2017-2018 OPERABLE UNIT 2 GROUNDWATER INVESTIGATION RE116 (VPB150) INSTALLATION REPORT

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
SITE 1 OPERABLE UNIT 2
BETHPAGE, NY

Prepared for:

Department of the Navy
Naval Facilities Engineering Command, Atlantic
9324 Virginia Avenue
Building Z-140
Norfolk, Virginia 23511

October 2019

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RE116 (VPB150)
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Prepared for:

Department of the Navy
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9324 Virginia Avenue
Building Z-140
Norfolk, Virginia 23511

Prepared by:

Resolution Consultants
A Joint Venture of AECOM & EnSafe
1500 Wells Fargo Building
440 Monticello Avenue
Norfolk, Virginia 23510

Contract Number: N62470-11-D-8013
CONTRACT TASK ORDER WE15

October 2019

Brian Caldwell

Brian Caldwell
Contract Task Order Manager

Table of Contents

Tables

Figures

Appendices

List of Acronyms and Abbreviations

AOC	Area of Concern
bgs	below ground surface
COR	Continuously Operating Reference
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
PCE	Tetrachloroethene
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 one monitoring well in 2017 and one initial groundwater monitoring event in 2018 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). The location of well RE116D1 is shown in Figure 2.

1.1 Scope and Objectives

This report provides information on the installation of monitoring well RE116D1 associated with Vertical Profile Boring (VPB) 150. The purpose of this investigation was to ascertain subsurface conditions and contaminant levels south of Hempstead Turnpike, north of Southern State Parkway, and east of Hicksville Road. The location of RE116D1, as well as other VPBs and monitoring well locations, is shown in Figure 2.

The field investigation included completing one monitoring well, well development, soil/groundwater analysis, groundwater samples, and surveying. Field tasks were conducted in 2017 and 2018 in accordance with the *United Federal Programs Sampling and Analysis Plan (UFP SAP)*, Bethpage, New York (Resolution Consultants, 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

1.3.1 Depositional Environment

Resolution Consultants applied a technique known as Environmental Sequence Stratigraphy (ESS) to combine results from regional studies with onsite continuous boring and gamma logs to develop a sequence stratigraphic framework for the Late Cretaceous Turonian age (~94 million years ago) Magothy Formation underlying NWIRP Bethpage. The ESS analysis, including the construction of high-resolution base-wide cross sections, is documented in Appendix B. A summary of salient conclusions regarding the depositional environment, stratigraphy and impact on hydrogreology at the site is provided here.

Previous sequence stratigraphic studies of the New Jersey and New York Coastal Plains have shown that facies successions in the region can largely be explained by global sea level oscillations and sediment supply. The Turonian age sea level changes resulted in several phases of seaward progradation and landward retrogradation that affected the deposition and preservation of lithologic sequences in the Magothy. Periods of elevated or low sea level have a distinct effect on shoreline position and the types of deltaic facies that are deposited on the coastal plain. During high sea level, marine to distal deltaic facies tend to form. In contrast, during periods of low relative sea level, marginal to nonmarine deltaic facies are deposited.

Changes in sediment supply resulting from the tectonic uplift and weathering of the ancestral Appalachians during the Albian stage (~100 million years ago) also influenced depositional environments in the region. The large influx of coarse sediments is reflected in the rapid seaward progradation of the shoreline and extensive delta plain deposits (Magothy Formation) on the New Jersey Coastal Plain.

1.3.2 Stratigraphy

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 in descending order: 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 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. The ESS analysis concluded that these continental deposits are considerably thicker than previously thought, ranging from 50 – 300 ft. Directly underlying this unit is the Magothy Formation with a thickness of 650 to 900 ft that extends to a depth 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 VPB150, the bottom of the Magothy (top of the Raritan Clay) is encountered at approximately 928 ft 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 groundwater 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.

1.3.3 Hydrogeology

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. Because of the presence of intermittent clay layers and the depths, the Magothy Aquifer is commonly regarded to function overall as an unconfined aquifer at shallow depths and a confined aquifer at greater 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.

Groundwater is encountered at an average 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. Depth to water in the vicinity of the RE116D1 well is approximately 29 ft bgs, as measured on March 29, 2018. The groundwater flow in the area is to the south-southeast.

The ESS results provide important insight into the distribution of transmissive and storage zones at the Site. Considerable heterogeneity exists in the subsurface due to alternating depositional environments that resulted from changes in sea level and sediment supply. Laterally continuous fluvial sands and distributary mouth bars are inferred to represent high permeability units and conduits for groundwater flow/contaminant transport, however, the continuity of those units is variable. Fine-grained muds deposited during maximum flooding appear to correlate to contamination data peaks, potentially acting as storage units by adsorption to fine-grained muds.

2.0 FIELD PROGRAM

One monitoring well was installed in the vicinity of VPB150 between December 4, 2017 and December 20, 2017. 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 well RE116D1 was installed using mud rotary drilling techniques (Figure 2). The depth of monitoring well RE116D1 was 595 ft. Well construction details are summarized in Table 1. The boring log for RE116D1 with lithologic descriptions of the well screen interval is included in Appendix A. *2014 OU2 Groundwater Investigation Data Summary Report VPB150* (Resolution Consultants, 2014) documents the installation of VPB150 including detailed lithologic descriptions, continuous gamma plot and multiple volatile organic compounds (VOC) sample results over the entire boring length. The gamma and trichloroethene (TCE)/ tetrachloroethene (PCE) plot for VPB150, which also depicts the well screen interval at RE116D1, is included in Appendix A.

Prior to installing the monitoring well, the screen interval was determined based on an ability to monitor the screen interval of nearby production well SFWD 3-1. 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.

Well RE116D1 was constructed of 4-inch diameter, Schedule 80, National Sanitation Foundation-approved polyvinylchloride (PVC) riser pipe and 0.010-slot well screen. The well was completed at the surface with a 12-inch diameter steel curb box. The well riser was set below grade and fit with lockable J plugs. A detailed monitoring well construction diagram is included in Appendix A.

2.2 Well Development

Following installation, RE116D1 was 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.

The well screen was 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.

2.3 Sampling

Following development, the well was allowed to stabilize for at least 2 weeks prior to groundwater sampling in accordance with low flow sampling procedures. The well was 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. After purging for 120 minutes and removing 18 gallons (approximately 1.5 screen volumes), turbidity at RE116D1 did not decrease below 630 NTU. Since other water quality parameters had stabilized it was decided to take the groundwater sample despite the high turbidity.

Samples were analyzed for VOCs via method 8260C and 1,4-dioxane via method 8270D SIM by Katahdin. The flow rate for sample collection was 200-250 mL/minute. 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 well RE116D1 was sampled by Resolution Consultants on February 8, 2018. Analytical results and stabilized field parameters for RE116D1 are summarized in Table 3 and 4, respectively. Data validation is documented in Appendix A. Monitoring well RE116D1 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 IDW (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 Semivolatile 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, NWIRP Bethpage, New York*. April 2013.

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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
2017-2018 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)
RE116D1	12/20/2017	73.35	72.82	595	50	570-590	590-595	608

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

TABLE 2
MONITORING WELL DEVELOPMENT SUMMARY
2017-2018 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)		
RE116D1	1/9/2018	4,500	1/10/18, 1/11/18	570-590	12,000	16,500	50

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

TABLE 3
ANALYTICAL DATA SUMMARY
2017-2018 OU2 GROUNDWATER INVESTIGATION

Location	NYSDEC Groundwater Guidance or Standard Value (Note 1)	RE116D1	RE116D1
Sample Date		2/8/2018	2/8/2018
Sample ID		RE116D1-GW-020818	DUP01-GW-020818
Sample type code		N	FD
VOC 8260C (ug/L)			
1,1,1-TRICHLOROETHANE	5	<0.5 U	<0.5 U
1,1,2,2-TETRACHLOROETHANE	5	<0.5 U	<0.5 U
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	5	<0.5 U	<0.5 U
1,1,2-TRICHLOROETHANE	1	<0.5 U	<0.5 U
1,1-DICHLOROETHANE	5	<0.5 U	<0.5 U
1,1-DICHLOROETHENE	5	<0.5 U	<0.5 U
1,2,4-TRICHLOROBENZENE	5	<0.5 U	<0.5 U
1,2-DIBROMO-3-CHLOROPROPANE	0.04	***<0.75 U***	***<0.75 U***
1,2-DIBROMOETHANE	NL	<0.5 U	<0.5 U
1,2-DICHLOROBENZENE	3	<0.5 U	<0.5 U
1,2-DICHLOROETHANE	5	<0.5 U	<0.5 U
1,2-DICHLOROETHENE, TOTAL	5	<1 U	<1 U
1,2-DICHLOROPROPANE	1	<0.5 U	<0.5 U
1,3-DICHLOROBENZENE	3	<0.5 U	<0.5 U
1,4-DICHLOROBENZENE	3	<0.5 U	<0.5 U
1,4-DIOXANE (Method 8270D_SIM)	NL	**4.9 J**	**3.4 J**
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 U	<2.5 U
BENZENE	1	<0.5 U	<0.5 U
BROMODICHLOROMETHANE	50	<0.5 U	<0.5 U
BROMOFORM	50	<0.5 U	<0.5 U
BROMOMETHANE	5	<1 U	<1 U
CARBON DISULFIDE	60	<0.5 U	<0.5 U
CARBON TETRACHLORIDE	5	<0.5 U	<0.5 U
CHLOROBENZENE	5	<0.5 U	<0.5 U
CHLOROETHANE	5	<1 U	<1 U
CHLOROFORM	7	<0.5 U	<0.5 U
CHLOROMETHANE	5	<1 U	<1 U
CIS-1,2-DICHLOROETHENE	5	<0.5 U	<0.5 U
CIS-1,3-DICHLOROPROPENE	0.4	***<0.5 U***	***<0.5 U***
CYCLOHEXANE	NL	<0.5 U	<0.5 U
DIBROMOCHLOROMETHANE	5	<0.5 U	<0.5 U
DICHLORODIFLUOROMETHANE	5	<1 U	<1 U
ETHYLBENZENE	5	<0.5 U	<0.5 U
ISOPROPYLBENZENE	5	<0.5 U	<0.5 U
M- AND P-XYLENE	NL	<1 U	<1 U
METHYL ACETATE	NL	<0.75 U	<0.75 U
METHYL CYCLOHEXANE	NL	<0.5 U	<0.5 U
METHYL TERT-BUTYL ETHER	10	<0.5 U	<0.5 U
METHYLENE CHLORIDE	5	<2.5 U	<2.5 U
O-XYLENE	NL	<0.5 U	<0.5 U
STYRENE	5	<0.5 U	<0.5 U
TETRACHLOROETHENE	5	<0.5 U	<0.5 U
TOLUENE	5	<0.5 U	<0.5 U
TRANS-1,2-DICHLOROETHENE	5	<0.5 U	<0.5 U
TRANS-1,3-DICHLOROPROPENE	0.4	***<0.5 U***	***<0.5 U***
TRICHLOROETHENE	5	<0.5 U	<0.5 U
TRICHLOROFLUOROMETHANE	5	<1 U	<1 U
VINYL CHLORIDE	2	<1 U	<1 U
XYLENES, TOTAL	5	<1.5 U	<1.5 U

TABLE 3
ANALYTICAL DATA SUMMARY
2017-2018 OU2 GROUNDWATER INVESTIGATION

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

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

U = Nondetected result. The analyte was not detected and was reported as less than the LOD or as defined by the customer. The LOD has been adjusted for any dilution or concentration of the sample.
J = Estimated value. One or more quality control parameters were outside control limits or the analyte concentration was less than the limit of quantitation.
LOD = Limit of detection.

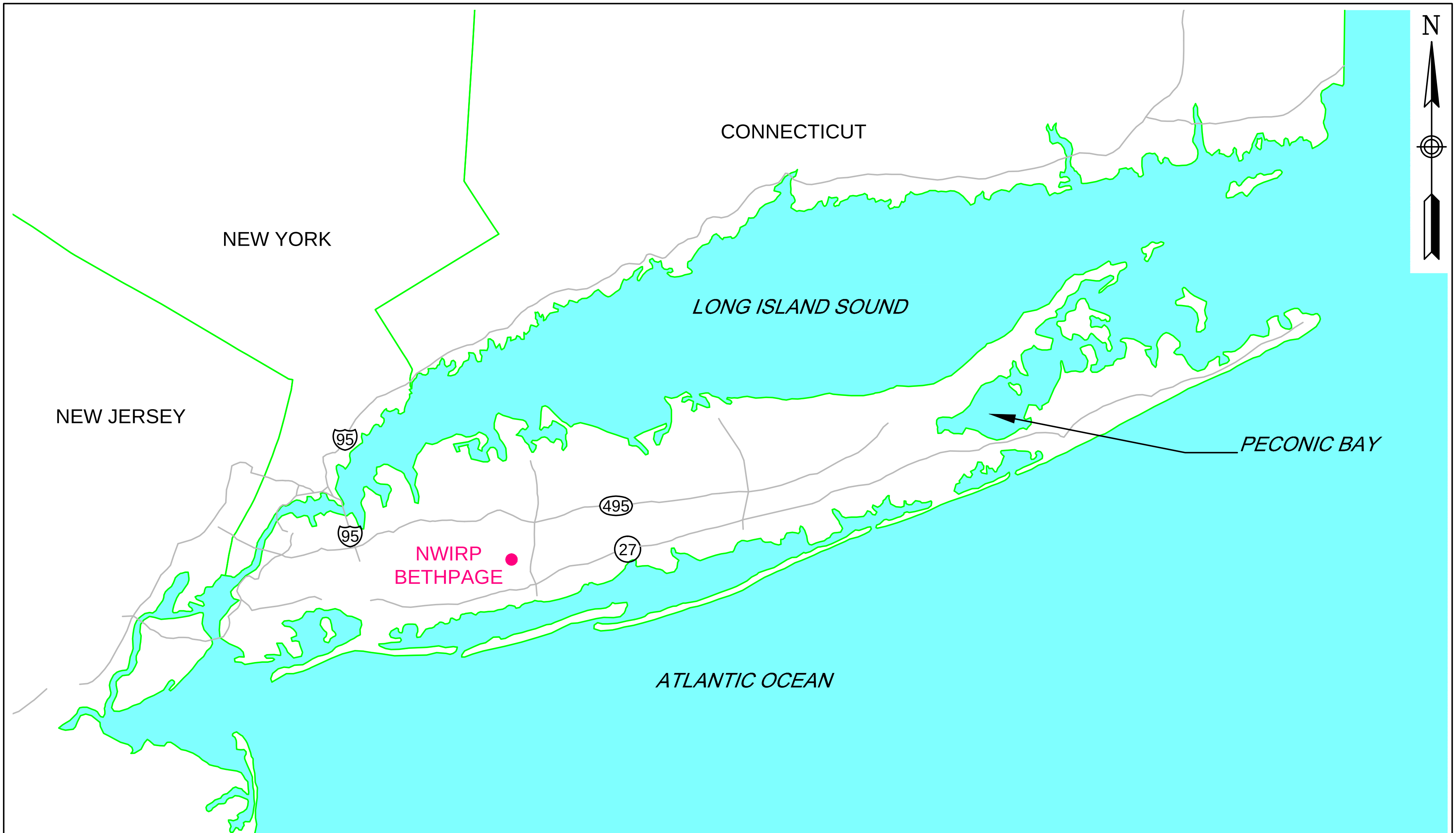
TABLE 4
STABILIZED FIELD PARAMETERS
2017-2018 OU2 GROUNDWATER INVESTIGATION
NWIRP BETHPAGE, NY

Well	Date	Temperature (°C)	Specific Conductance (µS/cm)	DO (mg/L)	pH	ORP (mV)	Turbidity (NTU)	Purge Flow rate (ml/min)	Depth to water (ft bgs)
RE116D1	2/8/2018	13.39	0.096	3.95	3.62	103.0	630	500	31.02

°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

After purging, wells were sampled at a flow rate of 200-250 ml/min.

