

GROUNDWATER MONITORING SYSTEM & SAMPLING AND ANALYSIS PROGRAM
AES PUERTO RICO LP, GUAYAMA, PUERTO RICO
(EPA COAL COMBUSTION RESIDUALS RULE)

AUGUST 2017

Prepared for:

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Alberto Meléndez
Principal, DNA-Environment, LLC

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Certifications

I hereby certify that the monitoring system described herein has been designed, constructed and installed to meet the requirements of §257.91, Groundwater Monitoring Systems, as included in 40 CFR Part 257, Subpart D, Disposal of Coal Combustion Residuals from Electric Utilities (the "CCR Rule").

I further certify that the selected statistical methods described herein are appropriate for evaluating the groundwater monitoring data for the CCR management area in accordance with §257.93(f)(6) of the CCR Rule.

I hereby certify that this report was prepared under my direct supervision, and that I am a duly registered Professional Engineer under the laws of the Commonwealth of Puerto Rico.



August 17, 2017
Date

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1 INTRODUCTION

1.1 Purpose and Scope

AES Puerto Rico, LP (AES-PR or Site) operates a coal-fired power plant located in the municipality of Guayama in the south coast of Puerto Rico (**Figure 1**). The Facility utilizes bituminous coal for energy production, and generates coal combustion residuals (CCR) in the process.

On April 17, 2015, the United States Environmental Protection Agency (EPA) published the final rule that establishes national minimum criteria for existing CCR landfills, surface impoundments, and lateral extensions of those units. Under the CCR Rule, the groundwater monitoring and corrective action requirements are contained in 40 CFR (Code of Federal Regulations), Parts 257.90 through 257.98. By October 17, 2017, owners and operators of CCR facilities must install a groundwater monitoring system, and implement sampling and analysis under a detection-monitoring program. Groundwater samples must be analyzed for a specified set of constituents. The concentration of each constituent is then to be compared to its corresponding site-specific background level.

This document describes the procedures that AES-PR will implement in order to comply with the aforementioned CCR Rule in regards to:

- The installation of the Groundwater Monitoring System; and
- The implementation of the Groundwater Monitoring Program.

1.2 Site Operations

AES-PR began operations of its 454 MW coal-fired power plant in 2002. The facility produces approximately 17% of the total electricity generated in Puerto Rico, which is supplied to the Puerto Rico Electric Power Authority (PREPA).

The CCR (i.e., coal ash) generated from energy production is stored as Agremax in a temporary stockpile storage cell that is located near the southern property boundary (**Figure 2**). Agremax is a partially solidified mixture of coal ash fractions containing calcium carbonate (as pulverized limestone and/or hydrated lime) as solidifying agent.

The nominal area of the CCR storage cell is 6 acres. However, the maximum extent of the CCR unit is about 7 acres. This includes the maximum historical extent of the CCR pile and associated structural controls for stormwater runoff.



PUERTO RICO

SITE



AES ILLUMINA
(SOLAR ENERGY FARM)

TAPI
(Inactive Pharmaceutical Plant)

AES-PR
(Power Plant)

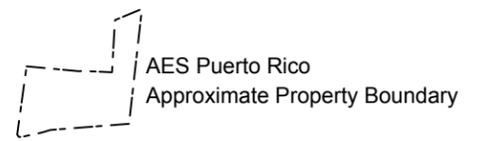
CHEVRON PHILLIPS
CHEMICAL PLANT
(INACTIVE)

Las Mareas Harbor

Caribbean Sea

Figure 1
Site Location Map
AES Puerto Rico, LP
Guayama, Puerto Rico

Legend



Legend

- ▲ Temporary Piezometer
- ▭ CCR Unit Limits (Approximate)



Figure 2

CCR Unit and Temporary Piezometers

**AES Puerto Rico, LP
Guayama, Puerto Rico**



0 200 400 600 ft



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1.3 Environmental Conditions of Neighboring Areas

Chevron Phillips Chemical Puerto Rico Core, LLC

Chevron Phillips Chemical Puerto Rico Core, LLC (CPCPRC) operated a chemical plant from 1966 to 2008. The former 211-acre chemical plant adjoins the AES-PR property to the east. CPCPRC processed naphtha into refined hydrocarbon products that included: benzene, toluene, ethylbenzene, xylenes (BTEX), cyclohexanes, liquefied petroleum gas, gasoline, and diesel fuels (EPA, 2017a). Sulfolane was used in the petroleum refining process.

In 1995, under an EPA Administrative Order of Consent, CRCPRC initiated Resource Conservation Act Facility Investigations (RFI) to evaluate impacts to groundwater, soil and sediments resulting from operations at the facility. Various RFI phases were conducted at the CPCPRC facility from 1995 to 1999. Additional site investigations, including facility-wide risk characterization, have been conducted through 2017. Among the findings, sulfolane and benzene plumes in the upper aquifer have been found to extend from the CPCPRC facility to the AES-PR property.

In 2009, CPCPRC began decommissioning and dismantling of all process units, tanks and related equipment at the facility. These activities were completed in 2014 (EPA, 2017a).

In June 2017, EPA emitted a Public Notice requesting public comments regarding proposed remedy decision to address BTEX and sulfolane impacts to groundwater. Remedial activities also will be undertaken to address impacts to sediments resulting from various metals (i.e., chromium, copper, manganese, nickel and zinc; EPA, 2017b).

Fibers Public Supply Wells Superfund Site

The Fiber Public Supply Wells site is located in Guayama, Puerto Rico, about 0.5-mile north of the AES-PR facility. The superfund site consists of parcels of land totaling 540 acres that include a former synthetic fibers manufacturing plant, and five public water supply wells owned and operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA).

The groundwater supply wells were closed after a 1982 survey confirmed groundwater contamination with volatile organic compounds. Remedial investigations since 1985 revealed various contaminated groundwater plumes including plumes of halogenated ethers in the upper and lower aquifers. These plumes were found to migrate southward, towards the AES-PR facility, where concentrations of perchloroethylene (PCE) and other haloethers were detected in the mid-1990s at the northern property boundary.

Operations of a pump-and-treat system began in May 1999 and are currently ongoing. Following cleanup activities at the superfund site, halogenated constituents have not been detected above cleanup criteria at the AES-PR facility.

2 SITE GEOLOGY AND HYDROGEOLOGY

Site geology is characteristic of an alluvial transitional zone, where alluvial deposits in the uppermost aquifer transitions to swamp and beach deposits near the southern boundary of the Site.

A site hydrogeologic characterization was conducted from May through June 2017 by evaluating data obtained from the installation of six temporary piezometers that were installed outside the perimeter of the CCR unit (**Figure 2**). The hydrogeologic study revealed that the area surrounding the CCR unit is underlain by fill material to an average depth of 10 feet below ground surface (bgs). The fill material consists of fine to medium sand and sandy clay with rock fragments. The fill stratum is underlain by the uppermost aquifer, which extends from about 10 to 25 feet bgs. This shallow aquifer is comprised of alluvial deposits consisting of layers of sandy clay, clayey sand, fine to medium sand and clayey silt. The lower bound of the uppermost aquifer was intercepted at depths ranging from 23 to 28 feet below existing grade, and consists of stiff clay of high plasticity. The confining layer was found to extent to the maximum drilling depth of 30 feet (lithologic data was not collected beyond the depth of 30 feet). Additional hydrogeologic data was collected after the installation of permanent monitoring wells that comprised the CCR monitoring system (**Figure 3**). Stratigraphic sections for the Site, corresponding to transects shown in **Figure 4**, are included in **Appendices A and B**.

The general direction of groundwater flow at the Site is southward. At the location of the CCR unit, the southward groundwater flow also exhibits southeastern and southwestern flow patterns. North of the CCR unit, groundwater flow is towards the west-southwest. **Figure 5** shows groundwater contour lines and general groundwater flow patterns for the Site. Groundwater contour lines were interpolated from groundwater table measurements using the Multilevel B-Spline method. Interpolations were performed in SAGA GIS and QGIS software (i.e., geographic information system software).

The estimated hydraulic gradient for the CCR Area is 0.0105 ft/ft. Based on slug tests performed at onsite monitoring wells, the hydraulic conductivity ranges from 0.035 to 0.67 ft/day, with a geometric mean for hydraulic conductivity of 0.13 ft/day. The average linear groundwater velocity is 6.8×10^{-3} ft/day (using an estimated effective porosity for the upper aquifer of 0.20).

3 INSTALLATION OF THE GROUNDWATER MONITORING SYSTEM

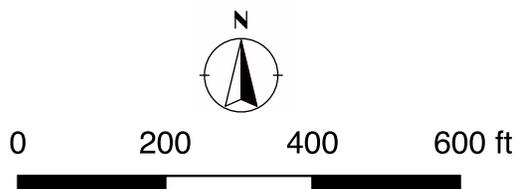
Five groundwater-monitoring wells were installed to comply with the CCR Rule requirements in 40 CFR Part 257.91, Groundwater Monitoring Systems. Monitoring well locations are shown in **Figure 3**. Three of these wells (MW-3, MW-4 and MW-5) were installed hydraulically downgradient of the CCR unit, whereas Monitoring Wells MW-1 and MW-2 were placed at hydraulically upgradient locations from the unit.

