2016 Groundwater Sampling Data Summary Report,

Bethpage, NY, Resolution Consultants, 2016.]

### September 2016 Final Results after Data Review

NWIRP Bethpage OU 2 Regional Groundwater Investigation

		Sar	Ery Group Lab ID Sample ID mple Date mple Type	SJ7597 SJ7597-1 RE133D1-GW-092016 9/20/2016 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	4.1	J	С	
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	UJ	С	
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	UJ	С	
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	U		
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	UJ	С	
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		
	1,4-DIOXANE	123-91-1	UG_L	0.16	J		

#### Notes:

UG\_L

= Micrograms per liter= Final qualifiers (See Attachment B)= Reason codes (See Attachment C) Qual RC

### September 2016 Final Results after Data Review

NWIRP Bethpage OU 2 Regional Groundwater Investigation

		Sar	Ery Group Lab ID Eample ID Inple Date Inple Type	SJ7597 SJ7597-2 RE133D2-GW-092016 9/20/2016 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	С
8260C	BENZENE	71-43-2	UG L	0.5	U	
8260C	BROMODICHLOROMETHANE	75-27-4	UG L	0.5	Ü	
8260C	BROMOFORM	75-25-2	UG L	0.5	Ü	
8260C	BROMOMETHANE	74-83-9	UG L	1	Ü	
8260C	CARBON DISULFIDE	75-15-0	UG L	0.5	UJ	С
8260C	CARBON TETRACHLORIDE	56-23-5	UG L	0.5	U	
8260C	CHLOROBENZENE	108-90-7	UG L	0.5	Ü	
8260C	CHLOROETHANE	75-00-3	UG L	1	UJ	С
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	Ü	
8260C	CIS-1,3-DICHLOROPROPENE	10061-01-5	UG L	0.5	Ü	
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	Ü	
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	UJ	С
8260C	METHYL CYCLOHEXANE	108-87-2	UG_L	0.5	U	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	
	1,4-DIOXANE	123-91-1	UG_L	0.17	U	

#### Notes:

UG\_L

= Micrograms per liter= Final qualifiers (See Attachment B)= Reason codes (See Attachment C) Qual RC



#### **DATA VALIDATION REPORT**

Project:	Regional Groundwater Investigation — NWIRP Bethpage						
Laboratory:	Katahdin Analytical						
Sample Delivery Groups:	SJ5057						
Analyses/Method:		Total Organic Carbon (TOC) by U.S. EPA SW-846 Method 9060A and Standard Method 5310B for Total Organic Carbon by High-Temperature Combustion					
Validation Level:	2						
Project Number:	0888812477.SA.DV						
Prepared by:	Dana Miller/Resolution Consultants	Completed on: 08/01/2016					
Reviewed by:	Tina Cantwell/Resolution Consultants	File Name: SJ5057_ 9060A_5310B					

#### **SUMMARY**

This report summarizes data review findings for samples listed below, collected by Resolution Consultants from the Regional Groundwater Investigation — NWIRP Bethpage site on 5 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
RE133D1-SO-070516-568-570	SJ5057-1	Soil	9060A, 2540G
RE133D1-EB-070516	SJ5057-2	Equipment Blank	5310B

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), *Method SM5310B, Total Organic Carbon by High-Temperature Combustion, U.S. Environmental Protection Agency (U.S. EPA) Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (NFG, January 2010, 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
- X Laboratory blanks/equipment 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  $(\checkmark)$  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. The symbol (X) indicates that a QC non-conformance resulted in the qualification of data. 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.

#### **RESULTS**

### Laboratory Blanks/ Equipment Blanks

Laboratory blanks and equipment blanks were analyzed with samples to assess contamination imparted by sample preparation and/or analysis. All results associated with a particular blank were evaluated to determine whether there was an inherent variability in the data, or if a problem was an isolated occurrence that did not affect the data. Samples were flagged in accordance with *Functional Guidelines* (shown below) where detections were not believed to be site-related.