Figures



NAVFAC

GENERAL LOCATION MAP
NWIRP BETHPAGE
BETHPAGE, NEW YORK

CONTRACT NUMBER	CTO NUMBER
N62470-11-D-8013	WE15
APPROVED BY — —	DATE — —
APPROVED BY — —	DATE — —
FIGURE NO. 1	REV 0

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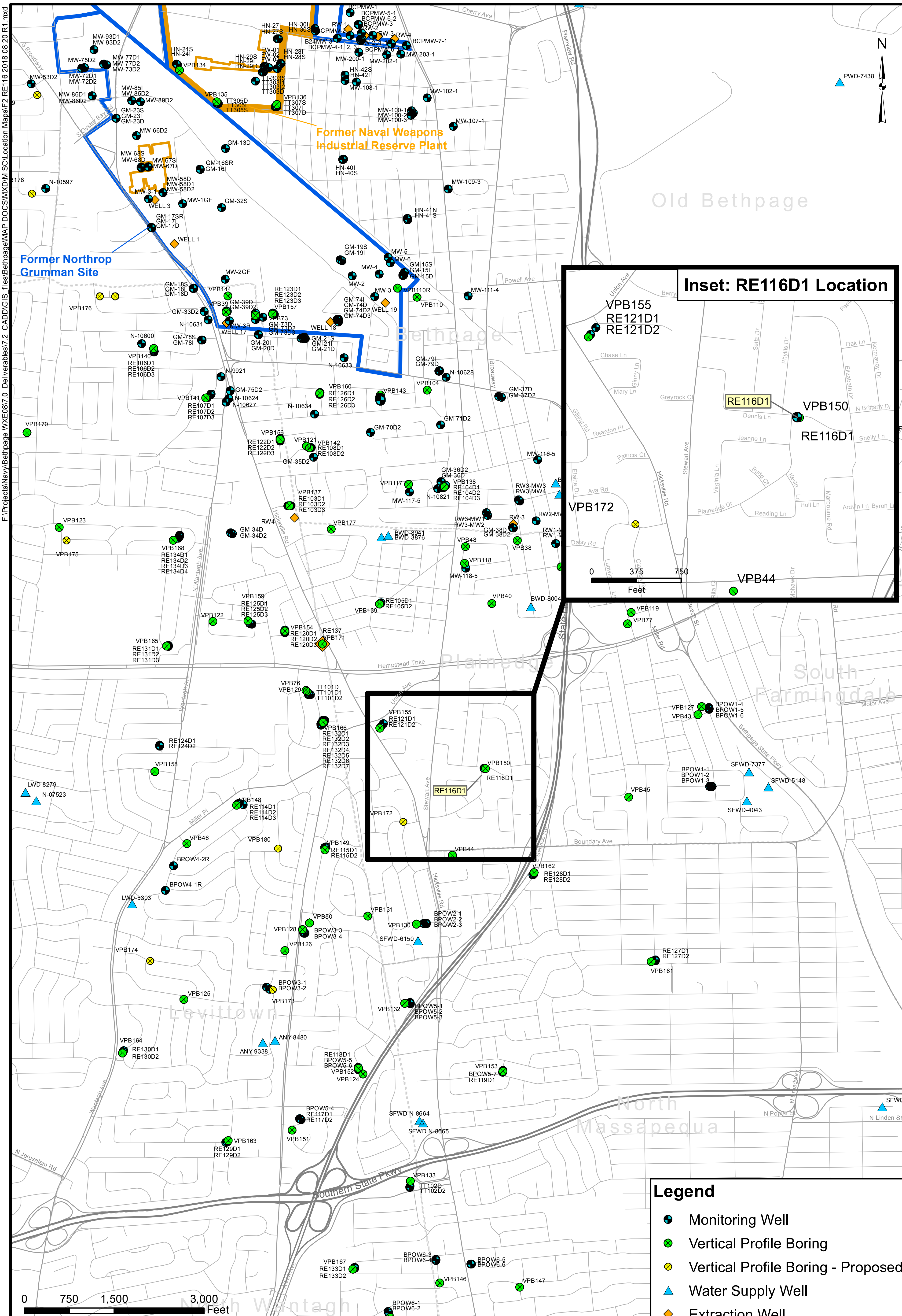

CONTRACT NUMBER	CTO NUMBER
N62470-11-D8013	WE15
APPROVED BY	DATE
PS	8/20/2018
APPROVED BY	DATE
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FIGURE NO.	REV
2	0

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RE116 LOCATION MAP
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT
BETHPAGE, NEW YORK

Appendices

Appendix A

RE116

Section 1

Boring Log

Resolution Consultants

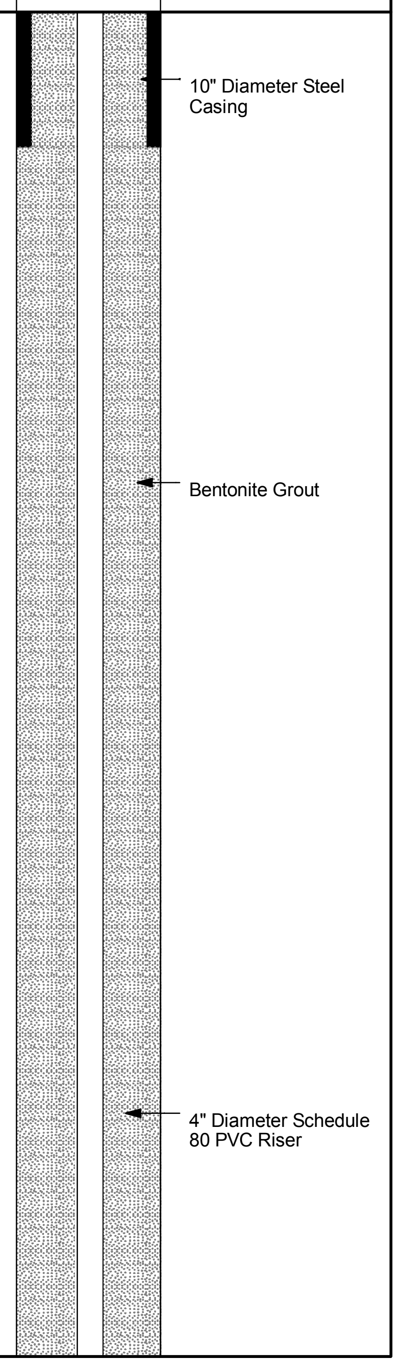
Boring Log

BORING #: **RE116D1**

Client: Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic		**Logged By:** F. Bell
Location: Dennis Lane and Plainedge Drive, Bethpage, NY		**Drilling Company:** Delta Well & Pump
Project #: 60266526	**Ground Elevation (msl):** 73.35	**Well Screen Interval (ft):** 570-590
Start Date: 12/4/2017	**Drilling Method:** Auger (0-50' bgs) Mud Rotary (>50' bgs)	**Water Level (ft):**
Finish Date: 12/20/2017	**Northing:** 202312.88 **Easting:** 1128388.54	**Total Depth (ft):** 608.0

Casing installed with auger rig 12/4/17 – 12/5/17.

DEPTH (ft)	PID (ppm)	Formation	USCS	GRAPHIC LOG	MATERIAL DESCRIPTION	Well Completion	Well Construction
0					0-573 ft bgs: See VPB150 for Descriptions		
50							
100							
150							
200							
250							
300							
350							
400							
450							
500							



Resolution Consultants

Boring Log

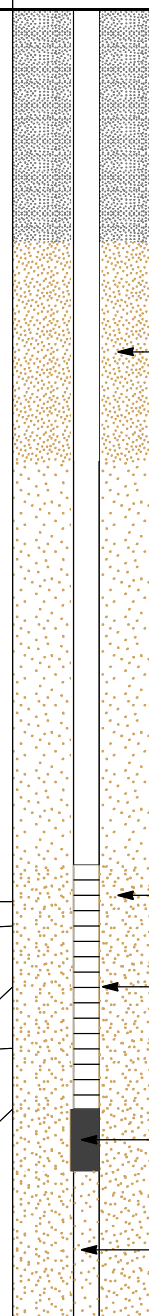
BORING #: **RE116D1**

Client: Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic		**Logged By:** F. Bell
Location: Dennis Lane and Plainedge Drive, Bethpage, NY		**Drilling Company:** Delta Well & Pump
Project #: 60266526	**Ground Elevation (msl):** 73.35	**Well Screen Interval (ft):** 570-590
Start Date: 12/4/2017	**Drilling Method:** Auger (0-50' bgs) Mud Rotary (>50' bgs)	**Water Level (ft):**
Finish Date: 12/20/2017	**Northing:** 202312.88 **Easting:** 1128388.54	**Total Depth (ft):** 608.0

DEPTH (ft)	PID (ppm)	Formation	USCS	GRAPHIC LOG	MATERIAL DESCRIPTION
500					0-573 ft bgs: See VPB150 for Descriptions *(continued)*
573-576	0		SP		Gray (10YR 5/1) poorly graded fine SAND, trace lean Clay
578-581	0		SP		Gray (10YR 5/1) poorly graded fine to medium subrounded SAND, trace Silt
583-586	0		SP		Gray (10YR 5/1) poorly graded subrounded SAND, trace Silt
588-591	0		SP		Grayish brown (10 YR 5/2) poorly graded fine SAND, trace Silt, pyrite and lignite
608					End of boring at 608.0 ft. bgs.

Depth scale (ft): 500, 502, 504, 506, 508, 510, 512, 514, 516, 518, 520, 522, 524, 526, 528, 530, 532, 534, 536, 538, 540, 542, 544, 546, 548, 550, 552, 554, 556, 558, 560, 562, 564, 566, 568, 570, 572, 574, 576, 578, 580, 582, 584, 586, 588, 590, 592, 594, 596, 598, 600, 602, 604, 606, 608

Well Completion



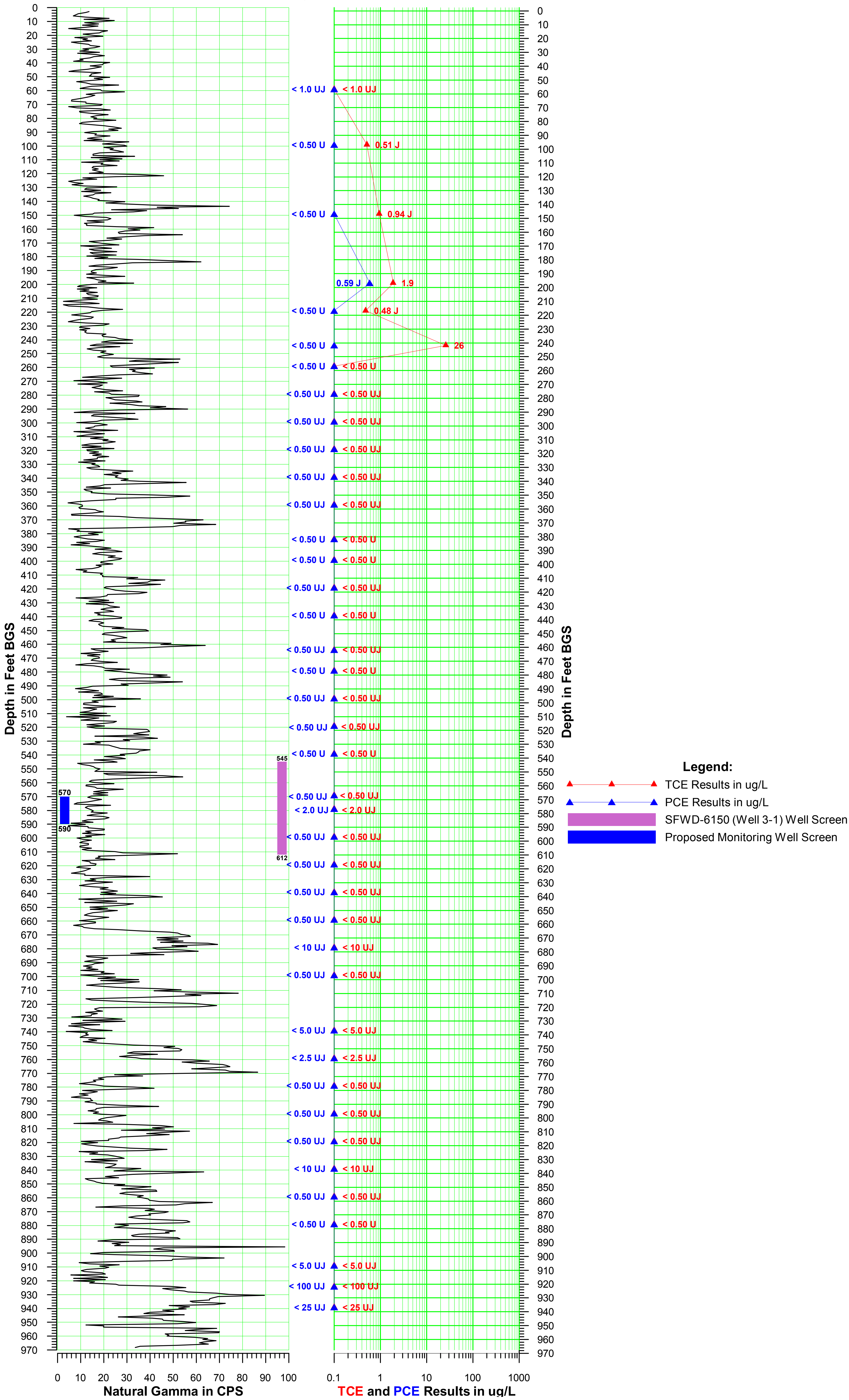
Well Construction

- 4" Diameter Schedule 80 PVC Riser *(continued)*
- #0 Filter Sand
- #1 Filter Sand
- 4" Diameter Schedule 80 PVC, 10 Slot Well Screen (570-590 ft bgs)
- Sump
- #1 Sand to bottom

Section 2

VPB150 Gamma and TCE / PCE Plot

Vertical Profile Boring VPB150
Downward Run - May 2, 2014
Validated Analytical Data



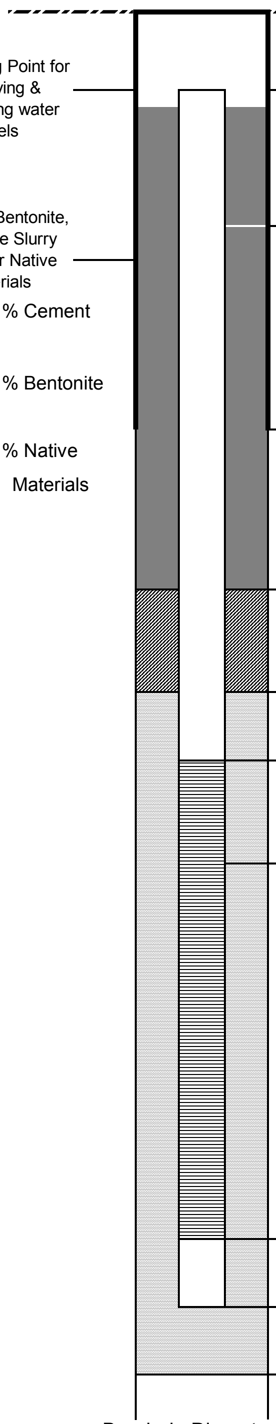
Section 3

Monitoring Well Construction Log

RESOLUTION CONSULTANTS	Client: NAVFAC	Project Number: 60266526
	Site Location: NWIRP BETHPAGE, NY	**WELL ID: RE116**
	Well Location: Dennis Ln. and Plainedge Dr., Bethpage, NY	Date Installed: 12/20/17
	Method: MUD ROTARY	Inspector: F. Bell
	Coords: Northing: 202312.88 Easting: 1128388.54	Contractor: DELTA WELL & PUMP

MONITORING WELL CONSTRUCTION DETAIL

* Casing installed with Auger rig 12/4/17 - 12/5/17.