The downgradient wells were installed at the closest practical distance from the hydraulically downgradient perimeter of the CCR unit, considering the presence of underground utilities,



Figure 3
CCR Groundwater Monitoring System

AES Puerto Rico, LP
Guayama, Puerto Rico



Legend

-  Upgradient Monitoring Well
-  Downgradient Monitoring Well
-  Temporary Piezometer
-  CCR Unit Limits (Approximate)
-  Cross-Sectional Transect
(refer to stratigraphy sections in appendices)

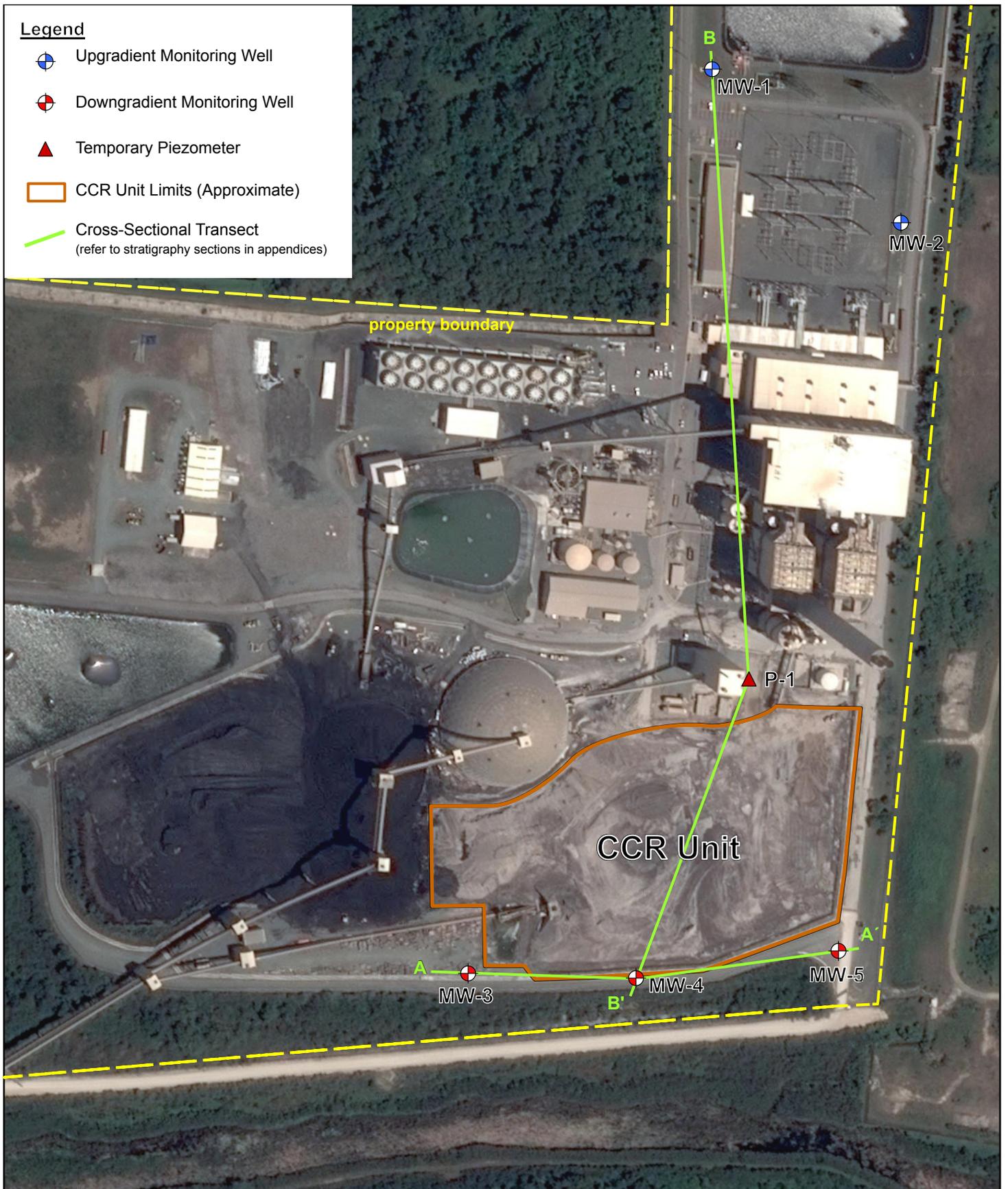


Figure 4

Cross Sectional Transects

**AES Puerto Rico, LP
Guayama, Puerto Rico**



0 200 400 600 ft



DNA-ENVIRONMENT, LLC

Legend

-  Upgradient Monitoring Well
-  Downgradient Monitoring Well
-  CCR Unit Limits (Approximate)
-  Groundwater Contour Line
-  GW Elevation in Feet above MSL
(Measured on 14-Aug-2017)
-  Groundwater Flow Direction



Figure 5
Groundwater Contour Lines

AES Puerto Rico, LP
Guayama, Puerto Rico



0 200 400 600 ft



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surface structures, and site traffic patterns. The upgradient wells were located outside of Site operations areas to obtain samples representative of the quality of background groundwater not affected by potential migration from the CCR unit.

All five wells were installed with 10-foot screen intervals vertically positioned to intercept groundwater from the same hydrostratigraphic zone in the uppermost aquifer. The soil boring and well construction logs are included in **Appendix C**. General information regarding well placement and well construction details are summarized in **Tables 1** and **2**, respectively.

Table 1. Placement of CCR Well Monitoring System

Well ID	Well Placement	Rationale
MW-1	Upgradient	MW-1 is located to the north of the CCR unit and outside of Site operation areas. This well was installed to obtain representative samples of background groundwater in the uppermost aquifer that has not been impacted by potential leachate from the CCR unit.
MW-2	Upgradient	MW-2 is located to the northeast of the CCR unit and outside of Site operation areas. This well was installed in the uppermost aquifer to monitor the quality of groundwater migrating into the CCR unit and potentially impacted by existing contamination at the Chevron Phillips Chemical Puerto Rico Core facility, adjoining property to the east.
MW-3	Downgradient	MW-3 is located to the south-southwest of the CCR stockpile and stormwater control system. This well was installed in the uppermost aquifer to detect potential impacts to the quality of groundwater passing the downgradient boundary of the CCR stockpile and stormwater control system, in the south-southwest direction.
MW-4	Downgradient	MW-4 is located to the south of the CCR stockpile and contiguous stormwater concrete ditch. This well was installed in the uppermost aquifer to detect potential impacts to the quality of groundwater passing the downgradient boundary of the CCR unit, southward.
MW-5	Downgradient	MW-5 is located to the south-southeast of the CCR stockpile and contiguous stormwater concrete ditch. This well was installed in the uppermost aquifer to detect potential impacts to the quality of groundwater passing the downgradient boundary of the CCR unit, in the south-southeast direction.

Table 2. CCR Monitoring Well Details

Well ID	Coordinates ¹		TOC ² Elevation (ft)	Screen Interval (ft bgs ³)	Well Diameter/ Slot Size	Well Type
	Northing	Easting				
MW-1	212731.35	230013.63	22.90	12.9 – 22.9	2-in/0.010-in	PVC stickup well
MW-2	212639.32	230127.80	23.10	9.9 – 19.9	2-in/0.010-in	PVC stickup well
MW-3	212188.69	229867.35	16.04	13.8 – 23.8	2-in/0.010-in	PVC stickup well
MW-4	212186.07	229968.59	17.85	15 – 25	2-in/0.010-in	PVC stickup well
MW-5	212202.55	230090.65	16.47	13.4 – 23.4	2-in/0.010-in	PVC stickup well

¹ Puerto Rico State Plane Coordinate System, NAD 83, Lambert Projection (meters)

² TOC – Top of Casing

³ bgs – below ground surface

The number and location of the downgradient monitoring wells have been deemed adequate to detect potential leachate migration from the CCR unit. This determination is based on the relatively small area of the CCR cell (i.e., nominal area of 6 acres), and linear distance of the CCR waste boundary located downgradient of groundwater flow (i.e., the length of the southern CCR boundary is approximately 775 feet).

4 GROUNDWATER SAMPLING AND ANALYSIS

The groundwater-monitoring program at AES-PR will be implemented according to 40 CFR 257.93. To that end, the Sampling and Analysis Program described herein contains the procedures for the implementation of the following:

- Statistical analysis;
- Sample collection;
- Sample preservation and shipment;
- Analytical procedures;
- Chain of custody control; and
- Quality assurance and control.

Sampling and analysis have been initiated in accordance with the document entitled *Sampling and Analysis Plan, EPA Coal Combustion Residuals Rule, AES Puerto Rico, LP, Guayama, Puerto Rico*, dated July 2017 (DNA, July 2017). Following is a description of the aforementioned elements.

4.1 Statistical Analysis

Statistical procedures will be performed in accordance with EPA guidance document entitled: *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (EPA, 2009). Graphical and statistical analyses will be conducted using EPA’s ProUCL statistical

software (EPA, 2013a and 2013b). Additional statistical software packages may be used to complement the analyses performed in ProUCL.

Detection Monitoring

During detection monitoring, analytical results will be statistically evaluated using the prediction limit method. Background levels for individual constituents will be computed as upper prediction limits (UPL) for a specified number of future observations, using a 95% confidence coefficient. The concentration of each constituent in individual compliance wells (i.e., downgradient) will be compared to the corresponding background value to determine if a statistically significant increase (SSI) over background exists.