# **Blank Non-conformance Charts:**

For co	ommon lab	contaminants (me	ethylene chloride, acetone, 2-butanone):
Blank type	Blank result	Sample result	Action for samples
Method,	Detects	Not detected	No qualification
Storage,		< 2x LOQ	Report sample LOQ value with a U
Trip, Field, or	<u>&lt;</u> 2x LOQ	2x LOQ and <     4x the LOQ	Report the sample result with a U**
Equipment		4x the LOQ	No qualifications
		< LOD	Report sample LOD value with a U**
		<u>&gt;</u> LOD and < 2x LOQ	Report sample LOQ value with a U
	> 2x LOQ	2x LOQ and < blank contamination	Report the blank result with a U or reject the sample result as unusable R
		2x LOQ and > blank	If the result is <2x blank result, report the sample result U.**
		contamination	If the result is > 2x blank result, no qualification is required. **
**Based on	Resolution	Consultants profe	essional judgment

	For all other compounds:									
Blank type	Blank result	Sample result	Action for samples							
	Detects	Not detected	No qualification							
	< 2x LOQ	< 2x LOQ	Report sample LOQ value with a U							
	< 2X LOQ	<u>&gt;</u> 2x LOQ	Use professional judgment							
		< 2x LOQ	Report sample LOQ value with a U							
Method, Storage,	> 2x LOQ	2x LOQ and < blank contamination	Report the blank result with a U or reject the sample result as unusable R							
Trip, Field, or Equipment		≥ 2x LOQ and ≥ blank contamination	If the result is <2x blank result, report the sample result U.  If the result is > 2x blank result, no qualification is required.							
	= 2x LOQ	< 2x LOQ	Report sample LOQ value with a U							
	- 2X LOQ	≥ 2x LOQ	Use professional judgment							
	Gross contamination	Detects	Qualify results as unusable R							

# Notes:

LOQ = Limit of quantitation LOD = Limit of detection

U = Undetected R = Rejected

The laboratory blank non-conformance is summarized in Attachment A in Table A-1.



# **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. All analytes detected at concentrations less than the limit of quantitation but greater than the method detection limit were qualified by the laboratory as estimated (J). This "J" qualifier was retained during data validation.

No results were rejected; therefore, analytical completeness was calculated to be 100 percent. Data not qualified during data review are considered usable by the project. The remaining results qualified as estimated may be high or low, but the data are usable for their intended purpose, according to U.S. EPA and Department of Defense guidelines. Final data review qualifiers used to describe results and how they should be interpreted by the end data user are provided in Attachment B, Table B-1.

#### **ATTACHMENTS**

Attachment A: Table A-1, Non-Conformance Summary Tables Attachment B: Table B-1, Final Results after Data Review

Attachment A
Non-Conformance Summary Table

Table A-1
Laboratory Blank Non-Conformance
Regional Groundwater Investigation NWIRP Bethpage

				Blank			
				Result		<b>Detected Associated</b>	
Blank ID	Batches	Method	Analyte	(MG_L)	LOQ	Samples	Qualifier
WG186943-1	WG186943	5310B	Total Organic Carbon	0.19	1	RE133D1-EB-070516	U

# Notes:

ID = Identification

MG\_L = Milligrams per liter

LOQ = Limit of quantitation

U = Undetected value

Attachment B Final Results after Data Review

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

Sample Delivery Group				SJ5057			SJ5057		
Lab ID				SJ5057-1			SJ5057-2		
Sample ID				RE133D1-SO-070516-568-570			RE133D1-EB-070516		
Sample Date			7/5/2016			7/5/2016			
Sample Type			Soil			Equipment Blank			
Method	Analyte	CAS No	Units	Result	Qual	RC	Result	Qual	RC
2540G	TOTAL SOLIDS	-29	PCT	82			NA		
5310B	TOTAL ORGANIC CARBON	-28	MG_L	NA			0.5	UJ	bl
9060A	TOTAL ORGANIC CARBON	-28	UG_G	720			NA		

#### Notes:

ID = Identification PCT = Percent

MG\_L = Milligrams per liter
UG\_G = Micrograms per gram

NA = Not analyzed

### Final Qualifier:

UJ = Undetected and estimated – The parameter was analyzed but not detected at concentrations above the listed sample detection limit; the sample detection limit is estimated because one quality control parameter was outside of control limits.

#### Reason Code:

bl = Qualified undetected and estimated due to lab blank contamination.