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	73.35
Top of 12 inch diameter Steel Curb Box		
Top of Riser Pipe fit with locking j-plug	0.53	72.82
Bottom of 10 inch diameter Steel Surface Casing	50.0	23.4
Bottom of Bentonite Grout	519.0	-445.7
Bottom of #00 Filter Sand/Top of #1 Filter Sand	537	-463.7
Top of Screen	570	-496.7
▲ Stabilized Water Level		
Bottom of Screen	590	-516.7
Bottom of Sump:	595	-521.7
Bottom of Borehole	608	-534.7

Riser Pipe:

- Length: 570
- 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: 71

Borehole Diameter: 10 inch

Approved: ____________ Signature ________ Date

Describe Measuring Point:

Ground Surface

Section 4

Groundwater Sample Log Sheets

Well ID: RE116-D1

RESOLUTION CONSULTANTS

Low Flow Ground Water Sample Collection Record

Client: Navy NWIRP Bethpage
Date: 2/ 8 /18
Time: Start 1115 am/pm
Project No: 60266526
Finish am/pm
Site Location:
Weather Conds: 30, SUN
Collector(s): S. WRIGHT | F. BELL

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

a. Total Well Length 595 ft
c. Length of Water Column 564 ft (a-b)
Casing Diameter/Material 4-inch PVC

b. Water Table Depth 31.30 ft
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	

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
1135	–	9.36	0.198	5.88	8.67	121.6	–	600	31.30	CLOUDY/NONE
1140		14.28	0.074	8.42	7.00	75.8	–	600	31.41	CLOUDY/NONE
1145		14.02	0.074	7.69	5.81	59.5	1000+	600	31.48	CLOUDY/NONE
1150		14.08	0.077	7.23	5.71	48.6	–	600	31.36	CLOUDY/NONE
1155		14.15	0.080	6.87	5.60	37.7	–	600	30.40	CLOUDY/NONE
1200		13.98	0.081	6.77	5.51	39.7	882	600	30.51	CLOUDY/NONE

(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

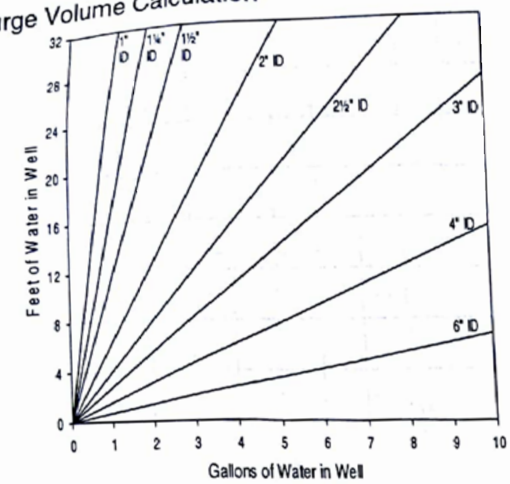
Sample ID	Container Type	No. of Containers	Preservation	Analysis Req.	Time
RE116-D1-020818	40-mL vials	3	HCl	VOCs	1345
RE116-D1-020818	1-L amber	2	none	1,4-Dioxane	1345

Comments DUPLICATE + MS/MSD + ~~[illegible]~~ COLLECTED

Signature

Date 2-8-18

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 (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	5	13.78	0.084	6.45	5.33	50.2	—	600	30.52	CLOUDY/NONE
1210	.	13.99	0.087	6.22	5.23	52.1	—	600	30.54	CLOUDY/NONE
1215		14.16	0.090	5.94	5.16	53.6	747	600	30.55	CLOUDY/NONE
1220	.	13.87	0.094	5.58	4.66	79.1	–	600	30.58	CLOUDY/NONE
1225	.	13.46	0.095	5.35	4.41	90.7	–	600	30.64	CLOUDY/NONE
1230	.	13.37	0.095	5.21	4.27	102.1	1000+	600	30.68	CLOUDY/NONE
1235	10	13.52	0.096	4.92	4.27	101.4	–	600	30.68	CLOUDY/NONE
1240		13.61	0.096	4.77	4.28	99.2	–	600	30.68	CLOUDY/NONE
1245	.	13.47	0.096	4.91	4.19	102.6	1000+	600	30.68	CLOUDY/NONE
1250	.	12.78	0.096	4.90	3.51	111.7	–	600	30.68	CLOUDY/NONE
1255	.	12.80	0.096	4.75	3.47	121.8	–	500	30.68	CLOUDY/NONE
1300	.	12.81	0.096	4.61	3.44	132.6	1000+	500	30.68	CLOUDY/NONE
1305	15	13.02	0.096	4.34	3.44	115.1	–	500	30.72	CLOUDY/NONE
1310		13.87	0.096	4.09	3.48	82.2	–	500	30.92	CLOUDY/NONE
1315		13.36	0.096	4.00	3.64	87.6	638	500	31.10	CLOUDY/NONE
1320		13.54	0.096	3.98	3.61	102.8	—	500	31.08	CLOUDY/NONE
1325		13.49	0.096	3.96	3.62	104.1	636	500	31.06	CLOUDY/NONE
1330		13.44	0.096	3.96	3.62	103.4	—	500	31.04	CLOUDY/NONE
1335	18	13.39	0.096	3.95	3.62	103.0	630	500	31.02	CLOUDY/NONE

Section 5

Analytical Data Validation

One total organic carbon soil sample was collected at
RE116D1 (12/15/2017);

One groundwater sample was collected at
RE116D1 on 2/8/2018

The groundwater sample is also reported in the *March 2018 Groundwater Sampling Data Summary Report, Bethpage, NY*, Resolution Consultants, 2018.

DATA VALIDATION REPORT

Project:	Regional Groundwater Investigation — Naval Weapons Industrial Reserve Plant Bethpage
Laboratory:	Katahdin Analytical
Sample Delivery Groups:	SL1069 and TK1898
Analyses/Method:	Volatile Organic Compounds by United States Environmental Protection Agency (U.S. EPA) SW-846 Method 8260C, Total Organic Carbon (TOC) by U.S. EPA SW-846 Method 9060A, and 1,4-Dioxane by U.S. EPA SW-846 Method 8270D via Selective Ion Monitoring
Validation Level:	Stage 3 Validation Electronic and Manual
Project Number:	0888812477.SA.DV
Prepared by:	Dana Miller/Resolution Consultants Completed on: 03/07/2018

SUMMARY

This report summarizes data review findings for the RE116 soil and groundwater sampling event (samples listed below) collected by Resolution Consultants from the Regional Groundwater Investigation — Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage Site on 12 December 2017 and 8 February 2018 in accordance with the following Uniform Federal Policy (UFP) 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 Identification	Matrix/Sample Type	Analysis
RE116D1-GW-020818	Groundwater	8260C/8270D_SIM
DUP01-GW-020818	Field Duplicate	8260C/8270D_SIM
EB01-WQ-020818	Equipment Blank	8260C/8270D_SIM
TB01-WQ-020818	Trip Blank	8260C
RE116D1-SOIL-121517-583-585	Soil	9060A
RE116D1-EB-121517	Equipment Blank	9060A

Note:
SIM = Selective Ion Monitoring

Data validation activities were conducted using the following guidance documents: *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, specifically Method 8260C, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry* (U.S. EPA 2006), *SW-846 Method 8270D, Semi volatile Organic Compounds by Gas Chromatograph/Mass Spectrometry* (U.S. EPA 2014), *National Functional Guidelines for Superfund Organic Methods Data Review* (U.S. EPA January 2017), *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use* (U.S. EPA January 2009), *Department of Defense (DoD) General Data Validation Guidelines (DoD February 2018), and DoD Quality Systems Manual for Environmental Laboratories*, Version 4.2 (DoD 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
- ✓ Gas chromatography/Mass spectrometer performance checks
- ✓ Initial calibration /initial calibration verification /continuing calibration verification
- ✓ Laboratory blanks/field blanks/trip blanks
- ✓ Surrogate spike recovery
- ✗ Matrix spike and/or matrix spike duplicate result
- ✓ Laboratory control sample /laboratory control sample duplicate result
- ✗ Field duplicate
- ✓ Internal standard
- ✓ Sample results/reporting issues

The symbol (✓) indicates that no validation qualifiers were applied based on this parameter. Acceptable data parameters for which all criteria were met, no qualification was performed, and/or non-conformance or other issues that were noted during validation, but did not result in qualification of data are not discussed further. The symbol (✗) indicates that a QC non-conformance resulted in the qualification of data. Any QC non-conformance that resulted in the qualification of data is discussed below.

RESULTS

Matrix Spike/Matrix Spike Duplicate Results

MS/MSDs are generated to provide information about the effect of each sample matrix on the sample preparation and the measurement methodology. MS/MSD percent %Rs assess the effect of the sample matrix on the accuracy of the analytical results and %Rs above the laboratory control limit could indicate a potential high result bias while %Rs below QC limits could indicate a potential low result bias. The relative percent differences (RPDs) between the MS and MSD results are evaluated to assess sample precision. The MS/MSD %Rs and RPDs were reviewed for conformance with the QC acceptance criteria. Data qualification to the analytes associated with the specific MS/MSD non-conformances were as follows:

Matrix Spike/Matrix Spike Duplicate Non-Conformances Chart:

Criteria	Action	
	Detected Compounds	**Non-Detected Compounds**
%R or RPD > Upper Limit	J	No qualification
20% ≤ %R < Lower Limit	J	UJ
%R < 20%	J	Rejected

Notes:

%R = Percent recovery
RPD = Relative percent difference
J = Estimated
UJ = Undetected and estimated

MS/MSD non-conformances are summarized in Attachment A in Table A-1.

Field Duplicate

One field duplicate pair were collected to assess precision: RE116D1-GW-020818/ DUP01-GW-020818. Field duplicate RPDs were reviewed for conformance with the Resolution Consultants QC criteria of ≤30% for aqueous matrices. These criteria apply if both results were greater than twice the limit of quantitation (LOQ). Data qualification to the analytes associated with the specific field duplicate RPDs was as follows:

Field Duplicate Non-conformances Chart:

Criteria	RPD	Action	
		Detected	**Non-**
Sample and duplicate are not detected	NC	No qualification	No
Sample and duplicate results ≥2x LOQ	>30 (aqueous)	J	Not Applicable
If sample or duplicate result is >2x LOQ and the other is not detected	NC	J	UJ
If sample or duplicate result is <2x LOQ and the other is not detected	NC	No qualification	No qualification

Notes:

NC	=	Not calculable	J	=	Estimated value
LOQ	=	Limit of quantitation	UJ	=	Undetected and estimated

The field duplicate non-conformance is summarized in Attachment A in Table A-2.

Qualification Actions

The data were reviewed independently from the laboratory to assess data quality. All compounds 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. Any sample that was analyzed at a dilution because of high concentrations of target or non-target analytes was checked to confirm that the results and/or sample-specific limit of quantitation and limit of detections were adjusted accordingly by the laboratory.

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. Attachment B provides a summary of all qualified results during this data review.

ATTACHMENTS

Attachment A: Non-Conformance Summary Table

Attachment B: Qualified Results Summary after Data Review and Analytical Data

Attachment A

Non-Conformance Summary Table

Table A-1 Matrix Spike/Matrix Spike Duplicate Percent Recovery Non-Conformance								
SDG	**Method**	**Spiked Sample ID**	**Analyte**	**Sample Result (UG_L)**	**MS %R**	**MSD %R**	**%R Limit**	**Qualifier**
SJ1069	8270D_SIM	RE116D1-GW-020818	1,4-Dioxane	4.9	79.3	**93.3**	10-90	J

Notes:

SDG = Sample delivery group
ID = Identification
UG_L = Micrograms per liter
MS = Matrix spike
MSD = Matrix spike duplicate
%R = Percent recovery
SIM = Selective ion monitoring
Bold = %R outside the 10-90% control limits
J = Analyte in associated sample qualified estimated "J" because %R is lower than the control limit and may be biased low.

Table A-2 Field Duplicate Non-Conformance										
Analyte	**Sample ID**	**Lab ID**	**Duplicate ID**	**Lab ID**	**Sample Result (UG_L)**	**Sample LOQ**	**Duplicate Result (UG_L)**	**Duplicate LOQ**	**RPD**	**Qualifier**
1,4-Dioxane	RE116D1-GW-020818	SJ1069-1	DUP01-GW-020818	SJ1069-2	4.9	0.38	3.4	0.25	36.1	J-both

Notes:

ID = Identification
UG_L = Micrograms per liter
LOQ = Limit of quantitation
RPD = Relative percent difference (limit ≤30
J = Analyte in associated samples qualified estimated "J" due to potential poor duplicate precision.

Attachment B

Qualified Results Summary after Data Review and Analytical Data

Table B-1 Qualified Summary Results after Data Review											
SDG	**Sample ID**	**Lab ID**	**Sample Date**	**DF**	**Analyte**	**Result**	**Units**	**Lab Qualifier**	**Validator Qualifier**	**Final Qualifier**	**RC**
SL1069	DUP01-GW-020818	SL1069-2	2/8/2018	1	1,4-Dioxane	3.4	UG_L		J	J	fd
SL1069	RE116D1-GW-020818	SL1069-1	2/8/2018	1	1,4-Dioxane	4.9	UG_L	M	J	J	m,fd

Notes:

SDG = Sample delivery group
ID = Identification
DF = Dilution factor
RC = Reason code
UG_L = Micrograms per liter
J = ***Estimated Value*** — One or more quality control parameters were outside control limits or the analyte concentration was less than the limit of quantitation.
M = Indicates that the analyte was detected outside of the control limits in the matrix spike/matrix spike duplicate prepared and/or analyzed concurrently with the native sample (laboratory qualifier).

Qualification Reason Code:

fd = Field duplicate relative percent difference
m = Matrix spike/matrix spike duplicate percent recovery

Table B-2
Analytical Data

			Sample Delivery Group	SL1069		
			Lab Identification	SL1069-1		
			Sample Identification	RE116D1-GW-020818		
			Sample Date	2/8/2018		
			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	U	
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	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	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	4.9	J	m,fd

Notes:

RC = Reason code
UG_L = Micrograms per liter
U = Nondetected for analyte
J = ***Estimated Value*** — One or more quality control parameters were outside control limits or the analyte concentration was less than the limit of quantitation.

Qualification Reason Code:

fd Field duplicate relative percent difference
m Matrix spike/matrix spike duplicate percent recovery

Table B-2
Analytical Data

			Sample Delivery Group	SL1069		
			Lab Identification	SL1069-2		
			Sample Identification	DUP01-GW-020818		
			Sample Date	2/8/2018		
			Sample Type	Field Duplicate		
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	U	
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	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	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	3.4	J	fd

Notes:

RC = Reason code
UG_L = Micrograms per liter
U = Nondetected for analyte
J = ***Estimated Value*** — One or more quality control parameters were outside control limits or the analyte concentration was less than the limit of quantitation.

Qualification Reason Code:

fd Field duplicate relative percent difference
m Matrix spike/matrix spike duplicate percent recovery

Table B-2
Analytical Data

			Sample Delivery Group	SL1069		
			Lab Identification	SL1069-3		
			Sample Identification	EB01-WQ-020818		
			Sample Date	2/8/2018		
			Sample Type	Equipment Blank		
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	U	
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	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	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:

RC = Reason code
UG_L = Micrograms per liter
U = Nondetected for analyte
J = ***Estimated Value*** — One or more quality control parameters were outside control limits or the analyte concentration was less than the limit of quantitation.

Qualification Reason Code:

fd Field duplicate relative percent difference
m Matrix spike/matrix spike duplicate percent recovery

Table B-2
Analytical Data

			Sample Delivery Group	SL1069		
			Lab Identification	SL1069-4		
			Sample Identification	TB01-WQ-020818		
			Sample Date	2/8/2018		
			Sample Type	Trip Blank		
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	U	
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	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	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			

Notes:

RC = Reason code
UG_L = Micrograms per liter
U = Nondetected for analyte
J = ***Estimated Value*** — One or more quality control parameters were outside control limits or the analyte concentration was less than the limit of quantitation.