Selection of appropriate and representative background data will be conducted in accordance with EPA's Unified Guidance. Background levels will be computed from upgradient wells for all constituents meeting the statistical requirement of spatial stationarity across the site (i.e., no natural-occurring spatial variation exists between upgradient and downgradient wells). For each constituent exhibiting spatial stationarity, the UPL will be computed from the upgradient wells, and upgradient-to-downgradient interwell comparisons will be conducted. For constituents showing spatial variability, background values will be computed from downgradient wells if it can be shown that the CCR unit has not impacted downgradient wells in regards to the constituents of concern. For each of these constituents, an UPL will be computed for each downgradient well, and subsequent semi-annual detection monitoring results will be evaluated using intrawell statistical comparisons.

Calculation of prediction limits will be preceded by data evaluation through graphical displays and statistical testing in order to:

- Identify and remove data outliers -
Data will be graphed using various methods (e.g., box plots and Quantile-Quantile plots) to visually identify data outliers. The presence of outliers will be confirmed by statistical testing (e.g., Dixon test or Rosner test). Following confirmation, outliers will be removed from the dataset.
- Test for trends –
Temporal trends present evidence that the data may not be representative of steady-state conditions, thus adversely affecting statistical results. Temporal trends will be evaluated using time series graphical methods and statistical tests (e.g., Mann-Kendall test). The presence of spatial trends will be tested using goodness-of-fit tests (see below).
- Identify the underlying population distribution –
Goodness-of-fit (GOF) tests will be conducted to evaluate the underlying population distribution of the data (i.e., normal, lognormal, gamma, or other). The data will be submitted to GOF tests (e.g., Shapiro Wilks test, Anderson Darlings, or other) to identify the theoretical distribution that best fits the

dataset. Comparison of data distribution among wells will also be used to identify if spatial trends exist between background and compliance wells. Identification of spatial trends between samples from two or more wells presents evidence that the samples were not drawn from the same population.

- Handle datasets with non-detect results –

An analytical result below the laboratory-reporting limit (RL) will be identified as a non-detect (ND) result. Non-detect results will be handled by fitting the appropriate parametric or nonparametric statistical model to replace the ND values with those of the fitted statistical distribution. For known distributions, regression of order statistics (ROS), or similar test, will be used to replace the ND values. For unknown distributions (i.e., nonparametric), the Kaplan-Meier, or similar test, will be used. Non-detects will be replaced with ½ the RL value, only when a low percentage of ND in the dataset (i.e., 10-15%) precludes the use of statistical methods. Datasets with 100% non-detects will be handled using the “double quantification rule”. In such cases an exceedance will be confirmed if a given constituent that had not been detected in previous events is subsequently detected in two consecutive sampling/resampling events.

- Calculate background levels according to data distributions –

Prediction limits will be computed using the appropriate parametric or nonparametric test. When appropriate, non-normally distributed data will be transformed to normally distributed data using log transformation or alternate transformation method according to the “ladder of powers” (i.e., $x^{1/2}$, x^2 , $x^{1/3}$, x^3 , etc.).

For any constituent, a determination of a SSI over background may trigger assessment monitoring and subsequent corrective action in the absence of evidence of natural variation, sampling/analysis error, or offsite source of contamination.

Assessment and Correction Action Monitoring

During assessment or corrective action monitoring, groundwater data is typically compared to a fixed numerical limit established as a groundwater protection standard (GWPS) or cleanup criterion (in the case of corrective action). If assessment or corrective action monitoring is warranted, groundwater data will be statistically evaluated using confidence intervals. The appropriate parametric or nonparametric confidence interval procedure will be selected based on the underlying population distribution of the dataset.

In assessment monitoring, the 95% lower confidence limit (LCL) for each constituent of concern will be computed to determine if a statistically significant level (SSL) above the corresponding GWPS exists in groundwater samples from compliance wells.

In corrective action monitoring, the 95% upper confidence limit (UCL) of groundwater data from compliance wells will be compared to the corresponding cleanup criterion. The

comparison will be made to determine whether groundwater concentrations exhibit a statistically significant decrease below the cleanup level.

For groundwater data exhibiting increasing or decreasing trends, the confidence intervals will be plotted as 95% confidence bands.

Calculation of confidence intervals will be preceded by data evaluation through graphical displays and statistical testing following the steps used for prediction limits as described above (i.e., evaluation of outliers, trends, population distribution, handling of ND results and data transformation).

4.2 Sampling Frequency

Detection Monitoring

To establish background levels, the initial phase of detection monitoring will be initiated by completing eight groundwater-sampling events by October 17, 2017. During this initial phase, groundwater samples from each upgradient and downgradient well will be analyzed for the constituents in Appendix III and IV of the CCR Rule (see Section 4.5, Analytical Methods). Following the establishment of background levels, detection monitoring will continue on a semiannual basis, and groundwater samples from each upgradient and downgradient well will be analyzed for the constituents in Appendix III.

Assessment Monitoring

If one or more constituents from Appendix III are detected at statistically significant levels above background, assessment monitoring will be initiated within 90 days if it cannot be demonstrated that the increase is attributable to naturally occurring variations in groundwater quality, other sources of contamination, or sampling/analysis error.

4.3 Sample Collection and Handling

Groundwater sampling will be conducted using the *Low Stress (Low Flow) Purging and Sampling Procedure* in accordance with EPA Region 2 (EPA, 1998). Low flow purging and sampling will be conducted using a peristaltic pump and flow cell attached to a handheld multi-parameter meter (to monitor pH, conductivity, dissolved oxygen, and temperature). Turbidity measurements will be collected using a turbidimeter. The peristaltic pump will be set at a flow rate not to exceed 150 milliliters/minute to attain laminar flow of groundwater inside the well screen. The pump tubing will be set at a depth corresponding to the vertical mid-section of the well screen. Purging will proceed until field parameters are stabilized. The detailed Low-Flow Purging and Sampling procedure is included in **Appendix D**.

Groundwater samples for metal analyses will not be field-filtered, so as to measure the “total recoverable metals” present in the particulate and dissolved fractions of the sample.

Groundwater and quality control samples will be collected in laboratory-supplied containers to which the analytical laboratory had added the required sample preservative. Sample containers will have pre-affixed labels indicating the required analytical methods. The type of sample container will be compatible with the sample matrix and analyses to be performed.

All samples for analyses requiring cooling will be kept iced, inside chest coolers, until samples are delivered to the analytical laboratory to ensure sample integrity. Samples for Radium 226 and 228 analyses will be packed inside chest coolers without ice (as cooling is not required for these analyses). Samples will be packed and shipped via overnight carrier to the analytical laboratory following chain-of-custody protocols. TestAmerica Laboratories, Inc. has been selected as the analytical laboratory for the initial phase of detection monitoring (i.e., eight groundwater sampling events). However, other providers of analytical services may be considered for subsequent groundwater monitoring phases.

4.4 Chain of Custody Control

A chain-of-custody (COC) record will be maintained to ensure that samples have not been tampered with throughout sample handling and analysis. A copy of the field COC Form that will be used in the groundwater-monitoring program is provided in **Appendix E**.

The COC Record will be filled out completely and legibly (in print) with indelible ink. Errors will be corrected by drawing a single line through the initial entry and initialing the change. All sample transfers will be recorded on the COC Form in the “relinquished by” and “received by” sections.

The field sampling-technician will be responsible for maintaining sample custody, and for delivering all sample-containing coolers to Federal Express for overnight shipping to the analytical laboratory.

4.5 Analytical Methods

The following table summarizes the analytical methods and testing requirements for groundwater and quality control samples for the constituents listed in Appendices III and IV of the CCR Rule.

Table 3. Analytical Methods and Testing Requirements for Groundwater and Quality Control Samples

Parameter	Testing Method	Holding Time Before Extraction	Container Type	Preservation
<i>CCR Rule Appendix III</i>				
Boron	EPA 6020 (ICP-MS with collision cell)	180 days	Plastic 250 mL	HNO ₃ to pH<2 ¹ Cool, ≤6 °C ³
Calcium	EPA 6020 (ICP-MS with collision cell)	180 days	Plastic 250 mL	HNO ₃ to pH<2 Cool, ≤6 °C
Chloride, Total	SM ³ 4500-Cl-E	28 days	Plastic 250 mL	Cool, ≤6 °C
Fluoride	SM 4500-F-C	28 days	Plastic 125 mL	Cool, ≤6 °C
Sulfate, Total	SM 4500-SO4-E	28 days	Plastic 250 mL	Cool, ≤6 °C
Total Dissolved Solids	SM 2540C	7 days	Plastic 500 mL	Cool, ≤6 °C
pH	Field pH Meter	Immediately	Plastic or Glass	Not Applicable
<i>CCR Rule Appendix IV</i>				
Metals (Sb, As, Ba, B, Cd, Ca, Cr, Co, Pb, Li, Mo, Se, Tl) ³	EPA 6020 (ICP-MS with collision cell)	180 days	Plastic 250 mL	HNO ₃ to pH<2 Cool, ≤6 °C
Mercury	EPA 7470A	28 days	Plastic 250 mL	HNO ₃ to pH<2 Cool, ≤6 °C
Fluoride	SM 4500-F-C	28 days	Plastic 125 mL	Cool, ≤6 °C
Radium-226 & 228	9315-Ra226 & 9320-Ra228	180 days	Plastic 1 L	HNO ₃
pH	Field pH Meter	Immediately	Plastic or Glass	Not Applicable

¹ HNO₃ to pH<2 = Nitric acid added to lower sample pH to less than two units.