#### **DATA VALIDATION REPORT**

Project:	Regional Groundwater Investigation — NWIRP Bethpage				
Laboratory:	Katahdin Analytical				
Sample Delivery Groups:	SJ4357				
Analyses/Method:	Total Organic Carbon (TOC) by U.S. EPA SW-846 Method 9060A and Standard Method 5310B for Total Organic Carbon by High-Temperature Combustion				
Validation Level:	2				
Project Number:	0888812477.SA.DV				
Prepared by:	Dana Miller/Resolution Consultants	Completed on: 08/01/2016			
Reviewed by:	Tina Cantwell/Resolution Consultants	File Name: SJ4357_ 9060A_5310B			

#### **SUMMARY**

This report summarizes data review findings for samples listed below, collected by Resolution Consultants from the Regional Groundwater Investigation — NWIRP Bethpage site on 10 June 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	
RE133D2-EB-061016	SJ4357-1	Equipment Blank	5310B	
RE133D2-SO-0610-783-785	SJ4357-2	Soil	9060A, 2540G	

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), *Method SM5310B, Total Organic Carbon by High-Temperature Combustion, U.S. Environmental Protection Agency (U.S. EPA) Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (NFG, January 2010, 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. All analytes detected at concentrations less than the limit of quantitation but greater than the method detection limit were qualified by the laboratory as estimated (J). This "J" qualifier was retained during data validation. 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			SJ4357	SJ4357	
	Lab ID			SJ4357-1	SJ4357-2	
	Sample ID			RE133D2-EB-061016	RE133D2-SO-0610-783-785	
	Sample Date			6/10/2016	6/10/2016	
	Sample		ample Type	Equipment Blank	Soil	
Method	Analyte	CAS No	Units	Result	Result	
2540G	TOTAL SOLIDS	-29	PCT	NA	90	
5310B	TOTAL ORGANIC CARBON	-28	MG_L	0.35 J	NA	
9060A	TOTAL ORGANIC CARBON	-28	UG_G	NA	400 J	

### Notes:

ID = Identification PCT = Percent

MG\_L = Milligrams per liter
UG\_G = Micrograms per gram

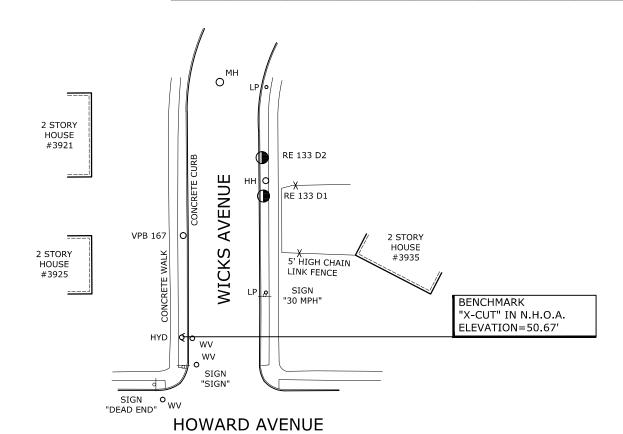
NA = Not analyzed

Estimated value – The reported value is greater than or equal to the method detection limit but less than the limit of quantitation.

Section 6

Survey

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 167 193959.30 1126194.17 N40-41-52.48 W73-29-17.15 48.85 NA NA RE 133 D1 193975.82 1126227.64 N40-41-52.64 W73-29-16.72 48.89 48.91 48.38 RE 133 D2 193991.82 1126227.06 N40-41-52.80 W73-29-16.72 48.91 49.02 48.72



#### Legend

O HH Hand Hole

4
HYD
Hydrant

LP Light Pole

Mw Monitoring Well

O MH Manhole

O VPB 167 Vertical Profile Boring

o wv Water Valve

#### Map Notes

CONCRETE CURB

- Information shown hereon was compiled from an actual field survey conducted on October 12, 2016.
- 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. 16-577

Date	RECORD OF	Appr.		
Drafter: GLB		Checker: JFC		
Appr. by: JFC		Proj. No. 14.4121		_ ا

VERTICAL PROFILE BORING 167 SURVEY LOCATION HOWARD AVENUE/WICKS AVENUE

TOWN OF BETHPAGE NASSAU COUNTY, NEW YORK

#### C.T. MALE ASSOCIATES

Engineering, Surveying, Architecture & Landscape Architecture, D.P.C.

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SCALE: 1"=40' DATE:OCT. 12, 2016

# **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 Conceptual Site Model (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 Environmental Sequence Stratigraphy (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).