Qualification Reason Code:

fd Field duplicate relative percent difference
m Matrix spike/matrix spike duplicate percent recovery

Table B-2
Analytical Data

			Sample Delivery Group	TK1898		TK1898	
			Lab Identification	TK1898-1		TK1898-2	
			Sample Identification	RE116D1-SOIL-121517-583-585		RE116D1-EB-121517	
			Sample Date	12/15/2017		12/15/2017	
			Sample Type	Soil		Equipment Blank	
Method	**Analyte**	**CAS No**	**Units**	Result	Qual	Result	Qual
2540G	TOTAL SOLIDS	-29	PCT	84		NA	
9060A	TOTAL ORGANIC CARBON	-28	UG_G	14000		NA	
9060A	TOTAL SOLIDS	-29	MG_L	NA		0.94	

Notes:

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

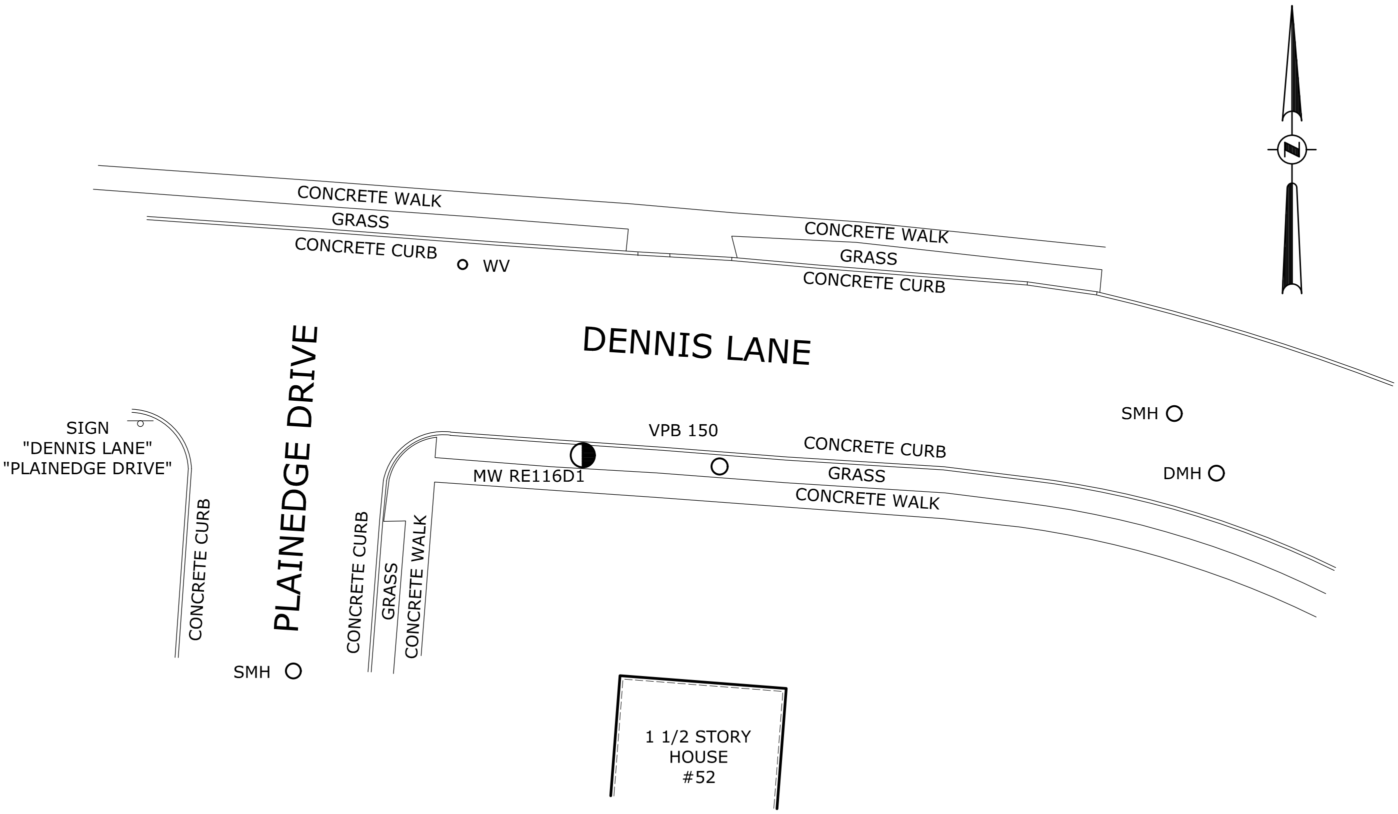
Section 6

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 150	202311.12	1128409.91	N40-43-14.88	W73-28-47.74	73.44	NA	NA
MW RE116D1	202312.88	1128388.54	N40-43-14.90	W73-28-48.02	73.35	73.31	72.82



Legend

○	DMH	Drainage Manhole
◑	MW RE116D1	Monitor Well
○	SMH	Sanitary Manhole
○	VPB 140	Vertical Profile Boring
∘	WV	Water Valve

Map Notes

1. Information shown hereon was compiled from an actual field survey conducted from September 23-25, 2014. Monitor Well RE116D1 was field located on August 8, 2018.
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.

BAR SCALE

30 0 15 30 60

1 inch = 30 ft.

DWG NO. 14-497

Date	RECORD OF WORK	Appr.
8/8/18	ADD MW RE116D1 AND ADD ELEVATION DATA	

Drafter: LMK

Checker: JFC

Appr. by: JFC

Proj. No. 14.4121

VERTICAL PROFILE BORING 150 SURVEY LOCATION
MW RE116D1 SURVEY LOCATION
52 PLAINEDGE 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"=30'

DATE: SEPT. 24, 2014

CAD DWG. FILE NAME: K:\Projects\144121\Survey\Drawings and Maps\2018 DRAWINGS\2018 VPB 150.dwg

Appendix B

Environmental Sequence Stratigraphy (ESS)

Analysis

To: Lora Fly and Brian Murray, DON, NAVFAC MIDLANT

From: Brian Caldwell, P.G., Resolution Consultants

Subject: Environmental Sequence Stratigraphy Analysis
Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage

Date: May 18, 2018

1. INTRODUCTION

Previous sequence stratigraphic studies of the New Jersey Coastal Plain (Kulpecz et al., 2008; Miller et al., 1998; and Sugarman et al., 2005) have demonstrated that repetitive and predictable facies successions in the region can largely be explained by cyclic sea level changes. In this Environmental Sequence Stratigraphic (ESS) analysis, we combine results from regional studies (Lanci et al., 2002; Kulpecz et al., 2008; Miller et al., 1998, 1999, 2004, 2006; and Sugarman et al., 2005) with sub-regional continuous geophysical logs (acquired during environmental investigations at NWIRP) to develop a high resolution sequence stratigraphic framework for the Late Cretaceous Turonian age (approximately 94 million years ago) Magothy Formation underlying NWIRP Bethpage. ESS is a method of utilizing available data, coupled with an interpretation of the geologic facies, or depositional environments of the geologic material, to develop and refine Conceptual Site Models (CSM's). The refined CSM is then used in the environmental perspective to optimize contaminated site investigation and remediation. A glossary of terms used in the ESS evaluation is presented in Appendix A.

2. DATA AND METHODS

Geophysical logs have been used to interpret paleoenvironments and correlate depositional facies since Serra and Sulpice (1975) used spontaneous potential (SP) and resistivity logs to determine the depositional history of strata in the Gulf of Mexico. Gamma logs, a measure of naturally occurring radiation in aquifer material, have become a useful tool for log-based facies interpretation, particularly in siliclastic fluvio-deltaic environments coupled with lithologic control from cores. Fine-grained sediments, clays, glauconite sands, and phosphorites, which are common elements in siliciclastic fluvio-deltaic facies, retain relatively high levels of radiogenic elements. Therefore, relative gamma log counts can be considered a good indicator of lithology and, in the case of the Magothy, a discriminator between gravels, sands, silts, and clays.

Six detailed cross sections of the Magothy Formation were generated using 29 gamma logs: one north-south trending dip section (B-B') and five east-west trending strike sections (1-1', 2-2', 3-3', 4-4', and 5-5') (Figure 1). Gamma logs were selected for inclusion on the basis of geographic location (i.e., satisfying areas of poor coverage), depth (substantial penetration through the Magothy Formation), and adequate quality. Although this study relied heavily on gamma log data as a method of correlation, lithologic logs were also used to calibrate the correlation and account for sub-regional facies changes.

2.1 Stratigraphic Framework

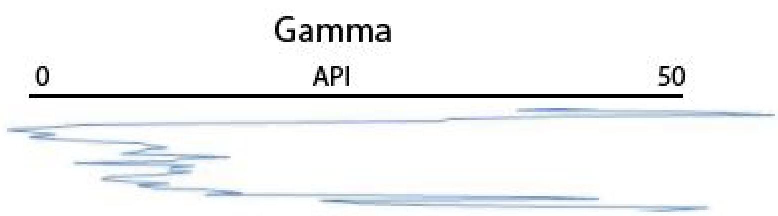
Based on the gamma log signatures, the stratigraphic units beneath the Site were divided into two major packages of depositions (sequences). Each sequence is bounded by conspicuous subaerial erosion or exposure surfaces (i.e., sequence boundary - red markers in the cross sections) that are the product of relative sea level changes. Each sequence was further divided into "parasequences", or building-blocks of the sequences, marked by flooding surfaces (shale/clay signatures). They are denoted by gray markers in the depositional facies interpretations cross sections representing thin tidal mud deposits.

2.2 Facies Architecture

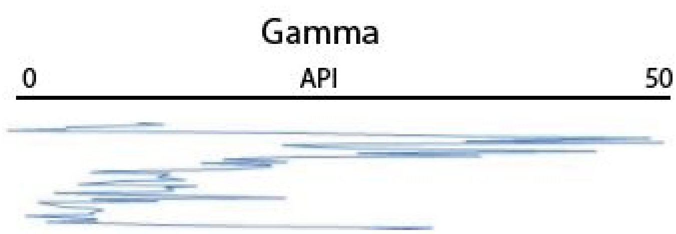
Parasequences were subdivided into marginal marine (delta front, wave-dominated shoreline, estuarine) and nonmarine (upper and lower delta plain/fluvial, glacial) depositional facies within the context of a wave-dominated deltaic depositional model (Sugarman et al., 2005). The individual depositional facies were identified on the basis of gamma log motifs and calibrated with modern wave-dominated deltaic analogs derived from Google Earth imagery (Figure 2). The analogs allowed prediction of the dimensions (i.e., approximate width and depth) of depositional elements for the Site area, but also leverage horizontal facies relationships based on vertical facies successions in logs (applying Walther's Law - a vertical sequence of facies will be the product of a series of depositional environments which occurred laterally adjacent to each other).

The following is a brief description of the recognition criteria for identifying depositional facies at NWIRP Bethpage using gamma logs.

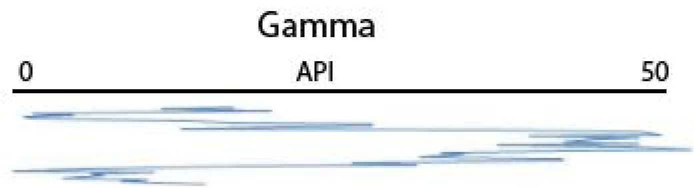
Delta Mouth Bars:
The gamma signature of a deltaic mouth bar is typically spiky and low, with sharp top and basal contacts. These deposits are very coarse.



Fluvial:
The gamma signature of a fluvial channel typically exhibits a sharp negative shift overlain by a gradual positive reflection (a "bell" shape) - indicative of a fining upward package.

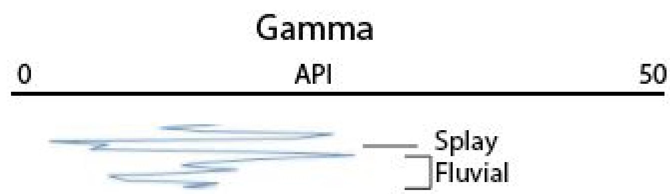


Overbank/Lagoonal:
The gamma signature of an overbank/Lagoonal deposit typically exhibits a high blocky reflection with a "cylindrical" shape. The top and basal contacts are sharp.



Splay:

The gamma signature of a splay deposit typically exhibits a sharp low reflection, however this spike tends to increase laterally. Splay deposits are most easily identified by their proximity to fluvial deposits.



3. RESULTS

Correlation of existing gamma logs beneath the Site reveals that the Magothy Formation consists of several phases of seaward progradation and landward retrogradation that are represented by two major depositional sequences (Figures 3 through 8). The culmination of the 2nd sequence is marked by a probable progradation of continental (glacial) deposits over coastal and deltaic deposits. The facies architecture of the Magothy Formation, resulting from these progradational and retrogradational patterns, provides important insights into the distribution of transmissive and storage zones at the Site over time. The sequences and facies of the Magothy Formation are described in more detail below.

3.1 Sequence 1

Sequence 1 separates the Magothy Formation from the underlying Raritan Formation by a Sequence Boundary (SB 1) which is represented by a basin-wide unconformity (manifested in the log signature as a distinctively low Gamma spike at approximately -800 feet [ft] above mean sea level [amsl]). According to core studies and field investigations by Sugarman et al. (2005), mottled clays and paleosols (after) locally demarcate the SB 1, indicating local subaerial exposure during relative sea level fall. Elsewhere, the sequence boundary may be represented by fluvial incisions.

SB 1 is juxtaposed by a Transgressive Surface (TS 1, light blue marker), indicating a rapid drowning of the coastline caused by a significant sea level rise. As the sea level began to rise during the Transgressive Systems Tract (TST) (between the blue and green markers), distributary channels and low accommodation deltas of the lowstand were subject to reworking into a predominantly estuarine condition. Backstepping delta mouth bars and muddy fluvial channels are the predominant depositional facies of this interval (resulting in 50-75 ft thick muddy units). Sandy lignite deposits and pyrite concretions observed in cores suggest that these thick, muddy deposits are representative of such estuarine/lagoonal deposits (Sugarman et al., 2005). Channels of the TST also gradually become interspersed and poorly connected. As a result, this unit indicates a high variability of transmissive units interspersed by units of storage.

The TST is bounded on top by two Maximum Flooding Surfaces (green marker, MFS1 and purple marker, MFS2) that represent progressive maximum landward incursions of the shoreline in two phases. As the muddiest intervals of the system, these maximum flooding surfaces seem to act as storage for contamination and show conspicuous spikes of contamination data. MFS1 heralds the first phase of highstand, with aggradational to progradational successions. MFS2 represents the second maximum flooding before the complete turnaround to highstand delta progradation. This highstand phase shows a facies architecture predominated by seaward (southerly) dipping delta mouth bars, with distributary channels locally incising into them. The greater continuity of these sand bodies indicates a higher transmissivity of these units for groundwater flow, and hence contaminant transport.

3.2 Sequence 2

Sequence 2 is separated from Sequence 1 by an erosional unconformity (SB 2, red marker) overlying the highstand delta deposits of the previous sequence. In contrast to Sequence 1, the lowstand deposits are locally preserved (between red and light blue markers) as predominantly channelized units and their associated overbank sediment, with a minor component of southerly prograding mouth bars. A Transgressive Surface (TS 2, light blue marker) above the sequence boundary indicates the renewed initiation of a flooding event. The TST (between blue and green markers) is marked by laterally continuous, backstepping deltaic deposits and thick lagoonal/estuarine deposits similar to the facies of TST in Sequence 1. However, the TST in this sequence shows a relatively thinner interval than in Sequence 1.

Sequence 2 represents a similar scenario as in Sequence 1 in relation to the culmination of the TST in two phases of maximum landward incursions of the shoreline (denoted by green marker, MFS1 and purple marker, MFS2). Observation of contamination data in relation to the maximum flooding surfaces show significant spikes as similarly observed in Sequence 1. The MFS1 is followed by the first phase of highstand aggradation and progradation of delta mouth bars, and the MFS2 is followed by a more pronounced turnaround to delta progradation. During the culmination of this highstand, a thick unit of continental deposits (possibly composed of coarse-grained glacial outwash) moves farther seaward, over-riding the highstand deltas and coastal deposits. While the grain size of these glacial deposits would be the coarsest, they may have poor transmissivity because of significant glacial mud in the matrices.

4. DISCUSSION

Because thermoflexural subsidence is the dominant tectonic component of evolution of passive margins (Watts and Steckler, 1979), the Turonian sequences and deltaic facies systems of the New Jersey and New York Coastal Plains primarily reflect the interplay of global sea level oscillations and sediment supply.

