CCR RULE ASSESSMENT OF CORRECTIVE MEASURES (ACM) REPORT

COAL COMBUSTION BYPRODUCT LANDFILL

Harrison Power Station
Harrison County, West Virginia

Prepared for:

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Tetra Tech Project No. 212C-SW-00069

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ACRONYMS/ABBREVIATIONS

ACM	Assessment of Corrective Measures
AGWMCA	Annual Groundwater Monitoring and Corrective Action
AM	Assessment Monitoring
ASD	Alternate Source Demonstration
bgs	Below ground surface
CCBL	Coal Combustion Byproduct Landfill
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
CSM	Conceptual Site Model
DM	Detection Monitoring
FE	FirstEnergy Generation
FGD	Flue Gas Desulfurization
gpm	Gallons Per Minute
GWPS	Groundwater Protection Standard
K	hydraulic conductivity
mg	milligrams
mg/L	milligrams per liter
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
MW	Megawatt
msl	Mean sea level
N&E	Nature and Extent of Release
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
POC	Point of Compliance
psi	Pounds per Square Inch
PZ	Piezeometer
PRB	Permeable Reactive Barrier
SAP	Sampling and Analysis Plan
SoR	Selection of Remedy
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
Station	Harrison Power Station
TDS	total dissolved solids
Tetra Tech	Tetra Tech, Inc.
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection
ZVI	Zero Valent Iron

1.0 INTRODUCTION

This Assessment of Corrective Measures (ACM) Report was prepared by Tetra Tech, Inc. (Tetra Tech) on behalf of FirstEnergy Generation (FE) for the Coal Combustion Byproduct Landfill ("CCBL", "CCR unit", or "Site") at the Harrison Power Station (hereinafter referred to as the "Station"). The Station is located near the town of Shinnston in Harrison County, West Virginia. This report was developed to comply with pertinent requirements of the United States Environmental Protection Agency (USEPA) Coal Combustion Residuals (CCR) Rule, specifically the Assessment of Corrective Measures requirements per 40 CFR § 257.96.

As discussed further below, CCR Rule groundwater Assessment Monitoring (AM) conducted at the Site identified arsenic concentrations in certain downgradient CCR monitoring wells which were at Statistically Significant Levels (SSLs) that exceeded the Groundwater Protection Standard (GWPS) for arsenic, resulting in the need to conduct an Assessment of Corrective Measures per 40 CFR § 257.96.

1.1 PURPOSE

The purpose of this ACM Report is to provide the following: background on groundwater monitoring findings leading to the ACM; an overview of potential corrective measures which were evaluated; and a comparative evaluation of the corrective measures with regard to the pertinent CCR Rule criteria. In addition, the report specifies the path for meeting Selection of Remedy (SoR) requirements of the CCR Rule (per 40 CFR § 257.97). The assessment of corrective measures has included developing and evaluating new field and laboratory information and data as well as reviewing historical field and laboratory information and data developed by other professional engineers and geologists. In preparing this report, Tetra Tech has exercised its professional judgement in accordance with generally accepted engineering and geologic principles and practices to identify and assess the range of potential corrective measures described herein.

1.2 REGULATORY REQUIREMENTS

Initiating and Completing an Assessment of Corrective Measures

40 CFR§ 257.96(a) requires that within 90 days of finding that any constituent listed in Appendix IV has been detected at a SSL exceeding the GWPS or immediately upon detection of a release from a CCR unit, the owner or operator must initiate an assessment of corrective measures to prevent further releases, to remediate any releases, and to restore affected areas to original conditions. The assessment of corrective measures must be completed within 90 days, unless the owner or operator demonstrates the need for additional time to complete the assessment of corrective measures due to site-specific conditions or circumstances. The 90-day deadline to complete the assessment of corrective measures may be extended for no longer than 60 days.

Characterizing the Nature and Extent of Release

Following identification that one or more Appendix IV constituents has been detected at a SSL exceeding the GWPS, the owner or operator of the CCR unit must also:

(1) Characterize the nature and extent of the release (N&E) and any relevant site conditions that may affect the remedy ultimately selected. The characterization must be sufficient to support a complete and accurate assessment of the corrective measures necessary to effectively clean up all releases from the CCR unit pursuant to § 257.96. Characterization of the release includes the following minimum measures:

(i) Install additional monitoring wells as necessary to define the contaminant plume(s);

(ii) Collect data on the nature and estimated quantity of material released including specific information on the constituents listed in Appendix IV and the levels at which they are present in the material released;

(iii) Install at least one additional monitoring well at the facility boundary in the direction of contaminant migration and sample this well in accordance with 40 CFR 257.95(d)(1) ; and

(iv) Sample all wells in accordance with 40 CFR 257.95(d)(1) to characterize the nature and extent of the release.

The following summarizes the timeline pertaining to compliance at the Site with the above CCR Rule requirements:

- February 13, 2019 (Revised April 5, 2019) - Pursuant to 40 CFR 257.95(g) and 257.105(h)(8), FE provided notification in the Operating Record that the 2018 groundwater Assessment Monitoring (AM) program at the Site had identified arsenic and molybdenum concentrations detected at SSLs above their respective GWPSs established as per 40 CFR 257.95(h). Also, at that time, FE initiated activities to characterize the nature and extent of release. The notification was posted to the publicly accessible website on April 5, 2019.
- April 15, 2019 - Pursuant to 40 CFR 257.95(g)(3)(i) and 257.105(h)(9), FE provided notification in the Operating Record that an Assessment of Corrective Measures (ACM) had been initiated for the Site. The notification was posted to the publicly accessible website on May 22, 2019.
- July 15, 2019 - Pursuant to 40 CFR 257.96(a), FE provided in the Operating Record a demonstration that, based on hydraulic characteristics of the uppermost aquifer, an additional 60 days was required to complete the ACM.

This document was developed to meet requirements of 40 CFR § 257.96(c), which states the following:

"The assessment under paragraph (a) of this section must include an analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of the remedy as described under § 257.97 addressing at least the following:

(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;

(2) The time required to begin and complete the remedy;

(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s)."

1.3 SITE BACKGROUND

CCRs produced at the Station are placed in the facility's captive CCBL, which is located approximately 1.5 miles north of the Station. The landfill is an existing CCR unit that is regulated under West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0075795. A WVDEP groundwater monitoring program for the landfill has been in effect since 1993 and a separate CCR Rule groundwater monitoring program has been in effect since 2017.

As shown on Figure 1-1, the landfill facility consists of three adjacent disposal areas, the Main Area (MA - approximately 150 acres), the Lower Area (LA - approximately 126 acres), and the Upper Area (UA - approximately 120 acres). Of this total combined area, approximately 310 acres are currently permitted for landfill operations. Historically, landfilling operations have primarily been performed in the MA and LA disposal areas, with the UA disposal area more recently developed for use. The MA disposal area, which has both unlined and lined portions, received CCR material from the station when the first units began operating in 1972, and was closed from 1979 (when disposal operations shifted over to the LA) until being reactivated in 2005. The LA disposal area is still active and also has both unlined (pre-1994) and lined portions, with the liner system consisting of a 24-inch thick engineered compacted clay liner underlain by a combined leachate detection/groundwater underdrain zone and overlain with a leachate collection system. The MA and UA have been used for CCR material disposal since 2005 and 2011, respectively, with MA disposal being an overlay of the materials originally placed there, and UA disposal being in new, lined areas that utilize one of two liner systems. Pre-CCR Rule areas in the UA have a liner consisting of “enhanced” FGD by-product (amended with excess lime) that is also underlain by a combined leachate detection/groundwater underdrain zone and overlain with a leachate collection system. Post-CCR Rule areas in the UA will have a composite-liner system comprised of a geomembrane and geosynthetic clay liner underlain by a combined leachate detection/groundwater underdrain zone and overlain by a leachate collection system. Stormwater runoff and leachate from the landfill discharge to a lined sedimentation pond, referred to as Sedimentation Pond No. 1.

Groundwater in the CCBL area occurs primarily within fractured bedrock and flow is controlled by a combination of topography and the bedrock structure (i.e., dip). The Lower Sewickley sandstone has been identified as the uppermost aquifer for CCR Rule groundwater monitoring for the CCBL area. This aquifer is situated approximately 60 to 70 feet above the Pittsburgh Coal which has been extensively deep-mined across the site. In some localized areas, collapse of the abandoned mine workings is potentially resulting in overburden fracturing that could serve as a drain for groundwater in the Lower Sewickley sandstone and other overlying rock units to migrate vertically into the abandoned mine workings; however, this is not believed to be significant on a large scale. Historic and recent groundwater level data indicate groundwater flow at the CCBL to be from west to east (approximating the dip of the Pittsburgh Coal), and that the flow exhibits little seasonal and temporal fluctuations. A representative set of water level data from the time period of this ACM (June 2019) were used for contouring groundwater elevations and identifying flow patterns at the Site. These water levels were similar to historical levels across the Site. As such, separate mapping for other time periods was not necessary for this report. A more detailed discussion of the site’s geologic and hydrogeologic characteristics can be found in Section 4.0 of this report.

As detailed in the CCR unit’s most recent Annual CCR Groundwater Monitoring and Corrective Action Report (“2018 AGWMCA Report”, accessible at http://ccrdocs.firstenergycorp.com/), the certified CCR monitoring well network consists of one upgradient (background) well (MW-5), and four downgradient wells (MW-17, -18, -19, and -20), as shown on Figure 1-1. These wells also serve as the Site’s groundwater monitoring network for the state solid waste permit (i.e., there are no other existing state program wells at the Site).

1.4 OVERVIEW OF REPORT CONTENTS

Section 1.0 of this report provided an overview of the CCR ACM regulatory requirements and background on the CCR unit and CCR groundwater monitoring well network. Section 2.0 summarizes Detection and Assessment Monitoring results as well as the findings of the Appendix III ASD and Appendix IV ASD. Section 3.0 summarizes the Nature and Extent of Release Characterization. Section 4.0 presents the Conceptual Site Model (CSM). Section 5.0 provides the identification and screening of remediation technologies to address arsenic SSLs in groundwater, and Section 6.0 presents the assessment of corrective measures by comparing the candidate technologies to ACM criteria in 40 CFR § 257.96(c). Section 7.0 summarizes the Selection of Remedy (SoR) process. Section 8.0 provides references for documents cited in this report.

2.0 GROUNDWATER MONITORING RESULTS

This section summarizes the findings of the Site's CCR Rule Detection Monitoring (DM) program, the associated Appendix III ASD, and the subsequent AM program and Appendix IV ASD which, taken together, led to the requirement to conduct the ACM. Details on each phase of monitoring and the ASDs can be found in the referenced documents and the pertinent Annual Groundwater Monitoring and Corrective Action Reports.

2.1 DETECTION MONITORING & APPENDIX III ALTERNATE SOURCE DEMONSTRATION

2.1.1 Detection Monitoring Results

FE performed the first DM sampling event in September 2017. Following receipt of the validated analytical results, a statistical evaluation of the data was completed in December 2017 and the results indicated that there were statistically significant increases (SSIs) for calcium, chloride, pH, sulfate and total dissolved solids (TDS) in one or more well comparisons. The DM sampling, analysis, statistical evaluation, and findings were included in the 2017 CCR Annual Groundwater Monitoring and Corrective Action Report, which is available on the Site's publicly accessible CCR website (http://ccrdocs.firstenergycorp.com/).

2.1.2 Alternate Source Demonstration

Following the identification of SSIs in downgradient Site well samples for Appendix III parameters identified in Section 2.1.1, FE performed an ASD per 40 CFR § 257.94(e)(2). The ASD was performed by Tetra Tech, Inc. (Tetra Tech) to determine whether a source other than the CCR unit caused the SSIs or that the apparent SSIs resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The ASD scope and findings are presented in the Tetra Tech report entitled, "CCR Appendix III Alternative Source Demonstration Report - 2017 Detection Monitoring, Coal Combustion Byproduct Landfill, Harrison Power Station," dated March 30, 2018. The subject report was placed in the facility's operating record in April 2018. The Appendix III ASD concluded that there are potential on-site sources which may have contributed to the SSIs for some constituents; however, it was not possible within the scope of work conducted to definitively confirm these sources resulted in all of the SSIs.

Since the ASD did not conclusively determine that all of the SSI constituents were related to sources or conditions other than the CCR unit, in accordance with 40 CFR 257.95(b), the Station transitioned from Detection Monitoring to Assessment Monitoring (discussed in the following section).

2.2 ASSESSMENT MONITORING & APPENDIX IV ALTERNATE SOURCE DEMONSTRATION

FE performed two rounds of Assessment Monitoring at the Site in May and September 2018 (events AM-1 and AM-2, respectively) in accordance with the facility's CCR groundwater monitoring plan. Following receipt of the validated analytical results, FE performed statistical evaluations of the 2018 AM data to determine whether there were any detected Appendix IV parameters with SSLs above the CCR Unit's established GWPSs. Arsenic and molybdenum were the only parameters detected at concentrations greater than their respective GWPS, as documented in the facility's Operating Record in February 2019. FE subsequently performed the first of the 2019 AM sampling events (AM-3) in February 2019, and the validated data was statistically evaluated in June 2019. The AM-3 results were consistent with the previous AM results for arsenic, but molybdenum was found at concentrations below its GWPS (the arsenic and molybdenum data from sampling events AM-1, -2, and -3 is provided in the Appendix IV ASD report included as Attachment A of this report). The second 2019 AM sampling event (AM-4) was performed by FE in August 2019, but the receipt and statistical evaluation of the validated data was not completed in time to be included with this ACM report. Those findings will be included as part of the CCR unit's 2019 AGWMCA Report. To date, no other Appendix IV constituents have been detected at SSLs above the their GWPS under the facility's AM program.

Pursuant to 40 CFR § 257.95(g)(3)(ii), Tetra Tech performed an ASD to assess if the Appendix IV SSLs for arsenic and molybdenum determined for events AM-1, -2, and -3 were attributable to a release from the CCR unit or from a demonstrable alternative source(s). As part of the Appendix IV ASD, a single nature and extent of release characterization sampling event was performed in July 2019 for wells MW-19 and MW-20 in an attempt to identify a source of documented odors and elevated pH in MW-20 during previous sampling events. Results of that sampling were inconclusive as to the source of the odors; however, the arsenic and molybdenum results from that sampling event were consistent with the AM-3 results (i.e. arsenic was above its GWPS and molybdenum was below its GWPS). The July sampling event was the second consecutive event in which molybdenum was below its GWPS. Based on this and other findings documented in the Appendix IV ASD report included as Attachment A, molybdenum has not been considered for this ACM but will continue to be monitored as part of the AM program. Conversely, the Appendix IV ASD work determined that the SSLs for arsenic could not be attributed to sources other than the CCR unit. As such, a transition to N&E characterization and ACM for arsenic per § 257.96 of the CCR Rule commenced as discussed in the following sections.

3.0 NATURE AND EXTENT OF RELEASE CHARACTERIZATION

Pursuant to 40 CFR 257.95(g)(1), FE initiated an N&E of release characterization concurrent with performing the Appendix IV ASD. Following confirmation that the arsenic SSLs were not attributed to sources other than the CCR unit, N&E characterization continued and ACM commenced. This section summarizes the occurrence and fate and migration characteristics of arsenic, N&E activities conducted as part of the CCR Rule requirements, temporal changes in arsenic concentrations in Site leachate and groundwater as well as the extent of arsenic in Site groundwater as identified by the N&E activities.

3.1 NATURE OF ARSENIC

The following is an overview of arsenic sources, its key geochemical properties, and current regulatory concentration limits for health and environmental protection.

3.1.1 Arsenic Sources and Key Geochemical Properties

Arsenic in groundwater can be derived from various natural and anthropogenic sources including CCRs. It can occur in various forms and its concentration and migration characteristics in groundwater are controlled by the properties of aquifer materials and geochemical conditions (e.g., pH, oxidation-reduction potential, presence of competing anions which may inhibit sorption, etc.). A change in downgradient aquifer properties and geochemical conditions can result in potentially changing the mobility and concentration of arsenic. Therefore, the factors which control arsenic concentrations at a given site can be very complex. The following summarizes the occurrence of arsenic and key geochemical properties which affect its fate and migration characteristics that should be considered in site characterization and remediation strategies:

- Natural sources of arsenic are derived from a wide array of geologic materials, including igneous, metamorphic and sedimentary rocks. Arsenic may subsequently be accumulated during secondary mineral formation in overburden materials and soils. In contrast, anthropogenic sources are typically derived from the land application of arsenical pesticides and herbicides and from disposal of arsenic-bearing wastes generated during processing of ore materials for production of commercial products. (USEPA, October 2007).

- The median concentration of arsenic across all coal types is 7.7 mg/kg. Most arsenic associated with bituminous coal is associated with iron sulfides. While arsenic concentrations in coal ash can be in the range of those measured in background soils, typical arsenic levels in fly ash are higher than the typical levels in soils. (EPRI 2010).
- The most common forms of arsenic in groundwater are their oxy-anions, arsenite [As(III)] and arsenate [As(V)]. Under moderately reducing conditions, arsenite is the predominant species. In oxygenated water, arsenate is the predominant species. Both anions are capable of adsorbing to various subsurface materials, such as ferric oxides and clay particles. Ferric oxides are particularly important to arsenate fate and transport as ferric oxides are abundant in the subsurface and arsenate strongly adsorbs to these surfaces in slightly acidic to neutral waters (USEPA CLU-IN website).
- Arsenic mobility is lowest at pH 3 to 7 and increases at very acidic or alkaline pH (EPRI 2010). At higher alkaline pH, sorption still occurs, but to a lesser degree. Hence, under alkaline conditions, arsenate/arsenite can be expected to be more mobile. The arsenic oxy-anions are also sensitive to redox conditions, and the dominance of arsenate versus arsenite will change with this changing redox. Arsenic can also complex with organic compounds, which can affect its mobility.
- The extent to which inorganic arsenic will partition to mineral surfaces will also be affected by the competition of sorption sites with other anions in solution. There are several commonly occurring anions in natural waters (e.g., phosphate and sulfate) that can compete with arsenic sorption to mineral surfaces. These competitive sorption reactions will be active for all arsenic aqueous species in oxidized and reduced systems.
- Arsenic-bearing colloidal material may be mobilized either from changes in the surface charge on colloids or through deflocculation and suspension of colloidal material through dissolution of cementing agents within the aquifer matrix. Both processes would be facilitated in aquifers impacted by organic contaminants where microbial activity may be stimulated resulting in the generation of reducing conditions and/or the production of low molecular weight organic compounds that partition to fine-grained sediments. (USEPA, October 2007)

3.1.2 Regulatory Concentration Limits for Health and Environmental Protection

Research into state and federal drinking water, National Pollutant Discharge Elimination System (NPDES), and environmental standards by Tetra Tech found the following with respect to concentration limits:

- The federal Maximum Contaminant Level (MCL) for arsenic in drinking water was revised from 0.05 milligrams per liter (mg/L) to 0.01 mg/L, which is the GWPS in effect at the Site.
- For non-potable water sources, federal ambient water quality criteria (AWQC) have been developed that are protective of aquatic life. For arsenic, current statutes list both acute and chronic criteria for arsenic in fresh waters as 0.34 mg/L and 0.15 mg/L, respectively (USEPA, October 2007).
- West Virginia water quality criteria are determined by the state’s water use category assigned to the receiving water which, for arsenic, varies from 0.01 mg/L (for public water supply or recreational water contact use) to 0.1 mg/L (for propagation and maintenance of fish and other

aquatic life). In those instances where a receiving water does not have a use category assigned, the protective concentration limits for human contact and public water supply (0.01 mg/L) are used. There are also separate criteria for arsenite [As(III)] that apply to aquatic life only and vary between 0.15 mg/L (chronic limit) and 0.34 mg/L (acute limit), which align with the federal AWQC criteria noted above.

3.2 NATURE AND EXTENT OF RELEASE CHARACTERIZATION ACTIVITIES

In an effort to characterize the nature and extent of arsenic in groundwater at the Site and gather information which could be helpful in evaluating potential corrective measures, the following activities were conducted by Tetra Tech in 2019.

3.2.1 Additional Monitoring Points

As previously noted, there were no other existing monitoring wells or piezometers that were part of the WVDEP groundwater monitoring system that could be used to support N&E activities. Based on groundwater flow patterns at the Site, it was determined that MW-19 fulfilled the requirement of 40 CFR § 257.95(g)(3)(iii) of having at least one monitoring well positioned at the facility boundary in the direction of contaminant migration (refer to Figure 1-2). MW-19 is also positioned downgradient of MW-20 which, as discussed in Section 3.3 below, was the only other monitoring well to exhibit elevated arsenic concentrations. As such, no additional monitoring wells have thus far been installed for N&E of release characterization.

3.2.2 N&E Sampling and Analysis Program

As previously noted in Section 2.2, two rounds of regularly scheduled AM sampling (AM-3 and AM-4) were performed for the N&E network described in Section 3.2.1 with the samples being analyzed for Appendix III parameters and all Appendix IV parameters. As also noted in Section 2.2, a third sampling event was performed as part of the Appendix IV ASD for wells MW-19 and MW-20. Laboratory analysis and data validation activities were completed for the AM-3 sample set but remain in progress for the AM-4 set. As such, the currently available findings (sampling events AM-1, -2, and -3 and July 2019 ASD/nature and extent) are presented in the following section. The AM-4 findings will be included as part of the CCR unit's 2019 AGWMCA Report. To date, no other Appendix IV constituents have been detected at SSLs above the their GWPS under the facility's AM program.

3.3 EXTENT OF ARSENIC AND TRENDS IN CONCENTRATION

Figure 3-1 presents all of the site-wide arsenic concentrations that have been measured in both groundwater and leachate since the inception of the CCR monitoring program in September 2016 (as previously noted, there is no historical data for arsenic in groundwater at the Site prior to 2016 since arsenic was not a parameter that was required for the WVDEP solid waste permit groundwater monitoring program). The data gap between August 2017 and March 2018 represents the period where the CCR DM program was in effect which only required analysis for Appendix III parameters. Referring to Figure 3-1, it's seen that the arsenic concentrations measured in the upgradient well (MW-5) during the background data collection phase of the CCR program (eight sampling events between September 2016 and August 2017) established an Upper Prediction Limit (UPL) for arsenic of 0.0005 mg/L, which is less than the federal Maximum Contaminant Level (MCL) of 0.01 mg/L. As such, the MCL was set as the GWPS for the CCR unit.

Once the AM program commenced in May 2018, arsenic concentrations for downgradient wells MW-19 and MW-20 were consistently measured at or above the GWPS, while arsenic concentrations in MW-17 were consistently measured slightly above or slightly below the UPL. MW-18 had no reportable results during the AM sampling period as available water volume was problematic in that well, but during the background sampling period, MW-18 arsenic concentrations were measured above the UPL but below the GWPS. Both MW-19 and -20 initially exhibited inconsistent concentration trends, with MW-19 stabilizing since May 2018 at concentrations slightly above the GWPS, but with MW-20 exhibiting an increasing trend that began after September 2018. Figure 3-1 also indicates that all the arsenic sampling data are below the range of arsenic concentrations measured in the CCBL leachate during the same period (sampling points LM01, LM02, LM05, LM07, and LM10), which varied between approximately 0.05 and 0.09 mg/L.

Figure 3-2 is an iso-concentration map representative of the distribution of total arsenic in groundwater in the monitored CCR aquifer. The arsenic concentrations presented are the results of the February 2019 sampling event, which as shown on Figure 3-1, is indicative of the trends being observed at the site over the last 18 months. Concentrations greater than the arsenic GWPS of 0.01 mg/L for the aquifer are shaded on the maps. Based on interpolation of concentration gradients between the well measurements, both figures show elevated arsenic concentrations occurring along the northeastern edge of the CCR unit, with the highest concentrations occurring at MW-20 and then apparent downgradient attenuation occurring with concentrations approaching the GWPS at MW-19. Based on these interpretations, arsenic concentrations in groundwater that are at or slightly above the Site's GWPS appear to be occurring at the downgradient facility boundary. In response to these findings, additional N&E of release characterization work was determined to be necessary and is currently in progress as discussed in Section 7.2 of this report. However, since arsenic concentrations greater than the GWPS may occur in the area situated immediately downgradient of the facility boundary, this ACM was performed.