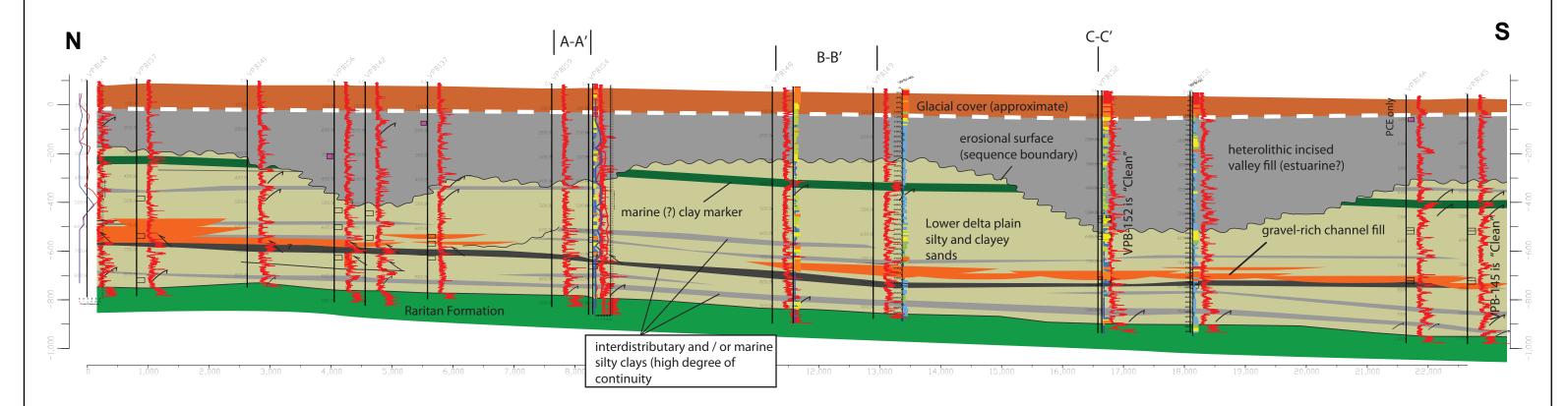
Logs of natural gamma emissions are a common proxy for grainsize. They typically are used as a correlation aide because repetitive spatially extensive trends in grainsize are easily identified visually when curves are examined along a given section. In non-granitic aquifer material, the chemistry of 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 tech 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 VPB-139 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)



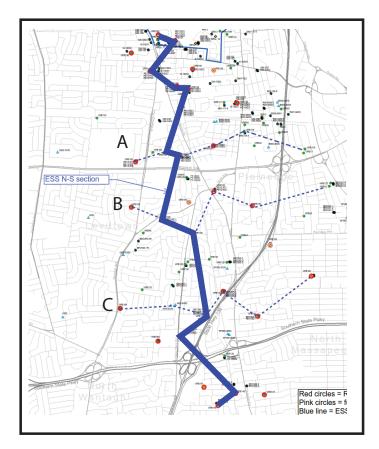
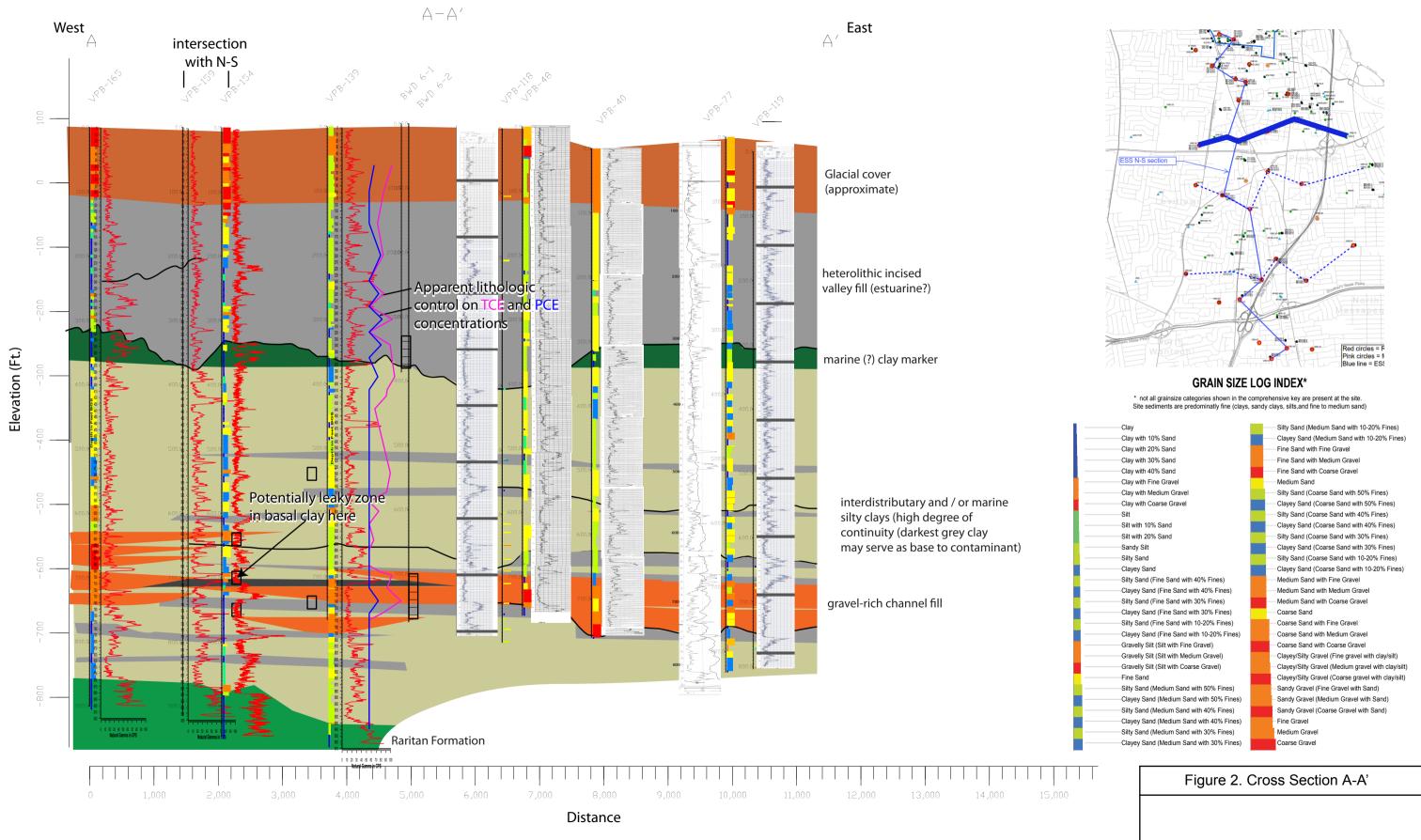
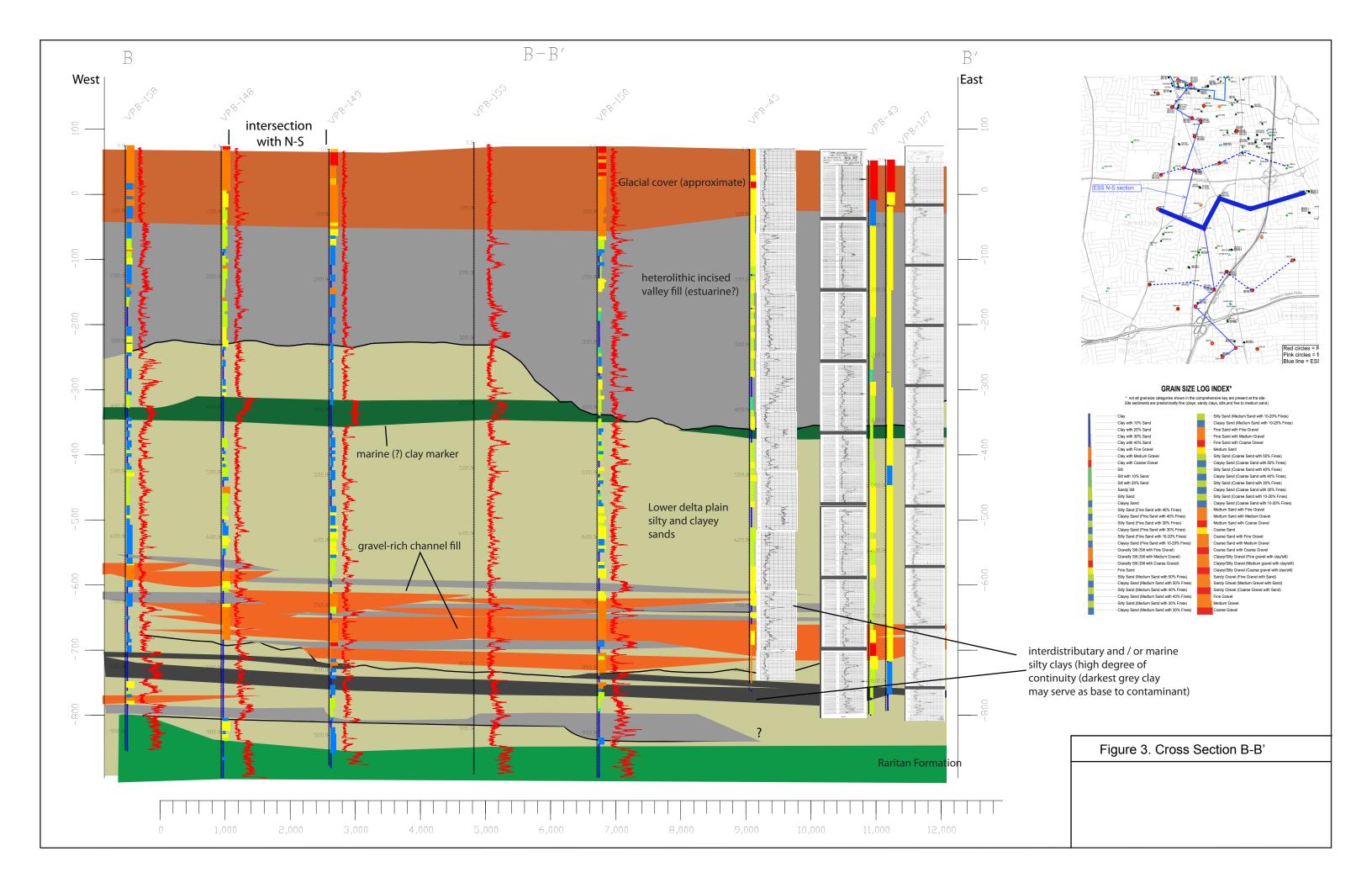
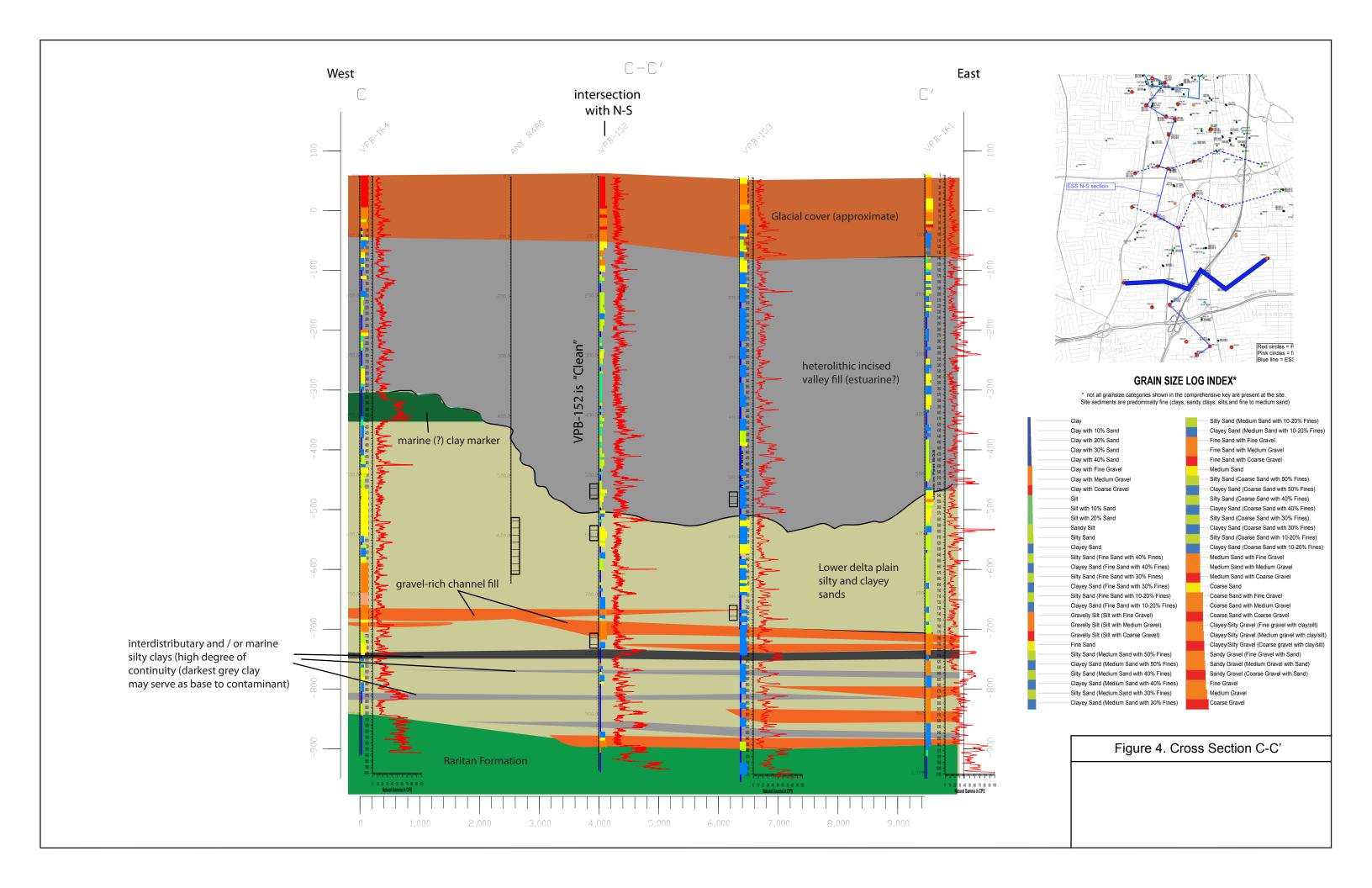