4.1 Sea Level Oscillations

Third order (1-10 million years) sea level changes (Figure 9) are well documented during the Turonian stage (Miller et al., 2005). Previous estimates from New Jersey Plain coreholes identified 4 sea level cycles in the Turonian with amplitudes as great as approximately 15 meters (Miller et al., 2005). These sea level changes primarily reflect a gradual sea level fall (Figure 9) and are the principal driver behind base-level changes, unconformities, and the development and preservation of the studied sequences on the New Jersey Coastal Plain.

Periods of elevated or low sea level have a distinct effect on shoreline position and the types of deltaic facies that are recorded on the coastal plain. During high sea level, marine to distal deltaic

This analysis from the Turonian Magothy Formation indicates that although global sea level oscillations provide the template for sequences and sequence preservation, changes in sediment supply also largely influence depositional environments in the region.

4.2 Sediment Supply

Peak rates of Late Cretaceous sediment accumulation on the mid-Atlantic Margin occurred during the Albian stage (100 million years ago), representing a phase of tectonic uplift and intense weathering of the ancestral Appalachians (Poag and Sevon, 1989). This large influx of sediments is reflected by the rapid seaward progradation of the shoreline and preservation of extensive delta plain deposits (Magothy Formation) on the New Jersey Coastal Plain (Sugarman et al., 2005; Kulpecz et al., 2008). These observations are consistent with offshore data that shows large amounts of coarse, deltaic material deposited across the New Jersey and New York shelves, a function of high sediment rates "flooding" the system (Poag and Sevon, 1989).

Despite the rapid weathering rates and an overall sea level fall, the Late Turonian also exhibits a rapid sea level transgression upwards of approximately 50 million years (Figure 9) (Miller et al., 2005). During such events, sedimentation is no longer able to keep up with the pace of sea level rise, resulting in shoreline retrogradation, facies backstepping, and lagoonal deposits overlying progradational deltaic facies.

4.3 Stratigraphic Impact on Hydrogeology

This analysis indicates that considerable heterogeneity exists in the subsurface due to an interplay of progradation and transgression. The thick channelized sand bodies at the Site are inferred to represent high permeability units and conduits for groundwater flow/contaminant transport. However, the continuity of those units is variable. Furthermore, while fluvial channels are cut into the underlying deltaic deposits of each sequence, those incisions are not necessarily infilled by channel bars. Lack of space (accommodation) in the coastal realm during each sea level fall forces sediments to deposit farther seaward as delta front (mouth bar) deposits. Parts of the channelized incisions are later infilled by bay-fills and lagoonal mud during the ensuing transgression. As a result, mouth bars show more continuity than their channelized counterparts (and associated splay deposits), which are much more heterogeneous.

5. CONCLUSIONS

- The Turonian Magothy Formation primarily reflects the interplay of global sea level oscillations and sediment supply.
- Correlation of existing gamma logs beneath the Site indicates that the Magothy Formation consists of two high frequency, depositional sequences. Each sequence boundary is either marked by subaerial exposure (paleosol) or fluvial incision.
- Previous CSMs for the Site have interpreted the depositional setting of the Magothy Formation to have been a glacially-derived delta such as the Mackenzie River Delta. This analysis indicates a better analog for the Magothy Formation is the wave-dominated Sao Francisco River delta, Brazil (Figure 2). The Mackenzie River Delta is more appropriate for the overtopping glacial sediments.
- Each sequence with the Magothy shows considerable intra-parasequence heterogeneity. This heterogeneity needs to be addressed in detail in order to understand the pathway of the contamination of the plume. Groundwater preferentially flows through laterally continuous fluvial sands and distributary mouth bars. The distributary mouth bars show more continuity than their channelized counterparts. Mud-plugged channels and bay/lagoonal deposits constitute the lower transmissive units of the Magothy.
- Contamination appears to be primarily traveling through laterally continuous fluvial and mouth bar sands, however, in some locations, such as VPB160 and VPB142 on section B-B’, major stratigraphic markers, (such as the maximum flooding surface in Sequence 1) appear to exhibit stratigraphic control on trichloroethene (TCE) and tetrachloroethene (PCE) concentrations.
- The Magothy Formation is topped by 200 to 300 feet of glacially-derived sediment, which in this analysis is considerably thicker than previous interpretations.
- The maximum flooding surfaces identified in this interpretation are strongly related to contamination data peaks. This may be explained by the fact that the maximum flooding surfaces are the muddiest intervals of the Site, rendering them potentially as storage units of contamination (adsorption by fine-grained aquifer material). Moreover, since the overlying deltaic sands lap against these surfaces, over time, groundwater contamination flowing

through those continuous sands could end up in storage within the maximum flooding surfaces. Conversely, desorption of contamination from the maximum flooding surface material could result in higher contamination migration rates in the deltaic sands if the concentration gradient is conducive for transfer (desorption).

Sequence stratigraphy and facies models provide a predictive framework for hydrostratigraphic units, but regional and local differences in sediment supply, depositional environment, and sea level affect the development of the hydrogeologic framework. Sequence stratigraphy allows packages of coarser sediments to be bracketed in a predictable manner by confining units. Facies analysis, coupled with depositional models, allows for the prediction of the potential scale and connectivity of coarser aquifer material. Sequence stratigraphy and facies analysis provides a means of roughly predicting permeability, porosity, and conductivity from aquifers, though exact estimates can only be achieved through hydraulic testing. However, understanding the sequence stratigraphy and depositional facies are critical for understanding scale and connectivity of aquifers and their confining units and predicting their local distributions.

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FIGURE LIST

ATTACHMENT LIST

FIGURES

Figure 1. Map of ESS Cross Sections

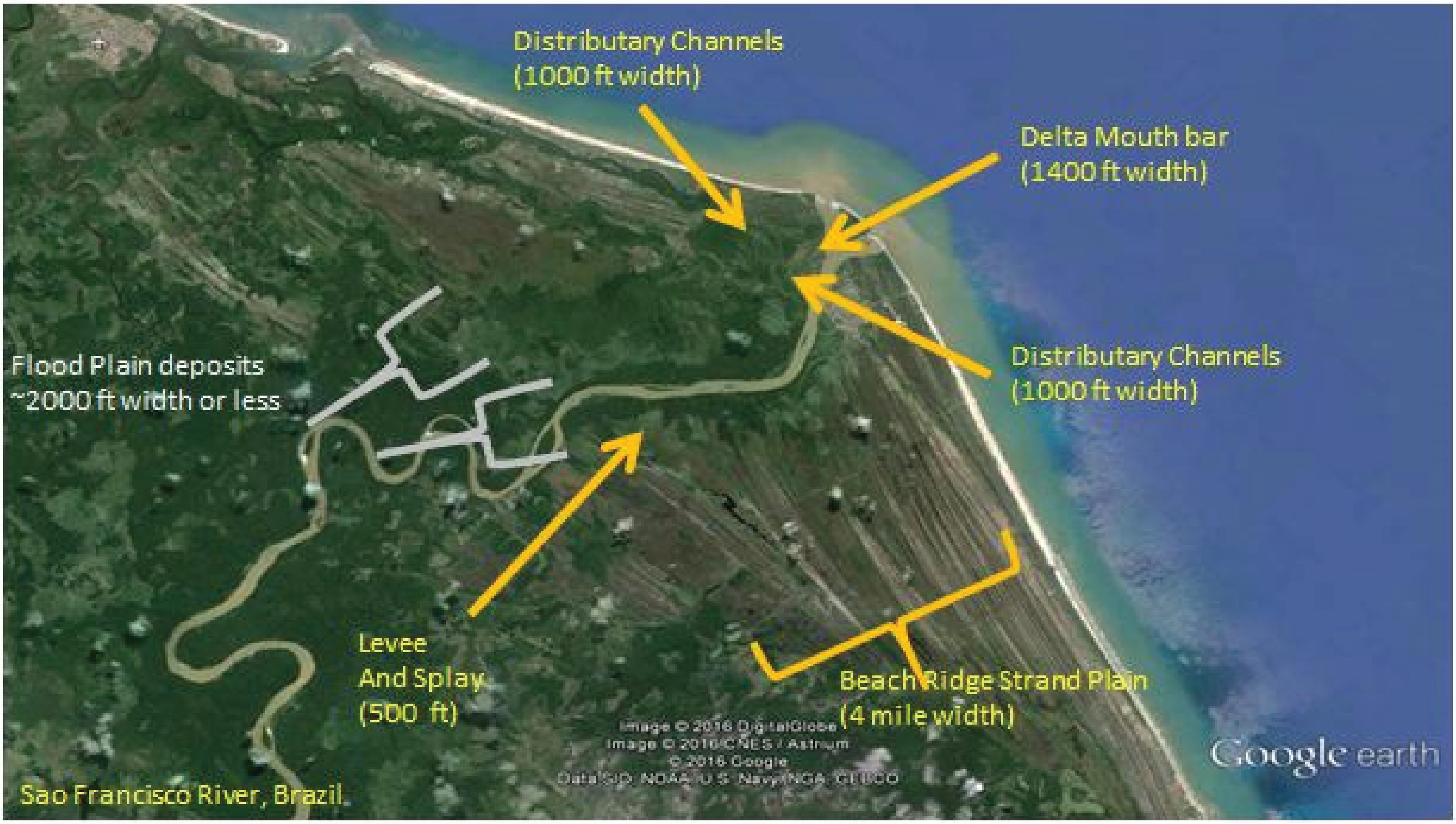


Figure 2a. Modern Analog

Source: Image ©2016 DigitalGlobe; Image ©2016 CNES/ Astrium; ©2016 Google Data SIO, NOAA, U.S. Navy, NGA, GEBCO

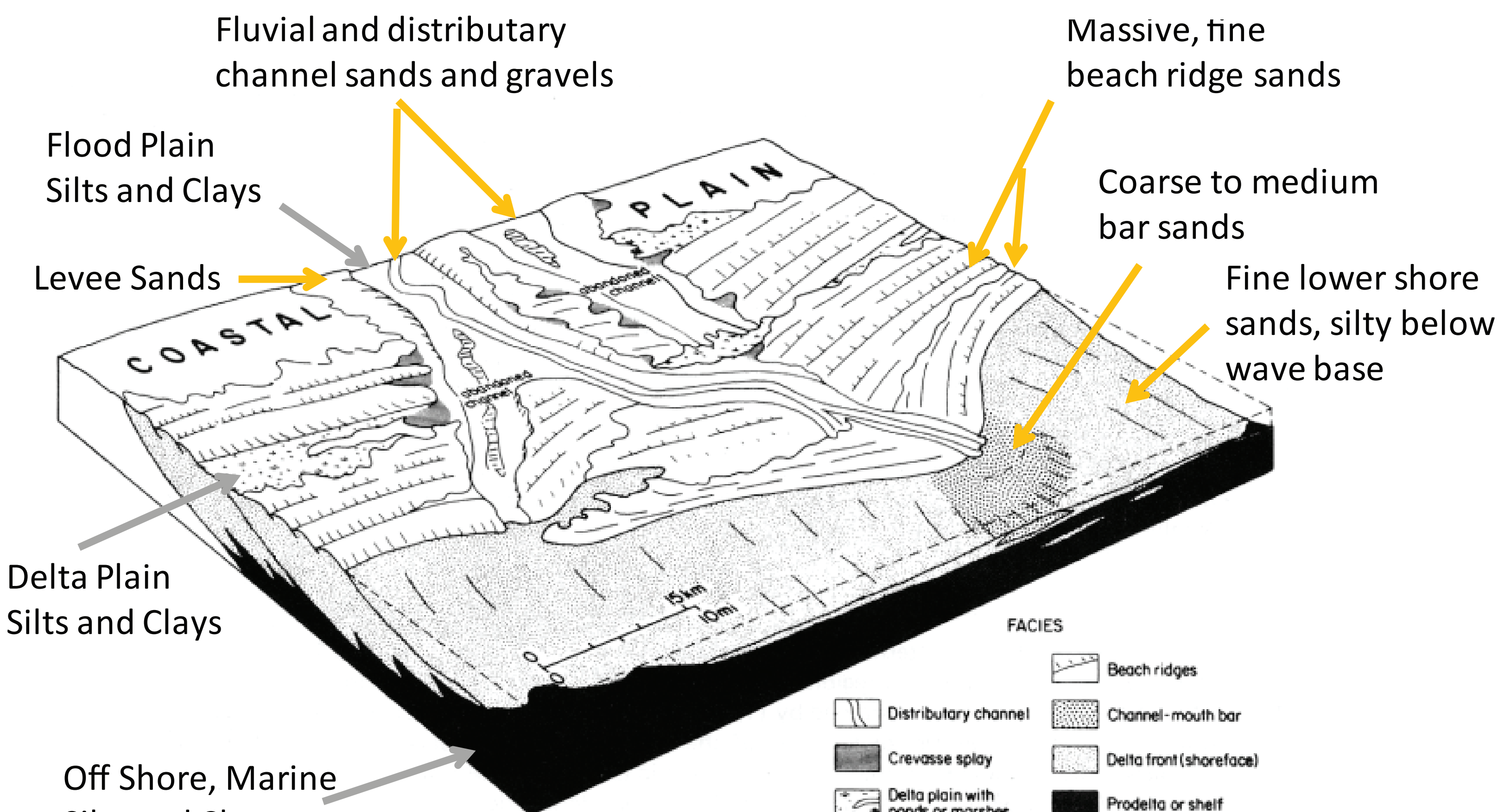


Figure 2b. Three-Dimensional Model of Wave-Dominated Delta System (source Weise, 1980)

Notes for Figures 3 through 8:

1. Approximate cross section dimensions:

Figure 3a & 3b (Section B-B') length is 19,690 feet, sequence 1+2 thickness is 1,000 feet.
Figure 4a & 4b (Section 1-1') length is 2,810 feet, sequence 1+2 thickness is 980 feet.
Figure 5a & 5b (Section 2-2') length is 6,340 feet, sequence 1+2 thickness is 970 feet.
Figure 6a & 6b (Section 3-3') length is 6,660 feet, sequence 1+2 thickness is 950 feet.
Figure 7a & 7b (Section 4-4') length is 9,280 feet, sequence 1+2 thickness is 930 feet.
Figure 8a & 8b (Section 5-5') length is 7,330 feet, sequence 1+2 thickness is 915 feet.