² SM = Standard Methods for the Examination of Waters and Wastewaters.

³ Cool, ≤6 °C = Cool sample to six degrees Centigrade or less.

⁴ Antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, lead, lithium, molybdenum, selenium, and thallium.

4.6 Quality Assurance and Control

In addition to the collection of groundwater samples, field and laboratory quality control samples will be prepared and analyzed for determination of data accuracy and precision.

4.6.1 Field Quality Control

The following field quality control samples will be collected for each groundwater-sampling event:

- Field duplicate
- Field blank
- Matrix Spike and Matrix Spike Duplicate (MS/MSD).

Equipment blanks will not be collected given that all sampling equipment in contact with the sample will be dedicated and disposable.

The duplicate groundwater sample will be collected from one of the downgradient wells at a rate of one field duplicate per sampling event. Sampling error, due to sampling technique and matrix heterogeneity, will be estimated by calculating the relative percent difference (RPD) between the field sample and corresponding field duplicate.

One field blank will be collected at a rate of one blank per sampling day. The field blank will be prepared in the field by pouring laboratory-supplied deionized water into the sample containers provided by the laboratory. The field blank will be kept opened during sampling and will be closed at the end of each sampling day.

Triple sample-volume from one of the monitoring wells will be collected in the field. This will result in the collection of three sets of sample containers for the preparation of laboratory QC samples, including the MS and MSD.

All field QC samples will be handled and shipped in the same manner as the collected groundwater samples, and will be analyzed for the required CCR constituents.

4.6.2 Analytical Quality Control

The analytical laboratory will prepare and analyze laboratory QC samples per its Quality Assurance Manual. Laboratory QC samples will consist of laboratory blanks, laboratory control samples, matrix spike/matrix spike duplicates (MS/MSD), and sample duplicates, among others.

The laboratory will prepare a method blank to evaluate if contamination has been introduced during sample preparation or analysis. The method blank will be prepared and analyzed along with the corresponding samples at a frequency of one blank per batch. The laboratory will take and document corrective action if the concentration of any target analyte is detected in the method blank above the laboratory-reporting limit, and if less than ten times of the amount of the analyte found in the associated sample. Corrective actions will include the re-preparation and re-analysis of all samples, where possible, along with a full set of the required QC samples. Data qualifiers will be applied to any result reported that is associated with a contaminated method blank.

The MS/MSD for each matrix will contain all method-specified analytes and will be analyzed once per every 20 samples for each analytical method. The MS and MSD will be evaluated against the corresponding method control limit. Any compound outside control limits will be qualified appropriately.

A Laboratory Control Sample (LCS) will be prepared by the laboratory to evaluate the performance of the entire analytical system including preparation and analysis. The LCS will contain all analytes specified by the analytical method and will be analyzed along with the

corresponding samples at a frequency of one blank per batch. The LCS will be evaluated against the corresponding method control limit. Any compound outside control limits will be qualified appropriately. Any associated sample containing and “outside of control” compound will be re-analyzed with a successful LCS or reported with the appropriate data qualifier.

5 ANNUAL REPORT

The Annual Groundwater Monitoring and Corrective Action Report will be prepared per requirements in 40 CFR 257.90(e). The annual report will be placed into the operating record by January 31, 2018 and annually thereafter.

6 REFERENCES

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7 APPENDICES

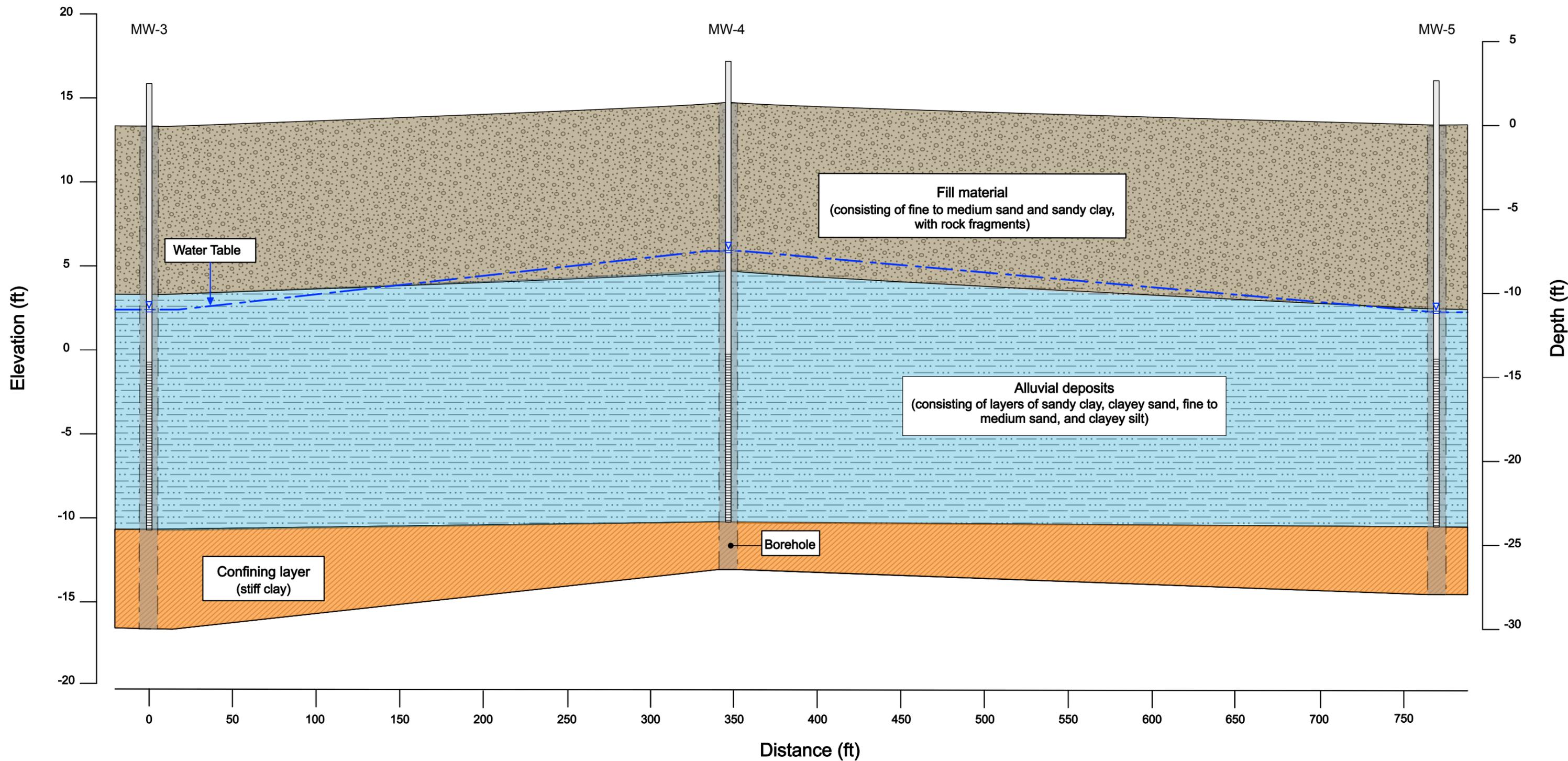
APPENDIX A

STATIGRAPHY SECTION A – A'

STRATIGRAPHY SECTION

A (West)

A' (East)



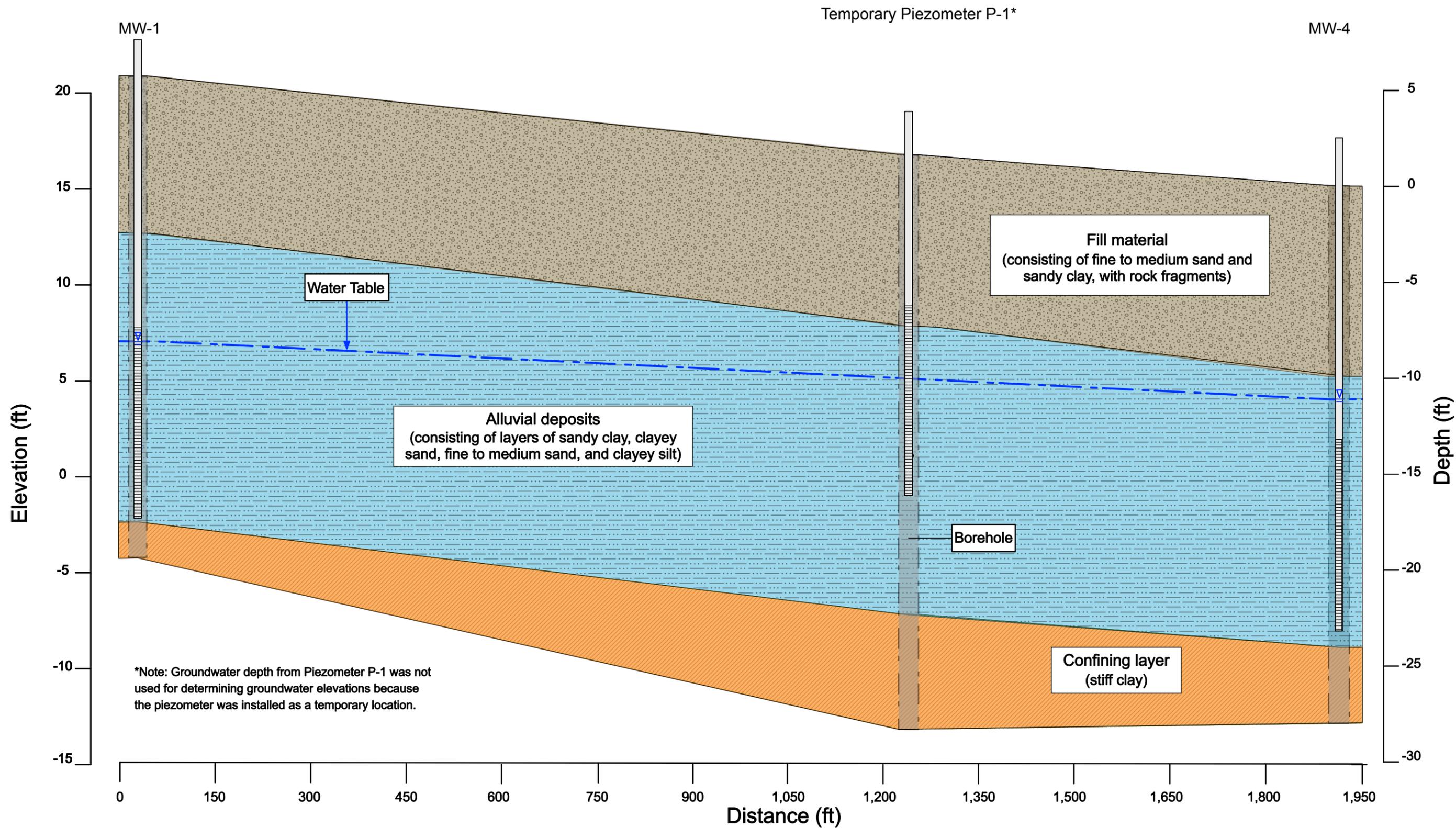
APPENDIX B

STATIGRAPHY SECTION B – B'

STRATIGRAPHY SECTION B - B'

B (North)

B' (South)



APPENDIX C

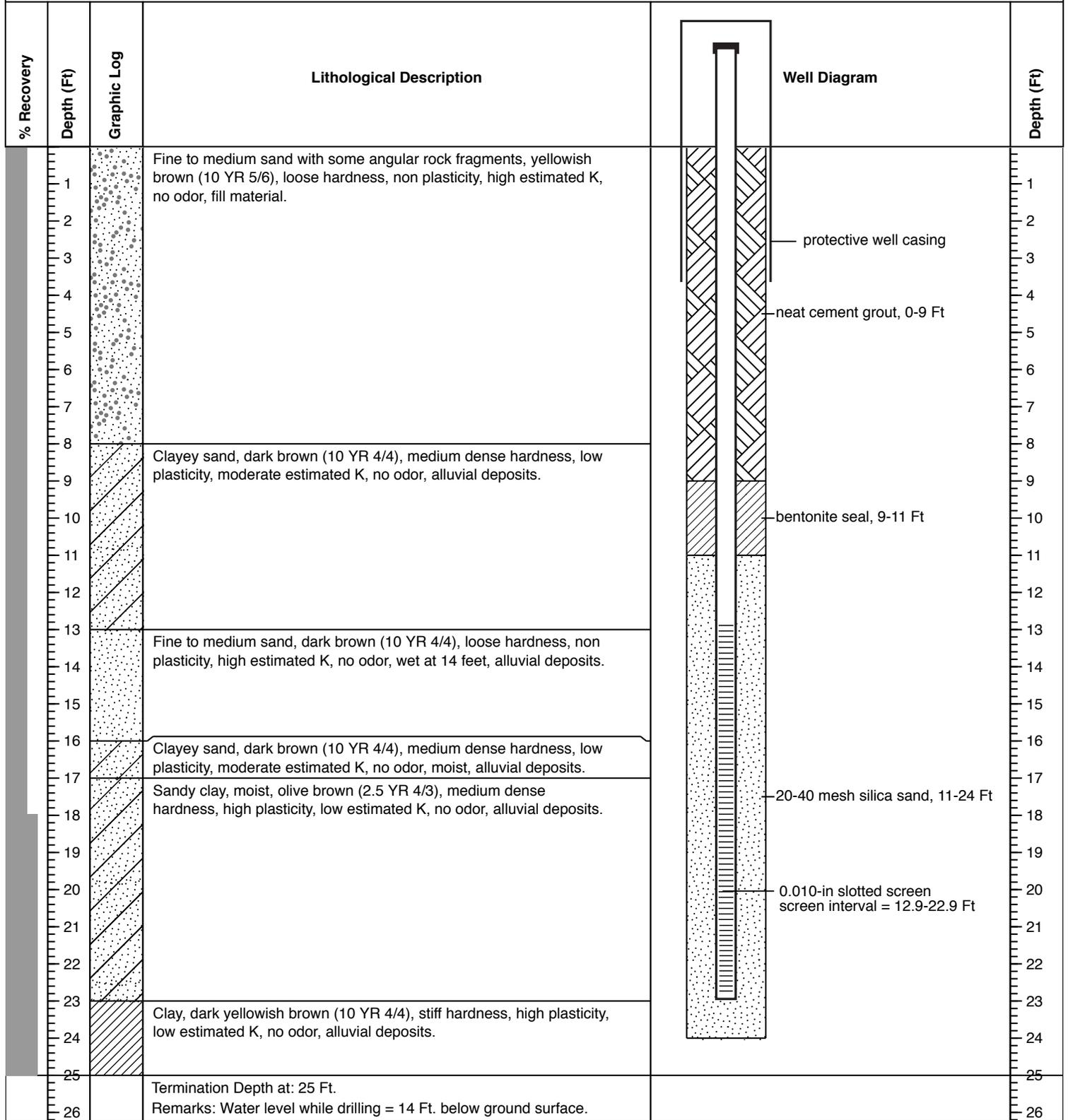
SOIL BORING AND WELL CONSTRUCTION LOGS

GROUNDWATER LOG MW-1

PROJECT NUMBER: DNA-170154	DRILLING DATE: July 20, 2017	COORDINATES: y = 222731.35, x = 230013.63
PROJECT NAME: CCR Groundwater Monitoring	WELL COMPLETION DATE: July 20, 2017	COORD SYS: NAD 83, PR State Plane, Lambert (m)
CLIENT: AES Puerto Rico, LP	WELL DIAMETER: 2-in	GROUND ELEVATION: 20.67 ft
ADDRESS: Guayama, Puerto Rico	WELL CASING: PVC	WELL ELEVATION AT TOC: 22.90 ft
DRILLERS: GeoEnviroTech, Inc. (Guaynabo, PR)	SCREEN: PVC Factory Slotted (0.010-in)	WELL DEPTH FROM GROUND: 22.92 ft

COMMENTS Upgradient Well
Borehole was drilled using 8.25-in o.d. hollow stem augers.

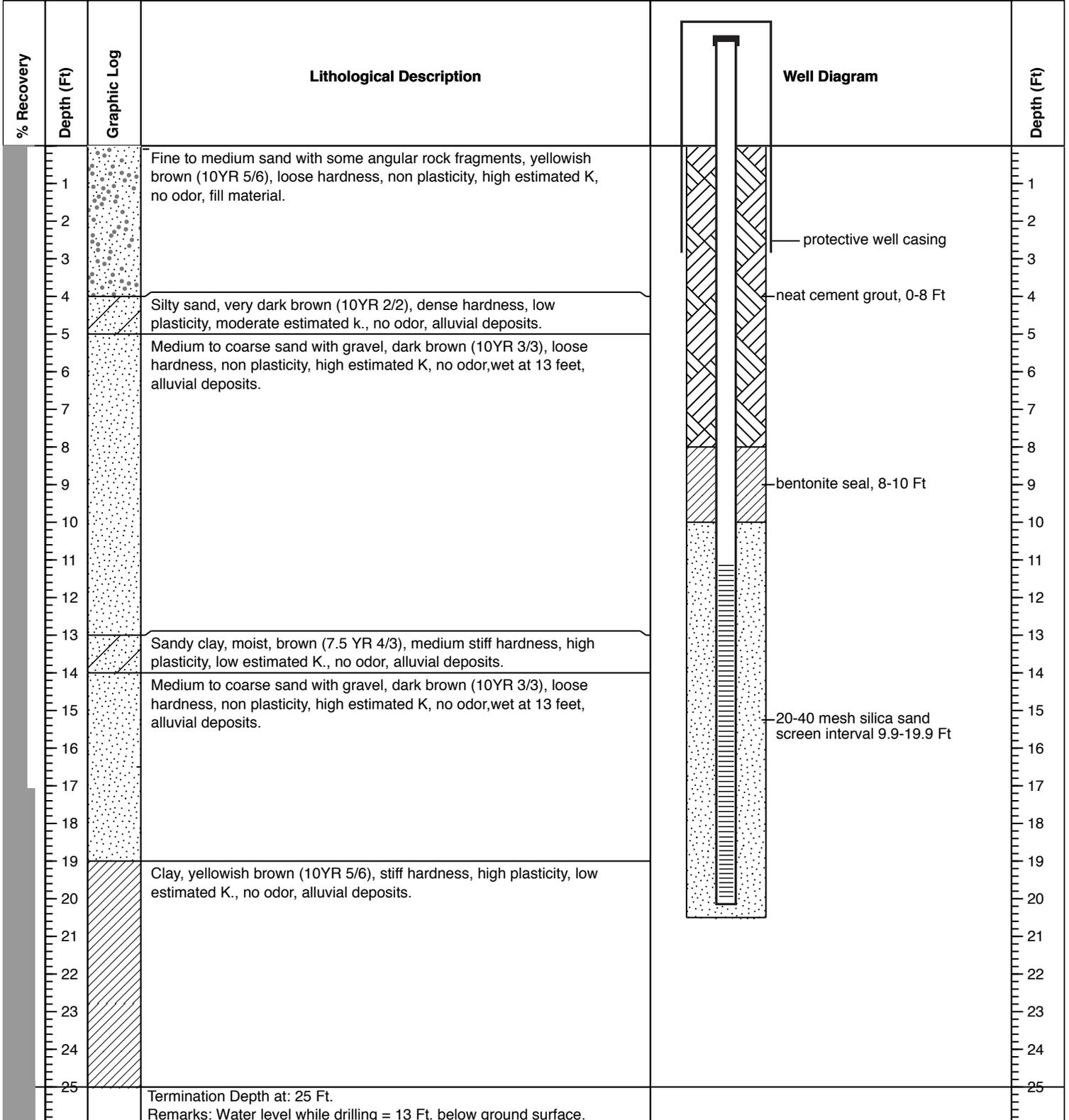
LOGGED BY Hardy Rodriguez
CHECKED BY Juan D. Negron, PG



GROUNDWATER LOG MW-2

PROJECT NUMBER: DNA-170154	DRILLING DATE: July 20, 2017	COORDINATES: y = 212639.32, x = 230127.80
PROJECT NAME: CCR Groundwater Monitoring	WELL COMPLETION DATE: July 20, 2017	COORD SYS: NAD 83, PR State Plane, Lambert (m)
CLIENT: AES Puerto Rico, LP	WELL DIAMETER: 2-in	GROUND ELEVATION: 20.73 ft
ADDRESS: Guayama, Puerto Rico	WELL CASING: PVC	WELL ELEVATION AT TOC: 23.10 ft
DRILLERS: GeoEnviroTech, Inc. (Guaynabo, PR)	SCREEN: PVC Factory Slotted (0.010-in)	WELL DEPTH FROM GROUND: 19.94 ft

COMMENTS Upgradient Well Borehole was drilled using 8.25-in o.d. hollow stem augers.	LOGGED BY Hardy Rodriguez CHECKED BY Juan D. Negrón, PG
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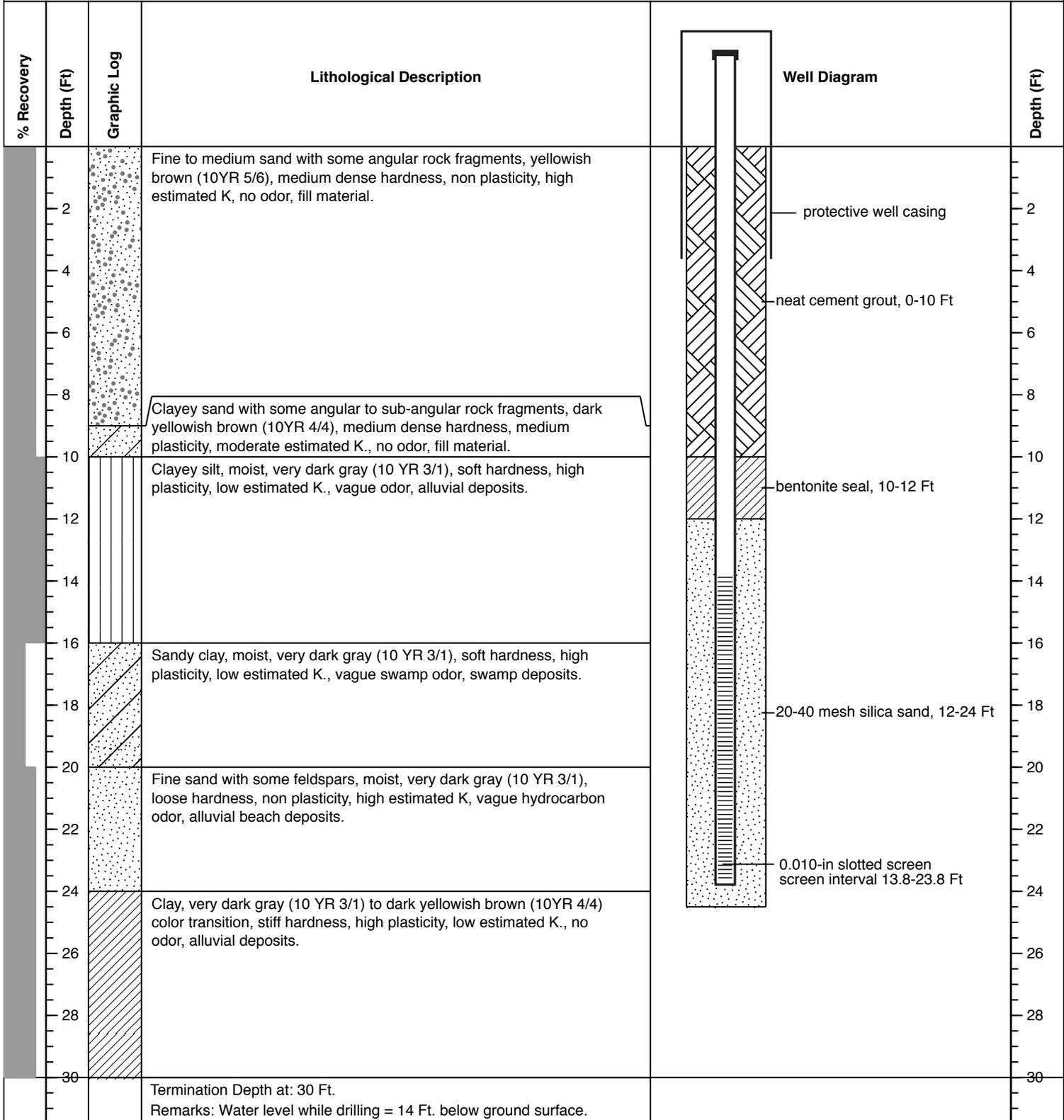


GROUNDWATER LOG MW-3

PROJECT NUMBER: DNA-170154 PROJECT NAME: CCR Groundwater Monitoring CLIENT: AES Puerto Rico, LP ADDRESS: Guayama, Puerto Rico DRILLERS: GeoEnviroTech, Inc. (Guaynabo, PR)	DRILLING DATE: July 21, 2017 WELL COMPLETION DATE: July 21, 2017 WELL DIAMETER: 2-in WELL CASING: PVC SCREEN: PVC Factory Slotted (0.010-in)	COORDINATES: y = 212188.69, x = 229867.35 COORD SYS: NAD 83, PR State Plane, Lambert (m) GROUND ELEVATION: 13.62 ft WELL ELEVATION AT TOC: 16.04 ft WELL DEPTH FROM GROUND: 23.77 ft
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COMMENTS Downgradient Well
Borehole was drilled using 8.25-in o.d. hollow stem augers.

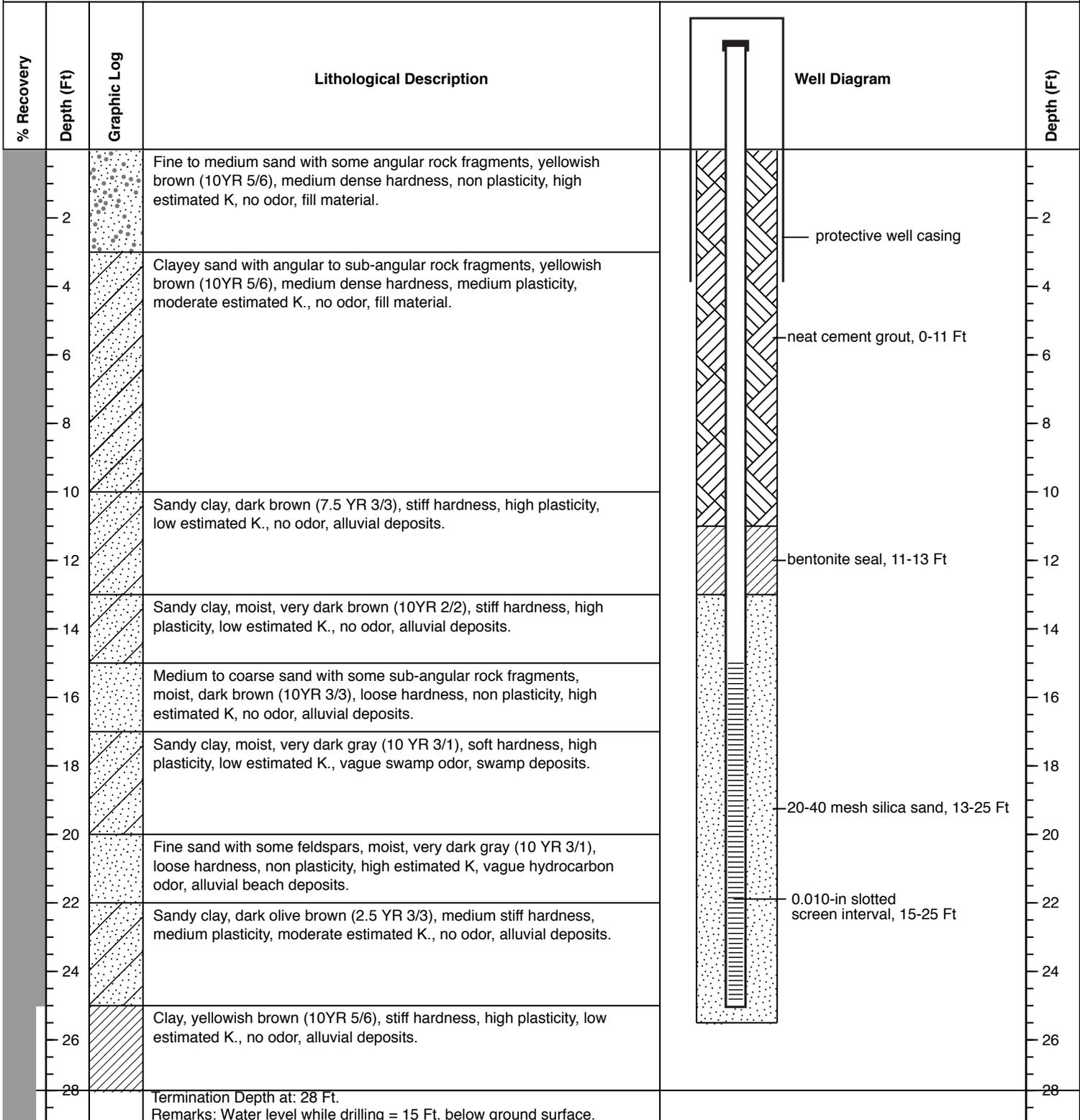
LOGGED BY Hardy Rodriguez
CHECKED BY Juan D. Negrón, PG



GROUNDWATER LOG MW-4

PROJECT NUMBER: DNA-170154 PROJECT NAME: CCR Groundwater Monitoring CLIENT: AES Puerto Rico, LP ADDRESS: Guayama, Puerto Rico DRILLERS: GeoEnviroTech, Inc. (Guaynabo, PR)	DRILLING DATE: July 21, 2017 WELL COMPLETION DATE: July 21, 2017 WELL DIAMETER: 2-in WELL CASING: PVC SCREEN: PVC Factory Slotted (0.010-in)	COORDINATES: y = 212186.07, x = 229968.59 COORD SYS: NAD 83, PR State Plane, Lambert (m) GROUND ELEVATION: 15.19 ft WELL ELEVATION AT TOC: 17.85 ft WELL DEPTH FROM GROUND: 25.09 ft
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COMMENTS Downgradient Well. Borehole was drilled using 8.25-in o.d. hollow stem augers.	LOGGED BY Hardy Rodriguez CHECKED BY Juan D. Negron, PG
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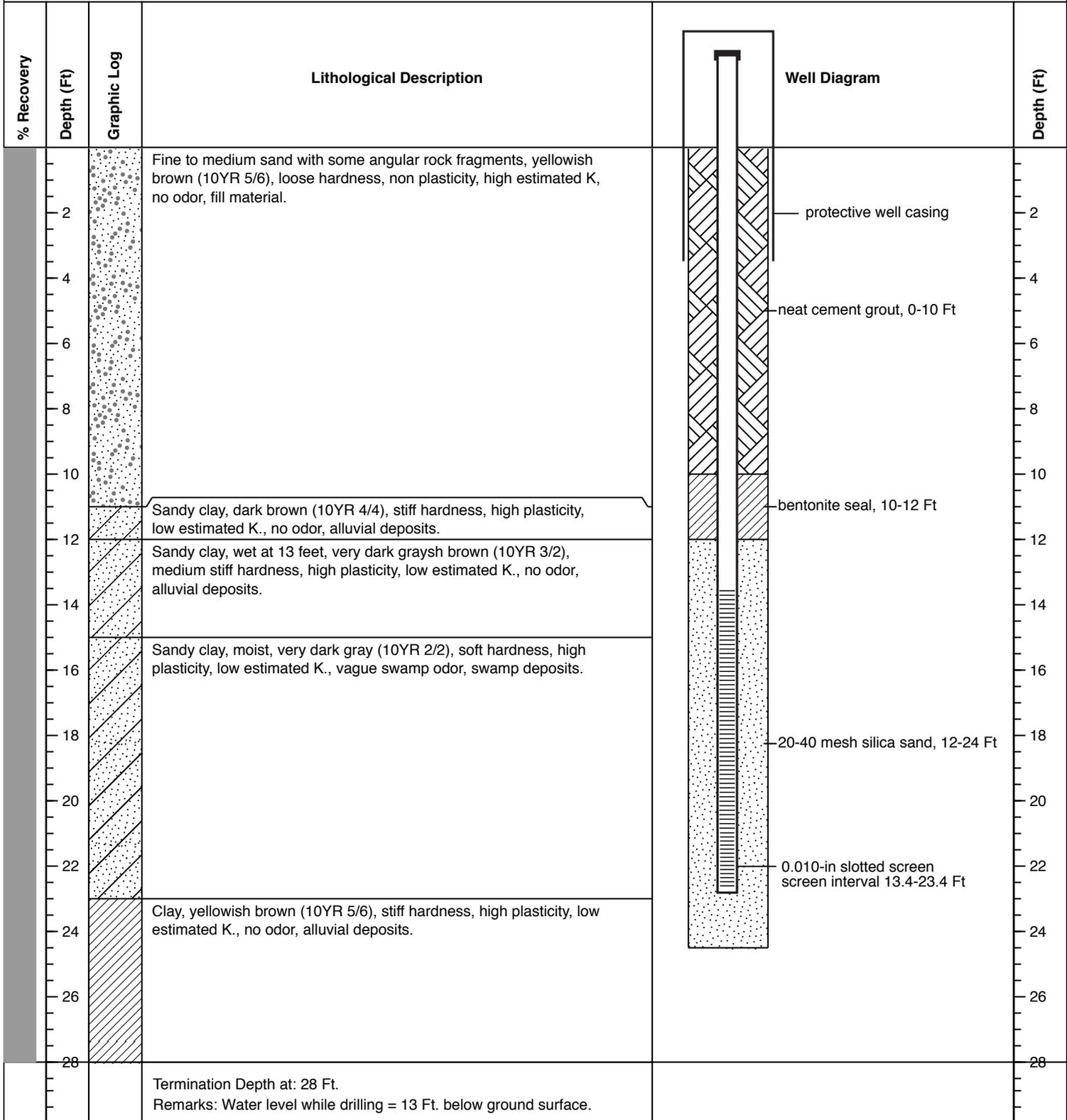


GROUNDWATER LOG MW-5

PROJECT NUMBER: DNA-170154	DRILLING DATE: July 19, 2017	COORDINATES: y = 212186.07, x = 229968.59
PROJECT NAME: CCR Groundwater Monitoring	WELL COMPLETION DATE: July 19, 2017	COORD SYS: NAD 83, PR State Plane, Lambert (m)
CLIENT: AES Puerto Rico, LP	WELL DIAMETER: 2-in	GROUND ELEVATION: 14.04 ft
ADDRESS: Guayama, Puerto Rico	WELL CASING: PVC	WELL ELEVATION AT TOC: 16.47 ft
DRILLERS: GeoEnviroTech, Inc. (Guaynabo, PR)	SCREEN: PVC Factory Slotted (0.010-in)	WELL DEPTH FROM GROUND: 23.39 ft

COMMENTS Downgradient Well.
Borehole was drilled using 8.25-in o.d. hollow stem augers.

LOGGED BY Hardy Rodriguez
CHECKED BY Juan D. Negrón



APPENDIX D

LOW FLOW PURGING AND SAMPLING PROCEDURE

A. Introduction

The purpose of Low-Flow Purging and Sampling (LFPS) is to collect groundwater samples from monitoring wells that are representative of ambient groundwater conditions in the aquifer. This is accomplished by setting the intake velocity of the sampling pump to a flow rate that limits drawdown inside the well. LFPS has three primary benefits. First, it minimizes disturbance of sediment in the bottom of the well, thereby producing a sample with low turbidity. Second, LFPS minimizes aeration of the groundwater during sample collection. Third, the amount of groundwater purged from a well is usually reduced as compared to conventional groundwater purging and sampling methods.

LFPS involves using a pump to purge water at a constant low rate to achieve field parameter stabilization, while minimizing stress on the aquifer. This method has been well documented as a preferred methodology for collecting representative samples from groundwater (*Low-Flow (Minimal Drawdown), Ground-Water Sampling Procedures*, Puls and Barcelona, USEPA, April 1996).

This procedure is accomplished by measuring field parameters at periodic intervals during purging with a flow cell container. The flow cell is an inline purge cell, which will allow the sample technician to constantly monitor field water quality parameters such as pH, dissolved oxygen, conductivity, redox potential (ORP), turbidity and temperature.

The following sections provide a general discussion on each aspect of the LFPS procedure with bulleted items being procedural steps.

Equipment

The sampling team should have all equipment necessary for purging and sampling wells at low flow rates. Other equipment may include:

- Water level indicator;
- Flow cell to monitor field parameters;
- Calibrated purge water container;
- Dedicated pump system or disposable sample tubing (for non-dedicated pumps); and
- Field Meters to measure pH, dissolved oxygen, conductivity, redox potential (ORP), turbidity and temperature.

Prior to each sampling event the field probes will be calibrated in accordance with the owner's manual provided and the site-specific sampling plan.

Decontamination

Sites that have observation wells without dedicated pumps will require the use of non-dedicated pumps. All non-dedicated equipment used during the purging and sampling

PROCEDURE FOR LOW-FLOW PURGING AND SAMPLING

process must be decontaminated prior to each use, including tubing, unless it is disposable):

- Downhole equipment, such as a water level indicator, is to be triple-rinsed between well locations.
- Discard disposable polyethylene tubing used with non-dedicated pumps after use at each well.

Sample bottles will be provided and properly prepared by the analytical laboratory scheduled to perform the analysis. No cleaning or preparation of sampling bottles by field personal will be performed.

Purge Volumes and Monitoring Frequency

Low-flow purging does not require the calculation of the water volume in the well, since purging is based solely on indicator parameter stabilization. Rather, the volume of the pump and discharge tubing are necessary for making calculations needed to determine field measurement frequency and/or the minimum purge (“passive”) sampling system purge volume. Pump chamber or bladder volumes can be obtained from the manufacturer. Volumes of the sample tubing can be calculated or taken from the table below.

Discharge Tubing Volumes	
Tubing Diameter	Volume/foot
1/2" OD/3/8" ID	20 ml
3/8" OD/1/4" ID	10 ml
1/4" OD/1/8" ID	5 ml

Sampling equipment volumes are calculated or recorded for use in determining the frequency of field measurements. Depending on the equipment configuration, calculate and record the volume of the pump and sample tubing using the methodology described above (the volumes are typically converted to liters). The frequency of field readings is based on the time required to purge at least one volume of the pump and tubing system. For example, a pump and tubing volume of 500-ml purged at a rate of 250 ml/minute will be purged in two minutes; readings should be at least two minutes apart. In any case, it is important to ensure that the field parameters are measured on independent samples of water.

Purge Rates

The objective of the purging process is to remove sufficient water from within the well screen zone to result in a sample that is representative of actual aquifer conditions adjacent to the well. The sampling pump or pump intake should be located within the well screen. This pump location is already established for dedicated pumps. For non-dedicated pumps, the intake is placed within the screened interval, typically in the

PROCEDURE FOR LOW-FLOW PURGING AND SAMPLING

center of the screen. If the water column in the screen is shorter than the overall screen length, the pump should be placed lower in the screen but no lower than about 6-12 inches from the bottom of the screen to avoid picking up any settled solids in the well.

A low pumping rate (typically less than 1,000 ml/min) is used to minimize drawdown within the well and formation and mobilization of formation solids. Lower flow rates may be required during sampling. Flow rate is determined by measuring the time it takes to fill a calibrated container, or by measuring the volume of one pump discharge cycle and multiplying this volume by the number of cycles per minute (e.g., 125 ml/cycle x 4 CPM = 500 ml/min). Drawdown is monitored by measuring the water level below the top of the well casing with a water level indicator or similar device (e.g. transducer) while pumping. Drawdown will be stabilized during purging. Flow rates and drawdown are recorded on a field log, field data form or with a data logger.

- Measure water levels prior to initiating purging;
- Calculate well volumes, if required by permit;
- Calculate sampling system volume and determine indicator parameter measurement frequency;
- Lower water level meter probe to 1-2 feet below static water level;
- Connect the flow cell to the discharge tube from the pump;
- Begin purge at a rate of 100-200 ml/min (or at a rate determined from prior events);
- Check drawdown with a water level tape while pumping;
- If drawdown stabilizes quickly, increase the pumping rate in increments of 100 ml/min until drawdown increases, then reduce the rate slightly after a few minutes to achieve a stable pumping water level;
- If the water level continues to drop, reduce purge rate by 100 ml/min increments until the water level stabilizes;
- Once water level stabilization is achieved, proceed to indicator parameter stabilization.

Parameter Stabilization

Parameter stabilization ensures that the well is adequately purged and sampled groundwater is representative of formation water. In order to determine when a well has been adequately purged, samplers should:

- Monitor pH, specific conductance, and dissolved oxygen of the ground water removed during purging;
- Observe and record the water level drawdown; and
- Record the purge rate and note the volume of water removed if required by guidance or permit.

PROCEDURE FOR LOW-FLOW PURGING AND SAMPLING

A well is adequately purged when the pH, specific conductance, and dissolved oxygen stabilize. Stabilization occurs as follows:

pH: +/- 0.2 pH units
Conductance: +/- 5 % of reading value
Dissolved oxygen: +/- 10.0% or 0.2 mg/L, whichever is greater.

Temperature is not a reliable indicator of stabilization, being affected by ambient temperature at the well head, sunlight, and some sampling devices such as electric pumps. Temperature is typically measured to provide correction for temperature dependent parameters (e.g., DO % saturation, pH, and specific conductance).

While turbidity is not a direct measurement of water chemistry and is not used as an indicator parameter of stabilization, it is useful to support data from metals analyses. To avoid artifacts in sample analysis, turbidity should be as low as possible when samples are taken. Turbidity should be measured at least three times, once when purging is initiated, again after the water level in the well stabilizes, and again when the water chemistry indicator parameters being measured are stable. Turbidity should also be measured any time the pumping rate is increased or the water level in the well drops noticeably. If the initial turbidity reading is high (>50 NTU) and the second reading is not significantly lower, the pump rate should be reduced. The turbidity value measured prior to sampling will be recorded. If this value exceeds 50 NTU, procedures should be reviewed and the source of the elevated turbidity determined.

Sampling

Wells should be sampled immediately upon completion of purging operations. Once the water level stabilizes, the purge rate should remain constant during low-flow sampling (generally less than 500 ml/min). For VOCs, lower sampling rates (100 - 200 milliliters/minute) may be required.

- Record field parameters prior to sampling;
- Record depth to water levels prior to sampling (note if the well has not stabilized).
- Record the flow rate determined using a calibrated measuring device;
- Disconnect the flow cell other equipment from the pump discharge tube;
- Collect samples from the pump discharge tube
- Collect large volume samples first (e.g., 1 liter bottles), then VOC samples, and any filtered samples last;

If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, the sampling team may elect to collect a sample. The conditions of sampling should be noted in the field log or field information form.

Low Yield Formations

In some situations, even with very slow purge rates, the well drawdown may not stabilize. In this case, sampling the water within the well screen zone provides the best opportunity to determine the formation water chemistry, as well evacuation can greatly affect sample chemistry through changes in dissolved gas levels, dissolved metals and VOCs.

Attempts should be made to avoid purging wells to dryness. This can usually be accomplished by slowing the purge rate. If the well is evacuated during the purging procedures shown above, the sample may be collected as soon as a sufficient volume of water has recovered in the well. If the well goes dry repeatedly (i.e. over multiple monitoring events) prior to sampling, then a minimum purge or “passive” sampling approach should be used in lieu of well evacuation.

Minimum Purge (“Passive”) Sampling

For wells that cannot achieve a stabilized water level and purge dry even at very low pumping rates, an alternative to the traditional evacuation approach is to use minimum purge (sometimes called “passive”) sampling techniques to avoid the pitfalls of well evacuation and obtain a better estimation of the formation water quality. Sampling the water present in the screen zone provides the greatest chance of obtaining samples with minimal alteration of the chemistry. Although the low movement rate of the ground water in the screen provides only a limited exchange, avoiding the alteration caused by the factors mentioned above is really the best alternative.

The minimum purge approach requires the removal of the smallest possible purge volume prior to sampling, generally limited to the volume of the sampling system. The sampling system volume is minimized by using very small diameter tubing and the smallest possible pump chamber volume. Plastic tubing should have sufficient wall thickness to minimize the potential for oxygen transfer through the tubing when pumping at very low flow rates. After purging 1-3 volumes of the sampling system, samples are taken from the subsequent water pumped. Since minimum purge sampling requires the minimum possible disturbance to the water column and surrounding formation, dedicated sampling systems are required for this approach.

The pumping rates used for minimum purge sampling are much lower than for low-flow purging, generally 100 ml/minute or less. Drawdown is expected, since it cannot be avoided; however, it is still advisable to pump at the lowest possible rate to limit drawdown to the minimum possible. Monitoring indicator parameters for stability is not part of this approach, since the intention is not to purge until stabilization of these measurements. The pH, specific conductance and turbidity or any other required field parameters should be measured during collection of the sample from the recovered volume. *Regulatory approval should be obtained prior to collecting a sample using this method.*

Field Records

Field information must be recorded during purging and sampling. At a minimum, the following information should be included in the field forms for each groundwater monitoring well.

- Purge Information (pumping rate, purge volume if required);
- Equipment Specifications (pump type, filter type and pore size if used);
- Well Data (depth to water, total depth, groundwater elevation);
- Field Measurements during purging and at the time of sample collection; and
- General weather conditions or other comments

This data is to be recorded on field forms and/or in a data logger.

Other Technical Issues

The following are other technical issues addressed as follows by the facility:

- Dedicated pump intakes are generally set at the middle of the screen. Where water levels have dropped due to drought conditions, the sampling team may lower the pump in order to obtain sufficient sample.
- For wells installed in bedrock, packers are only required to seal off the zone of interest if the bedrock has been determined to be competent (e.g. is not highly fractured).
- The flow cell system does not require decontamination between wells, because the act of purging removes any liquids from other wells and because sampling takes place upstream of the flow cell and only after disconnecting the pump discharge tubing.

APPENDIX E

CHAIN OF CUSTODY FORM