Figure 1. Cross Section N-S







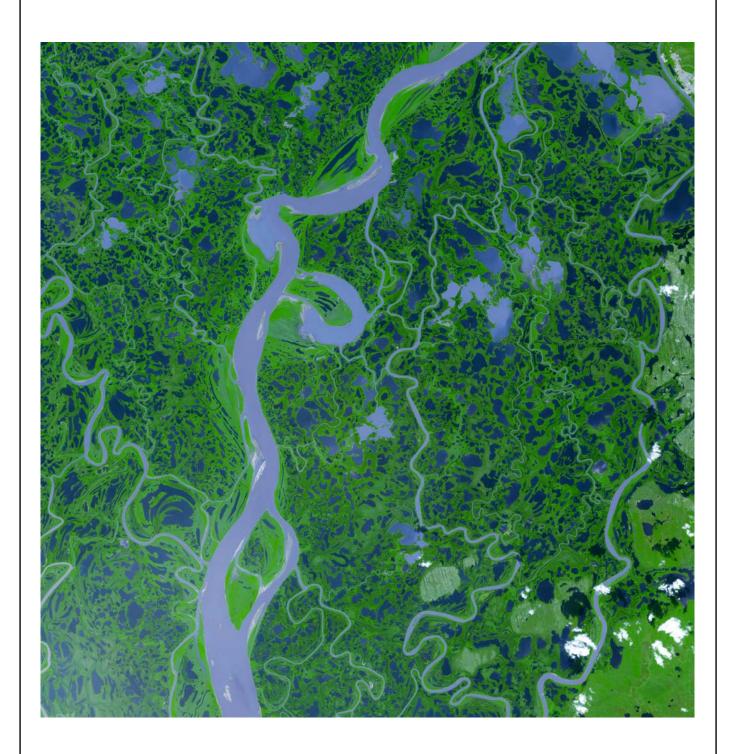




Figure 5. Mackenzie River Delta depositional environment

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. <a href="http://earthobservatory.nasa.gov/IOTD/view.php?id=8320">http://earthobservatory.nasa.gov/IOTD/view.php?id=8320</a>





Figure 6. Braided river depositional environment

Source: East Fork Toklat River, Alaska Range, Denali National Park <a href="https://pubs.usgs.gov/of/2004/1216/b/b.html">https://pubs.usgs.gov/of/2004/1216/b/b.html</a>