2. Vertical Profile Borings (VPBs) depicted along cross sections are explained below.

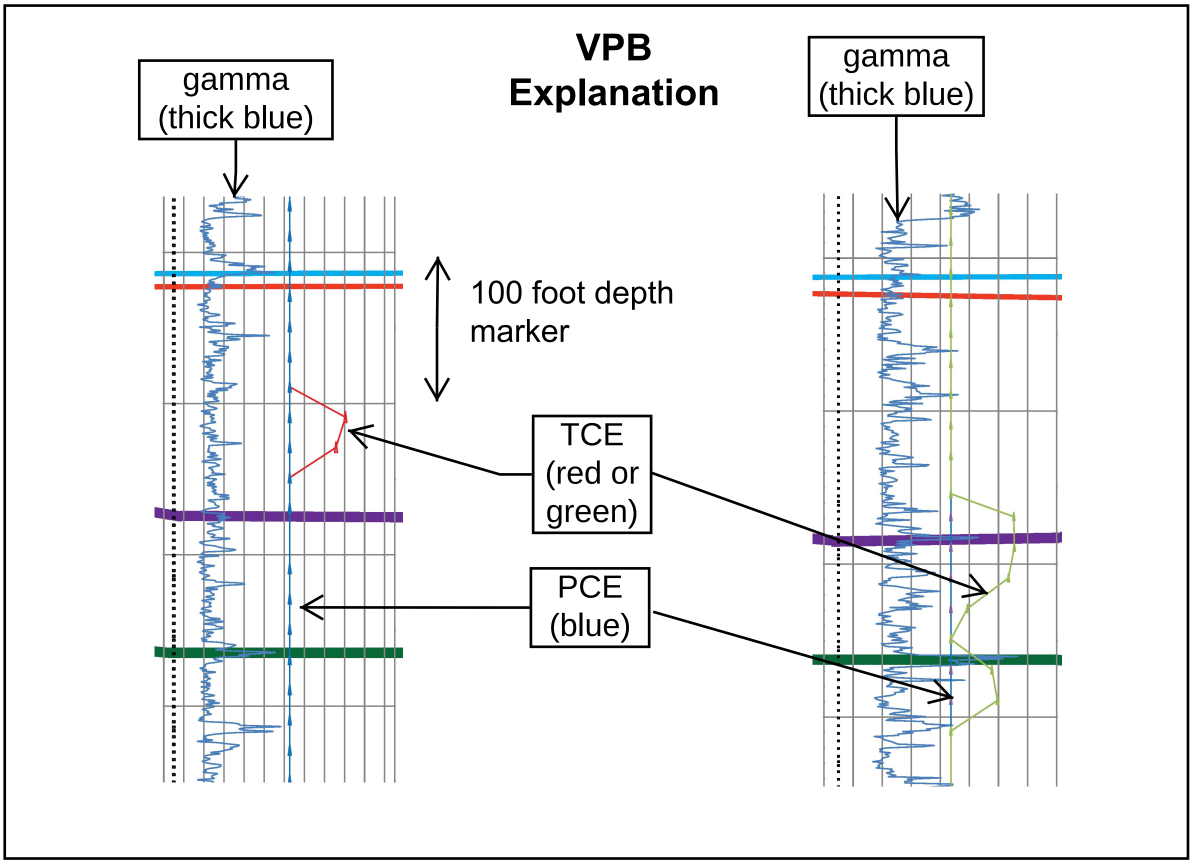


Figure 3a. Cross Section B-B' Showing Stratigraphic Framework

Figure 3b. Cross Section B-B' Showing Depositional Facies Interpretation

Figure 4a. Cross Section 1-1' Showing Stratigraphic Framework

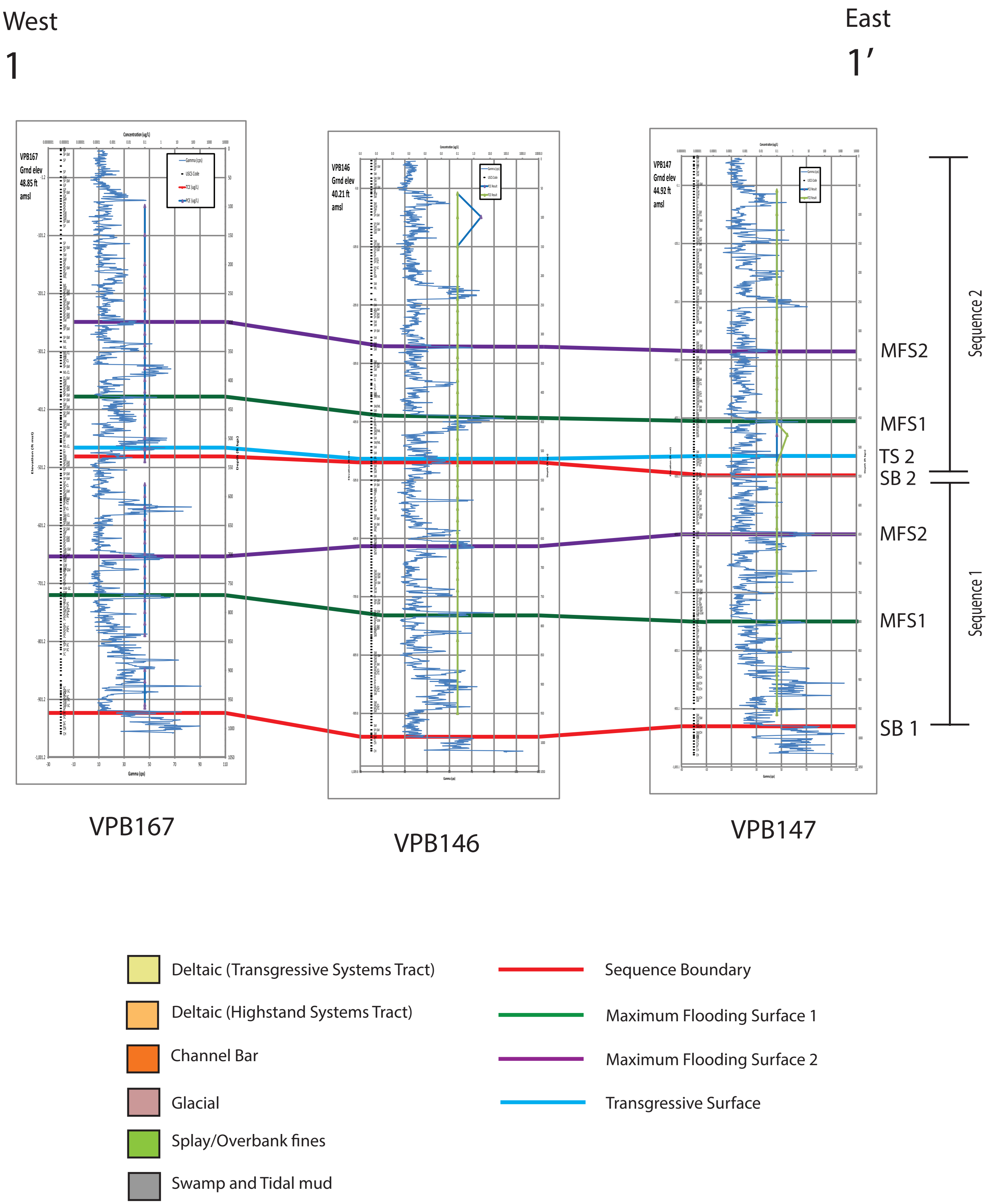
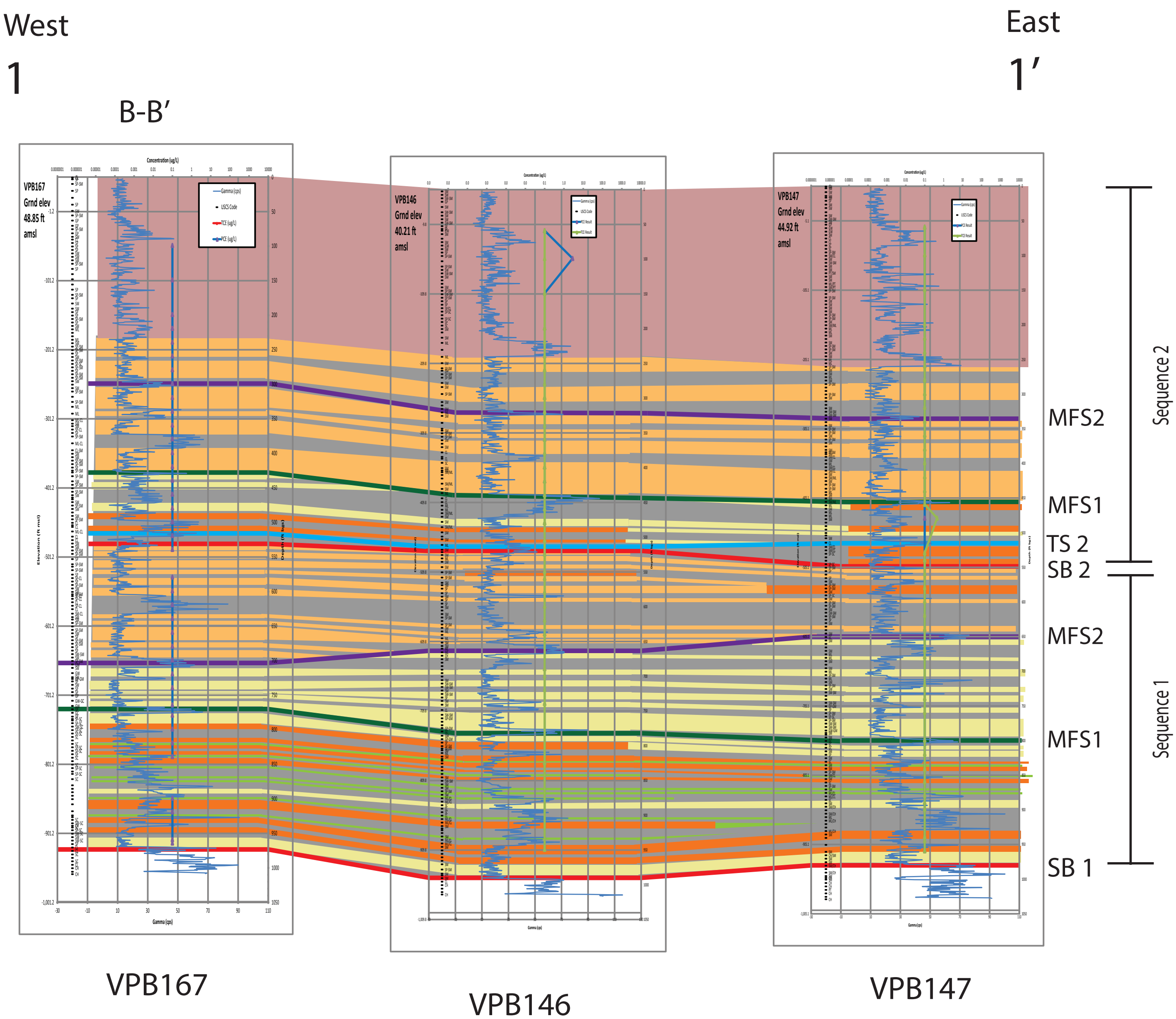


Figure 4b. Cross Section 1-1′ Showing Depositional Facies Interpretation



- Deltaic (Transgressive Systems Tract)
- Deltaic (Highstand Systems Tract)
- Channel Bar
- Glacial
- Splay/Overbank fines
- Swamp and Tidal mud
- Sequence Boundary
- Maximum Flooding Surface 1
- Maximum Flooding Surface 2
- Transgressive Surface