4.0 CONCEPTUAL SITE MODEL

4.1 HYDROGEOLOGIC CHARACTERISTICS

This section provides an overview of hydrogeologic characteristics at the Site based on previous studies as well as more recent work completed under the CCR Rule monitoring program. A more detailed discussion of the site's geologic and hydrogeologic characteristics can be found in the "CCR Groundwater Monitoring System Evaluation Report, Harrison Power Station CCB Landfill", Tetra Tech, October 2017.

Groundwater in the CCBL area occurs primarily within the fractured bedrock of the Monongahela Group, with flow patterns at the Site being primarily controlled by structure (i.e. migration down-dip within a groundwater flow unit). Three principal water-bearing units have been identified at the site, including in descending stratigraphic order the Lower Uniontown Coal horizon, the Lower Sewickley Sandstone, and the Pittsburgh Coal. The Lower Uniontown Coal is a perched aquifer restricted to ridge areas. The Lower Sewickley Sandstone is continuous under most of the area (except a portion of lower Pigott's Run where it has been eroded away), and the Pittsburgh Coal is also present under most of the area except where eroded away or strip-mined in the lower reaches of Pigott's Run. The Lower Sewickley Sandstone, which underlies most of the disposal area, is considered the appropriate groundwater monitoring zone (i.e., uppermost aquifer) for the CCBL.

Based on boring logs, cross sections, and structure contour mapping, the Lower Sewickley Sandstone is continuous beneath the UA and LA disposal areas. It is also present throughout the upper reaches of the MA disposal area but is eroded away along a narrow band on either side of Pigott's Run within the downstream reaches of the disposal area (the outcrop area is now covered by landfilled CCR material).

A total of 19 monitoring well borings have been advanced into the Lower Sewickley Sandstone at the CCBL over the last 25 years (MW-1 through MW-20; MW-14 was never drilled). The locations of the monitoring well borings are shown on Figure 1-1. Of those well borings, 14 have been abandoned due to a combination of site operations or, in some cases, little or no groundwater encountered during drilling. The active groundwater monitoring network at the site for both the WVDEP and CCR programs consists of the same wells: MW-5, MW-17, MW-18, MW-19, and MW-20. Based on both water level and bedrock structure data, well MW-5 is positioned as the Site's upgradient well and the remaining wells are positioned both downgradient and down dip of the CCBL. Depending on their topographic positioning, most of these wells range between 208 feet (MW-5) and 514 feet (MW-19) in total depth, with the exception being MW-17, which has a total depth of 63 feet.

Hydrogeologic properties for the CCBL area have been estimated as part of previous studies (referenced in Tetra Tech, October 2017). Estimates of hydraulic conductivity (K) are available for the landfill waste materials, natural soils, and bedrock. The estimates are based on limited testing data and should be considered generalized estimates only, particularly for the bedrock, as individual fractures in fractured rock groundwater flow systems typically vary widely in water-yielding capabilities. Estimated K values for landfill waste are in the range of 10^{-5} to 10^{-6} centimeters (cm)/second (sec), while remolded K values for the natural soils present across the site (mostly silt/clay) range from 10^{-7} to 10^{-9} cm/sec. Based on slug tests in well borings, bulk hydraulic conductivities of bedrock range from 10^{-4} to 10^{-7} cm/sec, with an overall geometric mean value of approximately 2.4×10^{-5} cm/sec (0.07 foot/day). Slug tests measure the overall K of the tested portion of a boring, so it is likely that discrete fracture K values are much higher than the overall average.

Historic and recent groundwater level data indicate the overall groundwater flow direction within the Lower Sewickley Sandstone is from west to east, which also approximates the dip of the bedrock. Groundwater elevations in upgradient well MW-5 typically fluctuate around elevation 1095 feet, with downgradient elevations averaging approximately the following: 1050 feet between MW-17 and MW-20; 1000 feet at MW-18; and 970 feet at MW-19. The lower groundwater elevations measured in MW-18 and MW-19 versus MW-17 and MW-20 may be due to some localized mine subsidence-related fracturing and associated vertical drainage of groundwater into the underlying abandoned Pittsburgh Coal mine workings, by the continuing development of the upgradient UA disposal area which reduces rainfall infiltration recharge to the monitored aquifer, or by a combination of both occurrences . As noted in Section 1.3, leachate and groundwater from lined portions of the MA and LA disposal areas and from all of the UA disposal area are captured by both a leachate collection system and a combined leachate detection/groundwater underdrain system. These flows are then routed through and discharged off-site via Sedimentation Pond No. 1. It is believed that the leachate collection and leachate detection/groundwater underdrain systems have a significant impact in reducing groundwater flow and hydraulic heads across the site as they capture and reroute surface infiltration which would otherwise provide recharge to the monitored aquifer and continue to flow downgradient of the landfill.

Appendix B provides geologic cross-sections completed as part of the solid waste permit application for the site. Cross-Section B-B' is a generally west-east section extending from the upgradient portion of the landfill area to the facility boundary (near the location of active well MW-18). The section cuts through the upper portion of the MA and the lower portions of the UA and LA and depicts the location and dip of the Lower Sewickley Sandstone below the CCBL. As shown, groundwater occurs under unconfined and semi-confined conditions in the line of section area, with unconfined conditions occurring at upgradient well MW-5. Cross-Section E-E' is generally a north-south section beginning at the upgradient end of the LA (near active well MW-20) and then extending through the center of the LA, across the lower MA (formerly the Piggott's Run valley), and then ending near the current facility boundary. As indicated, groundwater in the line of section area occurs under unconfined conditions in the Lower Sewickley Sandstone and the layer exhibits little to no dip in this direction.

4.2 POTENTIAL RECEPTORS

Based on information contained in the CCBL's recent state solid waste permit renewal applications, there are no private or public water supply wells located within 1, 200 feet of the landfill perimeter (this includes areas upgradient, side-gradient, and downgradient of the CCR unit). A review of current aerial imagery also indicates that the closest downgradient dwelling that could potentially use a water supply well is located approximately 3,000 feet east of the facility boundary. Given that the arsenic concentrations at the downgradient facility boundary (MW-19) are only slightly above the GWPS, the attenuation that would be expected to occur over such a long flow path is likely to result in downgradient arsenic levels that would be below levels of potential concern.

4.3 SUMMARY OF CSM

Figure 4-2 is a generalized cross-section presenting the Site CSM. In summary, the CSM consists of arsenic leaching from the CCRs at the Site and entering groundwater at the base of the CCBL. A relatively large volume of leachate and groundwater is removed from the groundwater system by the leachate collection and combined leachate detection/groundwater underdrain systems present in the lined portions of the MA, LA, and UA. These flows are collected and routed through Sedimentation Pond No. 1 before being discharged off-site. As the remaining impacted groundwater flows downgradient of the landfill it is expected to undergo attenuation based on a combination of advection, dispersion, and, potentially natural dilution resulting in concentrations that are anticipated to be below the arsenic GWPS before flow reaches a potential receptor. As previously noted, the nearest potential water supply user in the downgradient flow path is located approximately 3,000 ft from the facility boundary.

5.0 IDENTIFICATION AND SCREENING OF REMEDIATION TECHNOLOGIES

Technologies for the treatment of arsenic in groundwater are primarily based on ex-situ or in-situ approaches. Pump-and-treat technologies make use of processes common to water and wastewater treatment for removal of dissolved arsenic. In-situ treatment technologies are less common, but there is emerging research based on the application of permeable reactive barriers for arsenic removal from ground water. This technology is based on installation of reactive solid material into the subsurface to intercept and treat the contaminant plume (USEPA, October 2007). Monitored Natural Attenuation (MNA) may also be appropriate at some sites depending on aquifer properties and geochemical conditions. This section identifies the remediation technologies which were evaluated as part of this ACM and summarizes each technology including associated advantages and disadvantages. The technologies include those pertaining to source control and those addressing the impacted groundwater downgradient of the CCBL.

5.1 SOURCE CONTROL

When remediating impacted groundwater, controlling on-site sources of historical, current, and future contamination to the aquifer are key components to the overall remediation plan. Source control includes a range of potential actions such as treatment in-place, removal, or containment, or some combination of these actions with the goal of reducing or eliminating, to the extent practicable, future releases.

5.1.1 Treatment in Place

For a dry disposal landfill like the existing CCR unit, options for in place source treatment would include amending the landfilled CCRs to reduce their permeability in order to minimize surface water and groundwater infiltration and associated leachate development, or to chemically fixate the contaminants of concern and prevent them from leaching out. Amendment of the in-place CCRs would be accomplished by either localized excavation followed by blending with an appropriate amending agent (e.g., natural clays or lime) and then replacement, or by the use of drilled high-pressure injection wells to introduce an amending agent slurry (e.g., Portland cement). However, the CCRs placed in the landfill since the mid-1990’s have consisted of stabilized flue gas desulfurization (FGD) byproduct, which is a pozzolanic material that hardens like a low strength grout with an unconfined compressive strength that can vary between 100 and 1,000 pounds per square inch (psi). This self-hardening behavior results in both a low permeability waste mass (as previously noted in Section 4.1, in the range of 10^{-5} to 10^{-6} cm/sec) and in partial encapsulation of potential leaching constituents. Because of these material properties, and also considering the surface area and volume of materials present in a large landfill like the CCR unit, implementation of such treatment in-place technologies is impractical and has only been noted herein for completeness in presenting options.

5.1.2 Removal

Source removal for a dry disposal landfill can include both solid matrix (the CCRs themselves) and liquid matrix (the leachate generated due to infiltration of precipitation, surface water, and groundwater into and through the landfilled CCRs). Solid matrix removal would include excavating, loading and hauling all of the CCRs currently located in unlined disposal areas and placing them in existing or new on-site or off-site lined disposal areas. Liquid matrix removal would include collecting and conveying CCR leachate generated in unlined areas to appropriate holding/equalization facilities before discharging it for either treatment or transport and disposal (e.g., in deep underground injection wells).

In general, advantages include:

- Oftentimes reduces the timeframe over which remediation goals can be attained; and
- Effectively eliminates the potential for future contamination to occur.

In general, disadvantages include:

- For solid matrix removal, an increased overall risk to cleanup workers, the surrounding community, and the environment due to factors such as fugitive dust generation and heavy construction equipment emissions;
- If off-site transport and disposal is required, an increased potential for severe cross-media environmental effects and safety hazards due to accidents; and
- For a large volume site, removal activities could take an unreasonable amount of time to complete and be financially infeasible.

As previously noted in Section 1.3, the original unlined portions of the MA and LA have subsequently been overlain by both lined disposal areas and by placement of stabilized FGD which, as noted in Section 5.1.2, is a self-hardening, low permeability material. Given these Site development conditions and material characteristics, as well as the volume of materials present in a large landfill like the CCR unit and the corresponding effects that the disadvantages noted above would entail for a facility of such size, implementation of solid or liquid matrix removal from unlined areas at the site is impractical and noted herein for completeness in presenting options.

5.1.3 Containment

Source containment approaches for a dry disposal landfill would include the construction of a final cover (capping) system and/or the installation of a subsurface cutoff wall. Construction of a final cover system atop all exposed CCR surfaces would eliminate source material releases due to stormwater erosion or fugitive dust generation and would reduce leachate generation by minimizing the infiltration of storm water into the underlying CCRs. Installation of a low permeability upgradient groundwater cutoff wall by trench excavation and/or drilled high pressure injection grouting would minimize source contaminant mobilization by preventing groundwater flow into or through the landfilled CCRs.

In general, advantages include:

- Implementation can usually be completed in a relatively short period of time;
- Final cover system design and construction have well-established processes with a proven performance history;
- Oftentimes reduces the timeframe over which remediation goals can be attained; and
- Effectively minimizes the potential for future contamination to occur.

In general, disadvantages include:

- For cutoff walls, subsurface conditions must be favorable across the Site in order to construct an effective and reliable groundwater flow barrier (this is particularly difficult for controlling fractured bedrock flow);
- Depending on the landfill geometry, final cover systems can be difficult to design with respect to maintaining long-term slope stability and reliable stormwater collection and conveyance controls; and
- Final cover systems require routine monitoring, maintenance, and repair throughout their service life.

Given both the large size and the geologic and hydrogeologic characteristics of the Site, the installation of an effective groundwater cutoff wall is impractical and is noted herein for completeness in presenting options. However, construction of a final cover system (either a soil-only or typical regulatory composite cap) is a viable option for the CCR unit and is required under the solid waste permit issued by WVDEP for the Site after the landfill reaches design capacity and is closed.

5.2 GROUNDWATER EXTRACTION AND TREATMENT

Groundwater extraction and treatment (also referred to as “pump and treat”) can be used as a containment strategy at or near the source of contamination or to reduce or eliminate the downgradient migration of a plume. The technology accomplishes a certain amount of mass removal from the plume. In its simplest form, extraction and treatment involves the installation and pumping of vertical extraction wells with the extracted water treated for the contaminant(s) of concern using methods appropriate for the type of contaminant (e.g., air stripping for volatile organic compounds, chemical precipitation for certain inorganic compounds, etc.). As with most remedial technologies it is most effective following source control. In most cases the groundwater treatment results in a need to manage residuals (e.g., sludges, filters, etc.) which may also act as a source of contamination if not properly managed. Extraction and treatment system application often has associated contaminant “rebound” effects related to desorption of additional contaminant mass from aquifer materials following the initial extraction phase. Groundwater extraction and treatment can also be accomplished via horizontal wells.

In general, advantages include:

- Accomplishes some contaminant mass removal; and
- Can help to protect receptors (e.g., drinking water wells) by preventing migration beyond the extraction wells.

In general, disadvantages include:

- Likely to have limited success under heterogenous or low permeability aquifer conditions;
- Often requires long term operation and maintenance and power usage;
- Results in treatment residuals which must subsequently be managed; and
- “Rebound” effects can inhibit the ability to achieve remedial goals.

For arsenic, treatment methods include coagulation (i.e., with ferric chloride or alum) and adsorption on packed bed media (e.g., granular ferric hydroxide or activated alumina). Particularly for aluminum-based coagulants and sorbents, the efficiency of arsenic removal can be dramatically enhanced by pre-oxidation of As(III) to As(V). With greensand filtration, the filter media itself is an oxidant and removal of arsenic, whether it occurs in the groundwater as either As(III) or As(V), is enhanced if the groundwater also contains elevated concentrations of Fe(II).

5.3 IN-SITU TECHNOLOGIES

As opposed to technologies such as groundwater extraction and treatment which involve mechanical systems that must be continually operated, “passive” in-situ technologies operate primarily by using a site’s natural characteristics (e.g., groundwater flow direction, aquifer geochemical conditions, etc.) to achieve remedial goals. As discussed in this section, in-situ technologies require a strong understanding of an impacted aquifer’s physical and geochemical characteristics, which can be “built upon” to achieve remedial goals through adding appropriate reagents to the subsurface environment to achieve contaminant reduction through processes such as adsorption, precipitation, etc.

5.3.1 Permeable Reactive Barriers (PRBs)

A permeable reactive barrier (PRB) typically involves digging a trench perpendicular to groundwater flow and of sufficient depth to intercept a groundwater plume, then placing a reagent in the trench which will react with the impacted groundwater flowing through it in order to reduce contaminant concentrations, primarily through adsorption or precipitation. A funnel and gate type approach can also be utilized for PRBs where low permeability walls (the funnel) direct groundwater toward a permeable zone containing the reagent (the gate). Some gates are constructed to be readily accessible to facilitate the replacement of the reagent. The reagent is selected based on the constituent of concern and geochemical conditions of the aquifer (e.g. pH and redox conditions).

Certain contaminants are much more amenable to PRB treatment based on their physical and chemical properties. A commonly used reagent is Zero Valent Iron (ZVI) which can be used to convert certain contaminants to non-toxic or immobile species. ZVI has been shown to be effective in treating many halogenated hydrocarbons as well as removing hexavalent chromium, arsenic, and uranium (“Permeable Reactive Barriers, Permeable Treatment Zones and Application of Zero-Valent Iron”, USEPA Clu-In Technologies website.) Both As(III) and As(V) can be removed from water by iron wire or filings in batch systems or columns, and this removal has been attributed to sorption and/or surface precipitation of As onto iron oxides (or rust) produced at the metal surface. However, ZVI has not yet been applied in a permeable reactive barrier system for in situ treatment of arsenic-contaminated groundwater. (SERDP, August 2008).

In general, advantages include:

- Essentially a passive type approach (i.e., no continuous operational oversight needed, maintenance is infrequent, etc.); and
- Can be very effective for certain types of contaminants and under the necessary hydrogeologic conditions.

In general, disadvantages include:

- Not suitable for bedrock aquifers;
- Limited by viable trenching depth;
- Suitable reagents have not been proven for all contaminant types (e.g., arsenic); and
- Reactive agent(s) must be replaced on a scheduled basis.

Application of PRB technology at the Site is not considered viable since the uppermost aquifer system occurs downgradient of the site at depths between approximately 60 and 500 feet and includes a fractured bedrock flow component. In addition, Tetra Tech is not aware of any current application of PRB technology to remediate arsenic in groundwater. As such, it will not be considered in the evaluation of corrective measures discussion in Section 6.0.

5.3.2 In-Situ Chemical Stabilization via Injection Wells

In-situ chemical stabilization involves injection into the subsurface via drilled wells a reagent that will result in the precipitation or adsorption of the constituent of concern, and thereby reduce its concentration in groundwater within and downgradient of the injection area. The type of reagent used will depend on the constituent and geochemical conditions within the aquifer including pH, redox conditions, types of natural clays which may be present, etc. It is critical that the aquifer characteristics, particularly permeability, lend themselves to suitable mixing of the reagent with impacted groundwater. Bench scale testing is typically performed to evaluate viability and, if found to be viable, to support design.

In general, advantages include:

- An overall passive approach with minimal disruption of the Site.

In general, disadvantages include:

- Proven reagents are not available for all CCR constituents;
- Changes in geochemistry or aquifer conditions outside of the injection interval may cause certain reactions to “reverse”;
- It can be difficult to achieve the desired mixing of the reagent with impacted groundwater under low permeability and/or heterogenous aquifer conditions (e.g., fractured bedrock); and
- The longevity of the reagents can be difficult to forecast.

5.4 MONITORED NATURAL ATTENUATION (MNA)

The following summary of MNA is based on USEPA Directive 9200.4 – 17P “Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites”, April 21, 1999.

> The term ‘monitored natural attenuation’… refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The “natural

attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants

The USEPA directive lists the following among the advantages and disadvantages of the MNA approach:

Potential advantages of MNA include:

- As with any in situ process, generation of lesser volume of remediation wastes, reduced potential for cross-media transfer of contaminants commonly associated with ex situ treatment, and reduced risk of human exposure to contaminants, contaminated media, and other hazards, and reduced disturbances to ecological receptors;
- Less intrusion as few surface structures are required;
- Potential for application to all or part of a given site, depending on site conditions and remediation objectives;
- Use in conjunction with, or as a follow-up to, other (active) remedial measures; and
- Potentially lower overall remediation costs than those associated with active remediation.

The potential disadvantages of MNA include:

- Longer time frames may be required to achieve remediation objectives, compared to active remediation measures at a given site;
- Site characterization can often be more complex and costly;
- Long-term performance monitoring will generally be more extensive and for a longer time;
- Institutional controls may be necessary to ensure long term protectiveness;
- Potential exists for continued contamination migration, and/or cross-media transfer of contaminants; and
- Hydrologic and geochemical conditions amenable to natural attenuation may change over time and could result in renewed mobility of previously stabilized contaminants (or naturally occurring metals), adversely impacting remedial effectiveness.

In addition to the above USEPA Directive, a companion Directive was also issued: "Use of Monitored Natural Attenuation for Inorganic Contaminants In Groundwater At Superfund Sites", August 2015, USEPA. Although the Directive does not specifically address arsenic, it discusses a methodology for considering MNA as a remedial strategy for several inorganic constituents and expands upon the Tiered Analysis Approach for Developing Multiple Lines of Evidence presented in the original 1999 Directive.

6.0 ASSESSMENT OF CORRECTIVE MEASURES

6.1 OBJECTIVE

The objective of this Assessment of Corrective Measures section is to provide a high-level evaluation of each of the viable remediation technologies presented in Section 5.0 with regards to the criteria identified in 40 CFR § 257.96(c) and previously presented in Section 1.2 of this report. These evaluations are summarized below and in Table 6-1. The criteria evaluated in Sections 6.2 through 6.5 are performance-related, so each of the technologies has been assigned a subjective rating of “Low”, “Medium”, or “High” based on how they are anticipated to satisfy each criterion. For the criteria evaluated in Sections 6.6 (time to begin and complete remedy) and 6.7 (institutional requirements), subjective ratings of “Short”, “Medium”, or “Long” and “Minimal”, “Moderate”, and “Extensive” have been assigned, respectively. As discussed in Section 5.3.1, the PRB technology was not considered viable due to both the aquifer depth and that the primary aquifer type is fractured bedrock; therefore, it is not included in the evaluations below. A more detailed evaluation of technologies leading to a final selection of remedy will be performed and reported during the Selection of Remedy phase as discussed in Section 7 of this report.

6.2 PERFORMANCE

This section discusses the anticipated performance of each technology relative to its ability to achieve remedial goals in consideration of the CSM. Technologies are ranked as “Low”, “Medium”, or “High” with regard to their effectiveness in reducing arsenic concentrations in groundwater.

6.2.1 Source Control

Containment using Final Cover System – Medium to High

As discussed in Section 5.1.3, constructing a final cover system atop all exposed CCR surfaces would minimize the infiltration of storm water into the underlying CCRs which would, in turn, reduce both the groundwater flow rates and the total contaminant loading on the monitored aquifer(s). The magnitude and extent of these reductions depend on the type of final cover system(s) utilized at the Site. As per the CCR unit’s current Closure Plan (available on the Site’s publicly accessible CCR website - http://ccrdocs.firstenergycorp.com/), the existing disposal areas currently use a soil-only cover system. However, these existing areas and the future disposal areas will ultimately have a composite cover system installed that includes a geomembrane cap component once final closure of the entire landfill facility is initiated. The soil-only cover system provides a medium level of containment performance while the composite cover system would provide a high level of containment performance. With these factors in mind, it’s possible that the existing soil-only cover system may remain in place for several years, which would include much of the remediation activity period.

6.2.2 Groundwater Extraction and Treatment

Low. It is anticipated that the performance of a groundwater extraction and treatment system would be poor due to the anisotropic nature and overall low permeability of the aquifer. It is also noted that the cross-sectional area through the groundwater flow path downgradient of the landfill is wide. Given that and the fact that groundwater flow at the Site is primarily occurring through bedrock fractures, it is likely many extraction wells would be necessary to ensure that all groundwater flow paths were being captured.

6.2.3 In-Situ Technologies

Chemical Stabilization via Injection Wells – Low

The anisotropic nature and relatively low permeability of the monitored aquifer would make in-situ treatment by injection wells difficult from the standpoint of achieving adequate contact and reagent mixing with the impacted groundwater.

6.2.4 Monitored Natural Attenuation (MNA)

High. As discussed in Sections 3.2 and 4.2, it’s believed that attenuation of the arsenic levels down to the GWPS is occurring near the downgradient facility boundary based on interpolation of the measured concentration gradients. In addition, the nearest potential water supply user in the downgradient flow path is located approximately 3,000 ft from the facility boundary. Taken together, the anticipated ongoing performance of MNA would be high, provided it is combined with the eventual installation of a composite final cover system.

6.3 RELIABILITY

Reliability is the anticipated consistency of a technology to function as designed/expected under variable site-specific conditions. Factors which affect reliability can include aquifer variability (e.g., groundwater geochemistry and flow changes) and equipment performance (e.g., power outages and frequency of maintenance activities). Technologies are ranked as “Low”, “Medium”, or “High” with regard to their effectiveness in consistently reducing arsenic concentrations in groundwater.

6.3.1 Source Control

Containment Using Final Cover System - High

The existing soil-only cover system has been utilized and has functioned reliably on all the disposal areas that have been developed at the Site since operations commenced. The composite cover system that is proposed for use during final closure will be designed and constructed in accordance with well-established practices and incorporates an upper layer of vegetated cover soil that’s comparable to the soil-only cover system. Both systems are expected to continue to be highly reliable as long as they are properly monitored and maintained, which FE will do for the remainder of the landfill’s operating life and for the duration of the landfill’s post-closure period as required by the state Solid Waste Permit.

6.3.2 Groundwater Extraction and Treatment

Medium to High. Extraction and treatment would require proper operation and maintenance (O&M) of extraction well equipment (e.g., pumps) and treatment system in order to maintain reliability. Given that the uppermost aquifer is overlain by a water-bearing coal seam (Lower Uniontown Coal), the likely presence of relatively high iron concentrations in the aquifer would likely require measures to be taken to prevent fouling and deterioration of pumps and treatment equipment as well as any connecting piping.

6.3.3 In-Situ Technologies

Chemical Stabilization via Injection Wells – Low to Medium

It is anticipated that since chemical stabilization of arsenic in an aquifer system does not seem to be proven, that reliability would be questionable. Beyond concept reliability, the injection system itself would require proper O&M of the well equipment (e.g., pumps) and the surface batching and feed systems in order to maintain operational reliability.

6.3.4 Monitored Natural Attenuation

High. Based on the factors previously discussed in Section 6.2.4, it is anticipated that reductions in arsenic concentrations would be reliable going forward provided it is combined with the eventual installation of a composite final cover system.

6.4 EASE OF IMPLEMENTATION

Ease of implementation relates to how challenging the technology installation will be considering site-specific conditions (e.g., degree of aquifer heterogeneity), the complexity of the design effort (e.g., modeling, bench scale and pilot testing, etc.), and the availability of suitable equipment. Technologies are ranked as “Low”, “Medium”, or “High” with regard to their ease in being installed to begin reducing arsenic concentrations in groundwater.

6.4.1 Source Control

Containment using Final Cover System – Medium to High

The existing soil-only cover system is in-place on all inactive areas of the landfill and a regular monitoring and maintenance program is in effect. As such, its ease of installation is high. The proposed composite cover system would require the development of construction-level drawings and specifications and then have to proceed through the Station’s procurement process before construction could commence. Construction would entail the use of commonly accepted materials, means, and methods, but ease of completion would depend primarily on the size of the area(s) being covered and seasonal weather constraints. Because of these factors, ease of installation for the composite cover system is considered medium to high.

6.4.2 Groundwater Extraction and Treatment

Low. Based on the anisotropic and low permeability nature of the monitored aquifer, it is likely that many groundwater extraction wells would be needed to attempt to capture impacted groundwater. Given both the topography and the number of below and above ground gas conveyance lines in the targeted eastern intercept area and the interferences they would present, siting the wells in the desired locations would prove extremely difficult. Bench scale testing would also need to be conducted to identify the best reagent(s) for use in removing the arsenic from solution. Such a bench scale testing program would be expected to go through multiple iterations before establishing the treatment program needs. Because of these factors, ease of installation for this system is considered medium to low.

6.4.3 In-Situ Technologies

Chemical Stabilization via Injection Wells – Low

Implementation would likely be very challenging due to identifying the appropriate reagent(s) and "dosing" strategy to effectively and efficiently treat the aquifer due to the anisotropic conditions. It is likely that various phases of bench scale and field pilot testing would be necessary to support the design.

6.4.4 Monitored Natural Attenuation

Medium to High. No additional equipment would be necessary for a natural attenuation remedy. There would possibly be a need to add a limited number of properly constructed monitoring wells in the downgradient area east of the facility boundary to evaluate the program’s performance, and this could present significant difficulties due to the topography of this area and the potential need to negotiate monitoring well easements with downgradient property owners.

6.5 POTENTIAL IMPACTS OF APPROPRIATE REMEDIES (SAFETY, CROSS-MEDIA AND CONTROL OF EXPOSURE)

Potential impacts of technologies were evaluated considering the following:

- Safety: The likelihood that illness, injury, or death directly related to the technology would occur during construction or operations. In general, “active” technologies and those requiring significant construction effort were considered higher risk than “passive” technologies and those not requiring significant construction effort.

- Cross-Media: The likelihood that the technology will result in a transfer of contaminants to the air, surface water, or soil, either from a direct discharge or from management of treatment residuals.
- Control of Exposure: The likelihood that that the technology will result in exposure of contaminants to human or environmental receptors either from a direct discharge or from management of treatment residuals.

Technologies are ranked as “Low”, “Medium”, or “High” with regard to how likely they are to have negative effects for Safety and Cross-Media, and with regard to how well they avoid negative effects for Control of Exposure.

6.5.1 Source Control

Containment using Final Cover System

Safety Impacts: **Low to Medium**. The existing soil-only cover system is in-place and presents little to no implementation-related safety impacts. Construction of the proposed composite cover system would involve typical construction risks, both on-site and off-site, due primarily to material deliveries and heavy equipment operations. However, after construction is completed, the composite cover system would present little to no implementation-related safety impacts.

Cross-Media Impacts: **Low**. Construction of either a soil-only or a composite final cover system atop all exposed CCR surfaces would eliminate source material releases and potential cross-media impacts to the air, ground surface, or surface water due to stormwater erosion or fugitive dust generation.

Control of Exposure: **High**. Construction of either a soil-only or a composite final cover system atop all exposed CCR surfaces would eliminate direct and indirect exposure to the landfilled CCRs.

6.5.2 Groundwater Extraction and Treatment

Safety Impacts: **Medium**. Safety risks associated with drilling extraction wells and construction of a treatment facility would exist but could be minimized through implementation of an appropriate health and safety plan. Likewise, some safety risks would be associated with the operation of the treatment system; however, such risks could be minimized through proper O&M procedures and through implementation of an appropriate health and safety plan.

Cross-Media Impacts: **Medium**. Treatment residuals would need to be managed. In addition, the potential exists for releases from well connections, valves, system piping, and tanks that could impact site soils and potentially groundwater and surface water.

Control of Exposure: **Medium**. Treatment residuals would need to be properly managed to minimize exposure. In addition, the potential exists for exposure to workers and other on-site personnel from any releases which may occur at the well heads, piping, and any storage tanks that are part of the extraction and treatment system.

6.5.3 In-Situ Technologies

Chemical Stabilization via Injection Wells

Safety Impacts: **Medium** – There would be safety risks associated with drilling injection wells and handling reagent.

Cross-Media Impacts: **Low to Medium** – Would need to confirm that selected reagent would not have negative impacts associated with downgradient groundwater discharge to surface water.

Control of Exposure: **Medium to High** – Will require proper handling procedures for the selected reagent.

6.5.4 Monitored Natural Attenuation

Safety Impacts: **Medium** - Some additional construction or well installation would be necessary under the MNA remedy; there would be safety risks associated with possibly installing a limited number of properly constructed monitoring wells in the downgradient area east of the facility boundary to evaluate the program's performance, but this would not present significant safety impacts.

Cross-Media Impacts: **Low to Medium** – As noted in Section 4.3, the Site CSM indicates groundwater from the monitored aquifer flows to the east. The nearest drainage feature in this direction appears to be the West Fork River, which is located approximately one mile to the east/southeast of the facility boundary. However, it's believed that attenuation of the arsenic levels down to the GWPS is occurring near the facility boundary based on interpolation of the measured concentration gradients. In addition, the arsenic levels measured in the Site wells are well below the state and federal aquatic water quality criteria presented in Section 3.1.2, which would apply to the West Fork River.

Control of Exposure: **High** - No contamination residuals will be generated. As stated in Section 4.2, the closest potential downgradient drinking water user is located approximately 3,000 feet from the facility boundary.

6.6 TIME REQUIRED TO BEGIN AND COMPLETE REMEDY

The anticipated time required to begin and compete a remedy considers factors such as the complexity of the design, construction, and permitting efforts, as well as forecasting how efficient the technology is expected to be in achieving remedial goals in a timely manner. Technologies are ranked as "Short", "Medium", or "Long" with regard to their anticipated time to reduce arsenic concentrations in groundwater.

6.6.1 Source Control

Containment using Final Cover System

Time to Begin Remedy: **Short.** For the existing soil-only cover system, no lead time is required (short). For the composite final cover system, it is anticipated that preparation of construction drawings and documents and contractor procurement would take approximately one year (short).

Time to Complete Remedy: **Short to Medium.** For the existing soil-only cover system, no implementation time is required (short). For the composite cover system, installation would need to be performed using a phased construction approach that would include seasonal (winter) shutdowns, with the total time to complete construction being approximately five years.

6.6.2 Groundwater Extraction and Treatment

Time to Begin Remedy: **Medium.** It is anticipated that one to two years would be required to initiate a groundwater extraction and treatment remedy in order to allow time for modeling to select well locations; to complete well, pipeline and treatment system design and permitting, and to construct the extraction and treatment systems (medium).

Time to Complete Remedy: **Currently Unknown**. Extraction and treatment, while effective at containment in some settings, is often not successful in achieving remedial goals due to "rebound" effects and other field variables that become more defined during system startup and operation.

6.6.3 In-Situ Technologies

Chemical Stabilization via Injection Wells

Time to Begin Remedy: **Medium.** Two to three years are estimated for bench scale testing in order to select the treatment reagent(s), perform modeling to identify injection well locations, complete well and injection system design and permitting, and to install the injection wells and construct the injection system (medium).

Time to Complete Remedy: **Currently Unknown**. The time required to complete the remedy will depend on the duration of leaching of arsenic into the aquifer, which is expected to decrease as the CCR unit is covered/capped. The duration of treatment required is difficult to estimate until at least bench scale testing is performed on the selected reagent.

6.6.4 Monitored Natural Attenuation

Time to Begin Remedy: **Short**. As previously noted, it's believed that attenuation of the arsenic levels down to the GWPS is occurring near the facility boundary based on interpolation of the measured concentration gradients.

Time to Complete Remedy: **Long**. Additional monitoring and the installation of additional monitoring well locations would be necessary to confirm that the GWPS is being attained near the facility boundary. Ongoing monitoring to confirm the remedy continues to be effective would also be proposed with the duration to be determined as part of the Selection of Remedy process discussed in Section 7.0 of this report (long).

6.7 INSTITUTIONAL REQUIREMENTS (STATE AND LOCAL PERMITS AND OTHER APPROVALS)

Institutional requirements pertain to the anticipated state and local permits and other approvals needed to construct and operate the remedial technology. These can include programs already in-place for a given CCR unit (e.g., solid waste permit) that will need to be modified to accommodate a potential technology, or new programs that may result from a potential technology (e.g., NPDES permit). FE will continue to provide CCR Rule program notifications to WVDEP as required by 40 CFR § 257.106 and will also consult with WVDEP to confirm anticipated permitting requirements that would be associated with the selected remedy. As mentioned in Section 1.3, the CCBL is permitted under the WVDEP solid waste regulations; therefore, consultation with the agency will be required to support remedy selection, design, and implementation. The following summarizes the expected permits/approvals which may be required by WVDEP or local authorities for each technology and associated rankings of "Minimal", "Moderate", and "Extensive" with regard to the anticipated level of effort that will be needed to obtain them.

6.7.1 Source Control

Containment using Final Cover System – Minimal to Moderate

Both the existing soil-only cover system and a composite final cover system would be regulated under the state-issued Solid Waste Permit. The use of the soil-only cover system in its current operating capacity would only require the regular renewal of the Solid Waste Permit, while the use of a composite cover system would require a modification of the Solid Waste permit.

6.7.2 Groundwater Extraction and Treatment

It is anticipated that either an amendment to the landfill's combined Solid Waste/NPDES permit or a new individual NPDES permit will be required for construction and operation of the treatment system. This would likely constitute a moderate to extensive effort. Well locations, piping, and any excavation related to the treatment system would also need to undergo utility clearances.

6.7.3 In-Situ Technologies

Chemical Stabilization via Injection Wells - Moderate

It is anticipated that only an amendment to the landfill's Solid Waste Permit would be required for construction and operation of an injection system.

6.7.4 Monitored Natural Attenuation

No new or amended permits and/or approvals are anticipated from state or local agencies and authorities for an MNA remedy. The implementation of an MNA remedy would only require the regular renewal of the Solid Waste Permit, which would likely constitute a minimal effort.

6.8 COMPARATIVE ANALYSIS OF CORRECTIVE MEASURES ALTERNATIVES

Based on the evaluation of viable remediation technologies presented in Sections 6.1 through 6.7, MNA, combined with source control by the eventual installation of a composite cover system, ranks highest among the evaluated options. It ranks high in performance, reliability, ease of implementation, potential safety impacts and potential for residual contamination impacts. Also, additional monitoring of the groundwater network should be conducted to confirm that there are not trend changes that could impact effectiveness. These and other additional data needs that are part of the final Selection of Remedy at the Site are discussed in Section 7.2. It is also noted that it is anticipated that the composite final cover system should accelerate the effectiveness of whichever associated corrective measure is selected.

7.0 PROCESS FOR SELECTION OF REMEDY

7.1 SELECTION CRITERIA AND SCHEDULE

As required by 40 CFR § 257.97(a), FE will, as soon as feasible after completion of this ACM, select a remedy that, at a minimum, meets the performance standards listed in 40 CFR 257.97(b) and the evaluation factors listed in 40 CFR 257.97(c). As required by 40 CFR § 257.97(d), FE will specify as part of the selected remedy a schedule(s) for implementing and completing remedial activities. The schedule will require the completion of remedial activities within a reasonable period of time taking into consideration the factors set forth in 40 CFR § 257.97(d)(1) through (d)(6),

7.2 ADDITIONAL DATA NEEDS

In order to select a remedy that is both effective and implementable, additional data collection and analyses will be required as summarized below:

- Installation of at least one additional monitoring well downgradient of the MW-20/MW-19 flow paths to confirm attenuation of arsenic is occurring near the facility boundary and to monitor the continued effectiveness of the attenuation mechanisms.
- Modeling of the monitored aquifer to further evaluate the MNA alternative to assist in forecasting likely long-term effectiveness and to estimate timeframes for completing remedial activities.
- Additional research into potential reagents for chemical stabilization of arsenic via injection wells as presented in Section 5.3.2.

7.3 REMEDY SELECTION PROGRESS REPORTING

As required by 40 CFR § 257.97(a), FE will prepare a semi-annual report describing the progress in selecting and designing the remedy. One of the semi-annual reports will be included in the forthcoming 2019 Annual Groundwater Monitoring and Corrective Action Report, which will be completed in January 2020.

7.4 PUBLIC MEETING

As required by 40 CFR § 257.96(e), FE will discuss the results of the corrective measures assessment at least 30 days prior to the selection of remedy, in a public meeting with interested and affected parties.

7.5 FINAL REMEDY SELECTION

Upon selection of a remedy, FE will prepare a final report describing the selected remedy and how it meets the standards outlined in Section 7.1. The final report will include a certification from a qualified professional engineer that the remedy selected meets the requirements of the selection criteria and the final report will be placed in the Station's operating record as required by § 257.105(h)(12).

8.0 REFERENCES

EPRI, 2010. Arsenic in Coal Combustion Products. Technical Brief No. 1021212. December 2010.

Tetra Tech, 2017. CCR Rule Groundwater Monitoring System Evaluation Report, Harrison Power Station, Coal Combustion Byproduct Landfill. October 2017.

Tetra Tech, 2018. 2017 Annual CCR Groundwater Monitoring and Corrective Action Report, Coal Combustion Byproduct Landfill, Harrison Power Station. January 2018.

Tetra Tech, 2019. 2018 Annual CCR Groundwater Monitoring and Corrective Action Report, Coal Combustion Byproduct Landfill, Harrison Power Station. January 2019.

USEPA, 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. April 21, 1999.

USEPA, 2015. Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. Federal Register Vol. 80, No. 74, Part II 40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System. April 17, 2015.

USEPA, 2015. Use Of Monitored Natural Attenuation For Inorganic Contaminants In Groundwater At Superfund Sites. August 2015.

TABLES

Table 6-1. Screening of Potential Corrective Measures Summary
CCR Rule ACM Report
FirstEnergy - Harrison

	Potential Corrective Measures			
	Source Control	**Groundwater Extraction and Treatment**	**In-Situ Chemical Stabilization via Injeciton Wells**	**Monitored Natural Attenuation**
Evaluation Criteria [per 257.96(c)]	**Containment Using Final Cover System**			
Performance[1] [257.96(c)(1)]	Medium to High	Low	Low	High
Reliability[1] [257.96(c)(1)]	High	Medium to High	Low to Medium	High
Ease of Implementation[1] [257.96(c)(1)]	Medium to High	Low	Low	Medium to High
Potential Impacts of Appropriate Remedies[1] - Safety [257.96(c)(1)]	Low to Medium	Medium	Medium	Medium
Potential Impacts of Appropriate Remedies[1] - Cross-Media [257.96(c)(1)]	Low	Medium	Low to Medium	Low to Medium
Potential Impacts of Appropriate Remedies Control of Exposure to Residual Contamination[1] [257.96(c)(1)]	High	Medium	Medium to High	High
Time Required to Begin Remedy[2] [257.96(c)(2)]	Existing soil-only cover system - Short Composite final cover system - Short	Medium (~ 1 to 2 years)	Medium (~ 2 to 3 years)	Short
Time Required to Complete Remedy[2] [257.96(c)(2)]	Existing soil-only cover system - Short Composite final cover system - Medium (~5 years)	Currently Unknown	Currently Unknown	Long - Additional monitoring and wells would be necessary to confirm that the GWPS is not being exceeded.
Institutional Requirements (State and Local Permits and Other Approvals)[3] [257.96(c)(3)]	Minimal to Moderate	Moderate to Extensive	Moderate	Minimal

Notes:

1. Subjective ratings of “Low”, “Medium”, or “High” assigned based on how the potential corrective measures are anticipated to satisfy each evaluation criterion:
   Performance: Effectiveness in reducing arsenic concentrations in groundwater.
   Reliability: Effectiveness in consistently reducing arsenic concentrations in groundwater.
   Ease of Implementation: Ease in being installed to begin reducing arsenic concentrations in groundwater.
   Safty Impacts: Likelihood that illness, injury, or death directly related to the potential corrective measure would occur during construction or operations.
   Cross-Media Impacts: Likelihood that the potential corrective measure will result in a transfer of contaminants to the air, surface water, or soil, either from a direct discharge or from management of treatment residuals.
   Control of Exposure: Likelihood that that the potential corrective measure will result in exposure of contaminants to human or environmental receptors either from a direct discharge or from management of treatment residuals.

2. Subjective ratings of “Short”, “Medium”, or “Long” assigned with regard to the anticipated time for each potential corrective measure to reduce arsenic concentrations in groundwater, accounting for factors such as the complexity of the design, construction, and permitting efforts, as well as forecasting how efficient the technology is expected to be in

3. Subjective ratings of “Minimal”, “Moderate”, and “Extensive” assigned with regard to the anticipated level of effort that will be needed to obtain the permits/approvals which may be required by WVDEP or local authorities for each potential corrective measure.

FIGURES

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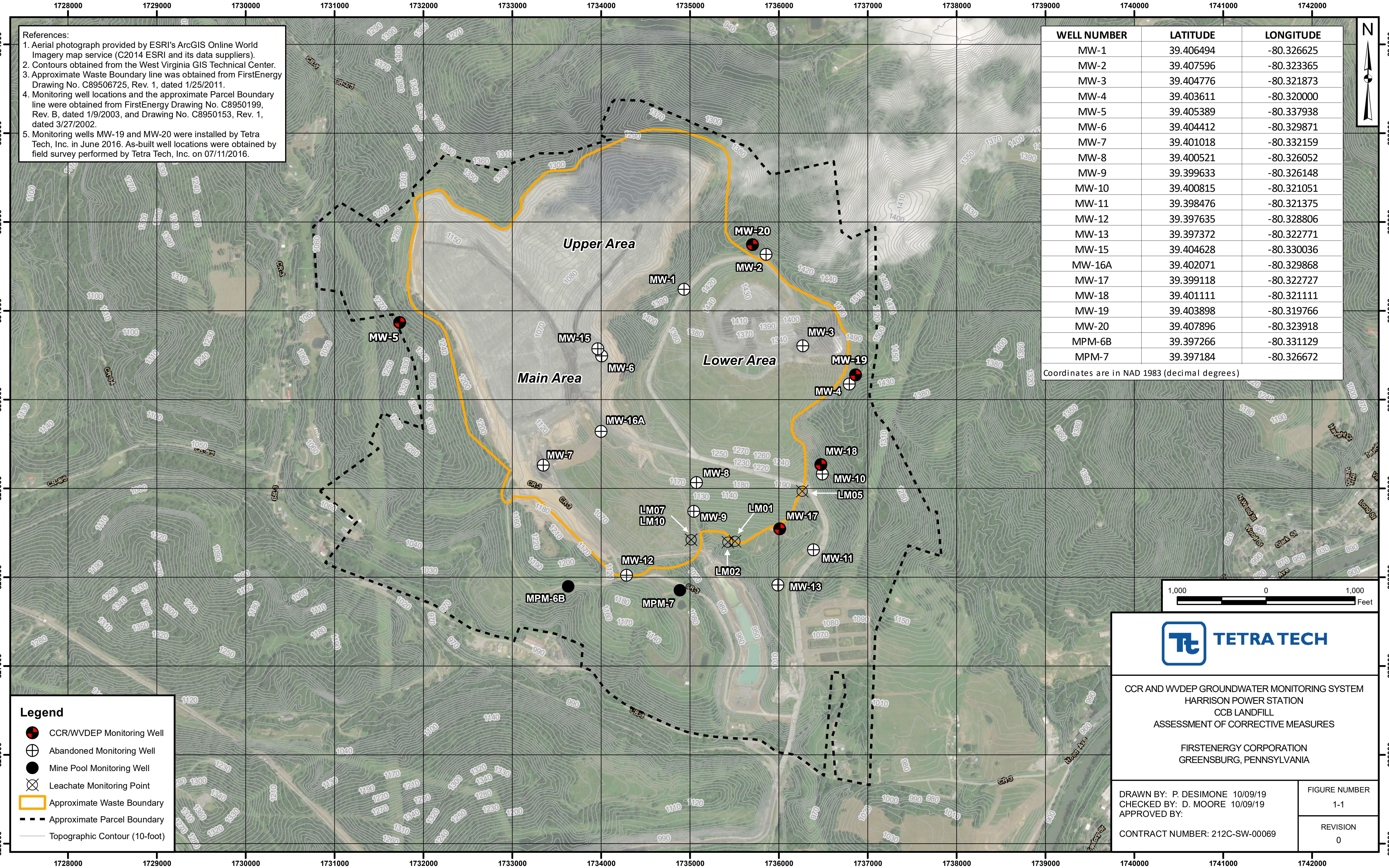

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (C2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Approximate Waste Boundary line was obtained from FirstEnergy Drawing No. C89506725, Rev. 1, dated 1/25/2011.
4. Monitoring well locations and the approximate Parcel Boundary line were obtained from FirstEnergy Drawing No. C8950199, Rev. B, dated 1/9/2003, and Drawing No. C8950153, Rev. 1, dated 3/27/2002.
5. Monitoring wells MW-19 and MW-20 were installed by Tetra Tech, Inc. in June 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 07/11/2016.

WELL NUMBER	LATITUDE	LONGITUDE
MW-1	39.406494	-80.326625
MW-2	39.407596	-80.323365
MW-3	39.404776	-80.321873
MW-4	39.403611	-80.320000
MW-5	39.405389	-80.337938
MW-6	39.404412	-80.329871
MW-7	39.401018	-80.332159
MW-8	39.400521	-80.326052
MW-9	39.399633	-80.326148
MW-10	39.400815	-80.321051
MW-11	39.398476	-80.321375
MW-12	39.397635	-80.328806
MW-13	39.397372	-80.322771
MW-15	39.404628	-80.330036
MW-16A	39.402071	-80.329868
MW-17	39.399118	-80.322727
MW-18	39.401111	-80.321111
MW-19	39.403898	-80.319766
MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

Legend

- CCR/WVDEP Monitoring Well
- Abandoned Monitoring Well
- Mine Pool Monitoring Well
- Leachate Monitoring Point
- Approximate Waste Boundary
- Approximate Parcel Boundary
- Topographic Contour (10-foot)

TETRA TECH

CCR AND WVDEP GROUNDWATER MONITORING SYSTEM
HARRISON POWER STATION
CCB LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 10/09/19
CHECKED BY: D. MOORE 10/09/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00069

FIGURE NUMBER 1-1

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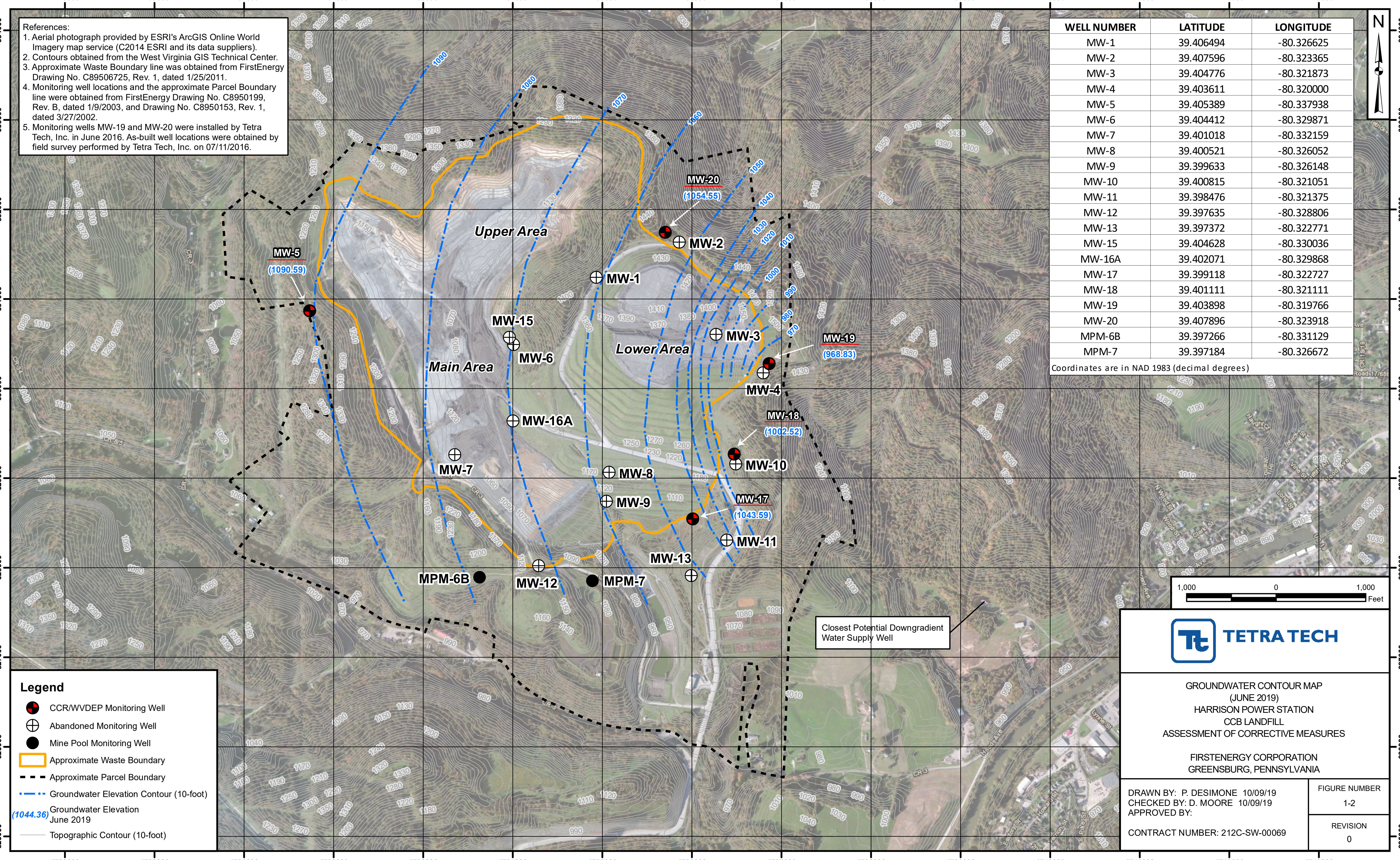

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (C2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Approximate Waste Boundary line was obtained from FirstEnergy Drawing No. C89506725, Rev. 1, dated 1/25/2011.
4. Monitoring well locations and the approximate Parcel Boundary line were obtained from FirstEnergy Drawing No. C8950199, Rev. B, dated 1/9/2003, and Drawing No. C8950153, Rev. 1, dated 3/27/2002.
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MW-7	39.401018	-80.332159
MW-8	39.400521	-80.326052
MW-9	39.399633	-80.326148
MW-10	39.400815	-80.321051
MW-11	39.398476	-80.321375
MW-12	39.397635	-80.328806
MW-13	39.397372	-80.322771
MW-15	39.404628	-80.330036
MW-16A	39.402071	-80.329868
MW-17	39.399118	-80.322727
MW-18	39.401111	-80.321111
MW-19	39.403898	-80.319766
MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

Legend

- CCR/WVDEP Monitoring Well
- Abandoned Monitoring Well
- Mine Pool Monitoring Well
- Approximate Waste Boundary
- Approximate Parcel Boundary
- Groundwater Elevation Contour (10-foot)
- (1044.36) Groundwater Elevation June 2019
- Topographic Contour (10-foot)

TETRA TECH

GROUNDWATER CONTOUR MAP
(JUNE 2019)
HARRISON POWER STATION
CCB LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 10/09/19
CHECKED BY: D. MOORE 10/09/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00069

FIGURE NUMBER
1-2

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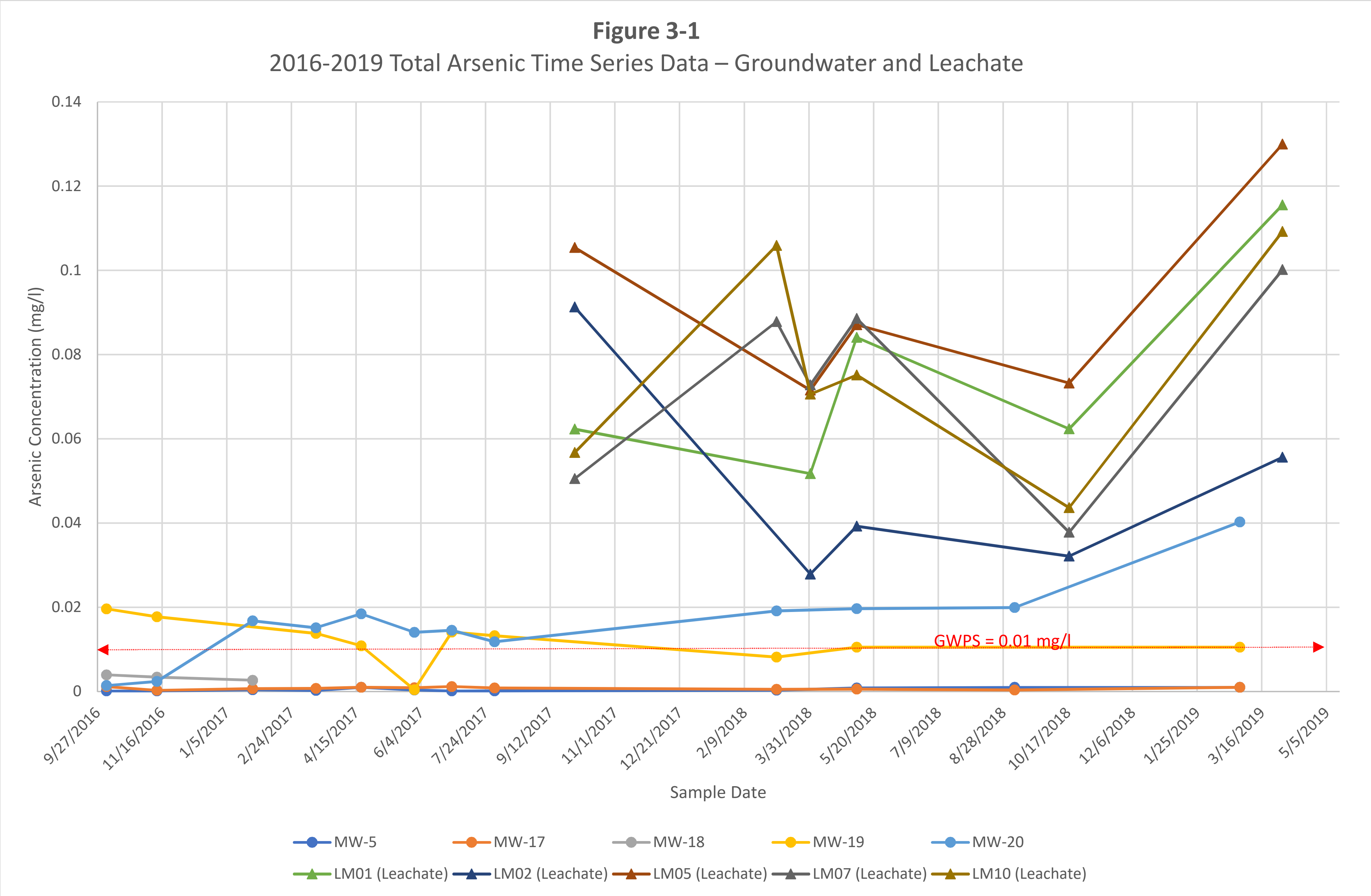
Figure 3-1
2016-2019 Total Arsenic Time Series Data – Groundwater and Leachate
Arsenic Concentration (mg/l)
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
GWPS = 0.01 mg/l
9/27/2016
11/16/2016
1/5/2017
2/24/2017
4/15/2017
6/4/2017
7/24/2017
9/12/2017
11/1/2017
12/21/2017
2/9/2018
3/31/2018
5/20/2018
7/9/2018
8/28/2018
10/17/2018
12/6/2018
1/25/2019
3/16/2019
5/5/2019
Sample Date
MW-5
MW-17
MW-18
MW-19
MW-20
LM01 (Leachate)
LM02 (Leachate)
LM05 (Leachate)
LM07 (Leachate)
LM10 (Leachate)

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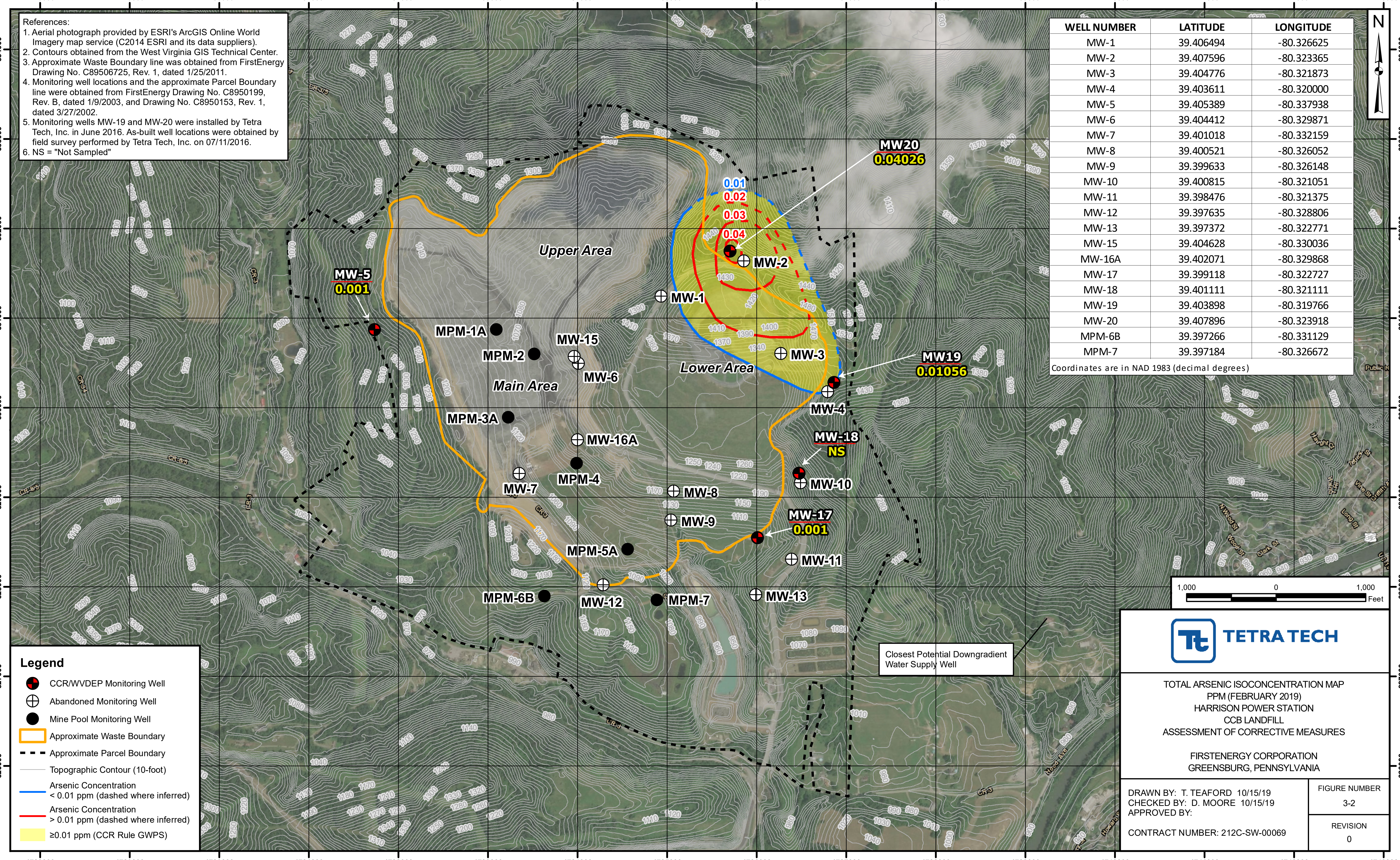

WELL NUMBER	LATITUDE	LONGITUDE
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MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

TETRA TECH

TOTAL ARSENIC ISOCONCENTRATION MAP
PPM (FEBRUARY 2019)
HARRISON POWER STATION
CCB LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: T. TEAFORD 10/15/19
CHECKED BY: D. MOORE 10/15/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00069

FIGURE NUMBER 3-2

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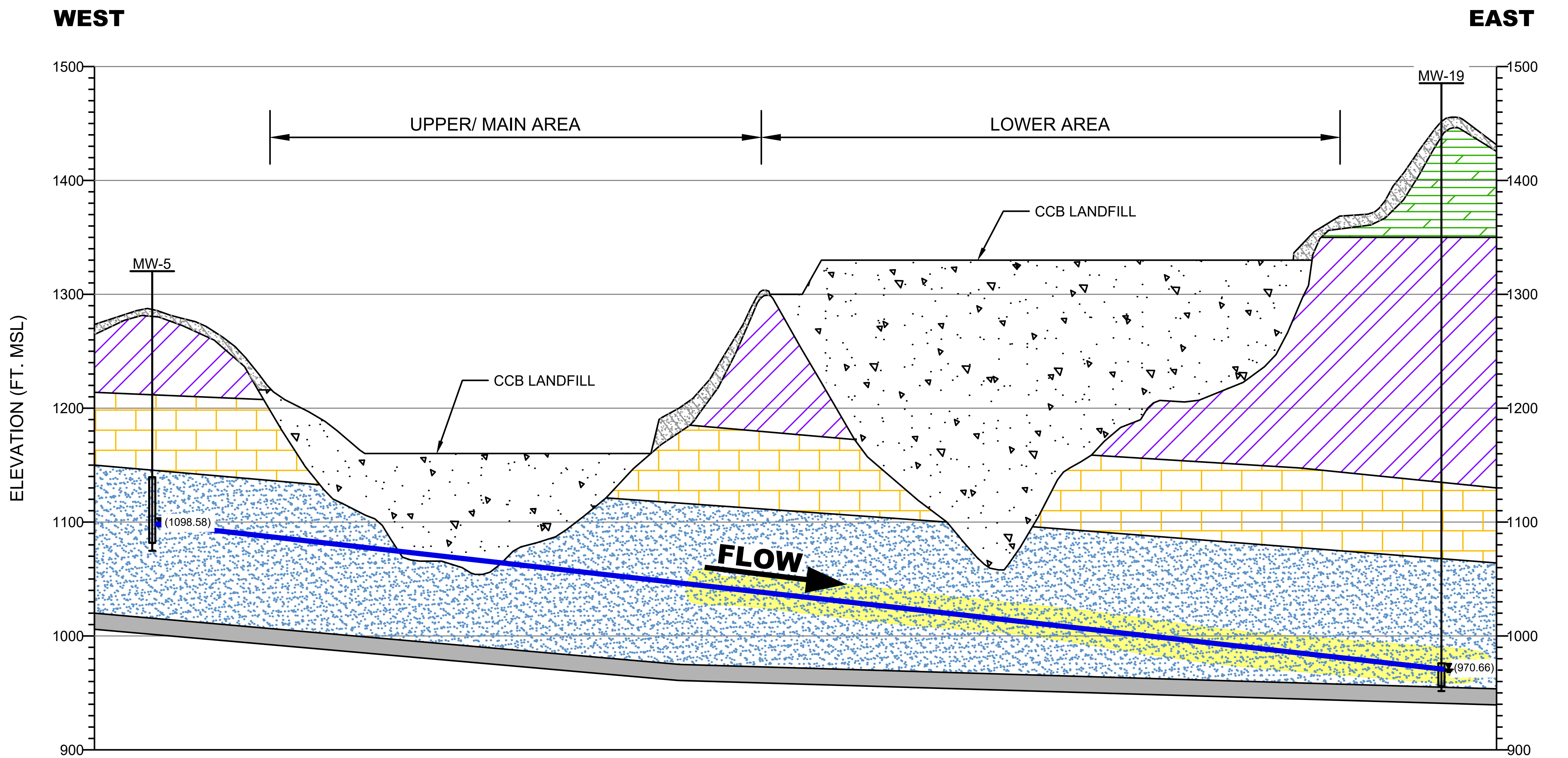

NOTES

1. FEBRUARY 2019 GROUNDWATER ELEVATIONS SHOWN.

LEGEND

- MONITORED AQUIFER
- GWPS EXCEEDANCE FOR ARSENIC
- CLAYEY SILT TRACE ROCK FRAGMENTS
- CCB LANDFILL
- WAYNESBURG FORMATION
- UNIONTOWN FORMATION
- BENWOOD LIMESTONE
- SEWICKLEY SANDSTONE / REDSTONE LIMESTONE
- PITTSBURGH COAL (MINED OUT)

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TETRA TECH
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661 ANDERSEN DRIVE - SUITE 200
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

FIRST ENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

HARRISON CCB LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES

HARRISON COUNTY, WEST VIRGINIA

CONCEPTUAL SITE MODEL (CSM)

NOT TO SCALE

DATE:	10/15/19
PROJECT NO.:	212C-SW-00069
DESIGNED BY:	DS
DRAWN BY:	NN
CHECKED BY:	DS

FIGURE 4-1

SHEET 1 OF 1

APPENDIX A

Appendix IV Alternative Source Demonstration Report – 2018/2019 Assessment Monitoring

CCR Rule Appendix IV Alternative Source Demonstration Report – 2018/2019 Assessment Monitoring

Coal Combustion Byproduct Landfill

Harrison Power Station
Harrison County, West Virginia

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.

400 Penn Center Boulevard, Suite 200
Pittsburgh, PA 15235
Phone: (412) 829-3600
Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00069

October 2019

CCR RULE APPENDIX IV ALTERNATIVE SOURCE DEMONSTRATION REPORT
2018/2019 ASSESSMENT MONITORING

COAL COMBUSTION BYPRODUCT LANDFILL

HARRISON POWER STATION
HARRISON COUNTY, WEST VIRGINIA

Prepared for:

FirstEnergy

800 Cabin Hill Drive
Greensburg, PA 15601

Prepared by:

Tetra Tech, Inc.
400 Penn Center Boulevard, Suite 200
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Fax: (412) 829-3260

Tetra Tech Project No. 212C-SW-00069

October 2019

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TABLES

FIGURES

1.0 INTRODUCTION/BACKGROUND

FirstEnergy (FE) owns and operates the coal-fired Harrison Power Station (hereinafter referred to as the "Station") located in Harrison County, West Virginia. Coal Combustion Residuals (CCRs) produced at the Station are placed in the facility's captive dry disposal landfill, which is located approximately 1.5 miles north of the Station. The landfill is regulated under both West Virginia Department of Environmental Protection (WVDEP) Solid Waste/National Pollutant Discharge Elimination System (NPDES) Water Pollution Control Permit No. WV0075795, and the United States Environmental Protection Agency (USEPA) Disposal of Coal Combustion Residuals from Electric Utilities rule (40 CFR Part 257, hereinafter referred to as the "CCR Rule" or "Rule"). Under the Rule the landfill is categorized as an active CCR unit and is subject to the groundwater monitoring requirements of 40 CFR §§ 257.90 through 257.98.

In accordance with § 257.94 of the Rule, the initial Detection Monitoring (DM) sampling and analysis event for the CCR unit was completed in September 2017, and the statistical evaluation of the resulting data was completed in December 2017. As required by § 257.90(e), results and findings from the 2017 groundwater monitoring program were documented in the 2017 Annual Groundwater Monitoring and Corrective Action Report (AGWMCA Report) that was posted in both the CCR unit's operating record and on its publicly accessible website in January 2018 (Tetra Tech, 2018). In that report, Statistically Significant Increases (SSIs) for calcium, chloride, pH, sulfate, and total dissolved solids (TDS) in one or more well comparisons were identified. Based on the various parameters for which SSIs were identified, an Appendix III Alternative Source Demonstration (ASD) was undertaken as discussed in the 2018 AGWMCA Report (Tetra Tech, 2019). However, all of the Appendix III SSIs that were identified for DM-1 could not be attributed to alternative sources.

During the transition period between completing the statistical evaluation of the DM-1 data and performing the Appendix III ASD, FE performed another round of DM sampling (event DM-2) in order to have data available should the ASD prove to be successful and the facility remained in the DM program. DM-2 sampling occurred in March 2018, with laboratory analysis and data validation completed by May 2018. However, before statistical evaluation of the DM-2 data commenced, it was determined that a transition to Assessment Monitoring (AM) was required which precluded the need to statistically evaluate the DM-2 data. As such, a transition to the applicable requirements of AM per § 257.95 of the CCR Rule commenced.

In accordance with 40 CFR § 257.95(b) and (d)(1), two AM sampling events (AM-1 and AM-2) were performed in May and September 2018. Pursuant to §§ 257.94(e)(3), 257.105(h)(5), and 257.106(h)(4), a notice was prepared and posted to the facility's Operating Record and issued to the WVDEP in August 2018 to provide notification that a groundwater Assessment Monitoring program for the CCR unit had been established. Pursuant to § 257.107(h)(4), the subject notice was posted to the facility's publicly accessible website in September 2018. Analytical data summary tables and a description of the 2018 AM program results can be found in the 2018 AGWMCA Report (Tetra Tech, 2019). Once initiated, the AM program continued in 2019 with two additional sampling events performed in February (AM-3) and August (AM-4).

Statistical evaluation of the AM sampling events was completed in January 2019 for AM-1 and -2 and in August 2019 for AM-3 (validated AM-4 results were not available in time to be included in this report). The statistical evaluations indicated Appendix IV constituent concentrations in downgradient wells at Statistically Significant Levels (SSLs) above applicable Groundwater Protection Standards (GWPS). As part of this ASD, a single nature and extent (N&E) of release characterization sampling event was performed in July 2019 for wells MW-19 and MW-20 in an attempt to identify a source of documented odors and elevated pH in MW-20 during previous sampling events as a potential cause of elevated molybdenum concentrations. Results of that sampling were inconclusive as to the source of the odors and/or elevated pH, however, the arsenic and molybdenum results of that sampling event were consistent with the AM-3 results (i.e. arsenic was above its GWPS in both wells while molybdenum was below its GWPS in both wells). The July N&E sampling event was the second consecutive event in which molybdenum was below its GWPS. The following CCR Rule Appendix IV parameters were determined in the downgradient monitoring wells (labeled "MW-#") to be above their respective GWPS as summarized in the following table:

Appendix IV Parameters	GWPS (mg/L)	MW-19 (mg/L)	MW-20 (mg/L)
Arsenic (As)	0.01	**SSL**	**SSL**
AM-1		0.01052	0.01970
AM-2		n/s	0.01997
AM-3		0.01056	0.04026
N&E-1		0.01014	0.05292
Molybdenum (Mo)	0.1		**SSL**
AM-1		<GWPS	0.15577
AM-2		n/s	0.12970
AM-3		<GWPS	<GWPS
N&E-1		<GWPS	<GWPS

Note: Downgradient well MW-19 was not sampled (n/s) during the AM-2 event due to insufficient available water.

In accordance with 40 CFR § 257.106(h)(6), a notice was prepared and posted to the facility's Operating Record, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of the SSLs for arsenic and molybdenum at the CCR unit. During this same notification period and in accordance with 40 CFR § 257.95(g)(3)(ii), an Appendix IV ASD was initiated to assess if the SSLs determined for the AM-1, AM-2, and AM-3 events were attributable to a release from the CCR unit, from a demonstrable alternative source(s), or if they resulted from errors in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Pursuant to § 257.95(g)(4), if a successful ASD has not been completed within 90 days from the date of determining that an SSL has occurred, the CCR unit owner or operator must initiate an Assessment of Corrective Measures (ACM) in accordance with 40 CFR § 257.96. Due to the additional monitoring points, sampling events, laboratory analyses, and evaluations needed to complete a successful ASD, the work could not be completed within the 90 day timeframe. Therefore, and in accordance with 40 CFR § 257.106(h)(7), a separate notice was prepared and posted to the facility's Operating Record, issued to the WVDEP, and then posted on the facility's publicly accessible website in April 2019, to provide notification of the initiation of an ACM for arsenic and molybdenum at the Site.

After initiating an ACM, the ongoing ASD activities were continued as they indicated a strong possibility that the molybdenum SSLs were attributable to demonstrable alternative source(s). As such, this ASD report has been prepared to document the evaluation of the AM-1, AM-2, and AM-3 Appendix IV SSLs and to incorporate the findings into the CCR unit's ACM.

2.0 APPROACH

For this ASD, a multiple Line of Evidence (LOE) approach as presented in *Guidance for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites* (EPRI, 2017) was followed. This approach divides LOEs into five separate ASD categories (types):

- Sampling causes (ASD Type I);
- Laboratory causes (ASD Type II);
- Statistical evaluation causes (ASD Type III);
- Natural variation not accounted for in the basic AM statistics (ASD Type IV); and
- Potential natural or anthropogenic sources (ASD Type V).

EPRI (2017) includes detailed checklists that provide a standardized, incremental approach that is followed to determine whether additional LOE evaluations are warranted. These checklists include:

- Checklist 1: Sampling, Laboratory, or Statistical Causes (ASD Types I, II, and III);
- Checklist 2: LOEs Associated with the CCR Unit (ASD Type IV); and
- Checklist 3: LOEs Associated with Alternative Natural or Anthropogenic Sources (ASD Type V).

For this ASD all three Checklists were completed and are attached as Tables 1, 2, and 3. Based on indications from these checklists as well as the CCR unit's topographic and geologic setting, development and operational history, and currently available information and data, it was determined that additional evaluations of the following site-specific LOEs were warranted:

- Regional groundwater chemistry studies/reports;
- CCR Rule-defined uppermost aquifer limits;
- Potential well construction effects; and
- Abandoned deep coal mine pool levels.

The findings from the checklist completion activities and site-specific LOE evaluations are summarized in Section 3.0 of this report.

3.0 SUMMARY OF FINDINGS

3.1 ASD CHECKLIST 1

ASD Checklist 1 is attached as Table 1 of this report. The checklist evaluations were performed by re-reviewing the CCR groundwater monitoring program's field sampling notes and chain-of-custody forms, laboratory data validation (Level 2) reports, statistical evaluation spreadsheets, and results from field-filtered duplicate samples that were obtained during events where turbid unfiltered samples had been obtained. Referring to Table 1 it's seen that for most potential sampling, laboratory, or statistical evaluation causes, no instances/issues/indications were identified. For those potential causes where some issues were identified, it was determined that they most likely did not contribute to the Appendix IV SSLs. Based on these LOE findings, sampling, laboratory analysis, and statistical evaluations are not demonstrable alternative sources of all the Appendix IV SSLs determined for the AM-1, -2, and -3 events.

3.2 ASD CHECKLIST 2

ASD Checklist 2 is attached as Table 2 of this report. The checklist evaluations were performed by re-reviewing the groundwater analytical results (background, DM, and AM) for both Appendix III and IV parameters, leachate data for the CCR unit (specifically arsenic and molybdenum) provided by FE, and hydrogeologic and design information and data included in the *CCR Rule Groundwater Monitoring System Evaluation Report for The Harrison Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 2, the following evaluation criteria were used:

- Primary Indicators – As per Table A-1 in EPRI (2017), primary indicator constituents for CCRs include the CCR Rule parameters Boron (Appendix III), Calcium (Appendix III), Chloride (Appendix III), Fluoride (Appendix III and IV), Lithium (Appendix IV), Molybdenum (Appendix IV), and Sulfate (Appendix III), as well as Bromide, Potassium, and Sodium, which are parameters that are not listed in the CCR Rule.
- Secondary Indicators – For this ASD, secondary indicator constituents for CCRs include those Appendix III and IV constituents that are not considered primary indicators.
- Leachate Data – Analytical results from five sampling events performed at the CCR unit between October 2017 and April 2019 at five locations (LM01, LM03, LM05, LM07, and LM10) were used for comparison to the March 2019 AM-3 results (included in Table 4). The comparison of leachate data for arsenic and molybdenum indicate that a localized, non-CCR molybdenum source near MW-19 and 20 may exist as evidenced by

molybdenum concentrations in those wells being greater than the average molybdenum concentrations in the leachate monitoring points. Alternatively, concentrations of arsenic in the leachate samples are orders of magnitude higher than that of the upgradient well and several times higher than those of the downgradient wells, indicating that the arsenic SSLs in groundwater are likely attributable to a release from the CCR unit. These results and associated comparisons are attached as Table 5 of this report.

- Site Hydrogeology - As discussed in in the *CCR Rule Groundwater Monitoring System Evaluation Report* (Tetra Tech, 2017), the Lower Sewickley sandstone of the Pennsylvanian Age Monongahela Group was determined to be the uppermost aquifer at the site. The CCR groundwater monitoring well network at the site consists of one upgradient well (MW-5) and four downgradient wells (MW-17, -18, -19, and -20) as shown on Figure 1. Based on historic and recent groundwater data from these wells, the overall groundwater flow direction within the Lower Sewickley sandstone is from west to east which is consistent with the structural dip as shown on Figures 2 and 5. Geologic and hydrogeologic characteristics of the site and the monitoring well network are both discussed in greater detail in the above-referenced report.
- CCR Unit Design - As shown on Figure 1, the CCR unit consists of three adjacent disposal areas, the Main Area (MA), the Lower Area (LA), and the Upper Area (UA). Historically, landfilling operations have primarily been performed in the MA and LA disposal areas since the Station commenced operations in 1972, with the UA disposal area more recently developed for use (beginning in 2011). The MA and LA disposal areas both have unlined and lined portions, with the liner system consisting of a 24-inch thick engineered compacted clay liner underlain by a combined leachate detection zone/groundwater underdrain and overlain with a leachate collection system. The UA disposal area is lined, with the liner consisting of 4-inches of “enhanced” FGD by-product (amended with excess lime) that is underlain by a combined leachate detection zone/groundwater underdrain and overlain with a leachate collection system. Stormwater runoff and leachate from the landfill discharge to a lined sedimentation pond, referred to as Sedimentation Pond No. 1.

Based on the LOE findings presented in Table 2, SSLs for arsenic and, to a lesser degree, molybdenum, that were determined for the 2018 AM events can most likely be attributed to a release from the CCR unit. However, the comparison of leachate data to upgradient and downgradient wells indicates that a source other than the CCR unit may be contributing to the occurrence of molybdenum in groundwater. Unidentified natural variations in groundwater concentrations or other unknown anthropogenic sources could be present at the Site. Additionally, the most recent AM event results (AM-3) and nature and extent results for MW-20 indicate molybdenum concentrations are below the GWPS, a continuing trend that began with the last of the eight CCR Rule background sampling events. Sampling Event AM-4 results were not received as of the completion of this report, but will be evaluated to determine if the decreasing trend in molybdenum concentrations in MW-20 continues, and whether the concentrations remain below the molybdenum GWPS. Potentially, the occurrence of molybdenum during the AM-1 -2, and -3 events was an anomaly, a function of seasonal variability, or possibly related to the lowering of groundwater levels in the monitored aquifer.

3.3 ASD CHECKLIST 3

ASD Checklist 3 is attached as Table 3 of this report. The checklist evaluations were performed in a similar manner to those of ASD Checklist 2 by re-reviewing the groundwater analytical results (background, DM, and AM) for both Appendix III and IV parameters, leachate data for the CCR unit (specifically arsenic and molybdenum) provided by FE, and hydrogeologic and design information and data included in *CCR Rule Groundwater Monitoring System Evaluation Report for The Harrison Power Station* (Tetra Tech, 2017). For the LOEs in Checklist 3, the following evaluation criteria were used in addition to those used for ASD Checklist 2:

- Historical site and nearby land uses – CCR unit historical land uses and ash disposal activities were reviewed. Nearby land uses were also researched for the presence of oil and gas exploration/extraction (Figure 3), coal mining, and/or industrial/commercial activities that could be potential alternative sources. Review of nearby land uses and activities were inconclusive in determining an alternative source for arsenic or molybdenum.
- Site Hydrogeology – Decreasing trends in groundwater elevations in the vicinity of MW-18 (often dry) and MW-19 could be affecting both water quantity and quality in the wells. The decreasing trend in MW-19 could be caused by the lower hydraulic conductivity of the formation leading to a longer post-installation water level stabilization period, localized subsidence of the underlying abandoned Pittsburgh Coal mine workings, by the continuing development of the upgradient UA disposal area which reduces rainfall infiltration recharge to the monitored aquifer, or by a combination of all three occurrences.

Based on the LOE findings presented in Table 3, the arsenic SSLs determined for the AM-1, -2, and -3 events can most likely be attributed to a release from the CCR unit, while the molybdenum SSLs can possibly be attributed to a source other than the CCR unit.

3.4 REGIONAL GROUNDWATER STUDY

In an effort to evaluate the potential for natural variation in groundwater quality in the Lower Sewickley sandstone to impact site groundwater quality for the SSL constituents, *Ground-Water Resources of Harrison County, West Virginia* (USGS and West Virginia Geological Survey, June 1958) was reviewed. No water quality data were available for the Monongahela Group aquifers in the CCR unit area. There was a general statement in the report (pp. 27) regarding water quality in the lower Monongahela Group rocks: “The Pittsburgh coal and closely associated permeable beds in the lower part of the Monongahela and the upper part of the Conemaugh formation yield water of fair to poor quality to springs and drains.” The report also mentions two drains from abandoned mine openings in the Pittsburgh Coal near Shinnston but does not reference any laboratory analytical results. It is stated that it is expected that the water from the drains is high in sulfuric acid and sulfate, typical of mine drainage. The report review did not yield any specific information regarding natural variation of arsenic or molybdenum in regional groundwater.

3.5 UPPERMOST AQUIFER CROP LINE MAPPING

As previously noted, the Lower Sewickley sandstone, which is part of the Pennsylvanian Monongahela Group, is the uppermost aquifer monitored at the site. As part of evaluating the potential for upgradient alternative sources, the lateral extent of the Lower Sewickley sandstone was evaluated. Figure 4 is a West Virginia Geologic and Economic Survey (WVGES) map which shows the Monongahela Group rocks present over most of the site with the overlying Pennsylvanian Dunkard Group being present at the northwestern and northeastern portions of the site. As indicated, the Monongahela Group rocks (including the Lower Sewickley sandstone) are eroded in the valley to the southwest of the site, resulting in the underlying Conemaugh Group rocks being exposed.

In order to define in more detail the crop line for the Lower Sewickley sandstone around the site, the elevation of the layer’s base was compared with surface topography. Figure 5 shows the approximate crop line for the Lower Sewickley Sandstone based on this comparison. As previously noted, and as depicted on Figure 2, groundwater flow across the site in the monitored aquifer is essentially from west to east. Based on the lateral extent of the Lower Sewickley sandstone, the potential upgradient area from which potential sources could impact the CCR unit is limited to relatively narrow bands south, north, and northwest of the site. A review of current land use in the subject areas utilizing Google Earth showed that the land use in these areas appears to be forested and limited rural residential and coal mining and storage activities occurring approximately one-mile upgradient (west) of the CCR unit. Based on these findings, no significant potential off-site sources were identified in the area considered within the lateral extent of the monitored aquifer.

3.6 MW-19 AND MW-20 CONSTRUCTION

As previously noted, SSLs for MW-19 and -20 included arsenic and molybdenum (MW-20 only). While the sulfate and TDS concentrations in MW-19 were marginally higher than those in downgradient well MW-17, they were much higher in MW-20 than in either MW-17 or MW-19. Since sulfate and TDS may be associated with coal impacts that could also be contributing arsenic or molybdenum to the Site groundwater, the lithologies in the boring logs for MW-19 and -20 were reviewed for the presence of coal within or near the intervals screened in the wells.

MW-19 is screened at a depth of 494 to 514 feet (ft) with the sand pack extending twelve feet above the screen (to a depth of 482 ft). The boring log describes most of the screened interval as a gray sandy limestone with some interbedded sandstone, with the lower four feet transitioning to a dark brown carbonaceous limestone horizon. This carbonaceous zone is located within the lowest portion of the screened interval so the potential exists that constituents such as sulfate could possibly impact water sampled from the well. However, given the relative differences between the sulfate and TDS concentrations in MW-19 and MW-17 (154 mg/L versus 111 mg/L and 792 mg/L versus 494 mg/L, respectively) any such impacts appear to be negligible.

MW-20 is screened at a depth of 355 to 365 ft with the sand pack extending three feet above the screen (to a depth of 352 ft). The boring log describes the screened interval as a gray, calcitic sandstone with no reference to coal being present. The Sewickley Coal is located immediately above the Lower Sewickley sandstone in the well and is shown on the log as having been encountered from a depth of 347 to 352 ft. The base of the Lower Sewickley Coal is therefore located immediately above the sand pack interval. Should there be a minor error in depth measurements for the sand pack and/or Sewickley Coal, the sand pack could be adjacent to the lower portion of the Sewickley Coal. If this were the case, there is the potential that constituents from the coal (e.g., sulfate) could possibly impact water sampled from the well. Likewise, should fractures extend from the Lower Sewickley sandstone to the overlying coal in the area near the well, the potential exists for hydraulic communication between the two intervals.

Additionally, the field notes for the monitoring well installation activities were reviewed for impacts related to the steel surface casing that could explain the occurrence of molybdenum and elevated pH (greater than 11) in groundwater in MW-20. However, there were no noteworthy observations related to the installation and drilling of MW-20 that could explain the presence of molybdenum previously above the GWPS in groundwater. The elevated pH, combined with increases in TDS over time within the well, are likely the result of grout infiltration into the sand pack from above through formation fractures and/or cracked/faulty casing. Molybdenum in the form of Molybdate is relatively mobile in alkaline groundwater (elevated pH) and could explain the spike previously observed at MW-20.

3.7 MINE POOL LEVELS

The potential for impacts on groundwater quality in the Lower Sewickley sandstone from hydraulic connection to the underlying mine pools in the abandoned Pittsburgh Coal deep mine workings was also evaluated. Typically, the base of the Lower Sewickley sandstone is situated approximately 70 feet above the top of the Pittsburgh Coal. Since there are no existing mine pool monitoring (MPM) points located within the existing footprint of the CCR unit, the maximum mine pool elevations from the two remaining MPM points (MPM-6B and MPM-7), which are located along the southern and southwestern edges of the CCR unit, were compared with the lowest elevation of the base of the Lower Sewickley Sandstone in the CCR wells which is approximately 994 ft (at MW-19). A summary of these comparisons is provided below:

	MPM-6B	MPM-7
Reference Elevation (Top of Casing)	1131.7	1083.2
Shallowest Depth to Mine Pool Water (ft)[1]	138	115.4
Highest Historical Mine Pool Elevation (ft)	993.7	967.8
Bottom Elevation of Sewickley SS in MW-19 (ft)	993.9	993.9
Mine Pool Elevation - Base of Sewickley SS Elev. (ft)	-0.2	-26.1

[1] Monitoring period from 8/1/2002 to 10/5/2017

As indicated, the highest mine pool elevation reported for MPM-6B is only approximately 0.20 ft below the elevation of the bottom of the Lower Sewickley sandstone at MW-19, while the highest mine pool elevation reported for MPM-7 is approximately 26 ft below the elevation of the bottom of the Lower Sewickley sandstone at MW-19. The most recent groundwater elevation data from

2016 to 2019 indicates that the water level in MW-19 is now at an elevation within the MPM-6B mine pool range and approaching the MPM-7 mine pool elevation (refer to Figure 6). This indicates that there is a potential for mine pool water to reach the base of the Lower Sewickley sandstone assuming that they are hydraulically connected (e.g., with fractures) and the mine pool elevations are at atypically high levels.

4.0 CERTIFICATION STATEMENT

In accordance with § 257.95(g)(3)(ii) of the CCR Rule, an ASD for Appendix IV constituents was undertaken for the CCR unit identified herein. Based on the information and data that were available for review, the arsenic SSLs that were identified for the AM-1, -2, and -3 events could not be solely attributed to sources other than the CCR unit, to errors in sampling, analysis, or statistical evaluation, or from natural variation in groundwater quality. However, for molybdenum, evidence exists that the CCR unit, combined with impacts from an as-yet unidentified alternate source (e.g., grout infiltration into the sand pack of the well), are likely the causes of elevated molybdenum concentrations observed in MW-20 (the only well to have a molybdenum SSL). It is also noted that the molybdenum concentration in MW-20 of 0.098466 mg/L during the AM-3 event in February 2019 and 0.079314 mg/L concentration during the July N&E event were below the GWPS, continuing a downward trend from a high of 0.25692 mg/L in background sampling Event 8 (July 2017). Future monitoring results should be evaluated to confirm whether this downward trend is statistically significant.

Considering all of the aforementioned findings, a transition to the applicable requirements of assessment of corrective measures for arsenic per § 257.96 of the CCR Rule appears to be warranted and assessment monitoring of molybdenum will continue.

5.0 REFERENCES

EPRI, 2017. *Guidelines for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites*. EPRI, Palo Alto, CA: 2017. 3002010920.

Tetra Tech, 2017. *Groundwater Monitoring System Evaluation Report for the Harrison Power Station, Coal Combustion Byproduct Landfill*. Tetra Tech, Inc., Pittsburgh, PA, October 2017.

Tetra Tech, 2018. *2017 Annual CCR Groundwater Monitoring and Corrective Action Report, Coal Combustion Byproduct Landfill, Harrison Power Station*. Tetra Tech, Inc., Pittsburgh, PA, January 2018. http://ccrdocs.firstenergycorp.com/

Tetra Tech, 2019. *2018 Annual CCR Groundwater Monitoring and Corrective Action Report, Coal Combustion Byproduct Landfill, Harrison Power Station*. Tetra Tech, Inc., Pittsburgh, PA, January 2019. http://ccrdocs.firstenergycorp.com/

TABLES

Table 1 - ASD Checklist 1: Sampling, Laboratory, or Statistical Causes

ASD Type	Potential Cause	Evaluation Summary
Sampling Causes (ASD Type I)	Sample mislabeling	No mislabeling found by comparing all COCs and lab data identifiers.
	Contamination	No concerns mentioned in field notes or Data Validation Reports for As or Mo.
	Sampling technique	Hydrasleeves used instead of bladder pumps on some dates in wells MW-19 and MW-20; insufficient water in MW-18 in all but Events 1-3; pump not working in MW-19 in Event 3 and in Event 12 pump controller not working.
	Turbidity	High turbidity (> 10 NTU) in MW-19 and MW-20 when Hydrasleeves used, but not clear relationship with As or Mo.
	Sampling anomalies	Besides pump issues in MW-19 and MW-20, no other issues described in field notes.
Laboratory Causes (ASD Type II)	Calibration	No comments on lab calibration in Data Validation Reports for Appendix IV parameters As and Mo.
	Contamination	Had As in lab blank in Event 5, but values for MW-5, MW-17 and duplicate of MW-17 were <10x blank, so values qualified “U”; As in lab blank in Event 12, but MW-5 and duplicate handled same way as in Event 5.
	Digestion methods	No differences for Appendix IV parameters As and Mo.
	Dilution corrections	Dilution factors in Event 6 different for As for MW-19 & MW-20 wells, but values detected, so no errors in detection limit calculations.
	Interference	No concerns mentioned in Data Validation Reports for As or Mo.
	Analytical methods	Methods same as in CCR GW Monitoring Plan for As and Mo.
	Laboratory technique / qualifier flags	In Event 2 had As differences >2 between MW-17 and duplicate, both results qualified “J”; In Event 6 had differences >2 between MW-17 and duplicate, results for As and Mo qualified “J”.
	Transcription error(s)	None identified.
Statistical Evaluation Causes (ASD Type III)	Lack of statistical independence	Sampling interval was monthly or longer in upgradient well MW-5, so not likely to be a concern.
	Outliers	None identified.
	False positives	In the case of small sample sizes (e.g., n < 10-20), there is no mathematical algorithm to statistically prove a false positive result without resampling.
	Non-detect processing	Upgradient well MW-5 had both detected and non-detect values for As and Mo, but number was sufficient to determine UPL. MW-17 had non-detect values for Mo in Events 12 and 13 (AM-2 and AM-3). MW-17 had all detected values for As, except in Event 5. MW-19 and MW-20 had detected values for As and Mo for all Events.
	Background data / change in normality	No new background data used for Assessment Monitoring (Events 11, 12, and 13 [AM-1, -2, and -3, respectively]).

Table 2 - ASD Checklist 2: Lines of Evidence Associated with the CCR Unit

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Primary CCR Indicators						
1a	If the CCR unit contains fly ash, is there an SSI/SSL for boron and sulfate?	No / Yes	CCR Release	Key	Monitoring Point	Boron – no; Sulfate – yes. Fly ash present on unlined original ground under parts of both the Main Area and Lower Area. Since ~ 1996, all fly ash has been commingled with stabilized FGD by-product for disposal.
1b	If the CCR unit contains FGD gypsum (only) is there an SSI/SSL for sulfate?	Yes	CCR Release	Key	Monitoring Point	Gypsum (calcium sulfate) not produced at station but stabilized FGD by-product (calcium sulfite) is produced.
1c	Are there other constituents in the groundwater that represent primary indicators? List the applicable constituents.	Yes	CCR Release	Supporting	Monitoring Point	Calcium, Chloride, Lithium, and Molybdenum are all found at detectible levels in all downgradient monitoring wells.
1d	Is there an SSI/SSL for any of the other primary indicators?	Yes	CCR Release	Key if No	Monitoring Point	Calcium (MW-17) and Chloride (MW-17, -19, and -20) have exhibited SSIs. Molybdenum (MW-19 and -20) has exhibited elevated downgradient concentrations as compared to upgradient concentrations. Statistical evaluations of the Molybdenum data collected during the 2018 assessment monitoring indicate Molybdenum as an SSL above the GWPS.
1e	Is the *leachate* concentration for any of the primary indicators (including boron and sulfate) with an SSI/SSL statistically higher than background? List the applicable constituents.	Yes	CCR Release	Key if No	Constituent	Calcium, Chloride, and Sulfate – yes; Lithium not analyzed in leachate sampling program; Molybdenum trace analysis has been performed in leachate sampling program and results are higher than background levels. It is noted that statistical analysis has not been performed on leachate results; evaluation is based on five leachate sampling events conducted between October 2017 and April 2019.
1f	Are concentrations for the primary indicators increasing?	No / Yes	Uncertain	Supporting	Monitoring Point	Calcium – no; Chloride – yes (MW-19, -20); Molybdenum – no (MW-20 has exhibited a decreasing trend starting with the last background sampling event (Event 8) in July 2017). It should be noted that the CCR dataset covers a very limited time range (~1.5 years) for trend analysis.
Secondary Indicators						
2a	Are there other SSI(s) or SSL(s) of Appendix III or IV parameters? (These are potential secondary indicators. List the applicable constituents.)	Yes	CCR Release	Supporting	Monitoring Point	Antimony (MW-20), Arsenic (MW-17, -19, and -20), and Selenium (MW--20) have exhibited elevated downgradient concentrations as compared to upgradient concentrations (SSIs). Statistical evaluations of Antimony or Arsenic have been performed as no assessment monitoring sampling has been required to date.
2b	Are the constituents identified in 2a present *in leachate* in concentrations statistically higher than background?	Yes / No	CCR Release	Key if No	Constituent	Antimony – no; Arsenic – yes; Selenium - yes Since Arsenic exhibited elevated concentrations at all downgradient wells, a CCR Release is indicated. It is noted that statistical analysis has not been performed on leachate results; evaluation based on five leachate sampling events conducted between October 2017 and April 2019.
2c	Are concentrations for any of the secondary indicators increasing? List the applicable constituents.	Yes	CCR Release	Supporting	Monitoring Point	Antimony – yes; Arsenic -yes (MW-20); Selenium - no. It should be noted that the CCR dataset covers a very limited time range (~1.5 year) for trend analysis.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type2	Applies to[3]	Weight of Evidence Determination / Basis
Other Chemistry						
3a	Are organic constituents present in concentrations statistically higher than background?	N/A	-----	Supporting	Monitoring Point	Organics not analyzed as part of groundwater testing program at site.
3b	Is major ion chemistry similar to leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix IV ASD.
3c	Does major ion chemistry suggest a mixture of leachate and background groundwater?	ND	-----			Based on primary and secondary indicator LOE's listed above, major chemistry analysis was not performed as part of Appendix IV ASD.
3d	Does tritium age dating indicate that the groundwater was recharged after the facility was first used?	N/A	-----	Key if No	Monitoring Point	Disposal site development initiated in the early 1970's.
3e	Does isotopic analysis show evidence of mixing with CCR leachate?	ND	-----	Key	Monitoring Point	Based on primary and secondary indicator LOE's listed above, isotopic analysis was not performed as part of Appendix IV ASD.
Hydrogeology						
4a	Is the monitoring well with an SSI/SSL downgradient from CCR unit at any point during year?	Yes	CCR Release	Key if No	Monitoring Point	Multiple SSIs and only Arsenic and Molybdenum SSLs were identified in the downgradient wells, all of which are positioned downgradient of the disposal site during all times of the year.
4b	Review the Hydrogeological vs Leachate Scenario Table (EPRI, Table A-2) and identify the most representative scenario for each SSI or SSL case. List cases and scenario numbers.	-----	-----	Key	Monitoring Point	Calcium – CCR Leachate Release (Row a) Chloride – CCR Leachate Release (Row a) Sulfate – CCR Leachate Release + Possible Alternative Source (Row b) Antimony –Possible Alternative Source (Row b) Arsenic – CCR Leachate Release (Row a) Molybdenum – CCR Leachate Release + Possible Alternative Source (Row b) Selenium – CCR Leachate Release + Possible Alternative Source (Row c)
4c	Is the CCR unit immediately underlain by clay, shale, or other geologic media with low hydraulic conductivity?	Varies	Uncertain	Supporting	Unit	Some areas of site are underlain by clayey colluvial soils (former valley slopes), while other older areas are underlain by alluvial deposits (former valley bottoms).
4d	Is the monitoring point distant from the facility AND does the constituent with an SSI/SSL have low mobility in groundwater given the hydrogeologic environment at the monitoring location (EPRI, Table A-3)?	No	CCR Release	Supporting	Case	All downgradient monitoring wells are located at the waste boundary.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Hydrogeology (Continued)						
4e	Are the background monitoring wells screened in the same hydrostratigraphic unit, and along the same groundwater flow path, as the monitoring location with the SSI?	Yes	CCR Release	Supporting	Monitoring Point	The upgradient (background) monitoring well (MW-5) is screened in the Lower Sewickley Sandstone which is the same hydrostratigraphic unit the downgradient wells are screened in and all wells (upgradient and downgradient) are located along the same groundwater flow path.
CCR Unit Design						
5a	Does the entire footprint of the monitored CCR unit have a liner?	No	CCR Release	Supporting	Unit	Portions of the Main Area and Lower Area are unlined and/or partially overlain with a liner system.
5b	If the facility is lined, is it a composite liner?	No	CCR Release	Supporting	Unit	Two different types of liner systems have been used at the site – 24 inches of compacted clay and 4 inches of excess lime-amended, stabilized FGD by-product.
5c	Does the entire footprint of the CCR unit have a leachate collection system?	No	CCR Release	Supporting	Unit	Much of the existing landfill footprint has both a Leachate Collection and a Leak Detection system.
5d	If the CCR unit is unlined, is it known to have or is it likely to have groundwater intersecting the CCR?	Yes	CCR Release	Supporting	Unit	The older, unlined portions of the Lower Area and Main Area directly contact former seeps and springs that were present in the valley system, indicating that groundwater likely intersects CCR in these areas.

Table Notes:

1. ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means lines of evidence not applicable to the CCR unit.
2. Line of Evidence (LOE) Types:
   Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
   Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.
3. This LOE applies to:
   Constituent: An SSI/SSL for that constituent at any monitoring point
   Monitoring Point: All SSIs/SSLs at a specific monitoring point
   Case: An SSI/SSL for a specific constituent at a specific monitoring point
   Unit: All SSIs/SSLs at the monitored unit

Table 3 – ASD Checklist 3: Lines of Evidence Associated with Alternative Natural and Anthropogenic Sources

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
General						
6a	Are there any known alternative sources for any of the constituents of concern on-site or off-site?	Yes	Potential Alternate Source	Supporting	Unit	Historical underground mining of the Pittsburgh Coal seam with mine pool monitoring indicates that the mine pool is within 7 vertical feet of the bottom of the monitored zone. Current groundwater conditions observed in MW-18 and MW-19 indicate that the Lower Sewickley sandstone may be flowing downward under fractured conditions into the mine pool, or conversely, that the mine pool may be encroaching upon the Lower Sewickley sandstone.
6b	Are any current or former potential alternative sources upgradient of the monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	The entire upgradient area at the Site and adjoining properties have been historically underground mined in the Pittsburgh Coal seam.
6c	Do monitoring locations between a potential upgradient source and CCR unit have concentrations at SSI/SSL levels?	No	No Alternate Source	Supporting	Constituent	There is only one monitoring location between a potential upgradient source and the CCR unit and it does not indicate impacts from a potential upgradient source.
On-Site Alternative Source						
7a	Is the monitoring point downgradient of or near a coal pile, or coal pile runoff, or coal pile leachate management area?	No	No Alternate Source	Supporting	Monitoring Point	There are no coal pile, coal pile runoff, or coal pile leachate management areas near the downgradient monitoring points.
7b	Are there former coal mines, mine spoil, or conveyers near the CCR unit or upgradient from the facility?	Yes	Potential Alternate Source	Supporting	Unit	Both deep and limited surface mining of the Pittsburgh Coal have occurred at the Site, but the mine workings are situated approximately 70 feet below the monitored CCR aquifer.
7c	Does the site have other CCR units that are upgradient or side gradient of the affected monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	There are no other CCR units located upgradient or side gradient of the affected monitoring locations.
7d	Is the CCR unit built on top of a former CCR disposal area (i.e., has a lined impoundment been built on top of a former unlined impoundment, or has a lined landfill been built on top of a portion of an unlined impoundment)?	Yes	Potential Alternate Source	Supporting	Unit	Portions of the Main Area and Lower Area are unlined and have been partially covered with an overlying liner system.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
On-Site Alternative Source (Continued)						
7e	Do the CCR unit or adjacent units have an active underdrain piping system or groundwater pumping system, or are there any groundwater pumping activities nearby, that could have localized influence on groundwater flow and quality?	Yes	Potential Alternate Source	Supporting	Unit	Much of the existing landfill footprint has both a Leachate Collection and a combined Leak Detection/Groundwater Underdrain system. However, these systems are expected to have minimal localized influence on groundwater flow and quality in the monitored CCR aquifer.
7f	Is there evidence that water used for dust suppression on uncovered CCR or coal piles flowed off the footprint of the liner or runoff containment system near the monitoring point?	No	No Alternate Source	Supporting	Monitoring Point	There is no evidence of dust suppression water to have flowed off the footprint of the liner system and near the monitoring points.
7g	Is leachate or sluice water used for dust control close to the monitoring location?	No	No Alternate Source	Supporting	Monitoring Point	Dust control water is obtained from non-potable sources at the power station.
7h	Is the monitoring point downgradient of or near a CCR handling area (silo, storage area, dewatering bin, sump, truck loading/unloading or washing area, etc.) or haul road?	Yes	Potential Alternate Source	Supporting	Monitoring Point	MW-17, -18, and -20 are located near a haul road.
7i	Is the monitoring point downgradient of or near sluice water lines, handling equipment, or storage areas?	No	No Alternate Source	Supporting	Monitoring Point	The landfill Site has no sluice infrastructure; all CCR management activities involve dry materials.
7j	Is the monitoring point downgradient of or close to a leachate collection pipeline or leachate storage structure?	No	No Alternate Source	Supporting	Monitoring Point	All downgradient monitoring locations are situated sidegradient of Sedimentation Pond No. 1 and are distant from leachate collection pipelines.
7k	Have there been any documented spills of CCR or leachate or sluice water in upgradient or nearby locations?	No	No Alternate Source	Supporting	Monitoring Point	There are no documented spills of CCR or leachate or sluice water in upgradient or nearby locations.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
On-Site Alternative Source (Continued)						
7l	Were CCRs ever drained or stockpiled in unlined areas and/or without run-off/leachate control in upgradient or nearby areas?	No	No Alternate Source	Supporting	Monitoring Point	CCRs have historically been dry disposed at the Site in both lined and unlined areas with appropriate run-off and leachate control measures (refer to LOEs 5a through 5c).
7m	Is there any history of on-site or upgradient oil or chemical spills or leaking underground storage tanks?	No	No Alternate Source	Supporting	Monitoring Point	No history of on-site or upgradient oil or chemical spills or use of underground storage tanks.
7n	Does a significant amount of road salting occur on-site? (also see 9b)	No	No Alternate Source	Supporting	Monitoring Point	Road salting has not been performed at the site.
7o	Are fertilizers being used on-site for cap vegetation or other uses?	Yes		Supporting	Monitoring Point	Fertilizers are used in the hydroseeding of all disturbed areas at the site (capped areas, borrow areas, etc.)
7p	Is there any history of on-site or upgradient ash utilization (structural fill, landfill, road base, berm construction, soil stabilization, etc.)?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Ash was disposed of in abandoned surface mine areas in the Main Valley, with thickness of ash in this area estimated to be approximately 50 feet.
7q	Was the power plant site subgrade prepared with CCR, dredge spoils, incinerator residue, construction debris, industrial waste, or non-native soils?	N/A	N/A	Supporting	Monitoring Point	The Power Plant is located downgradient of and across the West Fork River from CCR unit.
Natural Variation						
8a	Are background wells screened in the same geomedia as the monitoring point?	Yes	Potential Alternate Source	Supporting	Monitoring Point	The upgradient (background) monitoring well (MW-5) is screened in the Lower Sewickley Sandstone which is the same hydrostratigraphic unit the downgradient wells are screened in and all wells (upgradient and downgradient) are located along the same groundwater flow path.
8b	Is the aquifer comprised of poorly buffered media such as sand and gravel?	No	No Alternate Source	Supporting	Unit	The aquifer is comprised of the Lower Sewickley Sandstone which is not considered to be a poorly buffered media.
8c	Is the pH at the monitoring point similar to the background pH?	No	No Alternate Source	Supporting	Monitoring Point	The pH in MW-20 is consistently higher than the pH in MW-5 (approximately 11.5 versus 8.5, respectively.
8d	Is the monitoring point near a river?	No	No Alternate Source	Supporting	Monitoring Point	The monitoring points are located approximately 2,300 feet upgradient of the nearest stream and approximately 4,200 feet upgradient of the nearest river.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Natural Variation (Continued)						
8e	Is the constituent chemically reactive in groundwater, such that dissolution or desorption is possible (EPRI, Table A-3)?	Yes/No	Potential Alternate Source / No Alternate Source	Supporting	Constituent	Arsenic is reactive based upon pH and redox conditions. Molybdenum is not reactive with limited sorption above pH 8.
8f	Is there a difference in redox indicators between background and compliance monitoring data?	ND	ND	Supporting	Monitoring Point	Redox parameters were not analyzed as part of the Appendix IV ASD.
8g	Has there been a recent flood, recharge event, or dry period that caused groundwater elevation to rise or fall to elevations higher or lower than observed during the background monitoring period?	No	No Alternate Source	Supporting	Unit	Groundwater conditions have generally remained consistent with those during background monitoring in MW-5, -17, and -20, but with localized water level decreases in MW-18 and -19 that are not attributable to flooding and drought conditions (refer to LOE 6a).
8h	Does the aquifer contain saline water at depth?	No	No Alternate Source	Supporting	Unit	Saline conditions are not observed in Site groundwater.
8i	Was the direction of groundwater flow prior to or during the sample event different than observed during the background prior?	No.	No Alternate Source	Supporting	Monitoring Point	Groundwater flow has consistently been from west to east across the Site.
Off-Site Anthropogenic						
9a	Are there former coal mines, mine spoil, or conveyers near the CCR unit or upgradient from the facility (also consider under "On-site")?	Yes	Potential Alternate Source	Supporting	Unit	There is a large coal mine with conveyors, tipples, and impoundments located approximately 1 mile upgradient of the Site's property boundary.
9b	Does a significant amount of road salting occur off-site?	N/A	N/A	Supporting	Unit	CCR unit is a captive site situated above the surrounding off-site roadways.
9c	Does the surrounding land use include agriculture (crops)?	Yes	Potential Alternate Source	Supporting	Unit	The neighboring properties appear to have limited agricultural uses which are determined to present little to no impacts to groundwater as it relates to the CCR unit.
9d	Does the surrounding land use include agriculture (animal)?	Yes	Potential Alternate Source	Supporting	Unit	The neighboring properties appear to have limited agricultural uses which are determined to present little to no impacts to groundwater as it relates to the CCR unit.

	Line of Evidence (LOE)	Determination[1] (Yes, No, ND, N/A)	Indication	LOE Type[2]	Applies to[3]	Weight of Evidence Determination / Basis
Off-Site Anthropogenic (Continued)						
9e	Are there current or former underground or aboveground storage tanks that have had a release? (Consider gas stations and surrounding industrial activities.)	No	No Alternate Source	Supporting	Unit	There are no known uses of off-site underground or above ground storage tanks near the CCR unit.
9f	Are there, or were there, oil and gas production wells in the vicinity of the site?	Yes	Potential Alternate Source	Supporting	Unit	Oil and gas wells located near the CCR unit were mapped and visually inspected. SSLs of arsenic and molybdenum are assumed to have little correlation to nearby oil and gas activities nearby.
9g	Are there existing or historical commercial and/or industrial sources of impacts, such as metal manufacturing, mining, landfills, Superfund or brownfield sites, wood treatment, etc.?	No	No Alternate Source	Supporting	Unit	There are no known off-site industrial or commercial sources that could potentially impact the uppermost aquifer being monitored for the CCR unit.
9h	Could any potential anthropogenic sources be causing changes to groundwater chemistry that would result in release of the constituent of concern through changes to pH, redox, etc.?	Yes	Potential Alternate Source	Supporting	Unit	There are no known off-site industrial or commercial sources that could potentially impact the uppermost aquifer being monitored for the CCR unit.
Time-of-Travel Analysis						
10	Has groundwater flowing beneath potential sources had enough time to migrate to the affected monitoring well location?	Yes	Potential Alternate Source	Supporting	Monitoring Point	Given the age of the CCR unit and history of disposal activities dating back to the 1970s, there has been enough time for potentially affected groundwater to flow to the affected monitoring wells.

Table Notes:

1. ND (not determined) indicates that this line of evidence was not tested or there are insufficient data to make a determination; N/A means lines of evidence not applicable to the CCR unit.
2. Line of Evidence (LOE) Types:
   Key lines of evidence are based on relationships that must be observed in order for an SSI/SSL to be due to a release from a CCR unit. If these relationships are not observed, then they are critical to establishing an ASD. It is difficult to build a strong ASD without any key lines of evidence. It may be possible to build an ASD with a single key line of evidence, but the ASD will be stronger with additional key or supporting lines of evidence.
   Supporting lines of evidence provide additional information that supports the ASD. Supporting lines of evidence are generally not sufficient to build an ASD unless there is at least one key line of evidence, although it may be possible if there are many supporting lines of evidence.
3. This LOE applies to:
   Constituent: An SSI/SSL for that constituent at any monitoring point
   Monitoring Point: All SSIs/SSLs at a specific monitoring point
   Case: An SSI/SSL for a specific constituent at a specific monitoring point
   Unit: All SSIs/SSLs at the monitored unit

TABLE 4 - HARRISON CCR GROUNDWATER ASSESSMENT MONITORING - INTERWELL COMPARISON OF APPENDIX IV RESULTS - SAMPLING EVENTS AM-1, -2, and -3

Lower Sewickley Sandstone							Event 11 (AM-1) Downgradient Wells					
Parameter	Units	Data Distribution for Upgradient Well MW-5	UPL Type	UPL Value[a,b]	Federal MCLs/RSLs	GWPS	MW-17	MW-18[e]	MW-19	MW-20		
Antimony	mg/L	Unknown	Poisson	0.00143	0.006	0.006	<0.00017	NS	0.00129	0.00433		
Arsenic	mg/L	Unknown	Non-parametric	0.0005	0.01	0.01	0.00062	NS	0.01052	0.0197		
Barium	mg/L	Normal	Parametric	0.152477	2	2	0.1173	NS	0.0244	0.10362		
Beryllium	mg/L	Unknown	Poisson	0.00156	0.004	0.004	<0.00022	NS	<0.00022	<0.00022		
Cadmium	mg/L	Unknown	Poisson	0.00143	0.005	0.005	<0.00017	NS	<0.00017	<0.00017		
T. Chromium	mg/L	Unknown	Poisson	0.00758	0.1	0.1	<0.00045	NS	0.00139	0.00307		
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	NS	<0.00047	<0.00047		
Fluoride	mg/L	Normal	Parametric	2.251	4	4	0.035	NS	1.69	0.238		
Lead	mg/L	Unknown	Poisson	0.00425	0.015	0.015	<0.00052	NS	0.00097	0.00101		
Lithium	mg/L	Normal	Parametric	0.018835	0.04	0.04	0.01352	NS	<0.005	0.01051		
Mercury	mg/L	Unknown	Poisson	0.00032	0.002	0.002	<0.00004	NS	<0.00004	<0.00004		
Molybdenum	mg/L	Log Normal	Parametric	0.01496	0.1	0.1	0.00051	NS	0.03661	0.15577		
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0011	NS	0.0047	0.00279		
Thallium	mg/L	Unknown	Poisson	0.00143	0.002	0.002	<0.00017	NS	<0.00017	<0.00017		
Sum Ra226+Ra228	pCi/L	Log Normal	Parametric	1.599	5	5	0.177	NS	<0.296	0.178		

Event 11 (AM-1) Upgradient Well MW-5	
<0.00017	U
0.000885	J
0.02755	
<0.00022	U
<0.00017	U
<0.00045	U
<0.00047	U
2.045	J-
<0.00052	U
0.01197	J
<0.00004	U
0.0009	J
0.00118	J
<0.00017	U
0.36805	U

[a]Prediction Limits calculated using 5% alpha.
[b]Upper Prediction Limit used for all parameters.
[c]Data distribution set to Unknown if all values non-detect in upgradient well.
[d]DQ is Double Quantification Rule. If Event 11 sample is detectible, will need to resample the downgradient well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 11, would use Poisson PL instead.
[e]MW-18 not sampled (NS) due to insufficient water.

#.#### = UPL > Result > MCL/RSL
= SSI < GWPS
= SSI > GWPS
= DQ Parameter with Verification Sampling Needed

Lower Sewickley Sandstone							Event 12 (AM-2) Downgradient Wells					
Parameter	Units	Data Distribution for Upgradient Well MW-5	UPL Type	UPL Value[a,b]	Federal MCLs/RSLs	GWPS	MW-17	MW-18[e]	MW-19[e]	MW-20		
Antimony	mg/L	Unknown	Poisson	0.00143	0.006	0.006	<0.00017	NS	NS	0.00288		
Arsenic	mg/L	Unknown	Non-parametric	0.0005	0.01	0.01	0.00037	NS	NS	0.01997		
Barium	mg/L	Normal	Parametric	0.152477	2	2	0.07645	NS	NS	0.09978		
Beryllium	mg/L	Unknown	Poisson	0.00156	0.004	0.004	<0.00022	NS	NS	<0.00088		
Cadmium	mg/L	Unknown	Poisson	0.00143	0.005	0.005	<0.00017	NS	NS	<0.00017		
T. Chromium	mg/L	Unknown	Poisson	0.00758	0.1	0.1	<0.00045	NS	NS	0.00416		
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	NS	NS	<0.0019		
Fluoride	mg/L	Normal	Parametric	2.251	4	4	0.049	NS	NS	0.311		
Lead	mg/L	Unknown	Poisson	0.00425	0.015	0.015	<0.00052	NS	NS	0.0009		
Lithium	mg/L	Normal	Parametric	0.018835	0.04	0.04	0.01302	NS	NS	<0.02		
Mercury	mg/L	Unknown	Poisson	0.00032	0.002	0.002	0.00005	NS	NS	0.00007		
Molybdenum	mg/L	Log Normal	Parametric	0.01496	0.1	0.1	<0.00028	NS	NS	0.1297		
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0011	NS	NS	0.00196		
Thallium	mg/L	Unknown	Poisson	0.00143	0.002	0.002	<0.00017	NS	NS	<0.00017		
Sum Ra226+Ra228	pCi/L	Log Normal	Parametric	1.599	5	5	1.155	NS	NS	<1.36		

Event 12 (AM-2) Upgradient Well MW-5	
<0.00017	U
<0.001	U
0.110825	
<0.00022	U
<0.00017	U
<0.00045	U
<0.00047	U
0.588	
<0.00052	U
0.015025	J
0.000065	J
0.000365	J
<0.0011	U
<0.00017	U
<1.38	U

[a]Prediction Limits calculated using 5% alpha.
[b]Upper Prediction Limit used for all parameters.
[c]Data distribution set to Unknown if all values non-detect in upgradient well.
[d]DQ is Double Quantification Rule. If Event 12 sample is detectible but Event 11 was ND, need to resample the well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 12, would use Poisson PL instead.
[e]MW-18 and MW-19 not sampled (NS) due to insufficient water.

#.#### = UPL > Result > MCL/RSL
= SSI < GWPS
= SSI > GWPS
= DQ Parameter with Verification Sampling Needed

TABLE 4 - HARRISON CCR GROUNDWATER ASSESSMENT MONITORING - INTERWELL COMPARISON OF APPENDIX IV RESULTS - SAMPLING EVENTS AM-1, -2, and -3

Lower Sewickley Sandstone							Event 13 (AM-3) Downgradient Wells					
Parameter	Units	Data Distribution for Upgradient Well MW-5	UPL Type	UPL Value[a,b]	Federal MCLs/RSLs	GWPS	MW-17	MW-18[e]	MW-19	MW-20		
Antimony	mg/L	Unknown	Poisson	0.00143	0.006	0.006	<0.00107	NS	<0.00107	0.00242		
Arsenic	mg/L	Unknown	Non-parametric	0.0005	0.01	0.01	0.001135	NS	0.01056	0.04026		
Barium	mg/L	Normal	Parametric	0.152477	2	2	0.14288	NS	0.05569	0.18036		
Beryllium	mg/L	Unknown	Poisson	0.00156	0.004	0.004	<0.00022	NS	<0.00022	<0.00022		
Cadmium	mg/L	Unknown	Poisson	0.00143	0.005	0.005	<0.00067	NS	<0.00067	<0.00067		
T. Chromium	mg/L	Unknown	Poisson	0.00758	0.1	0.1	<0.00145	NS	0.00382	0.00985		
Cobalt	mg/L	Unknown[c]	DQ[d]	NA	0.006	0.006	<0.00047	NS	0.00132	0.00056		
Fluoride	mg/L	Normal	Parametric	2.251	4	4	0.056	NS	2.29	1.55		
Lead	mg/L	Unknown	Poisson	0.00425	0.015	0.015	<0.00052	NS	0.00219	0.00248		
Lithium	mg/L	Normal	Parametric	0.018835	0.04	0.04	0.00918	NS	0.01022	0.0155		
Mercury	mg/L	Unknown	Poisson	0.00032	0.002	0.002	<0.00016	NS	<0.00016	<0.00016		
Molybdenum	mg/L	Log Normal	Parametric	0.01496	0.1	0.1	<0.00113	NS	0.04371	0.09846		
Selenium	mg/L	Unknown[c]	DQ[d]	NA	0.5	0.5	<0.0034	NS	<0.0034	<0.0034		
Thallium	mg/L	Unknown	Poisson	0.00143	0.002	0.002	<0.00017	NS	<0.00017	<0.00017		
Sum Ra226+Ra228	pCi/L	Log Normal	Parametric	1.599	5	5	<0.5095	NS	<0.1604	0.95		

Event 13 (AM-3) Upgradient Well MW-5	
0.00107	U
0.00063	
0.03791	
0.00022	U
0.00067	U
0.00145	U
0.00047	U
1.58	
0.00052	U
0.01353	
0.00016	U
0.00113	U
0.0034	U
0.00017	U
0.1441	U

[a]Prediction Limits calculated using 5% alpha.
[b]Upper Prediction Limit used for all parameters.
[c]Data distribution set to Unknown if all values non-detect in upgradient well.
[d]DQ is Double Quantification Rule. If Event 13 sample is detectible but Event 12 was ND, need to resample the well to see if two successive, independent detected values occur. If so, that would be an SSI. If value was detected in upgradient well in Event 13, would use Poisson PL instead.
[e]MW-18 not sampled (NS) due to insufficient water.

#.#### = UPL > Result > MCL/RSL
(green) = SSI < GWPS
(red) = SSI > GWPS
(yellow) = DQ Parameter with Verification Sampling Needed

Table 5 - Leachate Data Summary

Parameters	Leachate Concentrations (mg/L)						GW Concentrations (mg/L)									
	LM01 Average	LM02 Average	LM05 Average	LM07 Average	LM10 Average	Leachate Avg.	UG UPL (MW-5)	MW-17	MW-19	MW-20	DG Avg.	Leachate Avg. > UG UPL?	DG Avg. > UG UPL?	MW-17 < Leachate Avg.?	MW-19 < Leachate Avg.?	MW-20 < Leachate Avg.?
Arsenic	0.075199	0.049247	0.093452	0.072958	0.076887	0.073650	0.0005	0.001104	0.010566	0.040263	0.017311	Yes	Yes	Yes	Yes	Yes
Molybdenum	0.031433	0.047454	0.067799	0.032323	0.002738	0.036349	0.01496	ND	0.043712	0.098466	0.071089	Yes	Yes	Yes	No	No

Notes: DG -Downgradient; GW - Groundwater; UG - Upgradient; UPL - Upper Prediction Limit
Leachate Concentration averages from five sampling events performed between October 2017 and April 2019.
GW Concentrations of App. IV SSL parameters from sampling and analysis completed in March 2019.
UG UPL's based on 8 baseline sampling events.
ND - Constituent not detected above the laboratory reporting Limit
LM01 = Phase I LCS; LM02 = Stages I & II LCS; LM05 = Phase III LCS; LM07 = Phase IVA & B LCS; LM10 = Phase IVA & B LCUU

FIGURES

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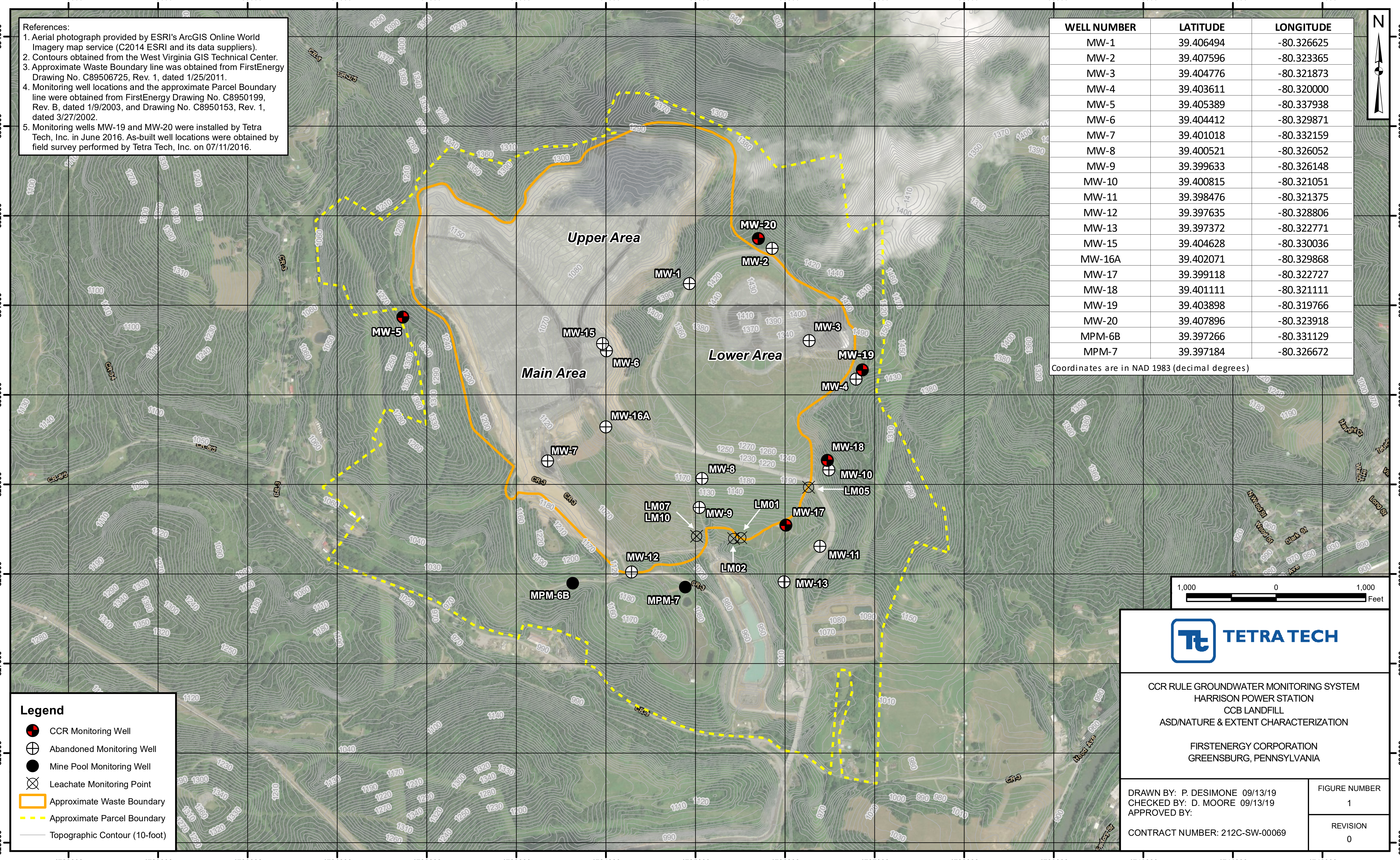

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (C2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Approximate Waste Boundary line was obtained from FirstEnergy Drawing No. C89506725, Rev. 1, dated 1/25/2011.
4. Monitoring well locations and the approximate Parcel Boundary line were obtained from FirstEnergy Drawing No. C8950199, Rev. B, dated 1/9/2003, and Drawing No. C8950153, Rev. 1, dated 3/27/2002.
5. Monitoring wells MW-19 and MW-20 were installed by Tetra Tech, Inc. in June 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 07/11/2016.

WELL NUMBER	LATITUDE	LONGITUDE
MW-1	39.406494	-80.326625
MW-2	39.407596	-80.323365
MW-3	39.404776	-80.321873
MW-4	39.403611	-80.320000
MW-5	39.405389	-80.337938
MW-6	39.404412	-80.329871
MW-7	39.401018	-80.332159
MW-8	39.400521	-80.326052
MW-9	39.399633	-80.326148
MW-10	39.400815	-80.321051
MW-11	39.398476	-80.321375
MW-12	39.397635	-80.328806
MW-13	39.397372	-80.322771
MW-15	39.404628	-80.330036
MW-16A	39.402071	-80.329868
MW-17	39.399118	-80.322727
MW-18	39.401111	-80.321111
MW-19	39.403898	-80.319766
MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

Legend

- CCR Monitoring Well
- Abandoned Monitoring Well
- Mine Pool Monitoring Well
- Leachate Monitoring Point
- Approximate Waste Boundary
- Approximate Parcel Boundary
- Topographic Contour (10-foot)

TETRA TECH

CCR RULE GROUNDWATER MONITORING SYSTEM
HARRISON POWER STATION
CCB LANDFILL
ASD/NATURE & EXTENT CHARACTERIZATION

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00069

FIGURE NUMBER
1

REVISION
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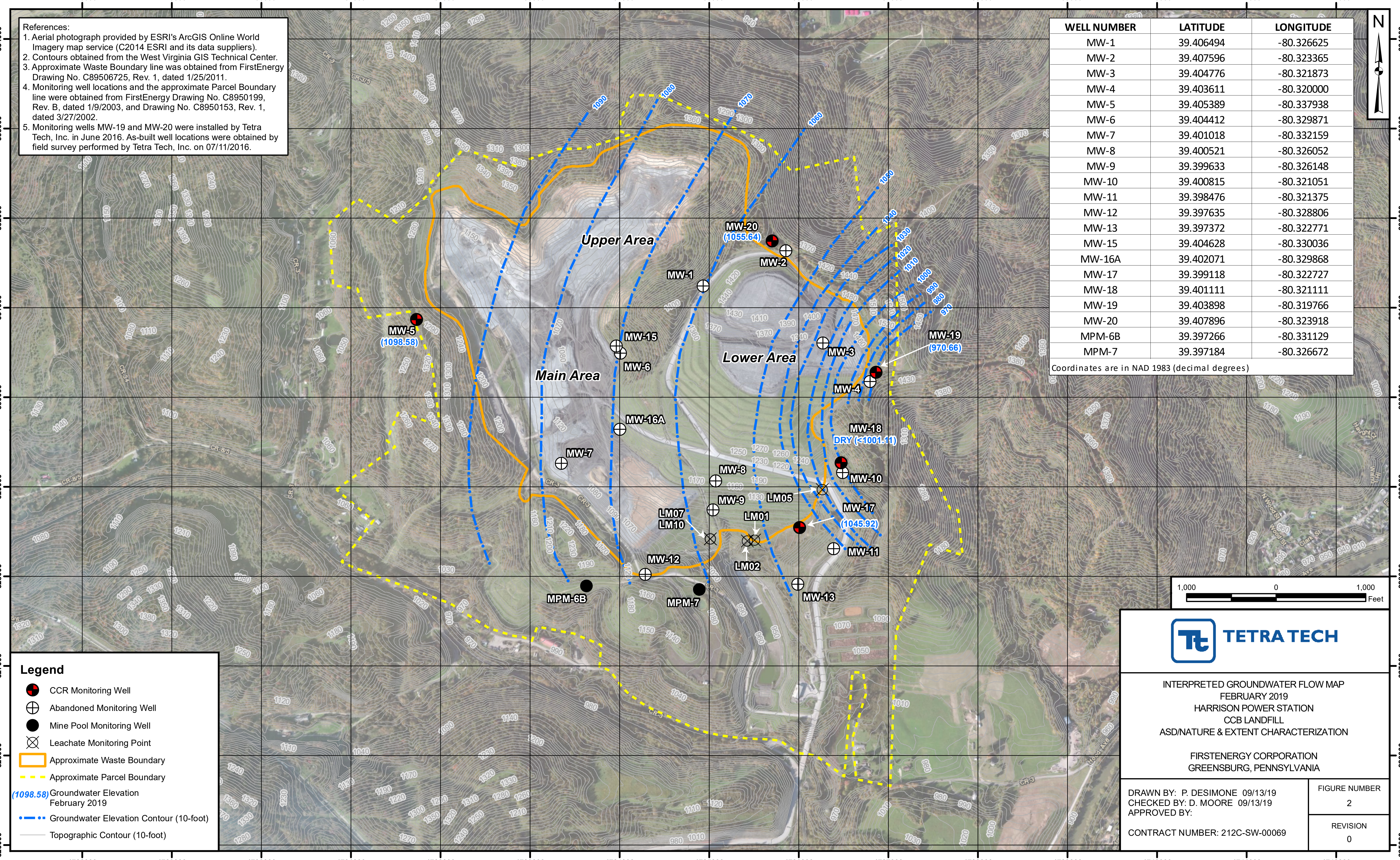

WELL NUMBER	LATITUDE	LONGITUDE
MW-1	39.406494	-80.326625
MW-2	39.407596	-80.323365
MW-3	39.404776	-80.321873
MW-4	39.403611	-80.320000
MW-5	39.405389	-80.337938
MW-6	39.404412	-80.329871
MW-7	39.401018	-80.332159
MW-8	39.400521	-80.326052
MW-9	39.399633	-80.326148
MW-10	39.400815	-80.321051
MW-11	39.398476	-80.321375
MW-12	39.397635	-80.328806
MW-13	39.397372	-80.322771
MW-15	39.404628	-80.330036
MW-16A	39.402071	-80.329868
MW-17	39.399118	-80.322727
MW-18	39.401111	-80.321111
MW-19	39.403898	-80.319766
MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

TETRA TECH

INTERPRETED GROUNDWATER FLOW MAP
FEBRUARY 2019
HARRISON POWER STATION
CCB LANDFILL
ASD/NATURE & EXTENT CHARACTERIZATION

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00069

FIGURE NUMBER
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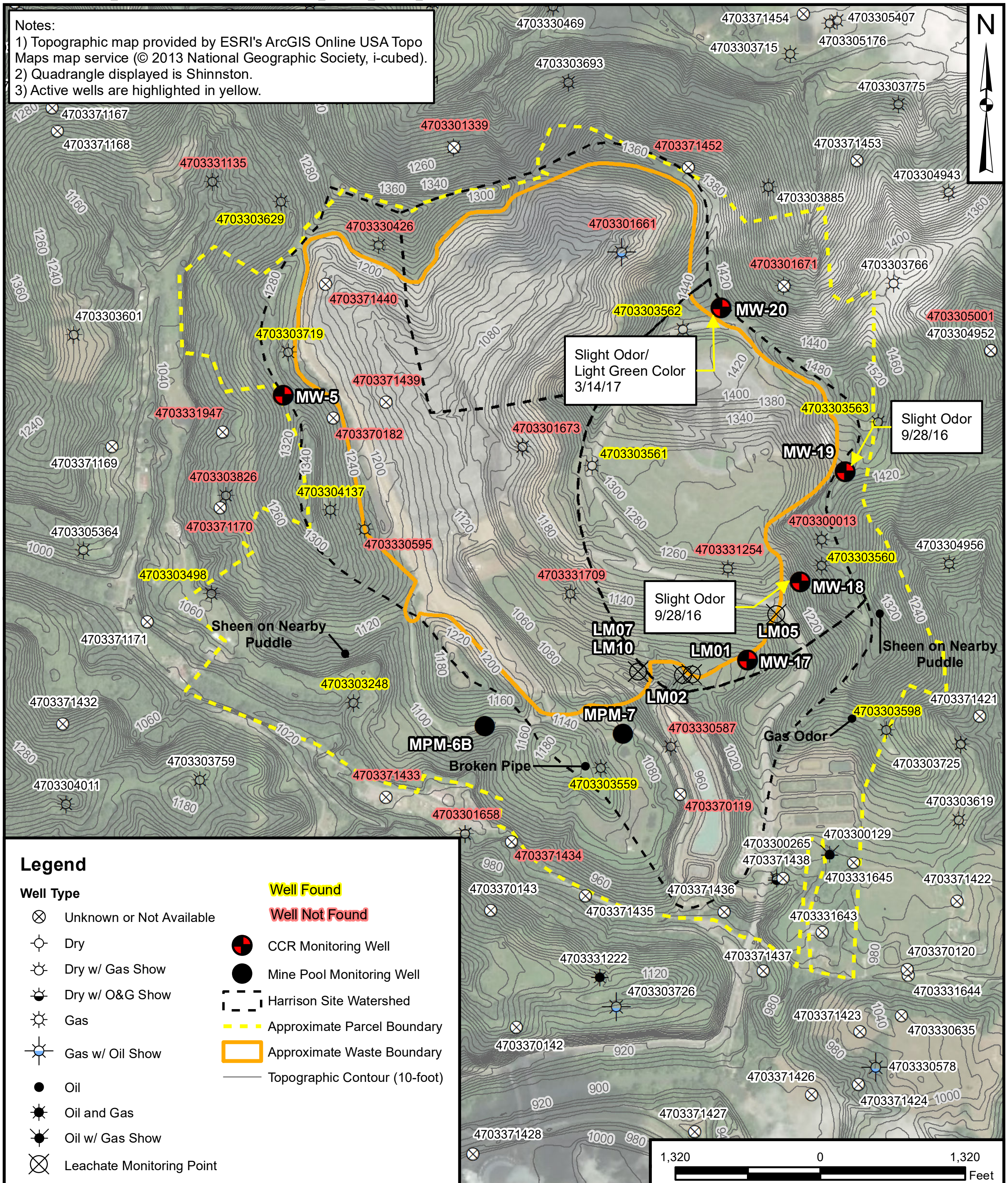

TETRA TECH	OIL AND GAS WELL LOCATIONS IN AOR HARRISON POWER STATION CCB LANDFILL FIRSTENERGY CORPORATION GREENSBURG, PENNSYLVANIA	DRAWN BY: P. DESIMONE 09/13/19 CHECKED BY: D. MOORE 09/13/19 APPROVED BY: CONTRACT NUMBER: 212C-SW-00069 FIGURE NUMBER 3	REV 0

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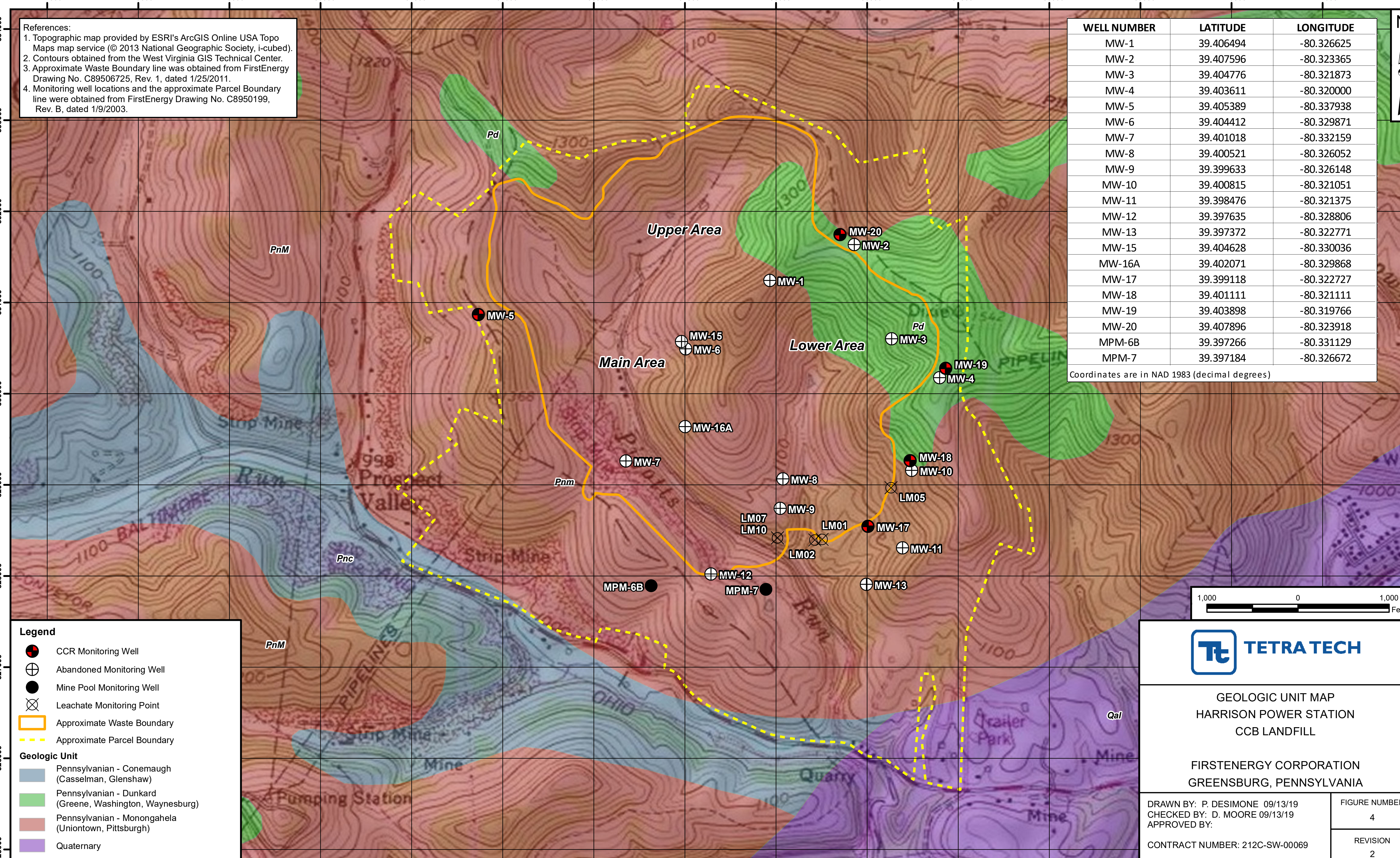

WELL NUMBER	LATITUDE	LONGITUDE
MW-1	39.406494	-80.326625
MW-2	39.407596	-80.323365
MW-3	39.404776	-80.321873
MW-4	39.403611	-80.320000
MW-5	39.405389	-80.337938
MW-6	39.404412	-80.329871
MW-7	39.401018	-80.332159
MW-8	39.400521	-80.326052
MW-9	39.399633	-80.326148
MW-10	39.400815	-80.321051
MW-11	39.398476	-80.321375
MW-12	39.397635	-80.328806
MW-13	39.397372	-80.322771
MW-15	39.404628	-80.330036
MW-16A	39.402071	-80.329868
MW-17	39.399118	-80.322727
MW-18	39.401111	-80.321111
MW-19	39.403898	-80.319766
MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

TETRA TECH

GEOLOGIC UNIT MAP
HARRISON POWER STATION
CCB LANDFILL

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19
CHECKED BY: D. MOORE 09/13/19
APPROVED BY:

CONTRACT NUMBER: 212C-SW-00069

FIGURE NUMBER 4

REVISION 2

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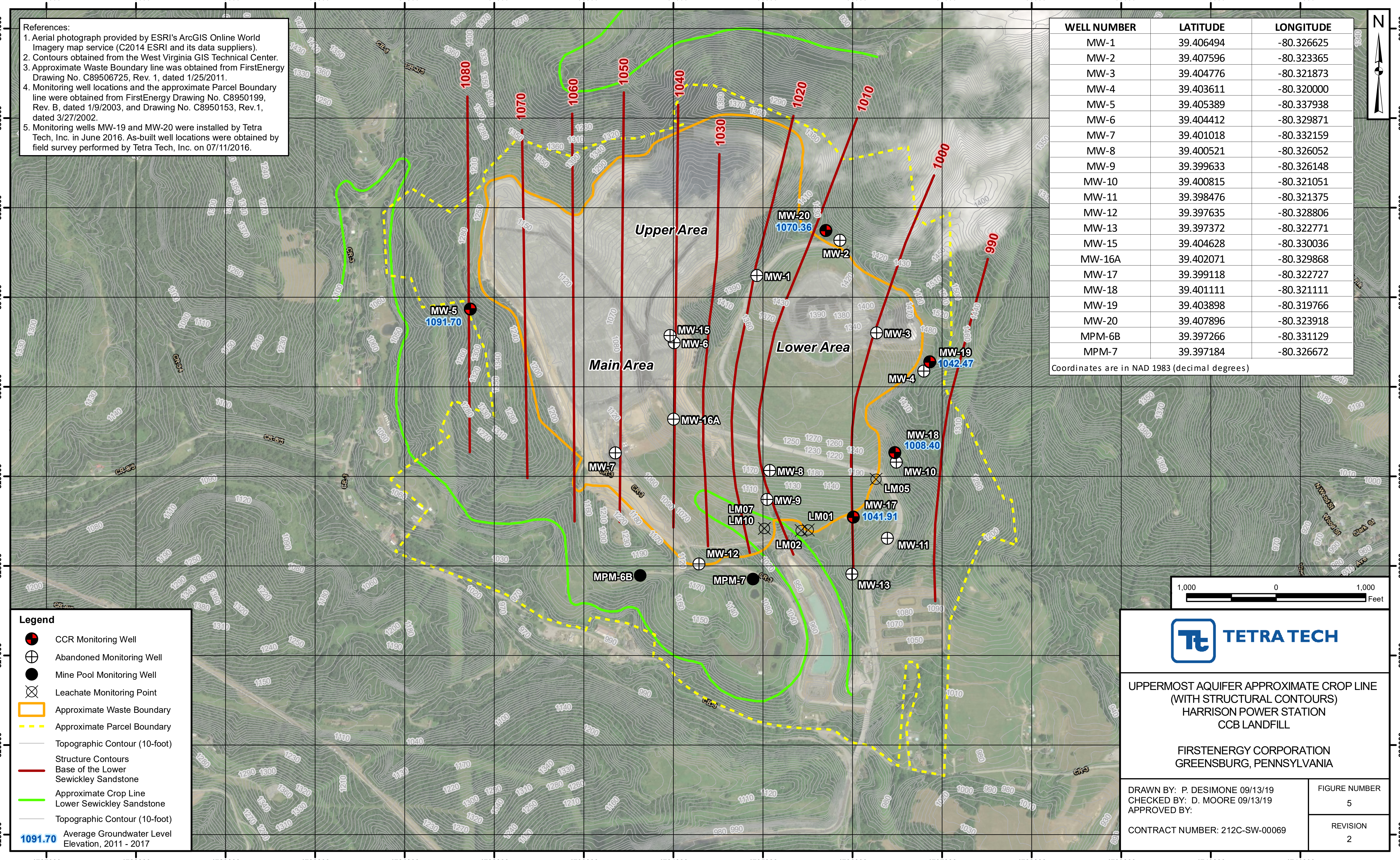

References:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (C2014 ESRI and its data suppliers).
2. Contours obtained from the West Virginia GIS Technical Center.
3. Approximate Waste Boundary line was obtained from FirstEnergy Drawing No. C89506725, Rev. 1, dated 1/25/2011.
4. Monitoring well locations and the approximate Parcel Boundary line were obtained from FirstEnergy Drawing No. C8950199, Rev. B, dated 1/9/2003, and Drawing No. C8950153, Rev.1, dated 3/27/2002.
5. Monitoring wells MW-19 and MW-20 were installed by Tetra Tech, Inc. in June 2016. As-built well locations were obtained by field survey performed by Tetra Tech, Inc. on 07/11/2016.

WELL NUMBER	LATITUDE	LONGITUDE
MW-1	39.406494	-80.326625
MW-2	39.407596	-80.323365
MW-3	39.404776	-80.321873
MW-4	39.403611	-80.320000
MW-5	39.405389	-80.337938
MW-6	39.404412	-80.329871
MW-7	39.401018	-80.332159
MW-8	39.400521	-80.326052
MW-9	39.399633	-80.326148
MW-10	39.400815	-80.321051
MW-11	39.398476	-80.321375
MW-12	39.397635	-80.328806
MW-13	39.397372	-80.322771
MW-15	39.404628	-80.330036
MW-16A	39.402071	-80.329868
MW-17	39.399118	-80.322727
MW-18	39.401111	-80.321111
MW-19	39.403898	-80.319766
MW-20	39.407896	-80.323918
MPM-6B	39.397266	-80.331129
MPM-7	39.397184	-80.326672

Coordinates are in NAD 1983 (decimal degrees)

Legend

- CCR Monitoring Well
- Abandoned Monitoring Well
- Mine Pool Monitoring Well
- Leachate Monitoring Point
- Approximate Waste Boundary
- Approximate Parcel Boundary
- Topographic Contour (10-foot)
- Structure Contours Base of the Lower Sewickley Sandstone
- Approximate Crop Line Lower Sewickley Sandstone
- Topographic Contour (10-foot)
- 1091.70 Average Groundwater Level Elevation, 2011 - 2017

TETRA TECH

UPPERMOST AQUIFER APPROXIMATE CROP LINE (WITH STRUCTURAL CONTOURS)
HARRISON POWER STATION
CCB LANDFILL

FIRSTENERGY CORPORATION
GREENSBURG, PENNSYLVANIA

DRAWN BY: P. DESIMONE 09/13/19 CHECKED BY: D. MOORE 09/13/19 APPROVED BY:	FIGURE NUMBER 5
CONTRACT NUMBER: 212C-SW-00069	REVISION 2

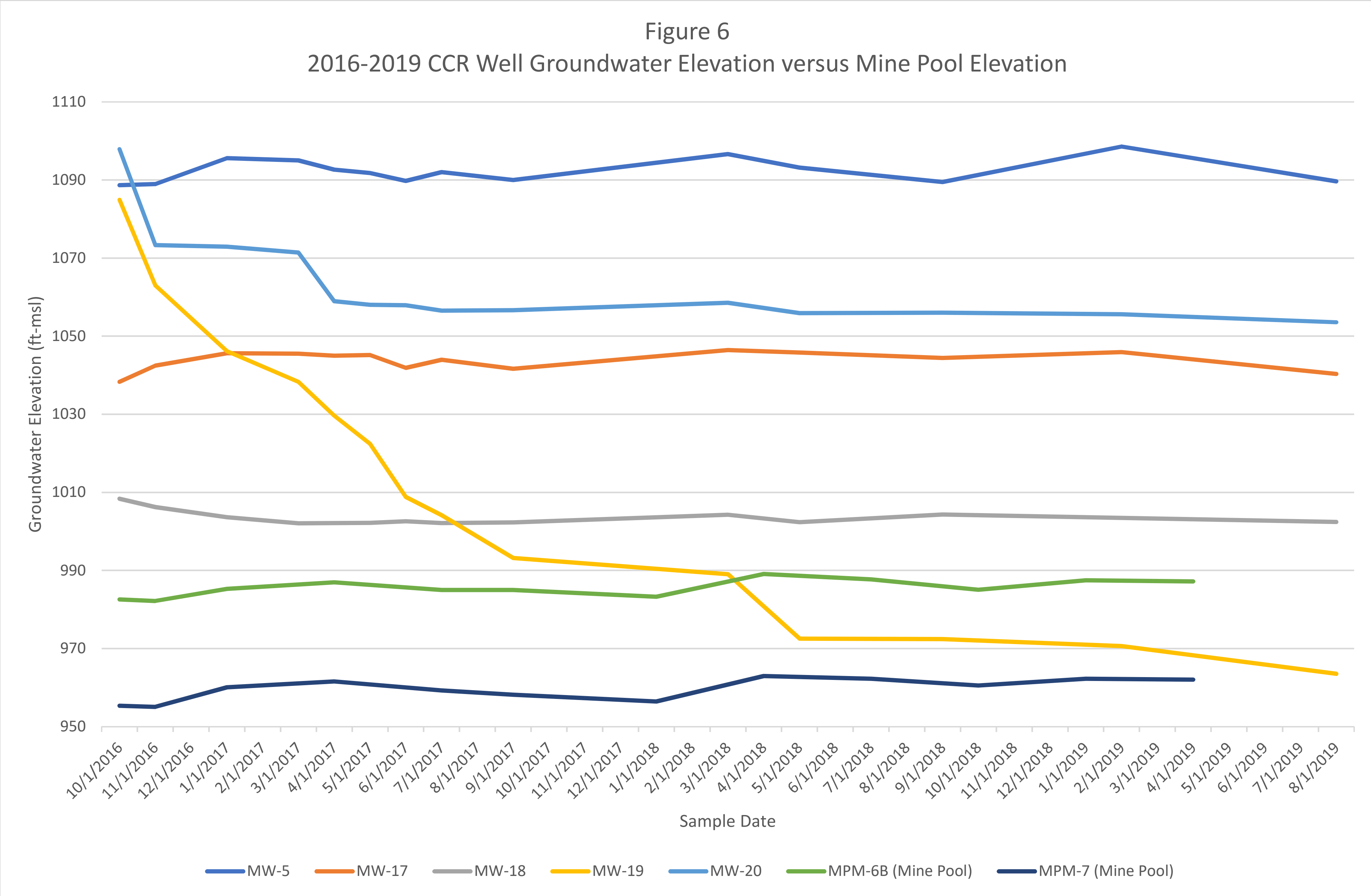

Figure 6
2016-2019 CCR Well Groundwater Elevation versus Mine Pool Elevation
Groundwater Elevation (ft-msl)
1110
1090
1070
1050
1030
1010
990
970
950
10/1/2016
11/1/2016
12/1/2016
1/1/2017
2/1/2017
3/1/2017
4/1/2017
5/1/2017
6/1/2017
7/1/2017
8/1/2017
9/1/2017
10/1/2017
11/1/2017
12/1/2017
1/1/2018
2/1/2018
3/1/2018
4/1/2018
5/1/2018
6/1/2018
7/1/2018
8/1/2018
9/1/2018
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
Sample Date
MW-5
MW-17
MW-18
MW-19
MW-20
MPM-6B (Mine Pool)
MPM-7 (Mine Pool)

APPENDIX B

Geologic Cross-Sections

K001405A.DWG

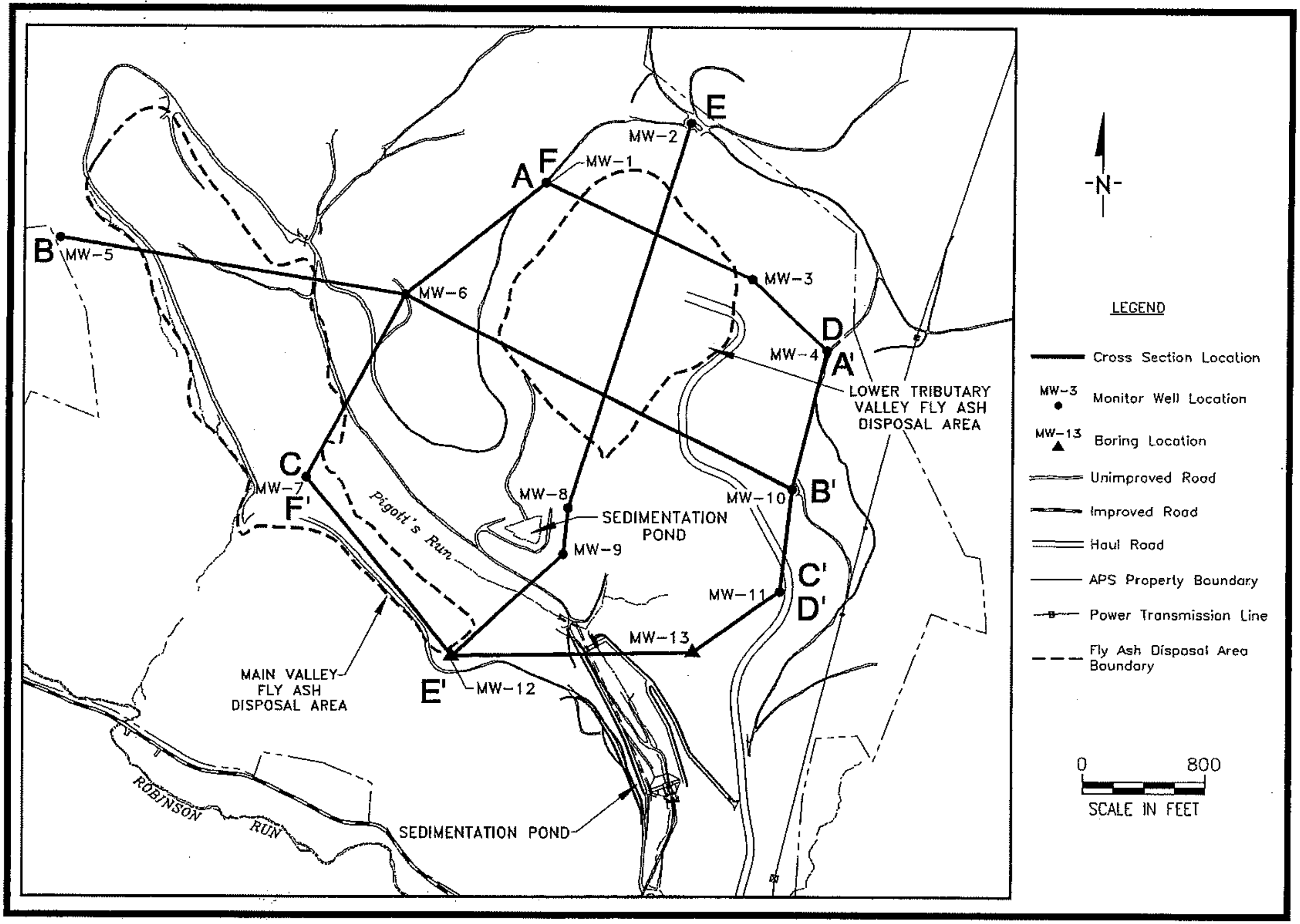

Figure 3-6 Locations of geologic cross-sections at the PRDF site.

K001407A.DWG

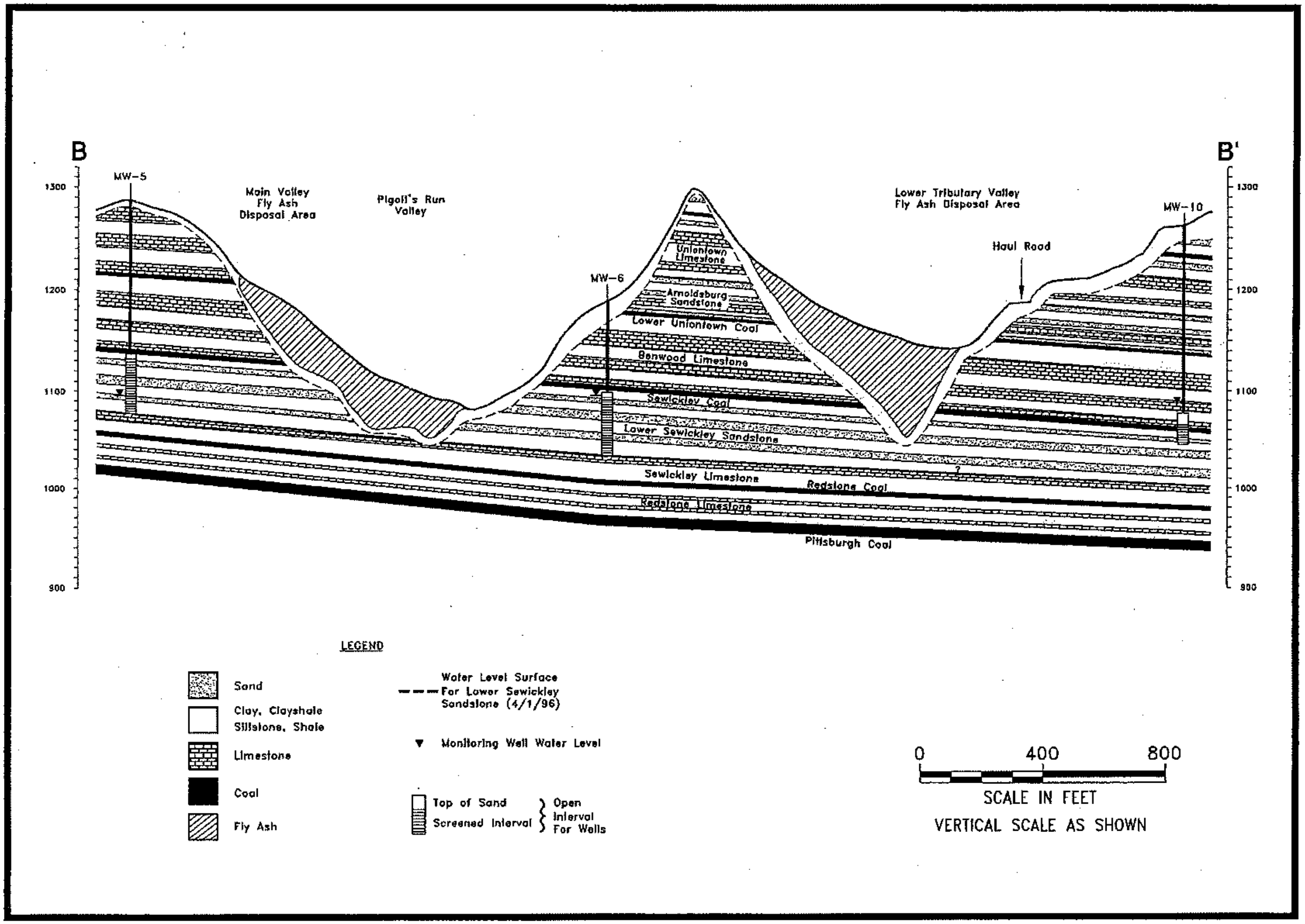

Figure 3-8 Geologic cross-section B-B' at the PRDF site.

K001410A.dwg

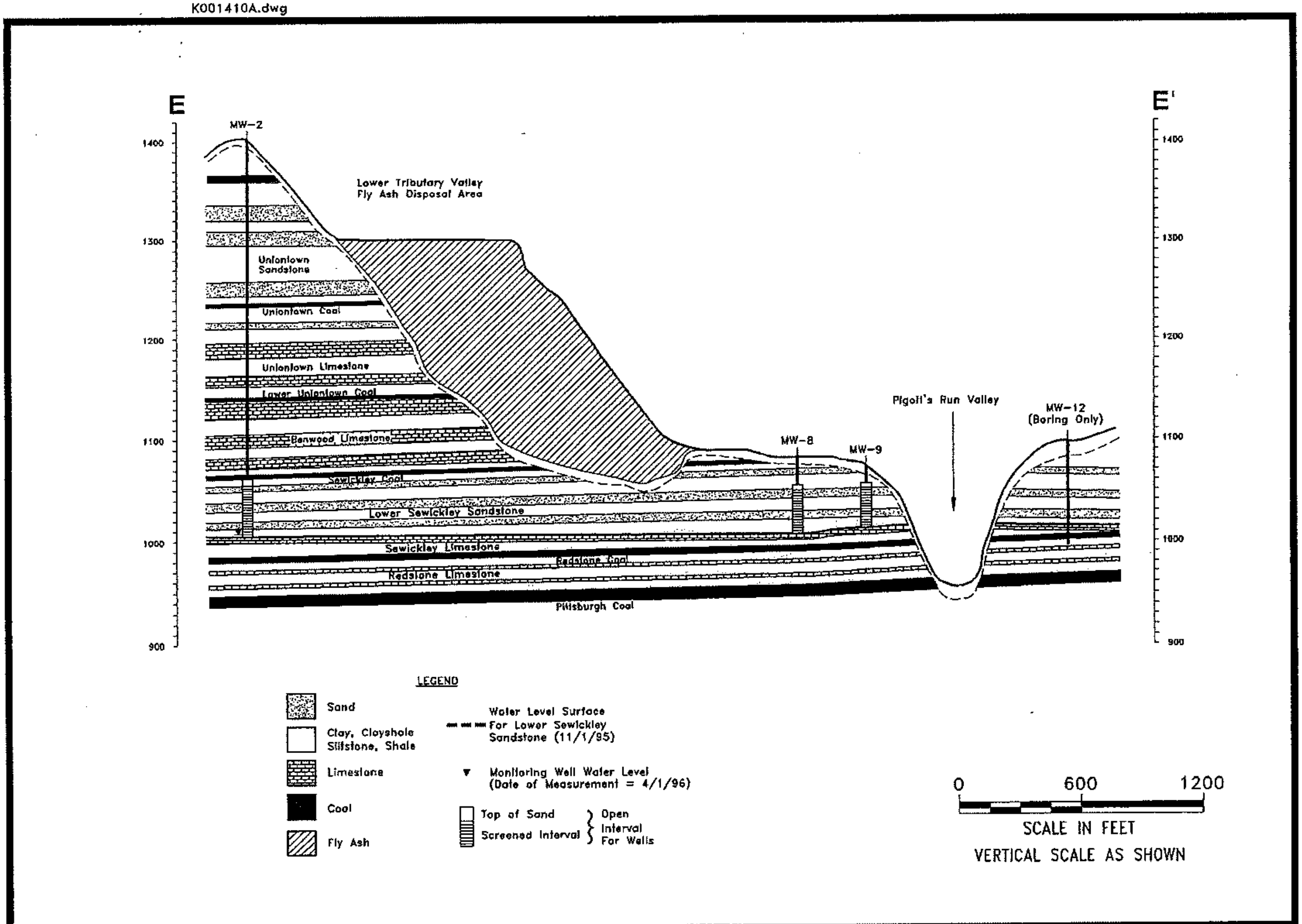

Figure 3-11 Geologic cross-section E-E' at the PRDF site.