Figure 5a. Cross Section 2-2' Showing Stratigraphic Framework

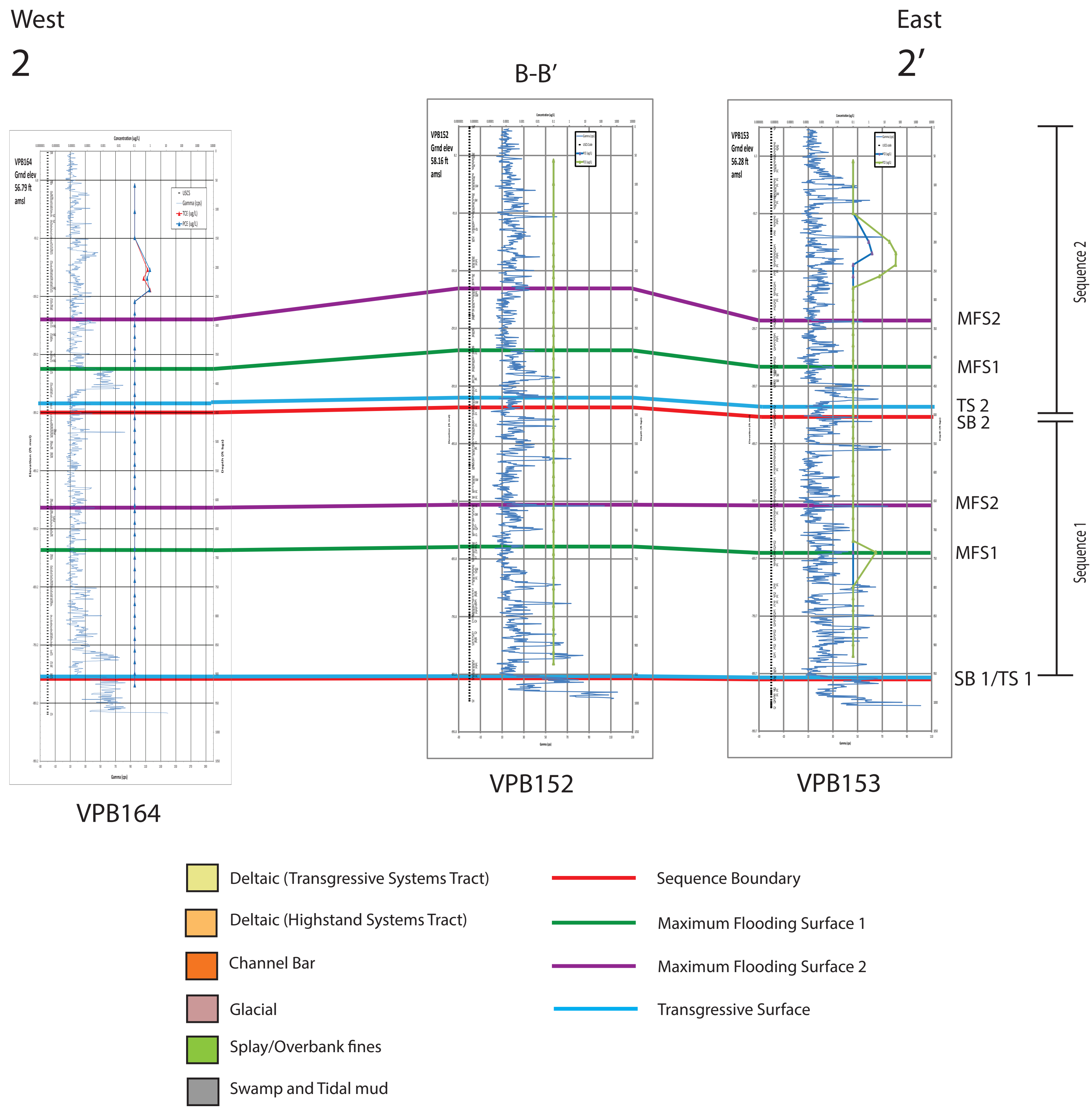


Figure 5b. Cross Section 2-2′ Showing Depositional Facies Interpretation

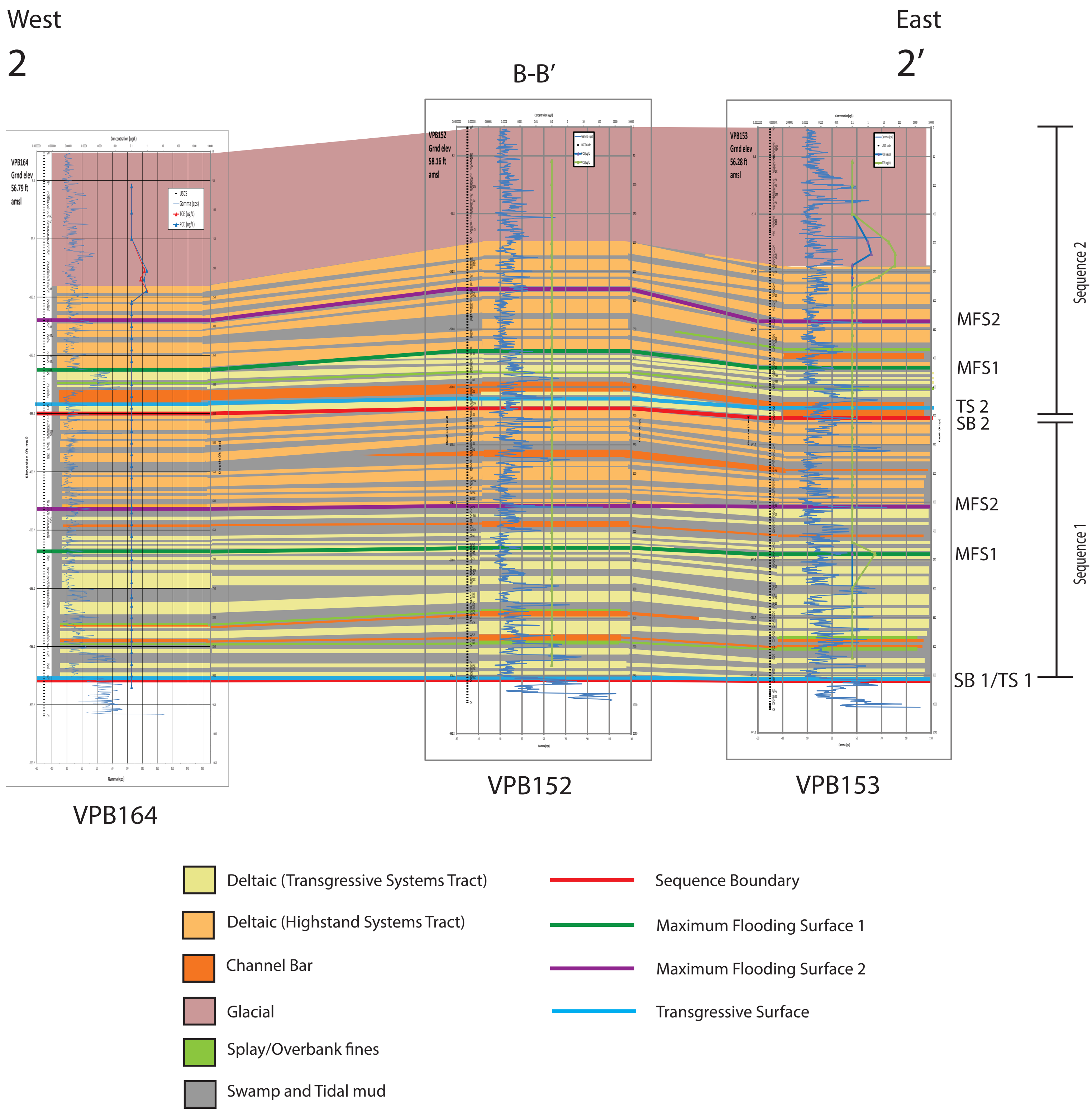


Figure 6a. Cross Section 3-3' Showing Stratigraphic Framework

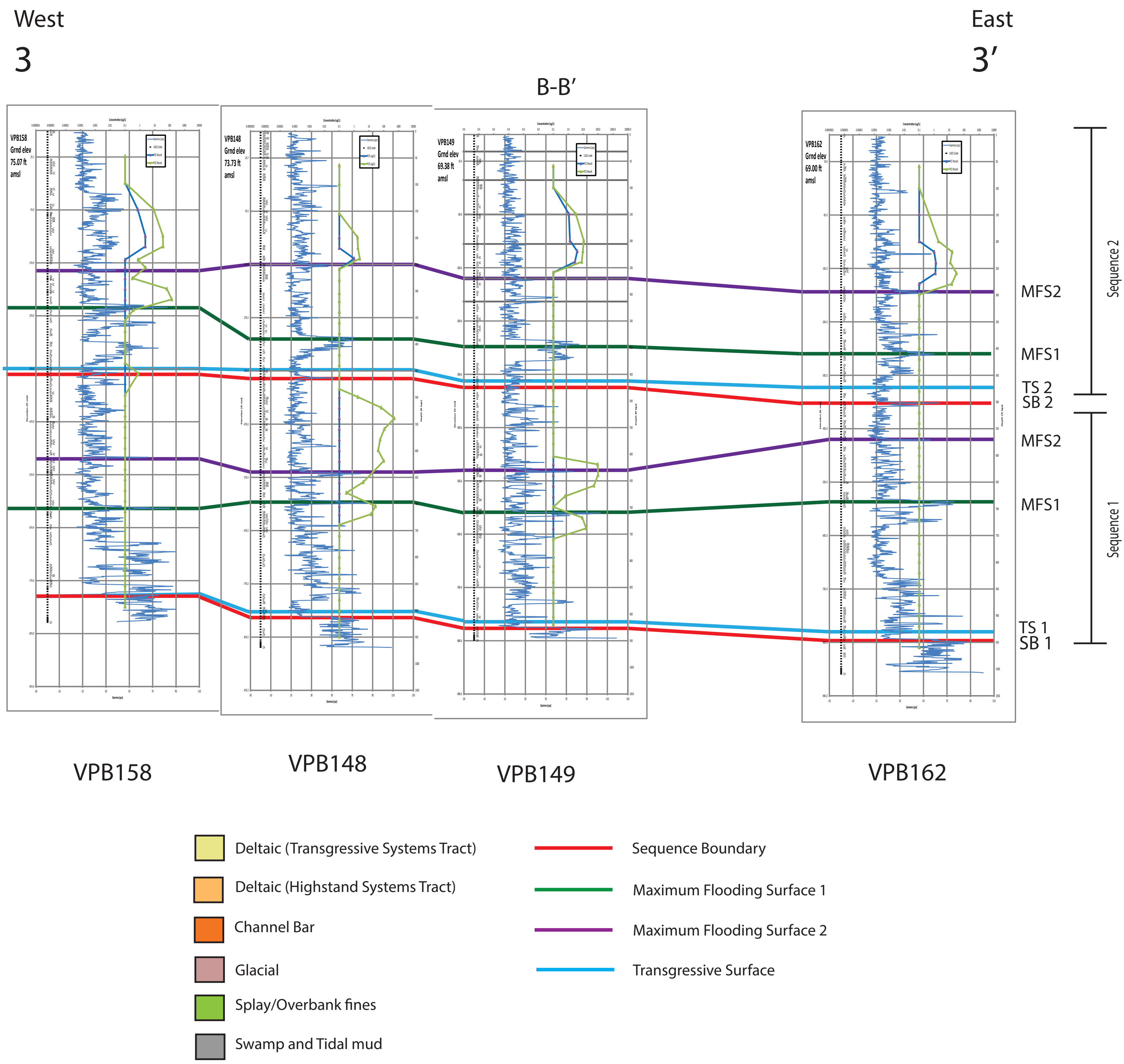


Figure 6b. Cross Section 3-3′ Showing Depositional Facies Interpretation

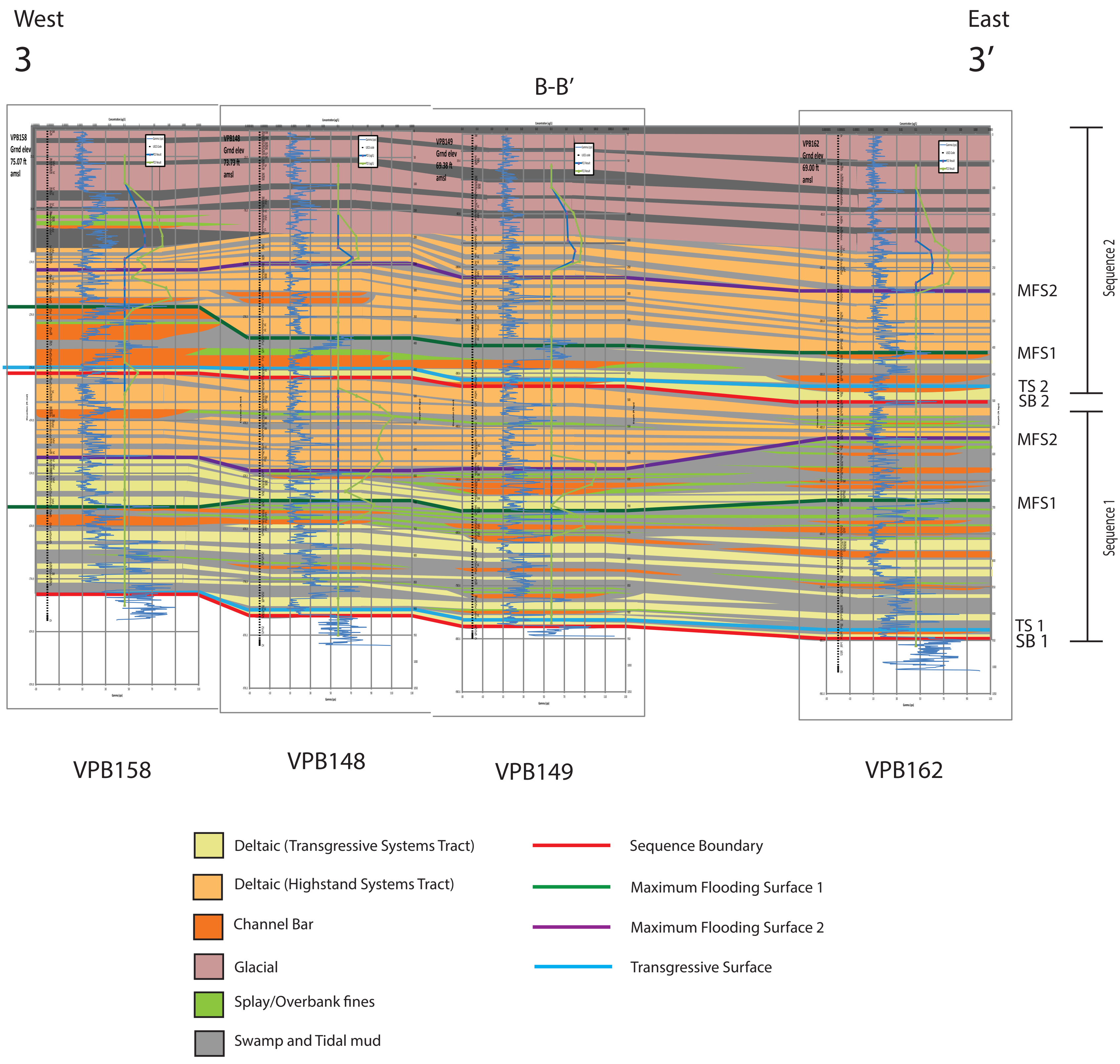


Figure 7a. Cross Section 4-4' Showing Stratigraphic Framework

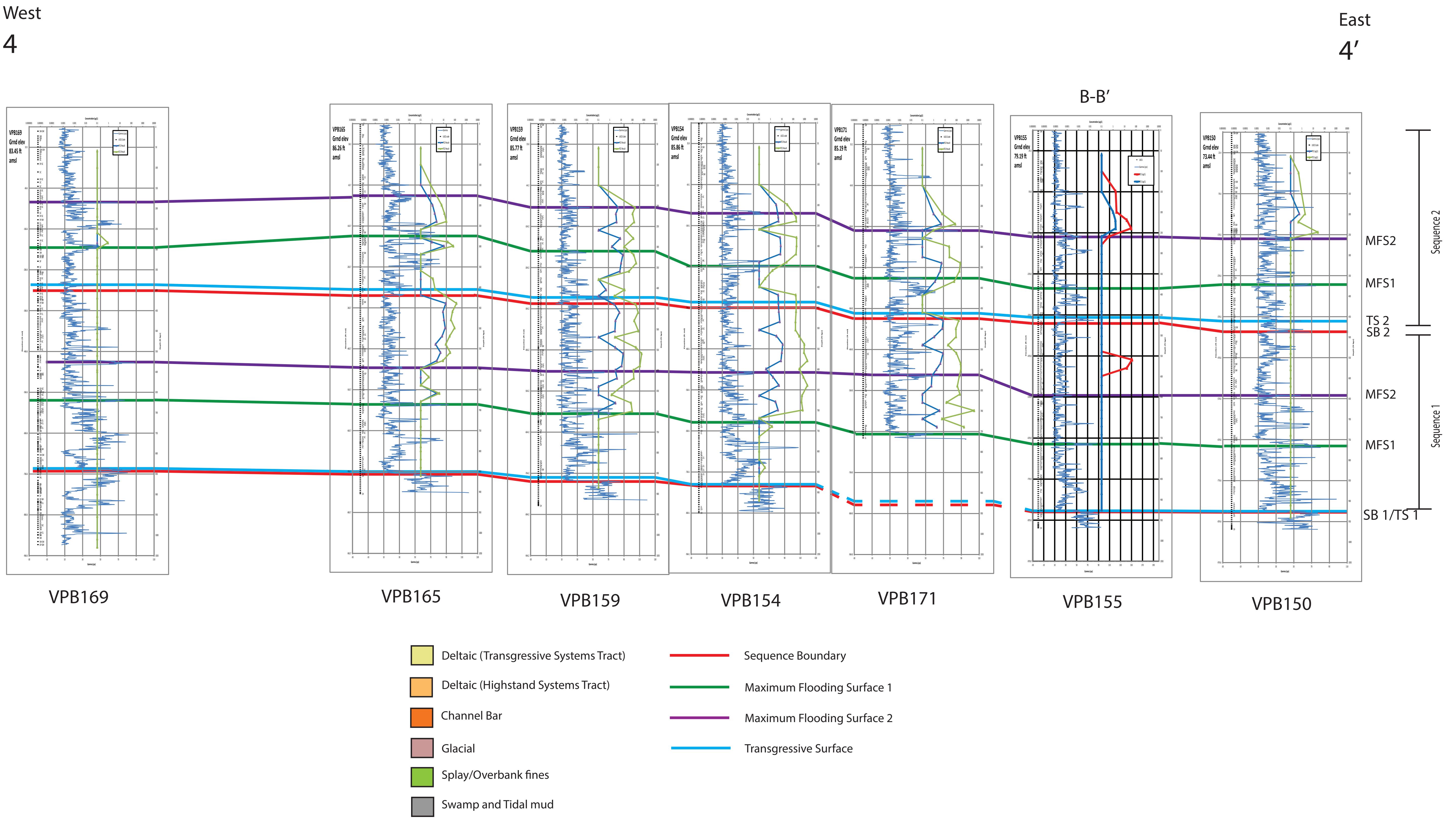


Figure 7b. Cross Section 4-4′ Showing Depositional Facies Interpretation

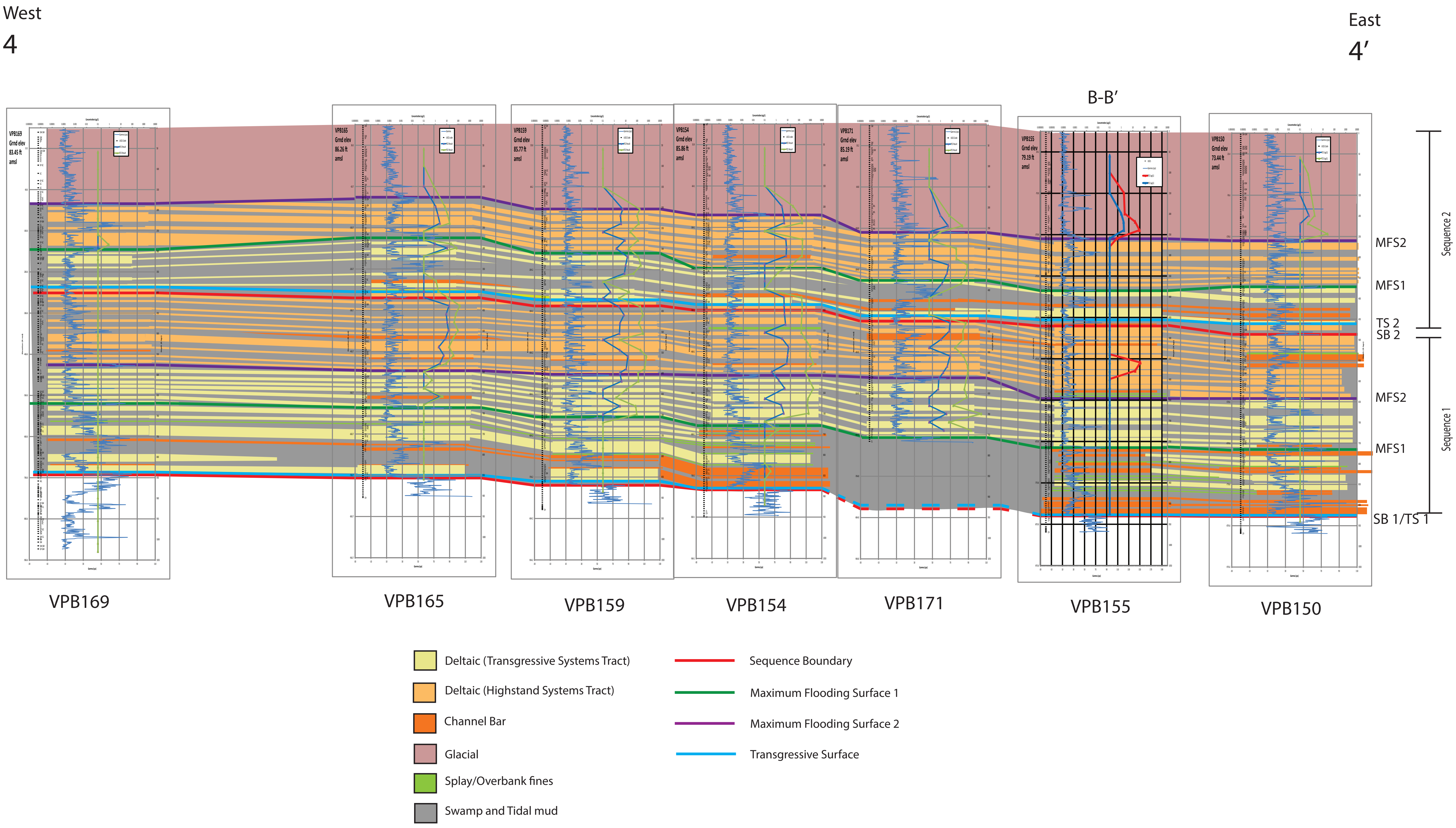


Figure 8a. Cross Section 5-5' Showing Stratigraphic Framework

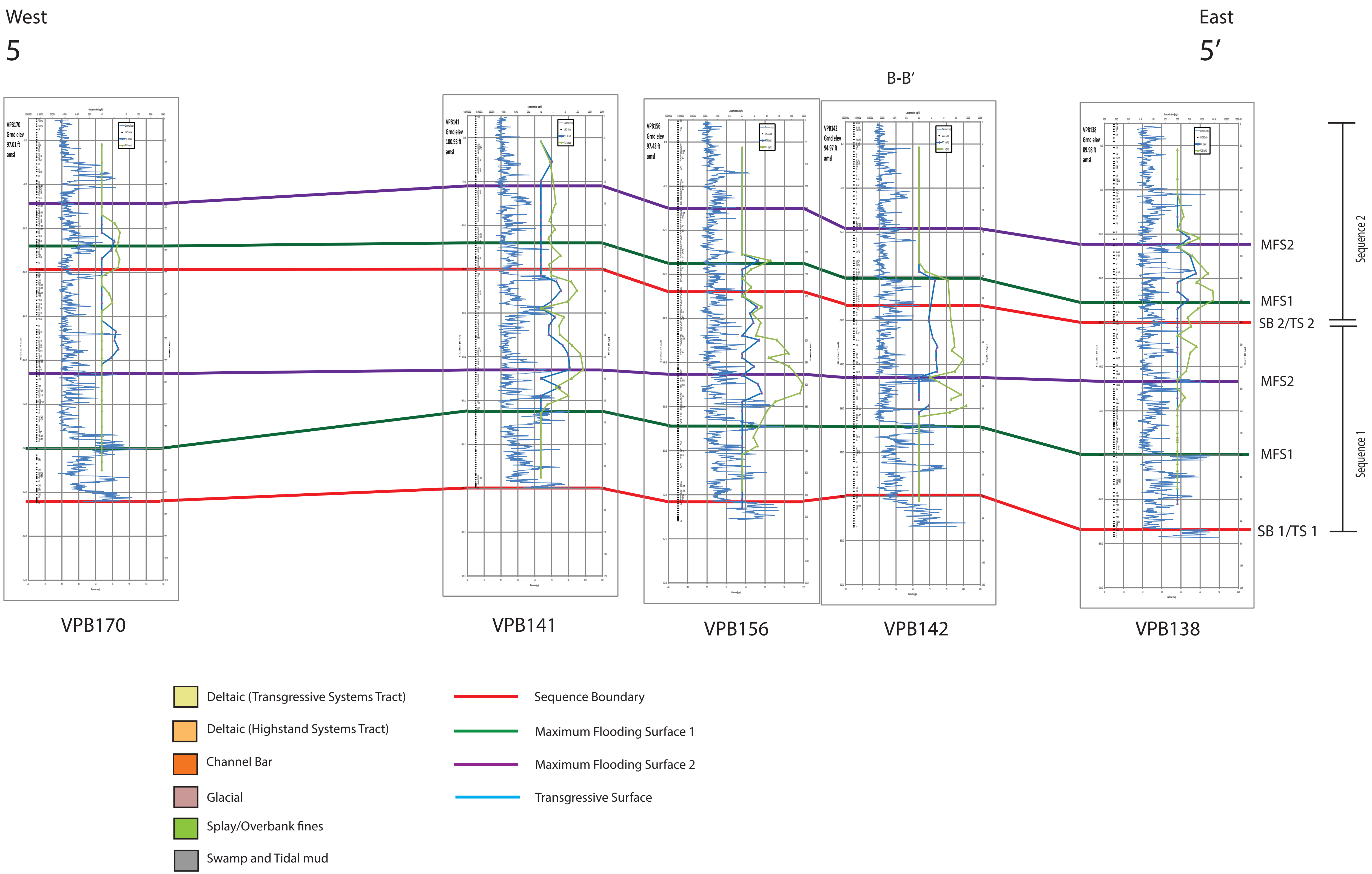
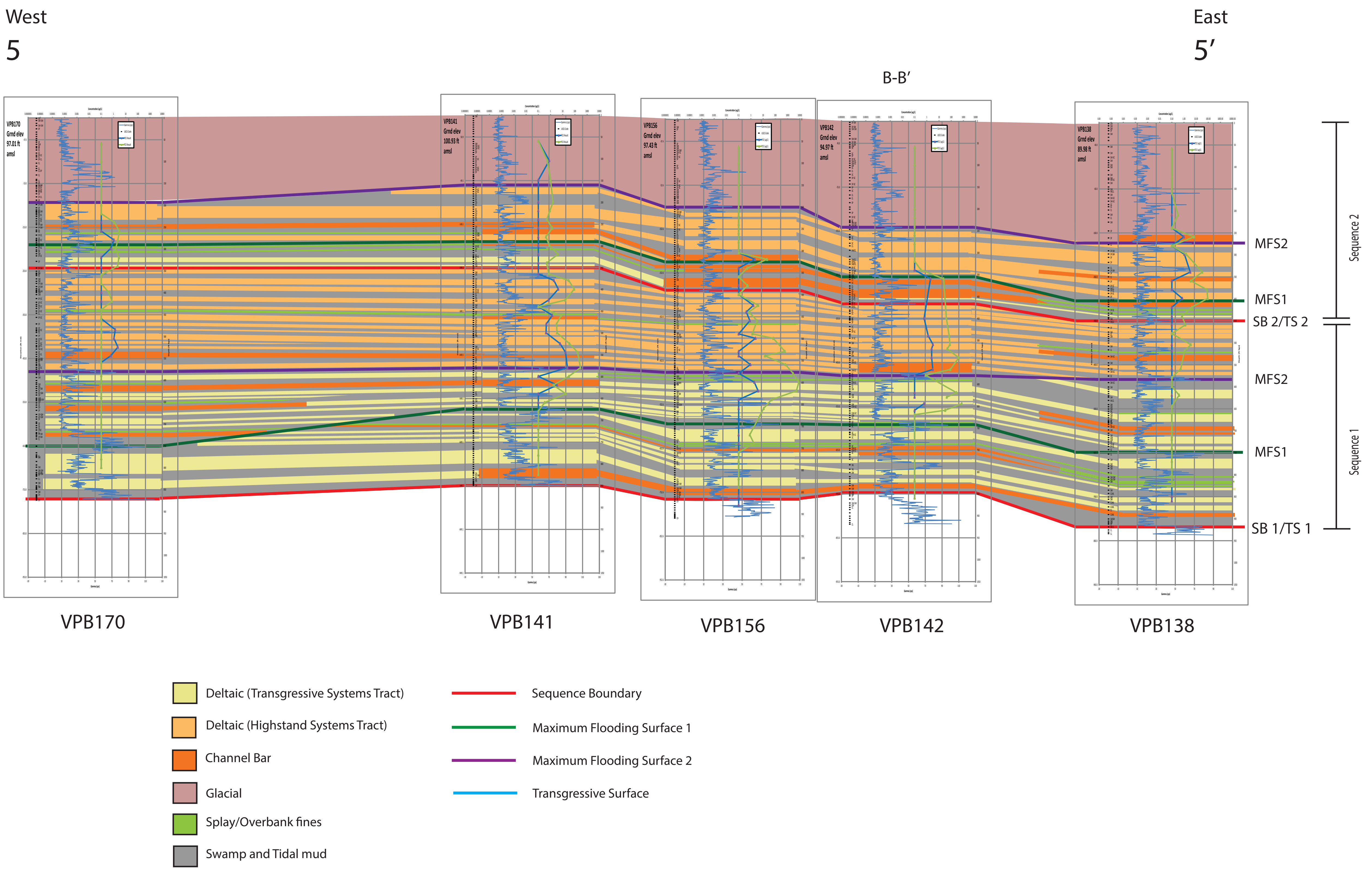


Figure 8b. Cross Section 5-5′ Showing Depositional Facies Interpretation



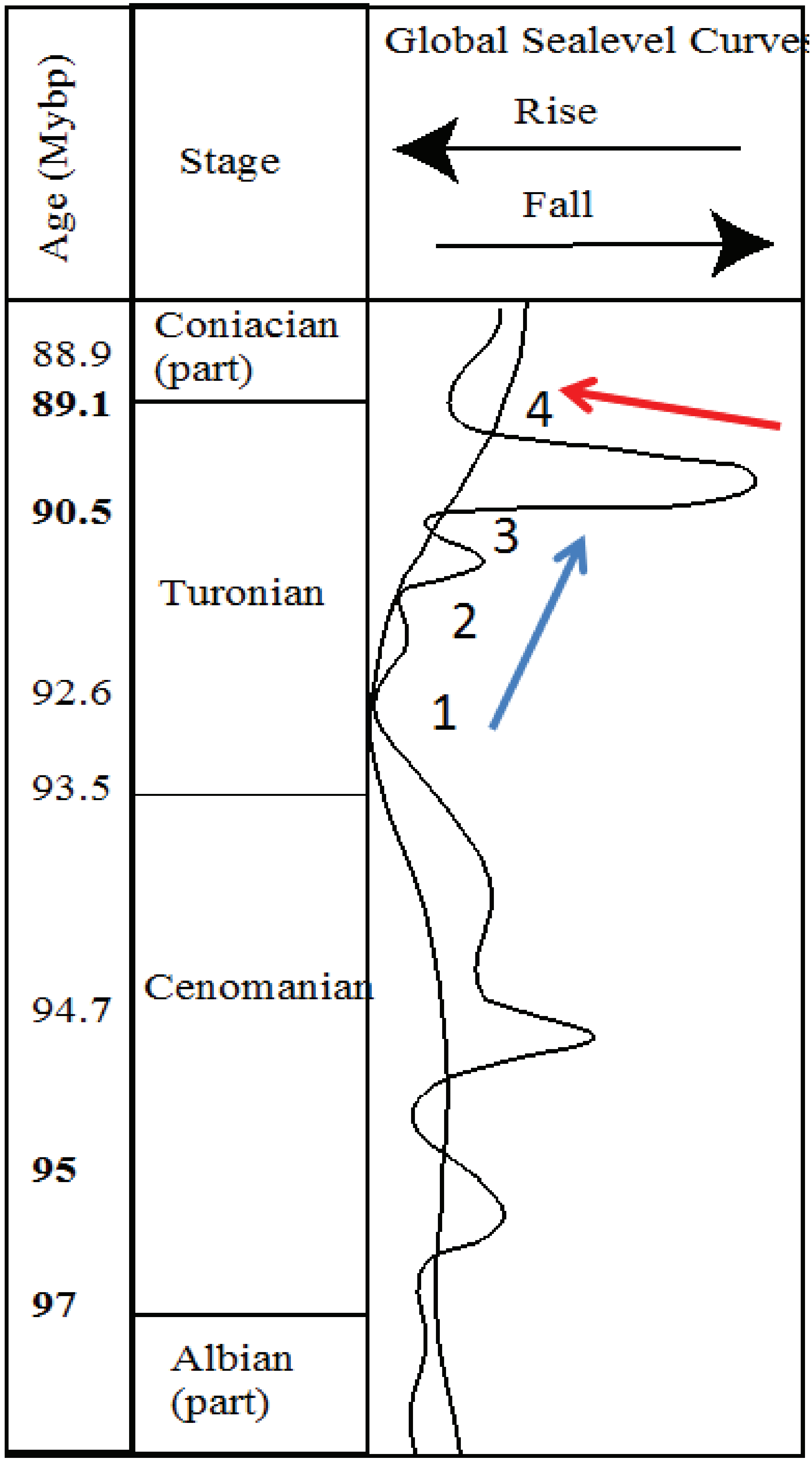


Figure 9. Historic Sea Level Curve (Miller, et al., 2005)

RESOLUTION CONSULTANTS

ATTACHMENT A

Glossary of Basic Terms

Glossary of Basic Terms

Accommodation: The space available for potential sediment accumulation. This space is the combined product of movement of:

1. The sea surface (global sea level measured from a datum, such as the center of earth)
2. The sea floor (tectonics)
3. Changes in rates of sediment accumulation.

Base level: a global reference surface to which continental erosion and marine deposition tend to proceed. It is effectively sea level, although rivers erode slightly below it.

Stratigraphy: The study of succession of the layered rocks (strata) and the lateral/vertical variations on a regional basis.

Facies: The sum total of physical and biological characteristics of a rock.

Depositional Environment: Geomorphological setting of a group of linked facies (depositional facies).

Sequence Stratigraphy: Stratigraphy in relation to accommodation within a framework of time-significant surfaces.

Relative sea level: Position of sea surface relative to a fixed datum near the sea floor determined by global sea level change (eustacy) and vertical movement of the sea floor (tectonism and/or sediment compaction).

Progradation: Sea-ward movement of the shoreline (sometimes called "regression").

Retrogradation: Land-ward movement of the shoreline (sometimes called "transgression").

Aggradation: No net land-ward or sea-ward movement of the shoreline.

Sequence: A relatively conformable successions of genetically-related strata bounded by subaerial unconformities and their correlative surfaces.

Sequence Boundary (SB): Surface of erosion or non-deposition (unconformity), separating one sequence from another.

Parasequence: Building block of a sequence. Bounded by Marine Flooding Surfaces.

Marine Flooding Surface (FS): Shale markers that record a rapid relative rise in sea level without deposition of sediment.

Transgressive Surface (TS): A prominent flooding surface that represents the first major flooding surface to follow the sequence boundary.

Maximum Flooding Surface (MFS): The last of the significant flooding surfaces and the widest landward extent of the marine incursion. It represents a turnaround from retrogradation to progradation.

Systems Tract: a three- dimensional group of depositional facies, genetically linked by active (modern) or inferred (ancient) processes and environments. We use the term, systems tract, to designate four subdivisions within each sequence of sea-level cycle: Lowstand, Transgressive, Highstand, and Falling-Stage systems tracts

Lowstand Systems Tract (LST): Systems tract bounded by the Sequence Boundary at the base and Transgressive Surface (TS) on top.

Transgressive Systems Tract (LST): Systems tract bounded by the Transgressive Surface (TS) at the base and Maximum Flooding Surface (MFS) on top.

Highstand Systems Tract (HST): Systems Tract bounded by the Maximum Flooding Surface (MFS) at the base and Basal Surface of Forced Regression (BS) on top.

Falling-Stage Systems Tract (FSST): The earliest portion of the Lowstand Systems Tract. Bounded by a Sequence Boundary (SB).

NEW YORK PROFESSIONAL GEOLOGIST SEAL

As a New York-licensed Professional Geologist, I have reviewed and approve this Well Instillation Data Summary Report for Monitoring Well RE116D1 - Groundwater Investigation at Naval Industrial Reserve Plant Bethpage Operable Unit 2, Site 1, and seal it in accordance with Article 145 Section 7209 of the New York State Education Laws. In sealing this document, I certify it was prepared under my direction, the geological information contained in it is true to the best of my knowledge and the geological methods and procedures included herein are consistent with currently accepted geological practices.

It is a violation of this law for any person to alter the contained drawings or the report in any way, unless he or she is acting under the direction of a NY-licensed Professional Geologist.

Name: Brian E. Caldwell
NY PG License Number: 000511
State: New York

Signature:

09/23/19

Date: