Karn Lined Impoundment Hydrogeological Monitoring Plan

DE Karn Power Plant Lined Impoundment
Essexville, Michigan

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1.0 Introduction

TRC has prepared this Hydrogeological Monitoring Plan (HMP) for the Karn Lined Impoundment (Karn Lined Impoundment HMP) on behalf of Consumers Energy Company.

1.1 Background and Program Summary

On April 17, 2015, the United States Environmental Protection Agency (US EPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) (CCR Rule) to regulate the solid waste management of CCRs at electrical generating facilities. The CCR Rule, which became effective on October 19, 2015, applies to the Consumers Energy Company (Consumers Energy) Karn Lined Impoundment (Figure 2) located at the DE Karn Power Plant site. This CCR impoundment was constructed with a double composite liner system and leachate collection system in advance of replacing the Karn Bottom Ash Pond (Figure 2).

Consumers Energy developed a groundwater monitoring system for the Karn Lined Impoundment in accordance with §257.91 and on June 7, 2018 the Karn Lined Impoundment began receipt of CCR and non-CCR. The initial detection monitoring sampling event occurred in November 2018, and subsequent sample collection, data evaluation, and reporting has continued pursuant to the CCR Rule. Based on the 2020 Annual Groundwater Monitoring and Corrective Action Report, the Karn Lined Impoundment is in detection monitoring.

After establishing the groundwater monitoring system and detection monitoring project pursuant to the requirements and schedule of §257.90 - §257.94, the State of Michigan enacted Public Act No. 640 of 2018 (PA 640) on December 28, 2018 to amend the Natural Resources and Environmental Protection Act (NREPA), also known as Part 115 of PA 451 of 1994, as amended (Part 115) (a.k.a., Michigan Part 115 Solid Waste Management). These amendments to Part 115 were developed to provide the State of Michigan oversight of coal ash impoundments and landfills and to better align existing state solid waste management rules and statutes with the CCR Rule. This alignment would ensure compliance with the CCR standards through a state-approved permitting program that would be deemed to be “equivalent to” or “as protective as” through an administrative application that would be reviewed and authorized by U.S. EPA. Therefore, the basis for establishing a groundwater monitoring system and initiating detection monitoring will need to conform requirements for any licensed coal ash impoundment or landfill after December 28, 2018 with Part 115 amendments and the CCR Rule.

1.2 Purpose and Scope

The Karn Lined Impoundment HMP is required for licensing the Karn Lined Impoundment in accordance with the provisions of the Michigan Part 115 Solid Waste Rules, as amended. The purpose of this HMP is to provide a means to comply with applicable monitoring requirements described in the Part 115 amendments, and the self-implementing standards and schedules of the CCR Rules, or until such a time as the USEPA recognizes Part 115, as amended, as an authorized permitting authority to regulate coal ash impoundments and landfills in Michigan. The monitoring program was developed based on the hydrogeologic characteristics of the site

and surrounding area and the known and potential influence of the surface impoundment on the hydrogeologic system.

The methodologies outlined in this HMP are consistent with applicable regulations, general federal and state guidance, TRC's and Consumers Energy's Standard Operating Procedures (SOPs), and industry standards.

1.3 Requirements

Consumers Energy is required to submit an HMP in compliance with Part 115 Rule 299.4905 to the Michigan Department of Environment, Great Lakes, and Energy (EGLE)[1]. Revisions to Part 115 as amended by PA 640, in particular Section 11512(a)(1), require an approved HMP that complies with 299.4440 to 299.4445, if applicable, and 299.4905 to 299.4908 of the Part 115 Rules prior to issuing a solid waste operating license to a coal ash impoundment or landfill. A copy of the EGLE-approved HMP will be placed in Consumers Energy's DE Karn Operating Record and used to monitor groundwater quality at the Karn Lined Impoundment.

Consumers Energy will notify the Director of the EGLE ("Director" or their designee) of any plans to modify monitoring points or schedules described in this HMP. Such changes will be implemented upon approval by the Director and documented in the operating record.

1.4 Site Overview

The DE Karn Power Plant site is located north of the JC Weadock Power Plant site, east of the Saginaw River, south and west of Saginaw Bay (Figure 1). A discharge channel runs along the majority of the southern perimeter of the DE Karn Power Plant site and separates the facility from the JC Weadock Power Plant Site to the south. The DE Karn Power Plant site began generating electricity in 1959. Two power generating units (Units 1 & 2) are coal-fueled and two units (Units 3 & 4) are oil- and natural gas-fueled.

The Karn Lined Impoundment is depicted on Figure 2 by a dashed blue outline and shading. This impoundment is used for wet ash dewatering and is the primary settling/detention structure for the National Pollutant Discharge Elimination System (NPDES) treatment system prior to discharge through the NPDES permitted outfall. Prior to being placed in service in June 2018, the Karn Bottom Ash Pond (Figure 2) functioned as coal ash storage and NPDES treatment unit for Karn Units 1&2. The CCR and berm structures associated with the Karn Bottom Ash Pond were documented as removed in 2019 (Golder, 2019). The approximate extent of the Bottom Ash Pond excavation is depicted by a dark grey dashed outline in Figure 2.

The footprint of operation for the Karn Lined Impoundment is constructed immediately adjacent to the former Karn Bottom Ash Pond. Groundwater in the vicinity of the Karn Lined Impoundment is documented to have been affected by CCR management before commencement of operation (January 2018, TRC). Groundwater conditions are discussed

[1] Effective Monday, April 22, 2019, the Michigan Department of Environmental Quality (MDEQ) became known as the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

further in the Alternate Source Demonstration for the October 2019 Detection Monitoring Sampling Event (Appendix A).

The liner system for the new impoundment is an alternative composite liner system, with the primary and secondary composite liners each consisting of 60-mil High Density Polyethylene (HDPE) geomembrane (GM) overlaying a 236-mil geosynthetic clay liner (GCL) (Golder, 2018a). There is also a secondary collection system consisting of 175-mil GSE HyperNet geonet located between the primary and secondary liner system. The Karn Lined Impoundment began receipt of CCR and non-CCR on June 7, 2018 when it replaced the Karn Bottom Ash Pond operations.

The Karn Bottom Ash Pond and Karn Lined Impoundment are located adjacent to the DE Karn 1&2 Solid Waste Disposal Area (Karn Landfill) consisting of 174-acres of a permitted, Type III Industrial Waste Landfill depicted by a yellow dashed outline and shading in Figure 2. Solid Waste Construction Permit No. 0195 was issued on December 12, 1986. The Karn Landfill served as the coal ash disposal for Karn Units 1&2 up until 2015 and then was closed by regrading coal ash and placement of final cover at minimum grades (Golder, 2018b). Final closure certification was accepted by EGLE on June 24, 2020.

The Karn Landfill is being monitored in accordance with the EGLE-approved Hydrogeological Monitoring Plan, Rev. 3, DE Karn Solid Waste Disposal Area (December 19, 2017) (Karn Landfill HMP). In addition to the HMP, the Karn Landfill is currently authorized under a permit (Groundwater Discharge Authorization GWE-0005) issued pursuant to Part 31 [2] to discharge to the unusable aquifer directly underlying the solid waste. Compliance monitoring pursuant to Part 31 and Part 115 is detailed in the Karn Landfill HMP approved by the EGLE on January 8, 2018 (2017 Karn Landfill HMP).

Groundwater in the vicinity of the Karn Lined Impoundment has been documented to be affected by the management of CCR prior to the construction of the unit. Given that the constituents associated with CCR currently managed in the new unit are indistinguishable from the constituents already present in groundwater from past operation of the Karn Bottom Ash Pond, the potential for a release from the new unit will be monitored utilizing a combination of intrawell trend tests as well as action flow rates in the secondary collection system, as discussed in Sections 3 and 6.

1.5 Geology/Hydrogeology

The majority of the Karn Lined Impoundment area is comprised of surficial CCR and sand fill. USGS topographic maps and aerial photographs dating back to 1938, in addition to field descriptions of subsurface soil at the site, indicate that the site was largely developed by reclaiming low-lands through construction of perimeter dikes and subsequent ash filling (AECOM, 2009).

[2] Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994.

The surficial fill consists of a mixture of varying percentages of ash, sand, and clay-rich fill ranging from 5 to 15 feet thick. Below the surficial fill, native alluvium and lacustrine soils are present at varying depths. Generally, there is a well graded sand unit present to depths of 10-30 feet below ground surface (ft bgs) overlying a clay till which is observed at depths ranging from 25 to 75 ft bgs. In general, the alluvium soils (sands) are deeper along the Saginaw River and there are shallower lacustrine deposits (clays, silts and sands deposited in or on the shores of glacial lakes) at other areas. The clay till acts as a hydraulic barrier that separates the shallow groundwater from the underlying sandstone. A sandstone unit, which is part of the Saginaw formation, was generally encountered at 80-90 ft bgs. Conceptual site cross sections are included in Appendix B.

The DE Karn Power Plant site is bound by several surface water features (Figure 1): the Saginaw River to the west, Saginaw Bay (Lake Huron) to the north and east, and a discharge channel to the south. In general, shallow groundwater is encountered at a similar or slightly higher elevation relative to the surrounding surface water features. Groundwater flow in the upper aquifer is largely controlled by the surface water elevations of Saginaw River and Saginaw Bay. In the vicinity of the Karn Bottom Ash Pond and Karn Lined Impoundment, the shallow groundwater flow is generally radial, flowing outward from the pond area toward the surrounding surface water bodies.

In previous investigations to the south, bedrock groundwater was generally encountered around 578 feet NAVD88, which is several feet lower than the shallow groundwater. Groundwater flow direction was generally to the northeast under a very shallow gradient. Given the different groundwater flow regime in the bedrock than the shallow saturated unit, bedrock wells near the surface water bodies are several feet below the surface water elevation. Based on the fact that the shallow sand and the bedrock are separated by over 50 ft of clay, the bedrock unit does not appear to be hydraulically connected to the shallow sand.

1.6 Groundwater Flow Rate and Direction

Groundwater elevations in the uppermost aquifer at the DE Karn Power Plant site are generally within the range of 580 to 588 feet NAVD88 and groundwater is typically encountered at equal elevation relative to the surrounding surface water features, flowing outward toward the bounding surface water features or within 6 feet higher. A representative contour map developed using data collected during the second calendar quarter of 2020 is included as Figure 3.

Although historically the point source discharge of sluiced bottom ash into the Karn Bottom Ash pond created localized mounding of the potentiometric surface, the Karn Lined Impoundment went into service on June 7, 2018 and has been continuously collecting the process water and bottom ash that went into the Karn Bottom Ash Pond. Porewater at the DE Karn Power Plant site is locally influenced by incidental infiltration from precipitation over the uncovered acreage. OW-11, OW-12, and DEK-MW-15003 represent a groundwater elevation high point with porewater flow generally flowing radially towards the adjacent surface water features. Due to the completion of closure by removal activities of the Karn Bottom Ash Pond and the completion

of the Karn Landfill capping activities, the gradient between the bottom ash pond area and the surrounding surface water bodies appears to be flattening out as compared to previous quarters, as expected.

The average hydraulic gradient throughout the Karn Lined Impoundment area during the May 2020 event is estimated at 0.0022 ft/ft. The gradient was calculated using the well pair DEK-MW-15004/DEK-MW-15005, as well as the well water elevation difference and distance between DEK-MW-15003 and the discharge channel. The discharge channel elevation was taken from the NOAA gauging station data recorded on the same date as the water level measurements. Using the mean hydraulic conductivity of 15 ft/day (ARCADIS, 2016; Appendix B) and an assumed effective porosity of 0.3, the estimated average seepage velocity was approximately 0.11 ft/day or 40 ft/year in May 2020, which is reduced relative to previous estimates (140 ft/year April 2018; 120 ft/year November 2018; 79 ft/year April 2019).

The general flow direction near the Karn Lined Impoundment is similar to those observed in previous monitoring events and continues to demonstrate that the downgradient wells are appropriately positioned to detect the presence of Appendix III constituents that could potentially migrate from the Karn Lined Impoundment.

2.0 Groundwater Monitoring Program

A detection monitoring program (performed quarterly) began in August 2018, after the Karn Lined Impoundment went into service in June 2018. This groundwater monitoring program was implemented in accordance with the Sampling and Analysis Plan (TRC, June 2018) prepared in accordance with the self-implementing CCR Rule. In November 2018, iron (Appendix III) and copper, nickel, silver, vanadium, and zinc (Appendix IV), were added to the sampling program to align with the Part 115 Amendments Detection Monitoring Constituents.

Rule 299.4905(1)(a) states that an HMP shall include a groundwater monitoring well system that is in compliance with the provisions of Rule 299.4906. The following groundwater monitoring program has been designed specific to the Karn Lined Impoundment.

Several other monitoring wells are present at the DE Karn Power Plant site and are used for routine monitoring throughout the site in accordance with the 2017 Karn Landfill HMP and the CCR Rule, and some wells are utilized in multiple programs (Figure 2). Data from the other monitoring wells will be utilized as needed to supplement the groundwater flow interpretation and/or alternate source demonstrations.

2.1 Groundwater Monitoring Well Network

In accordance with §257.91, Consumers Energy developed a groundwater monitoring system for the Karn Lined Impoundment prior to the initial receipt of waste in the CCR unit (TRC, 2018c). The groundwater monitoring system design incorporates an *intrawell statistical approach* for detection monitoring based on the following factors and in accordance with the "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance" (USEPA, 2009):

Groundwater Flow and Direction: A key assumption for an upgradient-to-downgradient interwell analysis statistical approach is that groundwater flows in a definable pathway beneath the regulated unit[3]. Although DEK-MW-15003 was initially identified as an upgradient well in the Groundwater Statistical Evaluation Plan – DE Karn Power Plant Lined Impoundment (2018 Stats Plan) (TRC, 2018a), the groundwater flow and direction in the vicinity of the Karn Lined Impoundment has been documented to demonstrate that the definable groundwater gradient has been changing in direction, depth, and magnitude based on operational changes at the Karn Power Plant site as described in Section 1.6 of this report. The lined impoundment is located near a topographical and groundwater elevation high point where groundwater from beneath the unit generally flows radially outward toward the surrounding lower elevations. Given that groundwater may flow towards both the previously determined upgradient and downgradient wells, an intrawell approach is a more valid statistical comparison to identify a potential release.

Unmonitorable Unit: The groundwater at the Karn Power Plant site has been documented as being impacted by the Karn Landfill (Consumers Energy, 2017) and Karn Bottom Ash Pond

[3] Unified Guidance (USEPA, 2009); page 6-29, paragraph 5.

(Consumers Energy, 2019). Since both of these coal ash units are located immediately adjacent to the Karn Lined Impoundment, the assumption that groundwater flow in a definable pathway from upgradient to downgradient wells beneath the CCR unit cannot be validated. Observations of groundwater impacts from the Karn Lined Impoundment can be demonstrated to be from an alternate source (see Alternate Source Demonstration – Appendix A); therefore, determining the release of constituents of downgradient wells relative to upgradient background wells cannot be achieved. An intrawell background approach allows for a reasonable baseline to be established at historically contaminated wells, which can be used to test future observations against[4]. Applying this approach for detection monitoring at the Lined Impoundment can be used to identify recent or future concentration increases above the baseline that may be indicative of a new release.

The final groundwater monitoring system well locations are shown on Figure 2. The following RCRA CCR program monitoring wells at the site that are screened in the uppermost saturated unit will be used for the Karn Lined Impoundment HMP detection monitoring and are shown on Figure 3 and Table 1:

- DEK-MW-15003
- DEK-MW-18001
- OW-01
- OW-11
- OW-12

2.2 Monitoring Well Construction

Table 1 provides a summary of monitoring well locations, construction, and elevation information. Soil boring logs and monitoring well construction details are provided in Appendix B. Each of the monitoring wells identified in Table 1 are clearly labeled and visible throughout the year. Protective covers (above-ground or flush-mounted) are installed for each of the monitoring wells.

2.3 Monitoring Parameters and Sampling Frequency

Groundwater monitoring will be conducted quarterly for the parameters identified in Section 11511a(3)(c)– Detection Monitoring Constituents during the active life of the Karn Lined Impoundment and semiannually during the postclosure care period. Table 2 provides a detailed summary of the monitoring parameters and sampling frequency of the detection monitoring program. Per Section 11511a(3)(e) of the Part 115 amendment, groundwater samples collected for metals analysis will not be field filtered.

2.4 Optional Additional Analyses

Piper and Stiff diagrams are a graphical representation of the major anion and cation composition of a water sample and are useful in assessing similarities and differences in water chemistry when compared with other water samples. These diagrams are not a required part of the detection monitoring program but may be used to further evaluate groundwater throughout the implementation of the detection monitoring program. To generate Piper and/or Stiff

[4] Unified Guidance (USEPA, 2009); page 6-32, paragraph 2.

diagrams, optional additional analyses of cation and anion constituents beyond those identified for detection monitoring will be collected as needed. The additional constituents and summary analytical method information for these optional analyses are included in Table 2.

2.5 Static Water Level Monitoring

Measurement of static groundwater level data will be collected from all monitoring wells listed on Table 1 during each sampling event, prior to sampling using the methods described in Section 3.3.2. The monitoring well locations are depicted on Figures 2 and 3.

3.0 Secondary Collection System Monitoring Program

Given that documented groundwater impacts from past operation of the Karn Bottom Ash Pond (Consumers Energy, 2019) and Karn Landfill (Consumers Energy, 2017) are indistinguishable from water quality monitored by the Karn Lined Impoundment groundwater monitoring system, the potential for a release from the Karn Lined Impoundment will be monitored utilizing a combination of intrawell trend tests as well as secondary collection system action flow rate measurements, as discussed in this section and Section 6. The Karn Lined Impoundment Secondary Collection System serves as a leak detection system and the secondary collection system flow rate data will be used to demonstrate compliance with Part 115.

Consumers Energy will remove liquids from the secondary collection system (SCS) to minimize the head on the SCS liner systems. In addition, the volumes of liquids removed from the SCS will be calculated monthly.

The leachate collection system will be inspected regularly to assure proper operation of the system in accordance with Part 115 Rule 299.4432(5).

3.1 SCS Volume Removal Data

The quantity of liquids removed from the Karn Lined Impoundment SCS will continue to be recorded weekly, as required by Part 115 Rule 299.4432(3)(b)(i). Due to the low accumulation of liquids, a reduction in the collection frequency of the Karn Lined Impoundment SCS volume removal data may be initiated based upon the provisions of Part 115, Rule 299.4432(3).

SCS volume removal data will be utilized to calculate SCS flow rates for Karn Lined Impoundment unit in gallons per acre per day (gpad). The action flow rate (AFR) for the Karn Lined Impoundment is 5 gpad per Rule 299.4432(4)(a). SCS flow rate data will be evaluated in accordance with the provisions of Rule 299.4437. The flow rate will be compared against the AFR of 5 gpad and transmitted to EGLE as part of the quarterly hydrogeologic monitoring report.

3.2 SCS Disposal

Leachate recovered from the Karn Lined Impoundment will be disposed of in accordance with Rule 299.4432(6), and in compliance with Part 31 of NREPA. Leachate is collected from the sump (Figure 3) and returned back into the primary basin.

3.3 SCS Analytical Testing Requirements

3.3.1 Sample Locations

SCS leachate is collected in a single sump. Liquid levels in the sumps are managed by pumping liquids from the sump). A composite leachate sample will be collected from the SCS sump located along the southern perimeter of Karn Lined Impoundment. The approximate sample collection location is shown on Figure 3.

3.3.2 SCS Analytical Testing Requirements

Consumers Energy will perform analytical testing of SCS liquids from the Karn Lined Impoundment if the average daily flow rate exceeds the action flow rate (AFR) of 5 gallons/acre/day (gpad). Parameters include:

- Primary Indicator Parameters: Section 11511a(3)(c) - Detection Monitoring Constituents
- Alternative Indicator Parameters: Section 11519b(2) - Assessment Monitoring Constituents
- Optional Analyses in support of Piper or Stiff diagrams

If SCS samples are required to be sampled as detailed above, samples will not be field filtered, in accordance with Table 3. Reporting limits are consistent with the monitoring plan for groundwater and are detailed on Table 3.

If the average daily flow rate decreases below the AFR in subsequent months, Consumers Energy will discontinue the sampling and analysis of the SCS liquids (Rule 299.4437(7)).

4.0 Field Sampling Procedures

The following sections address the methods and procedures associated with collection and handling of samples for the Karn Lined Impoundment groundwater monitoring system in conformance with 299.4907 of the Part 115 Rules.

4.1 Groundwater Sampling Procedures

The following sections address the methods and procedures associated with the collection and handling of groundwater samples at the site as per the requirements in 299.4907(1) of the Part 115 Rules. The monitoring well locations are shown in Figures 2 and 3. The relevant monitoring well construction details and well development information is provided in Table 1. A total of five (5) monitoring wells have been designated as a part of the monitoring well network for the Lined Impoundment CCR Unit at the DE Karn Power Plant site. In areas of known contamination, wells will be sampled from least contaminated to most contaminated well.

4.1.1 Pre-Sample Procedures

The field personnel will obtain all necessary field sampling forms (see Appendix C) to complete the fieldwork. In addition, sample bottles, trip blanks, and deionized water will be obtained from the contract laboratory prior to sample collection. Potential contaminants from the sample bottles and rinse water will be minimized by obtaining these materials directly from the laboratory.

4.1.2 Monitoring Well Inspection

Prior to opening any groundwater monitoring well, field personnel will visually inspect the protective casing and the concrete collar for damage and wear. Visual observations of the integrity of the wells will be recorded in the field notes. Field personnel will notify Consumers Energy of any damage to the monitoring wells or protective casings. Field personnel will ensure that all well caps are secured and locked when well is not in use and all wells are clearly and properly labeled and visible throughout the year.

4.1.3 Static Water Levels

After visual inspection of the monitoring well, the well will be unlocked and allowed to equilibrate with ambient air pressures prior to measuring the depths to water. Static water level measurements will be recorded using an electronic water level meter accurate to 0.01 foot, from each on-site well prior to purging and sampling. All water level measurements will be recorded within a 24-hour time period to minimize temporal bias of measured groundwater elevation changes for the monitoring well network.

Field personnel will measure water levels from an identified reference point on the well casing and record the measurement in the field notes. Depth-to-water measurements from the top-of-casing (TOC) will be subtracted from the TOC elevation to determine the potentiometric elevation.

The static water level meter will be cleaned prior to and between each monitoring well according

to the decontamination procedures described below.

4.1.4 Groundwater Sample Collection and Handling

Groundwater samples will be collected from the monitoring wells following Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures (US EPA, 1996), as detailed in the Groundwater Sampling Standard Operating Procedures (SOP) (Appendix C). Low flow sampling will commence with the installation of either a peristaltic, stainless-steel 12-volt submersible impeller pump or bladder pump to a depth representing the middle of the saturated screen interval. An appropriate length of polyethylene tubing will be connected to the pump discharge prior to pump placement. The discharge line will be connected to a flow-cell and multi-meter to collect water quality indicator parameters (described below) during well purging to determine water quality stabilization.

The pump will be operated at a flow rate that ensures low volatilization and low well disturbance. Water quality indicator parameters and depth to water will be recorded at 3 to 5-minute intervals during the purging process and recorded on the sampling worksheet provided in Appendix C. Purging and sampling will proceed at a low pumping rate, expected to be between approximately 0.1 and 0.5 liters per minute or less, such that the water column in the well is not lowered more than 0.3 feet below the initial static depth to water measurement. The subject well will be considered ready to sample when three consecutive water quality measurements meet the stabilization criteria presented below.

Parameter	Stabilization Criteria
pH	3 readings within +/- 0.1 standard units (SU)
Specific Conductance	3 readings within +/- 3% millisiemens per centimeter (mS/cm)
Temperature	For Information Only
Turbidity	+/- 10% Nephelometric Turbidity Unit (NTU) variance between three consecutive readings and a turbidity less than 10 NTU**
Oxygen Reduction Potential (ORP)	3 readings within +/- 10 millivolts (mV)
Dissolved Oxygen (DO)	3 readings within +/- 0.3 milligrams per liter (mg/L)

Note:
**See Section 4.2 for procedure if stabilization of less than 10 NTUs cannot be achieved

If the well is dry, no attempt at sampling will be conducted, as the aquifer is not considered to have sufficient quantity at that location. Additionally, if the well is pumped dry during low-flow monitoring activity, the well will be left overnight to accumulate water, then a sample collected assuming the NTU criteria can be met or, if necessary, filter the sample as laid out in Section 5.7 below. Prior to use, all equipment will be calibrated in accordance with the manufactures' recommendations. Calibration information will be recorded in the field notes.

4.2 Sample Preservation and Shipment

Samples will be collected immediately following stabilization of field parameters as set forth in in the preceding section. Groundwater samples will be collected into the laboratory provided sample containers required for the analyses specified in the following section. The groundwater samples will be collected from the discharge tubing upstream of the water quality meter flow cell. Care will be taken to allow for a non-turbulent filling of laboratory containers. Routine samples will not be filtered in the field to provide a measure of total recoverable metals that will include both the dissolved and particulate fractions of metals as per Section 11511a(3)(e) of the Part 115 amendment.

If a more detailed understanding of the source of metals concentrations in groundwater is required for select monitoring wells, field filtered samples may be analyzed in addition to routine analysis. Field filtering may also be completed on highly turbid samples (greater than 10 NTU at stabilization). Field filtering will be completed using a 0.45-micron filter. If required, an attempt will be made to redevelop any monitoring wells that produce highly turbid prior to the subsequent sampling event. Where samples are filtered, a corresponding, unfiltered sample will also be collected.

The samples will be labeled, stored and transported to the laboratory according to the Chain-of-Custody Procedures SOP presented in Appendix D. Following collection, samples will be immediately labeled, logged on the chain-of-custody, and placed in a cooler with ice. Sample coolers transported to the laboratory via overnight or next day air freight will be sealed with packing tape and a signed chain-of-custody seal. Sample coolers transported to the laboratory directly must be secured to ensure sample integrity is maintained. The samples will be packaged and shipped according to U. S. Department of Transportation and EPA regulations. The documentation of actual sample storage and transport will be by the use of chain-of-custody procedures. A laboratory provided chain-of-custody record will contain the dates and times of collection, receipt, and completion of all the analyses on a particular set of samples. The laboratory will return a copy of the chain-of-custody with the analytical report.

4.3 Secondary Collection System Leachate Sample Collection

If a secondary collection system (SCS) leachate sample is required, a grab sample will be collected by inserting a bailer into the SCS sump. The sample will be screened with water quality multi-meter and the pH, specific conductance, temperature, turbidity, ORP and DO at the time of sample collection will be recorded in the field notes. The sample will be labeled, stored and transported to the laboratory using the same methodologies as outlined for the groundwater samples in Section 4.4.

4.4 Quality Assurance/Quality Control (QA/QC)

Quality assurance/quality control (QA/QC) samples will be collected to ensure sample containers are free of analytes of interest, assess the variability of the sampling and laboratory methods, and monitor the effectiveness of decontamination protocols. As such, QA/QC samples will be collected on a site wide basis per sampling event rather than on a unit by unit

basis. The following QA/QC samples will be collected during each groundwater sampling event:

- Field duplicates will be collected at a frequency of one duplicate sample per 10 groundwater samples per event. The field duplicates will be collected at the same time and in the same manner as the original sample. The duplicates will be labeled as a blind sample and noted on the sampling form of the designated well.
- Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one MS/MSD sample per 20 groundwater samples per event. Duplicate and MS/MSD samples will be collected from different monitoring wells.
- Field blanks [5] will be collected at a frequency of one field blank per 20 groundwater samples.
- Equipment blanks will be collected at a frequency of one equipment blank per 20 groundwater samples per event. The equipment blank will be collected by pouring distilled or deionized water over the decontaminated static water level meter or sample tubing and into the laboratory supplied containers.

The groundwater monitoring system at the Karn Lined Impoundment consists of 5 monitoring wells. Therefore, a total of 1 field duplicate, 1 MS/MSD, 1 field blank, and 1 equipment blanks will be collected during each groundwater sampling event. The QA/QC samples will be submitted to the laboratory for the routine analyses specified in Section 2. The laboratory should provide adequate documentation of laboratory reporting and QA/QC procedures.

4.5 Equipment Decontamination Procedures

All non-dedicated equipment will be decontaminated prior to use and between samples. Non-dedicated equipment will include a water level meter and low flow sampling pump (submersible) (if used). Each item will be cleaned using distilled or deionized water, and when necessary, and non-phosphate detergent wash followed by a distilled or deionized water rinse. When a peristaltic pump is used for low flow sampling, decontamination is not required, only replacement of the pump head tubing.

All dedicated equipment will be disposed of after each sampling point. Dedicated equipment will include polyethylene tubing and bladders if a bladder pump is used for low-flow sampling.

The flow-cell and water quality multi-meter (sonde) will be decontaminated at the completion of low-flow sampling. All sample collection will occur upstream of this device and therefore will not affect groundwater sample analytical results.

4.6 Investigation Derived Waste (IDW)

All waste created during monitoring well sampling will remain on site. All purge water from the monitoring wells will be discharged back onto the ground near the well it was purged from in a

[5] Field blanks consist of analyte-free water exposed to the atmosphere during field sample collection. The water is containerized in an appropriate bottle with preservative for the analytical suite and shipped to the laboratory with the other field samples. The results are used to assess whether or not ambient/surrounding air conditions may have influenced analytical results.

manner that it does not directly enter a surface water or drain.

4.7 Field Documentation

All information pertinent to the field activities and sampling efforts will be recorded in a log or notebook following the documentation procedures presented in Section 5 of the SOP in Appendix C. Example field logs are provided in the attachments to Appendix C. At a minimum, entries in the sample logs will include the following:

- Property details and location
- Type of sample (for example, groundwater, surface water, waste)
- Number and volume of samples taken
- Sampling methodology
- Date and time of collection
- Sample identification number(s)
- Field observations including weather
- Any field measurements made (for example, pH, temperature, water depth and air monitoring data)
- Personnel present

Records shall contain sufficient information so that the sampling activity can be reconstructed without relying on the collector's memory. The sample logs will be preserved in electronic format.

5.0 Monitoring Well Installation and Development Procedures

The following sections address the methods and procedures associated with the installation of future monitoring wells, in the event that a well needs to be replaced as part of implementing this HMP. If required, field personnel will install and develop monitoring wells in accordance with the procedures detailed below.

5.1 Monitoring Well Installation Procedures

Soil borings for monitoring well installation will typically be constructed using hollow stem auger or direct push methods. At new monitoring well locations, soil samples will be collected during drilling activities in order to log local geology and verify depth to groundwater prior to well installation. Soil samples will be collected with split spoon or tube samplers at intervals appropriate to the local geology, typically ranging from continuous to 1 sample per 5-foot interval. The field personnel will log and document geology and drilling details on standard field forms similar to the logs provided in Appendix B.

Following drilling activities, soil borings will be converted into monitoring wells at the designated monitoring locations. Monitoring well casings and screens will arrive at the site in the original factory packaging and will remain in the packaging until the casing and screen materials are installed in the borehole. Permanent monitoring wells will typically be constructed of 2-inch Schedule 40 PVC flush-threaded riser pipe and equipped with a 5-foot, 0.01-inch slot screen.

After the screen and well casing are lowered into the borehole, the filter sand will be backfilled around the well screen and casing to a depth of approximately 2 feet above the top of the screen. Approximately 2 feet of bentonite chips will be used to seal the annular space above the sand pack. Additional bentonite chips or a bentonite slurry will be used to seal the remainder of the annular space above the sand pack, to approximately 1 foot below the ground surface. The slurry, if used, will be placed using a tremie from the bottom up. The remaining borehole annulus will be grouted with cement/bentonite grout to land surface.

Monitoring wells will be protected with a locking flush-mount or aboveground steel protective cover, and vented caps. The aboveground protective covers will be cemented in place around the PVC riser to stick up from the ground surface approximately 2 to 3 feet. The flush-mount protective covers will be installed flush with the ground surface, with the PVC riser finished below ground. The protective covers will be locked and clearly labeled for identification purposes. Monitoring well construction details will be recorded at the time of installation on well construction diagrams similar to the ones included in Appendix B.

5.2 Monitoring Well Development

Monitoring wells will be developed after the grout and well seal material has cured. Curing time will typically be 24 hours following well installation, although for shallow wells, where grout and well seal material is placed above the water table, well development may be performed immediately following well installation.

The development will remove fine particles around the well screen and filter pack to improve hydraulic communication between the well and the surrounding aquifer. Development will be accomplished using a pump or bailer to surge and purge the well. Development will be complete when the purge water turbidity measurements are less than 10 Nephelometric Turbidity Units (NTUs) as a goal. However, for wells that are screened in silt- or clay-rich units, this may be impractical. Development of these wells will be complete when the purge water is relatively clear (visibly) and free from suspended solids, after approximately five well volumes have been evacuated, or when well goes dry. Development notes will be recorded on the well construction diagrams.

5.3 Well Identification

Each permanent well installed will be identified as follows: DEK-MW-XXXXX. The first two digits of the variable -XX will be filled in with the last two digits of the calendar year during which the well was installed and the last three digits of the variable XXX will be filled in with the number of the well.

6.0 Laboratory Analysis

Groundwater samples collected at the Karn Lined Impoundment will be submitted to a laboratory for the analyses specified in Table 2 (Detection Monitoring). The analytical methods and practical quantitation limits (PQLs) for each detection monitoring constituent are summarized in Table 2 and the analytical methods and PQLs for each assessment monitoring constituent are summarized in Table 3. If required, and in consultation with the laboratory, a comparable analytical method may be substituted for the analytical methods in Table 2 and Table 3. Analytical methods may also be modified to incorporate newer versions of the stated methods. Samples will be submitted to a qualified laboratory for analysis using appropriate methods and chain-of-custody documentation. All analyses will be performed within required hold times and analytical methods consistent with the data quality objectives of this HMP as presented in Tables 2 and 3. The selected laboratory will follow the Laboratory Quality Assurance and Quality Control (QA/QC) procedures outlined in their Laboratory QA/QC Plan, included as Appendix D. Additional QA/QC procedures, i.e., duplicate sample collection, field data forms, and chain-of-custody procedures, are described in Section 2 of this HMP.

7.0 Data Evaluation and Reporting

Consumers Energy will evaluate the groundwater data for each constituent included in the groundwater monitoring program using statistical methods that comply with 299.4908 of the Part 115 Rules. The owner or operator of the CCR unit must select a statistical method specified pursuant to Rule 299.4908(1) to be used in evaluating groundwater monitoring data. The test shall meet the performance standards outlined in Rule 299.408(2). Statistical evaluations will be conducted in accordance with the "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance" USEPA, 2009 (Unified Guidance). The following sections describe the statistical data evaluation and reporting procedures. In addition to using applicable guidance documents, commercially available statistical evaluation tools will be utilized for the Karn Lined Impoundment groundwater data evaluation.

7.1 Statistical Evaluation of Groundwater Data

Groundwater in the vicinity of the Karn Lined Impoundment has been affected by CCR management before commencement of operation (January 2018, TRC). Given that the constituents associated with CCR currently managed in the Karn Lined Impoundment are indistinguishable from the constituents already present in groundwater from past operation of the Karn Bottom Ash Pond, intrawell trend tests, in conjunction with SCS flow rates, will be utilized to assess whether a release has occurred from operation of the unit. The detection monitoring constituent concentrations will be analyzed using Mann-Kendall and Sen's Slope trend tests to determine if there is an upward trend that may indicate a release from the Karn Lined Impoundment. The data will be analyzed in the context of the site's hydrogeologic characteristics and an assessment made as to whether the source of an upward trend, if identified, is from a possible landfill release, another on-site release, or on-site migration of nearby impact (i.e., Karn Bottom Ash Pond).

Data evaluation will include the following:

- Review of time versus concentration plots to:
  - Evaluate potential long-term trends in data
  - Identify potential outliers or otherwise unusual observations
- Perform trend analysis on the most recent eight sample results, such that trend analysis reflects recent conditions:
  - If concentrations of a given constituent at a well are generally lower than the Practical Quantitation Limit (PQL) (e.g, >70%), then trend analysis will not be performed, and the dataset will be designated as a non-detect dataset.
  - If concentrations are greater than the PQL, then trend analysis will be performed as outlined below:
    - Sen's estimate of slope will be performed to determine whether trend is upward or downward,
    - Mann-Kendall trend analysis (a non-parametric test) will be performed to determine whether or not the trend is statistically significant,
    - Two-sided, 95% confidence,

- Substitute ½ the PQL for non-detects when the percentage of non-detects is 15% or less of the total number of sample observations, or substitute the PQL for non-detects when the percentage of non-detects is between 15-70% (consistent with the *Unified Guidance*),
- Ho = no change in trend.

Consumers Energy will consider a positive statistically significant trend detected over two consecutive sampling rounds as an indicator that concentrations are increasing over time and the groundwater quality may be affected by an outside source, meaning there is a statistically significant increase (SSI) over background levels. According to Rule 299.4440(8), if the facility determines, pursuant to Rule 299.4908(5), that there is a SSI for one or more of the detection monitoring constituents, the facility will, within 14 days of the determination of an SSI, place a notice in the operating record that indicates which constituents show an SSI and notify EGLE. Within 45 days of detecting an SSI, the facility will prepare an assessment monitoring plan **<or>** demonstrate that:

- A source other than the CCR unit caused the SSI, or
- The SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

The owner or operator must complete a written demonstration (i.e., Alternative Source Demonstration; (ASD)), of the above within 30 days of confirming the SSI and submit the ASD to EGLE as required by Rule 299.4440(9). If a successful ASD is completed, a certification from a qualified professional engineer is required, and the CCR unit may continue with detection monitoring. If the ASD is successful and approved by EGLE, the facility must determine if the constituents in the groundwater render the unit unmonitorable in accordance with Rule 299.4440(9)(b).

If a successful ASD is not completed within the 30-day period, EGLE will issue a notification that the ASD was unsuccessful. Within 15 days of notification from EGLE that the demonstration was unsuccessful, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under Rule 299.4441 and submit a response action plan in accordance with requirements in Rule 299.4442. The facility will initiate the assessment monitoring program within 60 days of the submittal of the assessment monitoring plan as required in Rule 299.4441 and within 90 days of detecting a SSI as described further in Section 6.2 below.

Additionally, as required by Rule 299.4432 the results of the SCS monitoring data collection and evaluation will be placed in Consumers Energy files. If the AFR is exceeded, Consumers Energy will evaluate the quality of SCS liquids in accordance with Rule 299.4437(6) as outlined in Section 3.5. The AFR for the Karn Lined Impoundment is 5 gpad. Additional reporting and response action will be performed if monitoring indicates that the flow rates specified in or established in accordance with Rule 299.4437 are exceeded, hazardous constituent's indicative of leachate from the landfill unit are detected in the SCS, and the demonstration allowed by Rule 299.4437(6) cannot be made.

7.2 Assessment Monitoring

As discussed in Section 6.1, the facility must begin assessment monitoring for the CCR unit if an SSI is identified, and the SSI cannot be attributed to an ASD. Per Rule 299.4441, assessment monitoring must begin within 60 days of the assessment monitoring plan submittal. Per the CCR Rule, assessment monitoring must begin within 90 days of identification of an SSI that is not attributed to an alternative source. Wells included in the groundwater monitoring system will be sampled for assessment monitoring constituents identified in Table 3. Within 14 days of receiving sample results, the owner or operator will place a notice of the detected assessment monitoring parameters in the operating record and notify EGLE in accordance with Rule 299.4441(4)(a). Within 90 days of obtaining the results from the first assessment monitoring event, all of the wells will be sampled for detection monitoring and the detected assessment monitoring constituents in the initial assessment monitoring event.

If assessment monitoring is triggered pursuant to Rule 299.4440(8), data are compared to Groundwater Protection Standards (GWPSs) or background groundwater quality. The CCR Rule [§257.95(h)] and the Part 115 Rule [299.4441(4)(d)], require GWPSs to be established for assessment monitoring constituents that have been detected during baseline sampling, in addition, Part 115 requires GWPSs to be established for detection monitoring constituents. The GWPSs will be developed in accordance with Rule 299.4441(9). For GWPSs that are established using background, tolerance limits are anticipated to be used to calculate the GWPS. The background will be updated every two years, along with the resulting GWPS, consistent with the Unified Guidance. If additional assessment monitoring parameters become detected during the assessment monitoring, GWPSs will be developed for those parameters in the same manner as the initial parameters.

Consistent with the Unified Guidance, the preferred method for comparisons to a fixed standard will be confidence limits. An exceedance of the standard occurs when the 95 percent lower confidence level of the downgradient data exceeds the GWPS. Confidence intervals will be established in a manner appropriate to the data set being evaluated (proportion of non-detect data, distribution, etc.). If the statistical tests conclude that an exceedance of the GWPS has occurred, verification resampling may be conducted by the facility. Once the resampling data are available, the comparison to the GWPS or background will be evaluated.

Additionally, it is noted in §257.95(e) that if the concentrations of all constituents listed in Appendices III and IV are shown to be at or below background values using statistical procedures in §257.93(g) for two consecutive sampling events, the owner or operator may return to detection monitoring of the CCR unit. A notification must be prepared stating that the detection monitoring is resuming for the CCR unit. If statistical tests and verification resampling results corroborate the finding that an exceedance of the GWPS has occurred, the facility will conduct an assessment of corrective measures by selecting an appropriate remediation plan for the affected groundwater and implementing a remedial action plan per the requirements and schedules outlined in Rule 299.4444, and Rule 299.4445.

7.3 Reporting

Analytical results and data reports as defined below will be submitted to the director no later

than 30 days after the end of the calendar quarter in which the samples were obtained. Data reports will include the following:

- Statement of adherence to the approved HMP
- Description of the sampling event;
- Groundwater contour maps with summary of groundwater flow direction and rates.
- Tables of analytical results from the groundwater monitoring program that summarize the statistical exceedances (if any);
- Discussion of statistical data evaluation;
- Alternate source demonstration(s) (if applicable);
- Laboratory analytical results and chain of custody information;
- Field forms; and
- Signature of certified professional.

8.0 References

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Tables

Table 1
Monitoring Well Network Summary
Karn Lined Impoundment – Hydrogeological Monitoring Program
Essexville, Michigan

Well Location	Static Water Level Monitoring	HMP Sampling / Analysis Program	Northing (Int. ft)	Easting (Int. ft)	TOC Elevation (ft)	Date Installed	Geologic Unit of Screen Interval	Well Construction	Screen Interval Depth (ft BGS)			Screen Interval Elevation (ft)		
DEK Bottom Ash Pond (Water Levels Only)														
DEK-MW-15002	√	--	782691	13262817	590.87	10/9/2015	Sand	stick-up, 2" PVC, 10 Slot	10.0	to	13.0	578.3	to	575.3
DEK-MW-15004	√	--	783408	13262643	611.04	10/12/2015	Sand	stick-up, 2" PVC, 10 Slot	33.6	to	38.6	574.9	to	569.9
DEK-MW-15005	√	--	783163	13262105	589.72	10/13/2015	Sand	stick-up, 2" PVC, 10 Slot	14.5	to	19.5	572.3	to	567.3
DEK-MW-15006	√	--	782813	13262180	589.24	10/13/2015	Sand	stick-up, 2" PVC, 10 Slot	13.5	to	18.5	573.0	to	568.0
Karn Lined Impoundment														
DEK-MW-18001	√	√	782780	13263320	593.47	5/21/2018	Sand	stick-up, 2" PVC, 10 Slot	11.5	to	16.5	579.2	to	574.2
DEK-MW-15003	√	√	783113	13263202	602.74	10/12/2015	Sand	stick-up, 2" PVC, 10 Slot	21.0	to	25.0	578.8	to	574.8
OW-10	√	√	782739	13263728	591.58	5/20/2010	Silty Sand & Silty Clay	stick-up, 2" PVC, 0.007 inch	13.9	to	18.9	576.0	to	571.0
OW-11	√	√	783194	13263582	607.90	5/18/2010	Silt/Fly Ash	stick-up, 2" PVC, 0.007 inch	15.1	to	20.1	587.5	to	582.5
OW-12	√	√	782858	13263023	603.07	5/19/2010	Silty Sand	stick-up, 2" PVC, 0.007 inch	16.3	to	21.3	584.2	to	579.2
KLI-SCS	--	√	782917	13263263	Not Applicable - Secondary Collection System Sump									

Notes:

Survey data from: Rowe Professional Services Company (Nov. 2015) and Consumers Energy Company drawings: SG-21733, Sheet 1, Rev. G (Karn, 11/27/18)

Elevation in feet relative to North American Vertical Datum 1988 (NAVD 88).

--: Not Applicable

TOC: Top of well casing.

Int. ft: International Feet; Michigan State Plane South

ft BGS: Feet below ground surface.

Table 2
Detection Monitoring Constituents and Analytical Program Summary
Karn Lined Impoundment — Hydrogeological Monitoring Program
Essexville, Michigan

Part 115 Amendments - Public Act No. 640 of 2018							
Section 11511a(3)(c) - Detection Monitoring Constituents							
CONSTITUENT	**MONITORED UNDER 40 CFR 257 SUBPART D**	**ANALYTICAL METHOD**	**PRESERVATION[2]**	**HOLD TIME**	**REPORTING LIMIT (µg/L)**	**FILTER**	**FREQUENCY[3]**
Boron	√	6010/6020	HNO_3, pH <2	180 days	50	no	Quarterly
Calcium	√	6010/6020	HNO_3, pH <2	180 days	1,000	no	Quarterly
Chloride	√	EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly
Fluoride[1]	√	EPA 300.0	None	28 days	1,000	no	Quarterly
Iron	--	6010/6020	HNO_3, pH <2	6 months	20	no	Quarterly
pH	√	Stabilized field measurement	--	--	0.1 standard units	no	Quarterly
Sulfate	√	EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly
Total Dissolved Solids	√	SM 2540C	None, <6ºC	7 days	50,000	no	Quarterly
Optional Additional Constituents							
Bicarbonate, carbonate, and total alkalinity	--	SM 2320B	None, <6ºC	14 days	10,000	no	Optional
Magnesium	--	6010/6020	HNO_3, pH <2	180 days	1,000	no	Optional
Sodium	--	6010/6020	HNO_3, pH <2	180 days	1,000	no	Optional
Potassium	--	6010/6020	HNO_3, pH <2	180 days	500	no	Optional

Notes:

HNO_3: Nitric acid

--: Not applicable

[1] Listed in both detection and assessment monitoring constituent lists.

[2] All samples will be cooled to 4°C as part of sample preservation.

[3] Frequency reduction to semiannual will be evaluated after a minimum of 8 quarterly events have been completed.

Table 3
Assessment Monitoring Constituents and Analytical Program Summary
Karn Lined Impoundment – Hydrogeological Monitoring Program
Essexville, Michigan

Part 115 Amendments - Public Act No. 640 of 2018							
Section 11511a(3)(c) - Detection Monitoring Constituents							
CONSTITUENT	**MONITORED UNDER 40 CFR 257 SUBPART D**	**ANALYTICAL METHOD**	**PRESERVATION[3]**	**HOLD TIME**	**REPORTING LIMIT (µg/L)**	**FILTER**	**FREQUENCY[4]**
Boron	√	6010/6020	HNO_3, pH <2	180 days	50	no	Quarterly
Calcium	√	6010/6020	HNO_3, pH <2	180 days	1,000	no	Quarterly
Chloride	√	EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly
Fluoride[1]	√	EPA 300.0	None	28 days	1,000	no	Quarterly
Iron	--	6010/6020	HNO_3, pH <2	6 months	20	no	Quarterly
pH	√	Stabilized field measurement	--	--	0.1 standard units	no	Quarterly
Sulfate	√	EPA 300.0	None, <6ºC	28 days	2,000	no	Quarterly
Total Dissolved Solids	√	SM 2540C	None, <6ºC	7 days	50,000	no	Quarterly
Section 11519b(2) - Assessment Monitoring Constituents							
Antimony	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Arsenic	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Barium	√	6020	HNO_3, pH <2	180 days	5	no	Quarterly
Beryllium	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Cadmium	√	6020	HNO_3, pH <2	180 days	0.2	no	Quarterly
Chromium, total	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Cobalt	√	6020	HNO_3, pH <2	180 days	6	no	Quarterly
Copper	--	6020	HNO_3, pH <2	6 months	1	no	Quarterly
Fluoride[1]	√	EPA 300.0	None, <6ºC	28 days	1,000	no	Quarterly
Lead	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Lithium	√	6010/6020	HNO_3, pH <2	180 days	10	no	Quarterly
Mercury	√	7470	HNO_3, pH <2	28 days	0.2	no	Quarterly
Molybdenum	√	6020	HNO_3, pH <2	180 days	5	no	Quarterly
Nickel	--	6010/6020	HNO_3, pH <2	6 months	2	no	Quarterly
Selenium	√	6020	HNO_3, pH <2	180 days	1	no	Quarterly
Silver	--	6020	HNO_3, pH <2	6 months	0.2	no	Quarterly
Thallium	√	6020	HNO_3, pH <2	180 days	2	no	Quarterly
Vanadium	--	6020	HNO_3, pH <2	6 months	2	no	Quarterly
Zinc	--	6020	HNO_3, pH <2	6 months	10	no	Quarterly
Radium 226 and 228 combined[2]	√	EPA 903.1/904.0	HNO_3, pH <2	None	1.00 picocurie per liter (pCi/L)	no	Semiannual

Notes:

HNO_3: Nitric acid --: Not applicable

[1] Listed in both detection and assessment monitoring constituent lists

[2] Requires a larger sample volume (minimum 2 liter)

[3] All samples will be cooled to 4°C as part of sample preservation.

[4] Frequency reduction to semiannual will be evaluated after a minimum of 8 quarterly events have been completed.

Table 3
Assessment Monitoring Constituents and Analytical Program Summary
Karn Lined Impoundment – Hydrogeological Monitoring Program
Essexville, Michigan

Optional Additional Constituents							
CONSTITUENT	MONITORED UNDER 40 CFR 257 SUBPART D	ANALYTICAL METHOD	PRESERVATION[3]	HOLD TIME	REPORTING LIMIT (µg/L)	FILTER	FREQUENCY[4]
Bicarbonate, carbonate, and total alkalinity	--	SM 2320B	None, <6ºC	14 days	10,000	no	Optional
Magnesium	--	6010/6020	HNO_3, pH <2	180 days	1,000	no	Optional
Sodium	--	6010/6020	HNO_3, pH <2	180 days	1,000	no	Optional
Potassium	--	6010/6020	HNO_3, pH <2	180 days	500	no	Optional

Notes:

HNO_3: Nitric acid --: Not applicable

[1] Listed in both detection and assessment monitoring constituent lists

[2] Requires a larger sample volume (minimum 2 liter)

[3] All samples will be cooled to 4°C as part of sample preservation.

[4] Frequency reduction to semiannual will be evaluated after a minimum of 8 quarterly events have been completed.

Figures

BASE MAP FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE SERIES.

N

1 " = 3,000 '
1:36,000

0 3,000 6,000 FEET

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

TRC - GIS

PROJECT:

CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:

SITE LOCATION MAP

DRAWN BY:	S. MAJOR
CHECKED BY:	D. LITZ
APPROVED BY:	G. CROCKFORD
DATE:	AUGUST 2020
PROJ. NO.:	367388-001-002
FILE:	367388-001-007slm.mxd

FIGURE 1

S:\1-PROJECTS\Consumers_Energy_Company\Michigan\CCR_GW\2017_269767\367388-001-007slm.mxd -- Saved By: SMAJOR on 8/24/2020, 08:33:29 AM

LEGEND

- DEK BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK BOTTOM ASH POND MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- DECOMMISSIONED MONITORING WELL
- MONITORING WELL (STATIC ONLY)
- SURFACE WATER GAUGING STATION
- NATURE AND EXTENT WELL
- SLURRY WALL (APPROXIMATE)
- LINED IMPOUNDMENT (COVENANT BOUNDARY)
- LANDFILL (COVENANT BOUNDARY)
- FORMER BOTTOM ASH POND (LIMITS OF EXCAVATION)

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. NOAA/NATIONAL OCEANIC SERVICE GREAT LAKES GAUGING STATION, ESSEXVILLE, MI (ID: 9075035).

N

0 600 1,200 Feet

1 " = 600 '
1:7,200

PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN POWER PLANT
ESSEXVILLE, MICHIGAN

TITLE:
SITE FEATURES MAP

DRAWN BY:	S. MAJOR	PROJ NO.:	367388.0001
CHECKED BY:	D. LITZ		
APPROVED BY:	D. LITZ		**FIGURE 2**
DATE:	AUGUST 2020		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trccompanies.com

FILE NO.: 367388-001-008x.mxd

Plot Date: 8/27/2020, 14:20:40 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: S:\1-PROJECTS\Consumers Energy Company\Michigan\CCR GW\2017 269767\367388-001-008x.mxd
Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0
TRC - GIS

LEGEND

- DEK BOTTOM ASH POND MONITORING WELL
- DECOMMISSIONED WELL
- BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- MONITORING WELL (STATIC WATER LEVEL ONLY)
- SECONDARY CONTAINMENT SUMP (KLI-SCS)
- LINED IMPOUNDMENT (COVENANT BOUNDARY)
- EXTENT OF GEOSYNTHETICS

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. SECONDARY CONTAINMENT SUMP LOCATION BASED ON DRAWINGS 695-1278-120-REV-A.DWG DATED 11/27/19, PROVIDED BY CONSUMERS ENERGY.

N

0 200 400 Feet

1 " = 200 '
1:2,400

PROJECT:

CONSUMERS ENERGY COMPANY
DE KARN POWER PLANT
ESSEXVILLE, MICHIGAN

TITLE:

KARN LINED IMPOUNDMENT AREA

DRAWN BY:	S. MAJOR	PROJ NO.:	367388-001
CHECKED BY:	D. LITZ		
APPROVED BY:	D. LITZ		**FIGURE 3**
DATE:	AUGUST 2020		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080

FILE NO.: 367388-001-009.mxd

Plot Date: 8/27/2020, 15:32:37 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
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Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0
TRC - GIS

LEGEND

- DECOMMISSIONED MONITORING WELL
- MONITORING WELL (STATIC ONLY)
- SURFACE WATER GAUGING STATION
- NATURE AND EXTENT WELL
- SLURRY WALL (APPROXIMATE)
- LINED IMPOUNDMENT (COVENANT BOUNDARY)
- GROUNDWATER ELEVATION CONTOUR (1' INTERVAL, DASHED WHERE INFERRED)
- *(580.50)* GROUNDWATER ELEVATION (FEET)
- *(NM)* NOT MEASURED

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. NOAA/NATIONAL OCEANIC SERVICE GREAT LAKES GAUGING STATION, ESSEXVILLE, MI (ID: 9075035).

N

0 600 1,200 Feet

1 " = 600 '
1:7,200

PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN POWER PLANT
ESSEXVILLE, MICHIGAN

TITLE:
SHALLOW GROUNDWATER CONTOUR MAP
MAY 11, 2020

DRAWN BY:	S. MAJOR	PROJ NO.:	367388.0001
CHECKED BY:	J. KRENZ		
APPROVED BY:	D. LITZ		
DATE:	AUGUST 2020		

FIGURE 4

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
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FILE NO.: 367388-001-010.mxd

Plot Date: 8/27/2020, 11:11:49 AM by SMAJOR -- LAYOUT: ANSI B (11"x17")
Path: S:\1-PROJECTS\Consumers Energy Company\Michigan\CCR GW\2017 2697\7367388-001\Map Projects\
Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
TRC - GIS

Appendix A
Alternate Source Demonstration
(January 2020)

Consumers Energy
Count on Us®

A CMS Energy Company

Date: January 27. 2020

To: Operating Record

From: Harold D. Register, Jr., P.E. HDR

RE: Alternate Source Demonstration Professional Engineer Certification, §257.94(e)(2)
DE Karn Lined Surface Impoundment CCR Unit

Professional Engineer Certification Statement [40 CFR 257.94(e)(2)]

I hereby certify that the alternative source demonstration presented within this document for the DE Karn Lined Impoundment CCR unit has been prepared to meet the requirements of Title 40 CFR §257.94(e)(2) of the Federal CCR Rule. This document is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of Title 40 CFR §257.94(e)(2).

Harold D. Register Jr.

Signature

January 27, 2020

Date of Certification

Harold D. Register, Jr., P.E.

Name

6201056266

Professional Engineer Certification Number

STATE OF MICHIGAN
HAROLD D. REGISTER, JR.
ENGINEER
No. 6201056266
LICENSED PROFESSIONAL ENGINEER

01/27/2020

ENCLOSURES

TRC (December 2019). "*Alternate Source Demonstration: October 2019 Detection Monitoring Sampling Event DE Karn Lined Impoundment, Consumers Energy Company, Essexville, Michigan*"

1540 Eisenhower Pl.
Ann Arbor, MI 48108

T 734.971.7080
TRCcompanies.com

Technical Memorandum

Date: December 19, 2019

To: J.R. Register, Consumers Energy

From: Darby Litz, TRC

Kristin Lowery, TRC

cc: Brad Runkel, Consumers Energy
Bethany Swanberg, Consumers Energy

Project No.: 322172.0000 Phase 001, Task 003

Subject: Alternate Source Demonstration: October 2019 Detection Monitoring Sampling Event DE Karn Lined Impoundment, Consumers Energy Company, Essexville, Michigan

Introduction

Pursuant to the United States Environmental Protection Agency's (U.S. EPA's) Resource Conservation and Recovery Act (RCRA) Coal Combustion Residuals rule (the CCR Rule), promulgated on April 17, 2015, Consumers Energy initiated a detection monitoring program for the Karn Lined Impoundment CCR unit that includes semiannual sampling for constituents listed in Appendix III to Part 257 of the CCR Rule. The second semiannual detection monitoring event for 2019 was conducted on October 14 through 16, 2019. The October 2019 event is the detection monitoring compliance event per the CCR Rule; however, a supplemental sampling event was also conducted on August 13 and 14, 2019 to further assess changing site conditions relative to the dewatering and CCR removal from the Karn Bottom Ash Pond to support evaluation of the potential for a future intra-well statistical program for detection monitoring. Pursuant to §257.93(f) and (g), and in accordance with the *Groundwater Statistical Evaluation Plan* (Stats Plan) (TRC, June 2018), the October 2019 detection monitoring results were statistically evaluated to identify potential statistically significant increases (SSIs) in detection monitoring constituents to determine if concentrations in detection monitoring well samples exceed background levels.

The statistical evaluation of the October 2019 Appendix III constituents showed potential SSIs over background levels for:

- Boron at DEK-MW-18001
- Calcium at OW-12

- Chloride at DEK-MW-18001, OW-11, and OW-12
- Sulfate at OW-12
- Total dissolved solids at OW-12
- pH at OW-12

All other Appendix III constituent concentrations were within the statistical background limits.

In accordance with §257.94(e)(2), Consumers Energy may demonstrate that a source other than the CCR unit caused the SSI or that the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The following Alternate Source Demonstration (ASD) has been prepared to address the potential SSIs identified in the October 2019 detection monitoring event.

Alternate Source Demonstration

The following ASD evaluation provides multiple lines of evidence of alternative sources for the potential SSIs indicated for boron, calcium, chloride, sulfate, total dissolved solids (TDS), and pH at the Karn Lined Impoundment. The groundwater chemistry observed in the Karn Lined Impoundment monitoring well network is due to the history of CCR-related operations throughout the DE Karn Site, rather than a release from the new impoundment. These lines of evidence have been updated to reflect current site conditions and are consistent with information that has been presented in past ASDs:

- boron, chloride, fluoride, and sulfate[1]
- pH[2].

New Unit Construction

The liner system for the Karn Lined Impoundment was designed as a double composite liner system, with the primary and secondary composite liners each consisting of 60-mil (HDPE) geomembrane (GM) overlaying a 236-mil geosynthetic clay liner (GCL). The double composite liner system construction and the limited active life (only one year) of the Karn Lined Impoundment make it unlikely that wet ash dewatering liquids managed within the unit have migrated through the liner system and affected groundwater quality.

Secondary Collection System (SCS) Chemistry

Piper diagrams were prepared using the groundwater and KLI-SCS sample data collected during the August 2019 and October 2019 events (Attachment 1). The leachate chemistry (KLI-SCS) is distinctly different from the groundwater chemistry observed at the Karn Lined Impoundment wells. The piper diagrams also illustrate that the groundwater chemistry observed at the downgradient wells are not

[1] TRC. 2019. *Detection Monitoring Data Summary and Background Statistical Evaluation, Consumers Energy, DE Karn Site, Lined Impoundment CCR Unit.* March 13.
[2] TRC. 2019. *April 2019 Detection Monitoring Data Summary, Consumers Energy, DE Karn Site, Lined Impoundment CCR Unit*. Revised October 15.

uniquely different than the background wells, even if an individual downgradient concentration comparison to the background based on DEK-MW-15003 indicates a potential SSI.

Pre-Existing Groundwater Conditions

The footprint of the new Karn Lined Impoundment is immediately adjacent to the pre-existing Karn Bottom Ash Pond. As reported in the *2017 Annual Groundwater Monitoring Report: DE Karn Bottom Ash Pond CCR Unit* (January 2018, TRC), potential SSIs over background limits were noted for boron, fluoride, pH, and sulfate in one or more downgradient wells during September 2017. Therefore, the groundwater in the vicinity of the Karn Lined Impoundment is documented to have been affected by CCR due to the pre-existing unit. This line of evidence is further documented in the ASD included in the *Detection Monitoring Data Summary and Background Statistical Evaluation* (March 2019, TRC).

Limited Background Sampling Timeline to Capture Change in Background Conditions

As mentioned above, the Karn Bottom Ash Pond has completed source removal activities which included: reducing hydraulic loading (potential for infiltration to groundwater), dewatering by gravity so that the local groundwater flow regime is returning to equilibrium, and the CCR has been removed and regraded with clean fill to eliminate impacts from precipitation infiltration. DEK-MW-15003 is still located upgradient of the Karn Lined Impoundment; however, conditions at DEK-MW-15003 are changing as evidenced by the attached time-series plots (Attachment 1). Limited data are available from after the change in operation of the bottom ash pond (June 2018 – present) to assess a change in background limits, and due to changes in flow direction, DEK-MW-15003 may not represent upgradient groundwater conditions. Consumers Energy will be submitting an application for operating a CCR Surface Impoundment to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) in 2020 that will require a Hydrogeological Monitoring Plan (HMP). This HMP will conform with both the federal CCR rules §257.90 - §257.94 and the state standards in PA 640. At that time the statistical evaluation program will be re-evaluated.

pH Values are Neutral and Within Expected Range

Although the pH of 7.1 standard units measured at OW-12 is 0.2 standard units below the background lower tolerance limit of 7.3 standard units, the pH value is neutral and are not indicative of a release from the Karn Lined Impoundment.

- The value for pH observed at OW-12 are similar to pH values measured in the Karn Bottom Ash Pond background wells located on the JC Weadock property. Four monitoring wells located between ¾ and 1 mile south of the Karn Bottom Ash Pond on the JC Weadock property provide data on background groundwater quality that has not been affected by the CCR unit (MW-15002, MW-15008, MW-15016, and MW-15019) (Figure 2). Background values for pH were established in these wells ranging from 6.5 to 7.3 standard units as reported in Appendix C of the *2017 Annual Groundwater Monitoring Report* (TRC, January 2018). This demonstrates that the pH value of 7.1 standard units observed at OW-12 is within the range of values expected to occur naturally in the shallow saturated unit.

- The OW-12 measured pH value is also neutral (7.0 standard units) and in the middle of the USEPA's established range of pH drinking water standards (6.5 to 8.5 S.U.) (USEPA, April 2012).

Conclusions and Recommendations

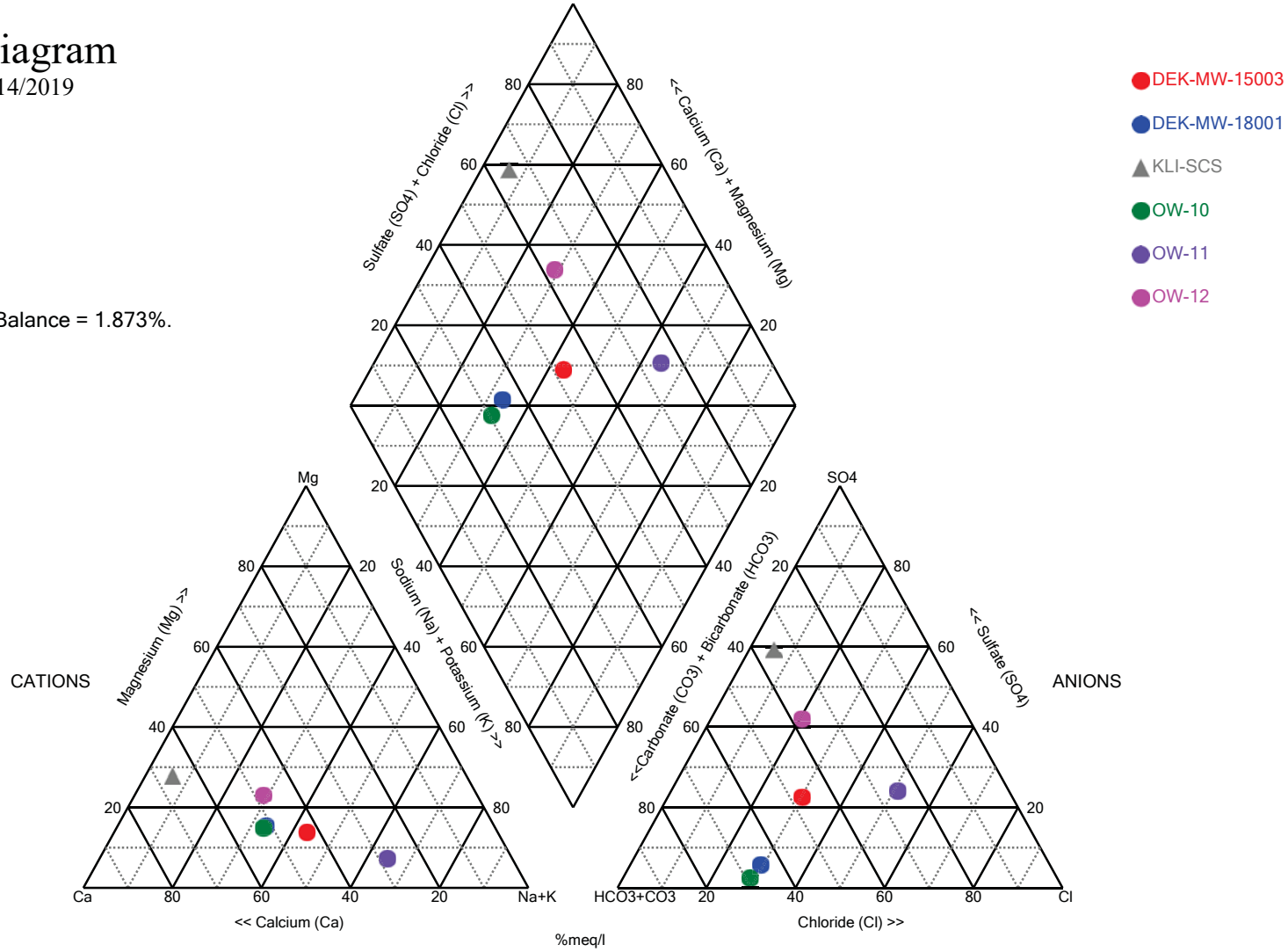
The information provided in this report serves as the ASD for the Karn Lined Impoundment, was prepared in accordance with 40 CFR 257.94(e)(2) of the CCR Rule and demonstrates that the potential SSIs determined based on the second semiannual detection monitoring event performed in 2019 is not due to a release of CCR leachate into the groundwater. Therefore, based on the information provided in this ASD, Consumers Energy will continue detection monitoring as per 40 CFR 257.94 at the Karn Lined Impoundment.

Attachment 1
ASD Supporting Documentation

Piper Diagram

8/13/2019, 8/14/2019

Cation-Anion Balance = 1.873%.



Analysis Run 12/18/2019 4:59 PM

Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Piper Diagram

Analysis Run 12/18/2019 5:00 PM

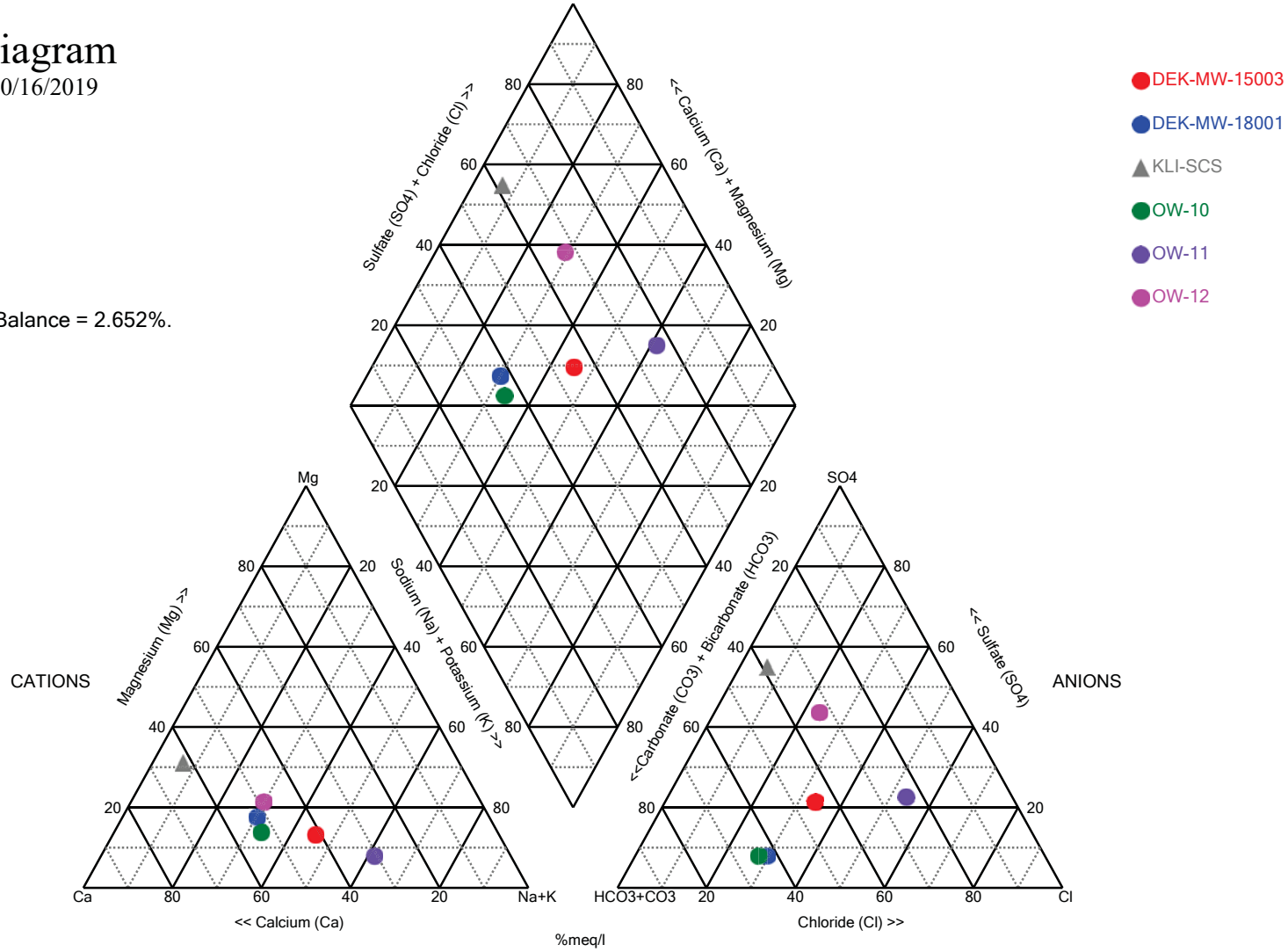
Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Totals (ppm)	Na	K	Ca	Mg	Cl	SO4	HCO3	CO3
DEK-MW-15003	46	4.6	42	8.2	56	58	140	10
DEK-MW-18001	68	5.4	95	17	78	20	290	10
KLI-SCS	14	6.4	170	43	21	350	250	10
OW-10	65	5.1	94	16	77	9	320	10
OW-11	63	5.1	25	3.8	89	58	59	10
OW-12	71	7.9	110	31.5	80	230	245	10

Piper Diagram

10/15/2019, 10/16/2019

Cation-Anion Balance = 2.652%.



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Piper Diagram

Analysis Run 12/18/2019 5:01 PM

Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Totals (ppm)	Na	K	Ca	Mg	Cl	SO4	HCO3	CO3
DEK-MW-15003	47	4.8	39	7.7	58	52	130	5
DEK-MW-18001	53	4.4	84	17	81	31	300	5
KLI-SCS	14	5.5	140	42	24	320	280	5
OW-10	62	5.1	90	14	82	31	330	5
OW-11	59	5	27	4.2	91	52	57	7.9
OW-12	88	8.95	135	35.5	120	310	290	5

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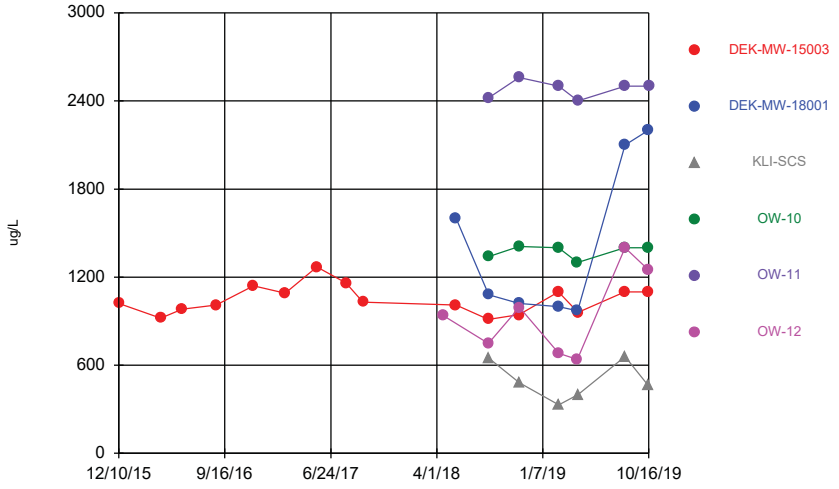
Boron, Total



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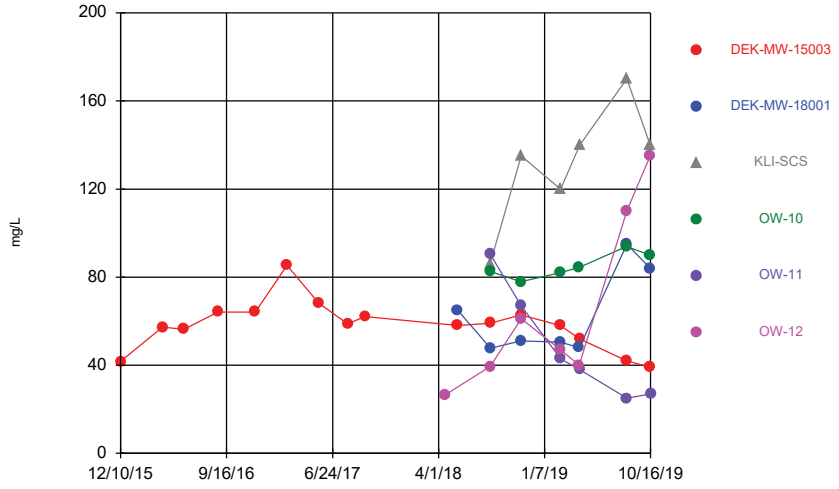
Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA

Calcium, Total



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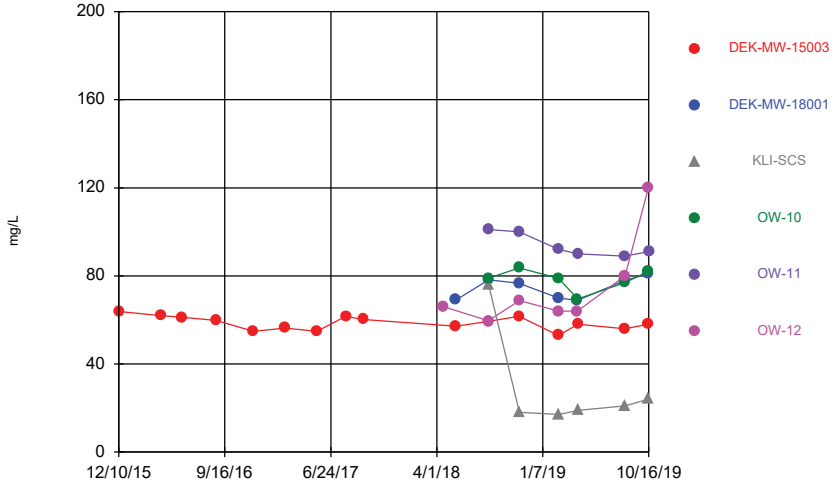
Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA

Chloride



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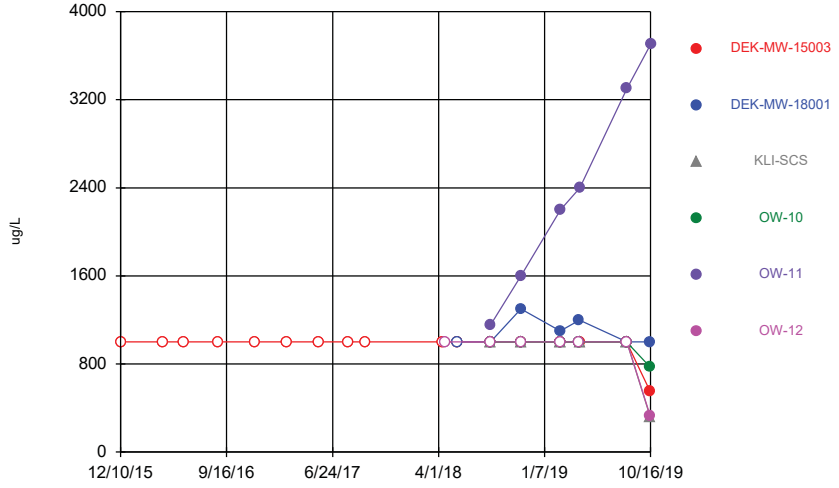
Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

Fluoride



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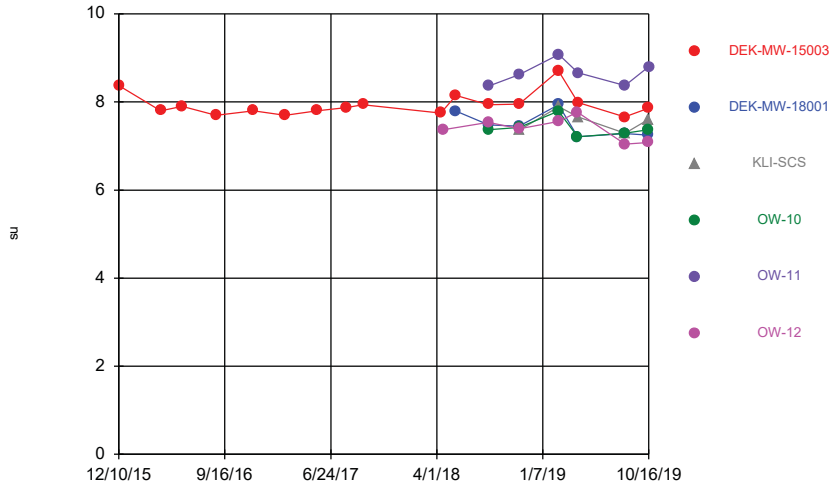
pH, Field



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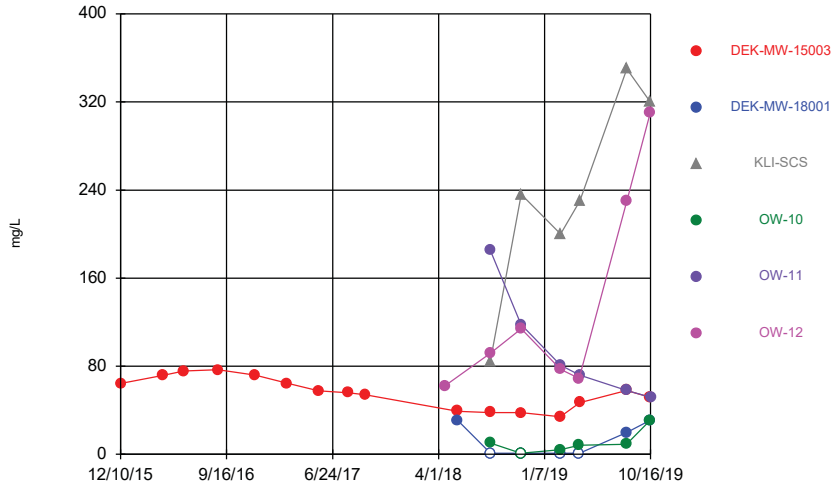
Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA

Hollow symbols indicate censored values.

Sulfate



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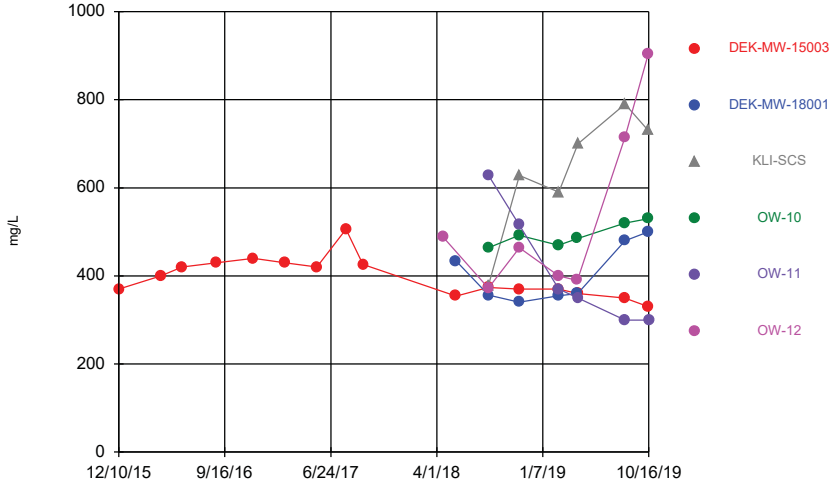
Total Dissolved Solids, Total



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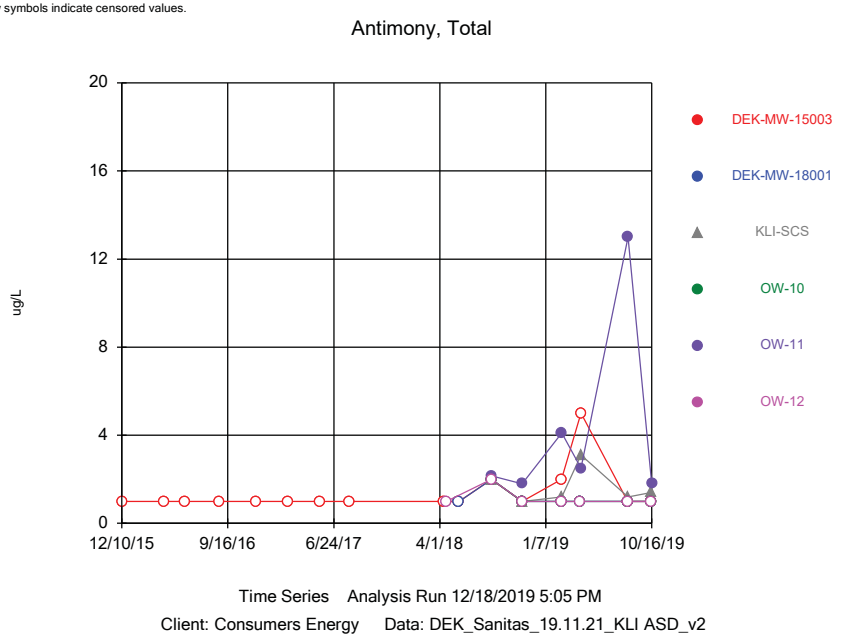

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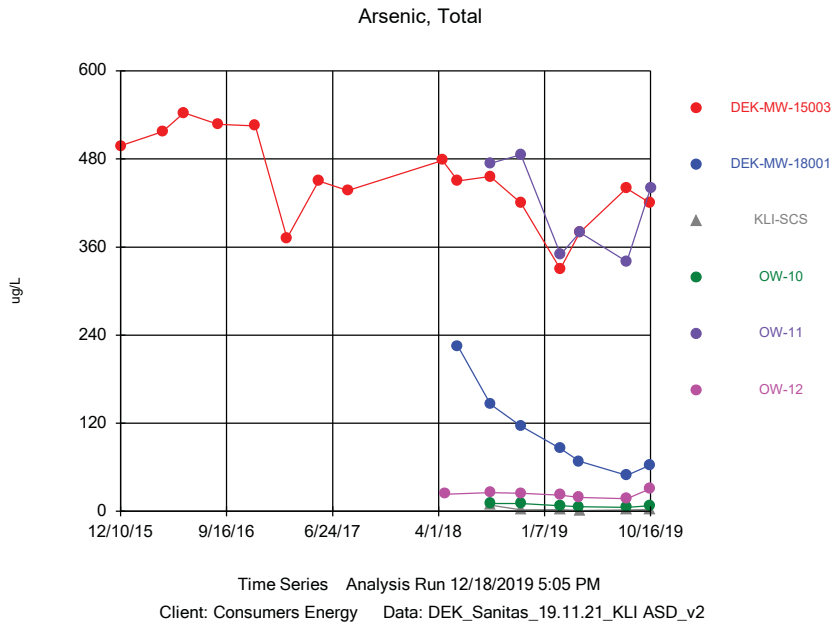

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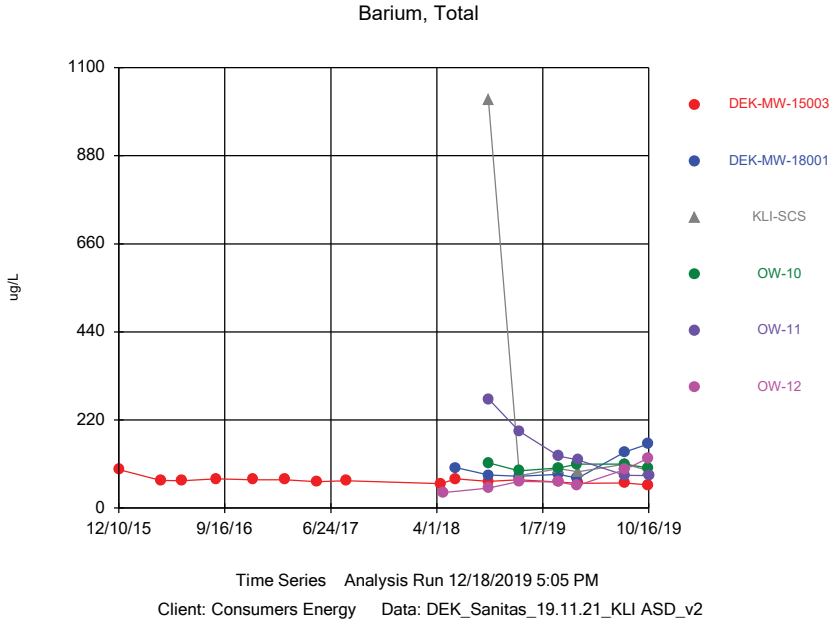

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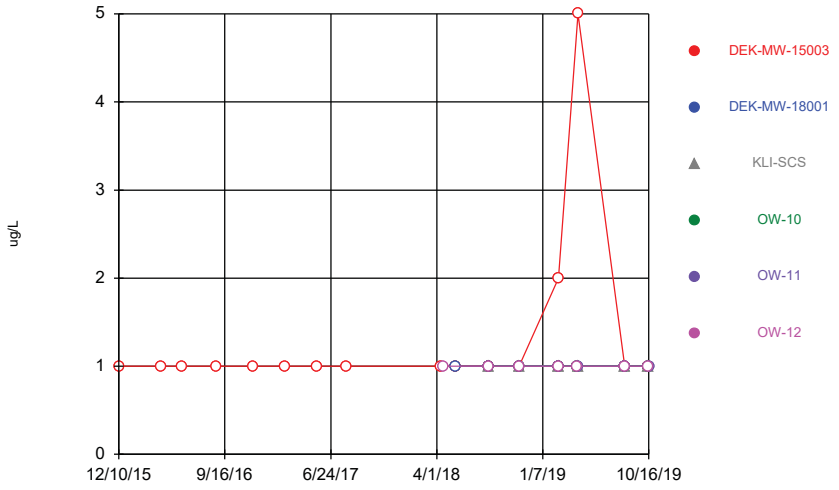
Beryllium, Total



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Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
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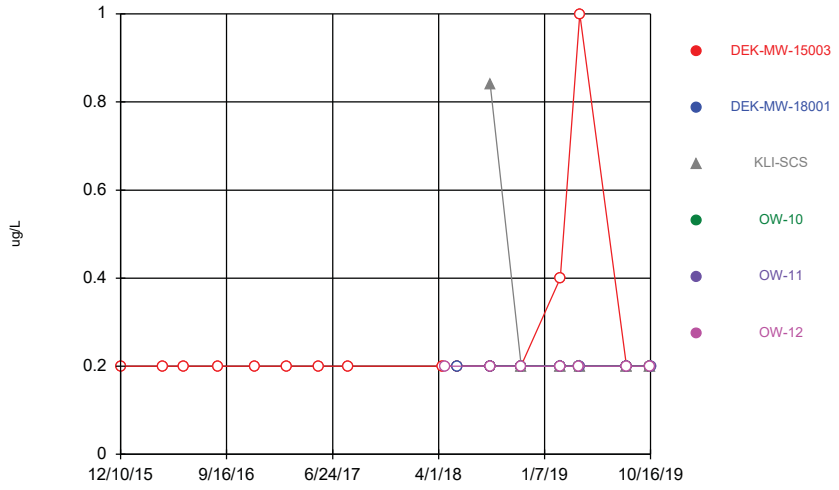
Cadmium, Total



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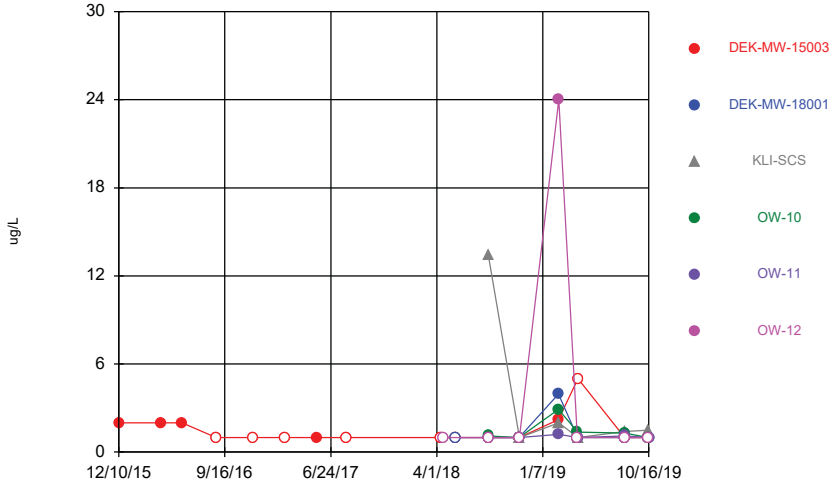
Chromium, Total



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Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
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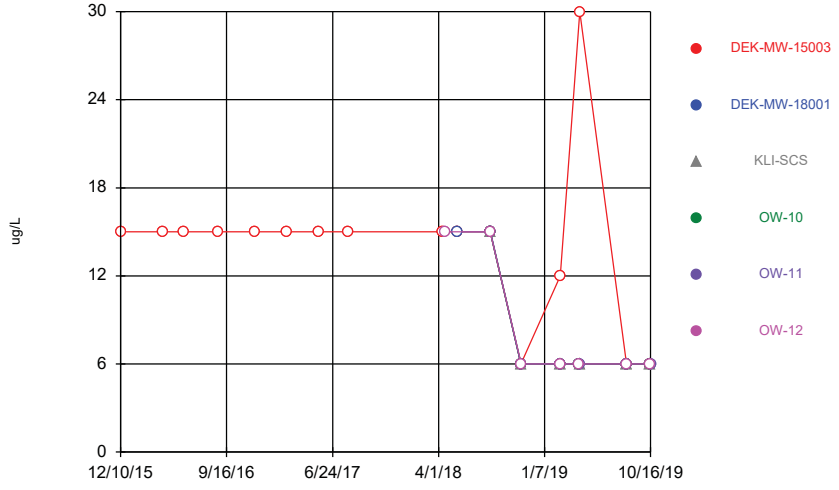
Cobalt, Total



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Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
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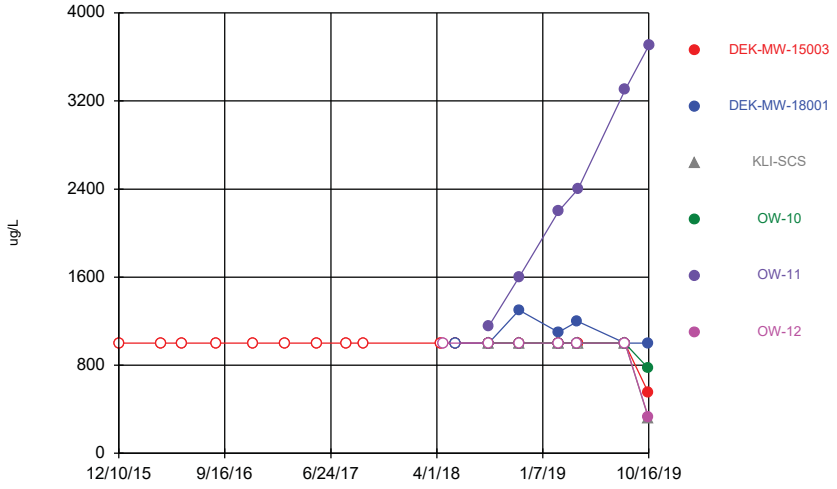
Fluoride



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Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
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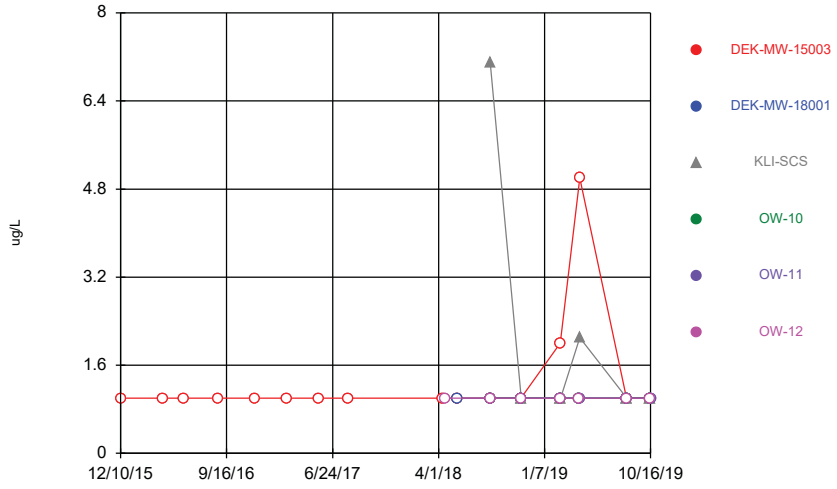
Lead, Total



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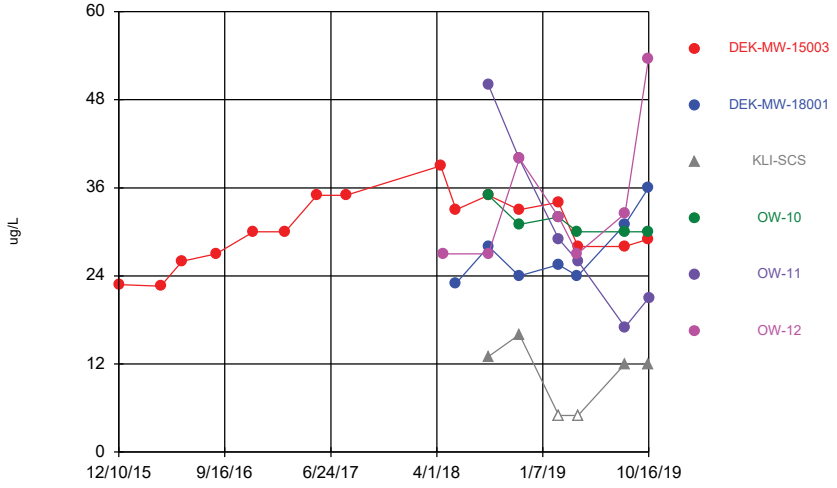
Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

Lithium, Total



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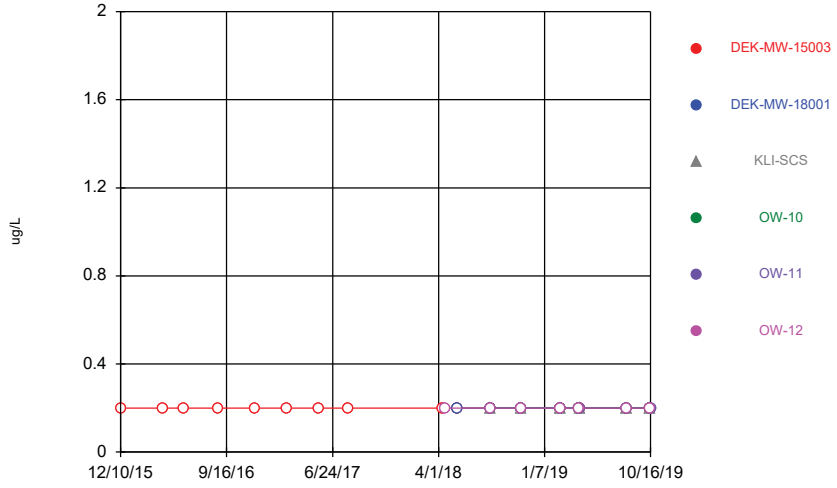
Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

Mercury, Total



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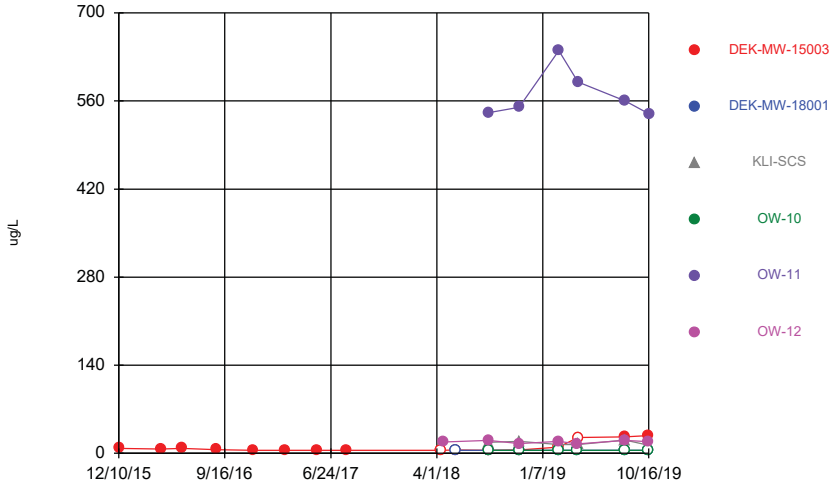
Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

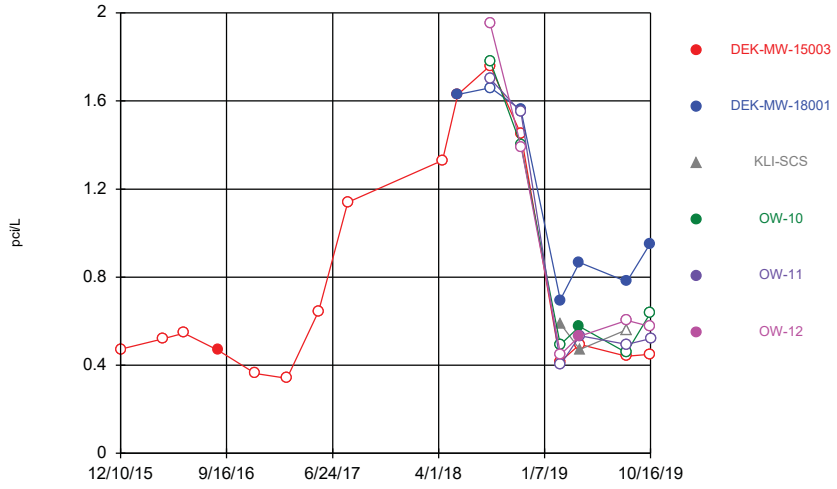
Molybdenum, Total



Time Series Analysis Run 12/18/2019 5:05 PM
Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

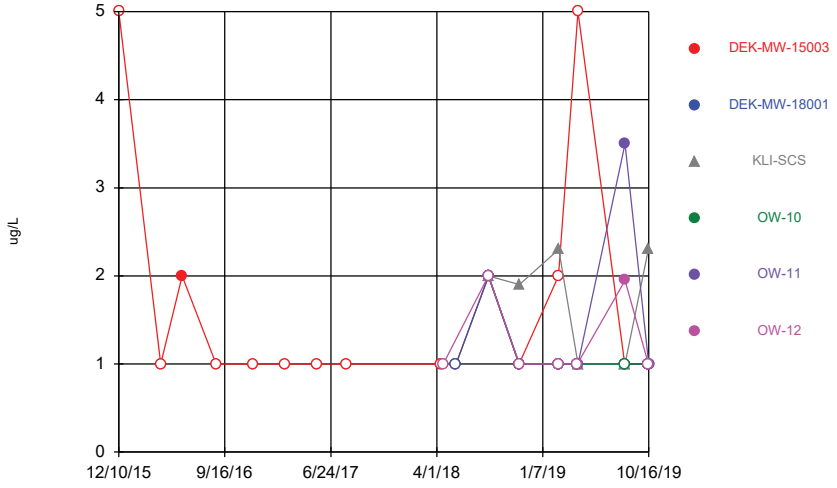
Radium-226/228



Time Series Analysis Run 12/18/2019 5:05 PM
Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

Selenium, Total



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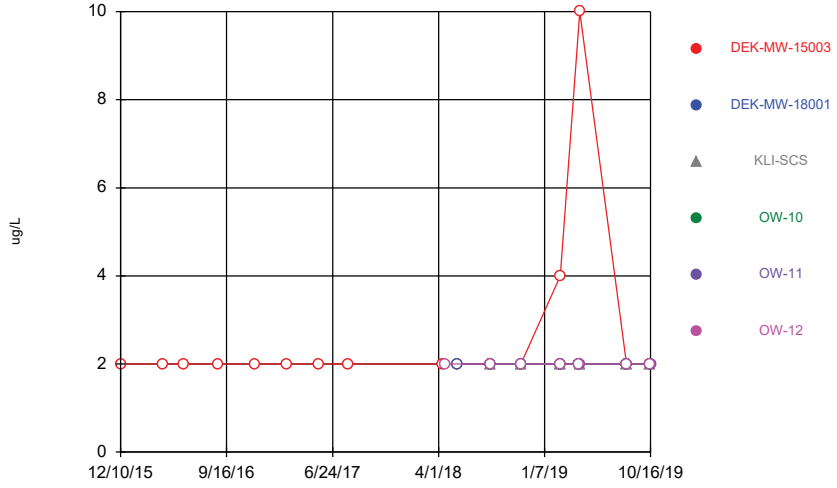
Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Sanitas™ v.9.6.24 Sanitas software licensed to Consumers Energy. EPA
Hollow symbols indicate censored values.

Thallium, Total



Time Series Analysis Run 12/18/2019 5:05 PM
Client: Consumers Energy Data: DEK_Sanitas_19.11.21_KLI ASD_v2

Appendix B
Soil Boring Logs and Well Construction Diagrams

LEGEND

- BACKGROUND MONITORING WELL
- DEK BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK BOTTOM ASH POND MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- JCW BEDROCK MONITORING WELL
- JCW BOTTOM ASH POND MONITORING WELL
- JCW LANDFILL CCR WELL
- MONITORING WELL (STATIC WATER LEVEL ONLY)
- LEACHATE HEADWELL
- DEK DECOMMISSIONED MONITORING WELL
- SURFACE WATER GAUGING STATION
- SOIL BORING
- SLURRY WALL (APPROXIMATE)
- EXTENT OF GEOSYNTHETICS (KARN LINED IMPOUNDMENT)
- CROSS SECTION LOCATION

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. NOAA/NATIONAL OCEANIC SERVICE GREAT LAKES GAUGING STATION, ESSEXVILLE, MI (ID: 9075035).

N

0 1,000 2,000 Feet

1 " = 1,000 '
1:12,000

PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:
CROSS SECTION LOCATION MAP

DRAWN BY:	S. MAJOR	PROJ NO.:	322173-001
CHECKED BY:	D. LITZ		
APPROVED BY:	G. CROCKFORD		**FIGURE 1**
DATE:	OCTOBER 2019		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trcsolutions.com

FILE NO.: 322173-001-015.mxd

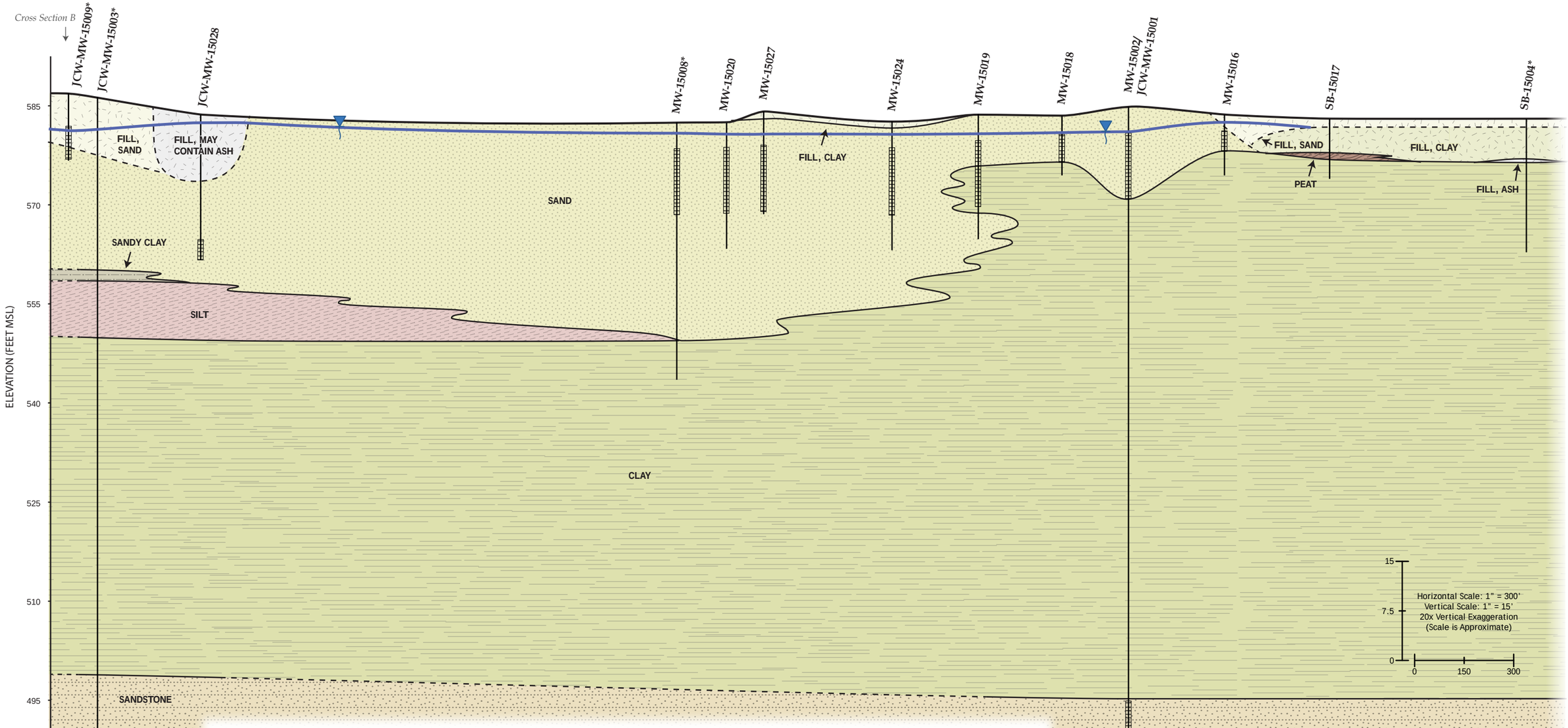
Plot Date: 10/25/2019, 12:49:49 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\322173-001-015.mxd
Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

TRC - GIS

Generalized Geologic Cross Section

A
(Northwest)

A′
(Southeast)



LEGEND

- APPROXIMATE GROUND SURFACE
- STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED
- APPROXIMATE GROUNDWATER ELEVATION (MAY 2017)

SOIL UNIT SYMBOLOGY

- FILL, MAY CONTAIN ASH
- FILL, SAND
- FILL, CLAY
- SANDY CLAY
- SAND
- CLAY
- SILT
- PEAT
- SANDSTONE

- WELL BOREHOLE
- WELL SCREEN

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM THE RCRA WELL INSTALLATION REPORTS (ARCADIS, 2016), DE KARN HMP (CEC, 2015) AND DE KARN BAP CLOSURE ASSESSMENT (GOLDER, 2017).
3. * INDICATES THAT SOIL TYPE WAS INFERRED FOR THE 0'-6' INTERVAL BECAUSE NO LITHOLOGY WAS RECORDED FOR THOSE DEPTHS.

PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS SECTION A-A'

DRAWN BY:	L. AUNER	PROJ NO.:	322173
CHECKED BY:	D. LITZ		
APPROVED BY:	G. CROCKFORD		**FIGURE 2**
DATE:	OCTOBER 2019		

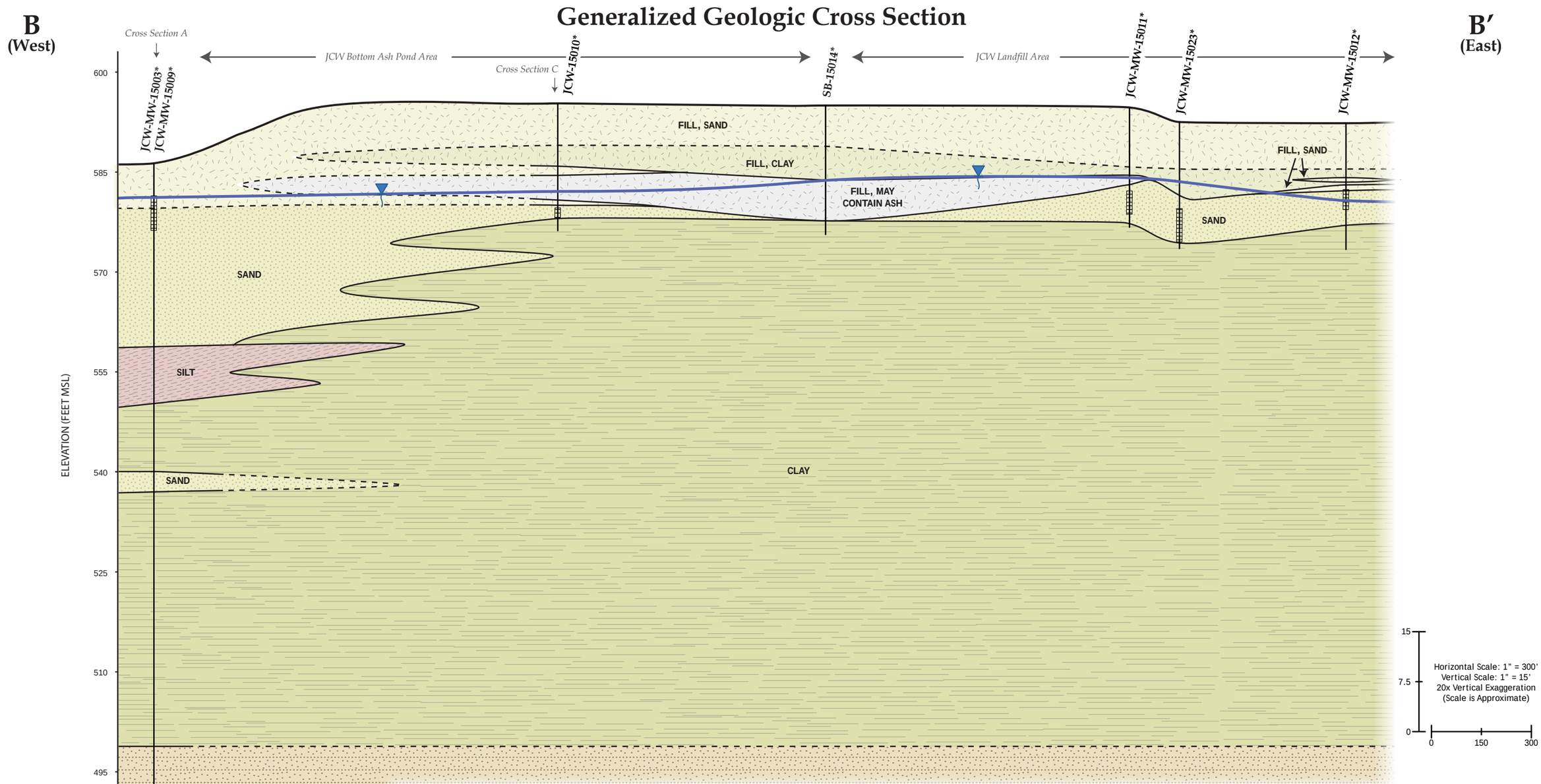
TRC

1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

FILE NO.: 322173_ai01_A.ai

File Path: P:\All\ConsumersEnergy\DEKarn_JCWeadock_EssexvilleMI\290805\322173_ai01_A.ai

Generalized Geologic Cross Section



LEGEND

- APPROXIMATE GROUND SURFACE
- STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED
- APPROXIMATE GROUNDWATER ELEVATION (MAY 2017)

SOIL UNIT SYMBOLOGY

- FILL, MAY CONTAIN ASH
- FILL, SAND
- FILL, CLAY
- SILT
- SAND
- CLAY
- SANDSTONE
- WELL BOREHOLE
- WELL SCREEN

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM THE RCRA WELL INSTALLATION REPORTS (ARCADIS, 2016), DE KARN HMP (CEC, 2015) AND DE KARN BAP CLOSURE ASSESSMENT (GOLDER, 2017).
3. * INDICATES THAT SOIL TYPE WAS INFERRED FOR THE 0'-6' INTERVAL BECAUSE NO LITHOLOGY WAS RECORDED FOR THOSE DEPTHS.

PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:
GENERALIZED GEOLOGIC CROSS SECTION B-B'

DRAWN BY:	L. AUNER	PROJ NO.:	322173
CHECKED BY:	D. LITZ		
APPROVED BY:	G. CROCKFORD		**FIGURE 3**
DATE:	OCTOBER 2019		

TRC

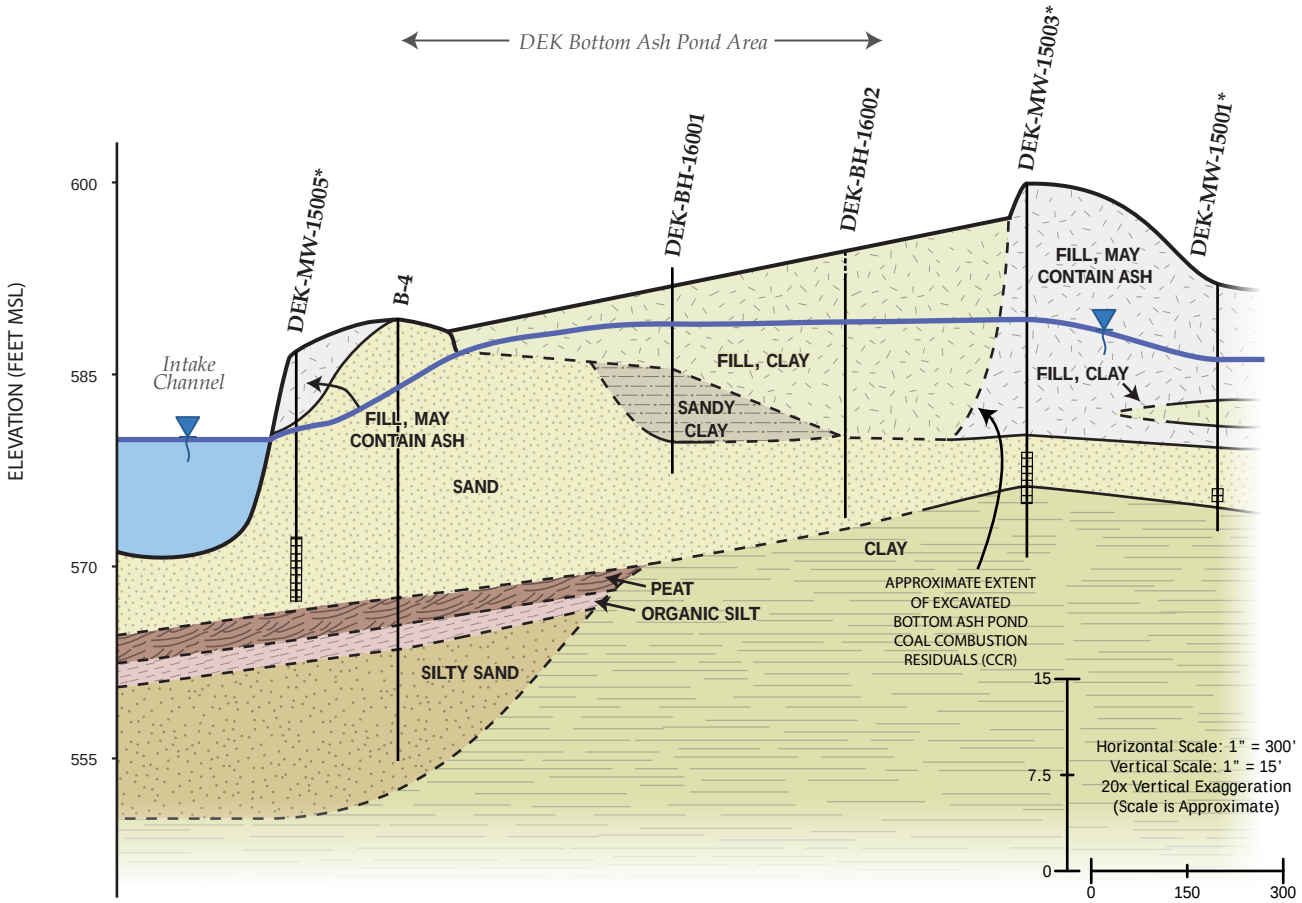
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

FILE NO.: 322173_ai02_B.ai

File Path: P:\AI\ConsumersEnergy\DEKarn_JCWeadock_EssexvilleMI\290805\322173_ai02_B

Generalized Geologic Cross Section

C (West) — **C′ (East)**



LEGEND

- APPROXIMATE GROUND SURFACE
- STRATIGRAPHIC BOUNDARY, DASHED WHERE INFERRED
- APPROXIMATE GROUNDWATER ELEVATION (MAY 2020)

SOIL UNIT SYMBOLOGY

- FILL, MAY CONTAIN ASH
- FILL, CLAY
- CCR
- CLAY
- SAND
- SILTY SAND
- SANDY CLAY
- PEAT
- ORGANIC SILT
- WELL BOREHOLE
- WELL SCREEN

NOTES

1. FEATURE LOCATIONS AND SCALE ARE APPROXIMATE.
2. CROSS SECTION BASED UPON INFORMATION FROM THE RCRA WELL INSTALLATION REPORTS (ARCADIS, 2016), DE KARN HMP (CEC, 2015) AND DE KARN BAP CLOSURE ASSESSMENT (GOLDER, 2017).
3. * INDICATES THAT SOIL TYPE WAS INFERRED FOR THE 0'-6' INTERVAL BECAUSE NO LITHOLOGY WAS RECORDED FOR THOSE DEPTHS.

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108
Phone: 734.971.7080

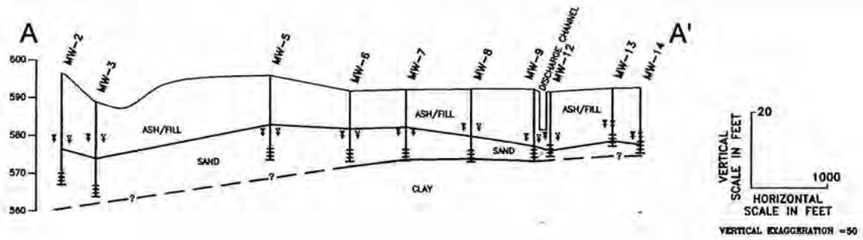
PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

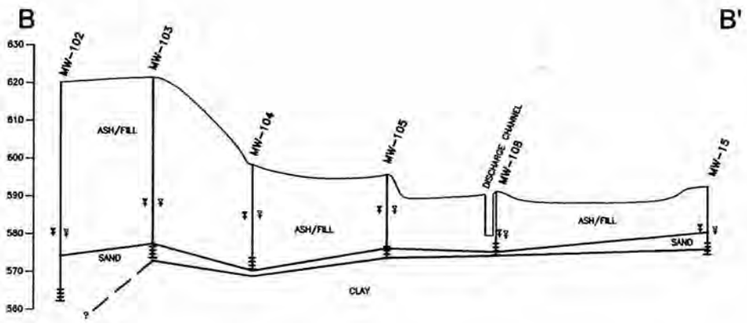
TITLE:
GENERALIZED GEOLOGIC CROSS SECTION C-C'

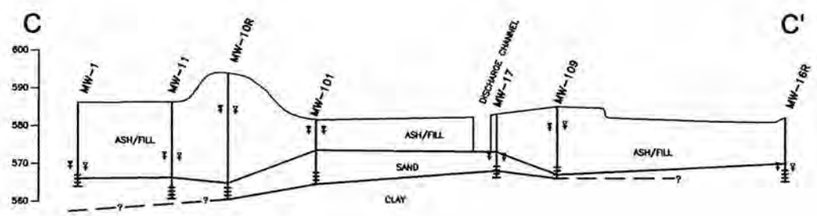
DRAWN BY:	L. AUNER
CHECKED BY:	D. LITZ
APPROVED BY:	G. CROCKFORD
DATE:	AUGUST 2020
PROJ. NO.:	367388
FILE:	367388_ai01_C.ai

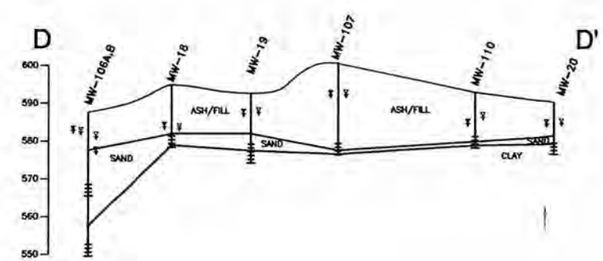
FIGURE 4

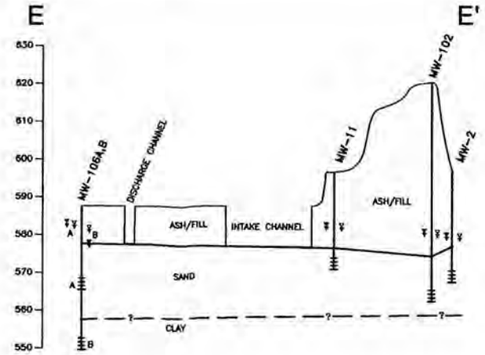
FILE PATH: P:\AI\ConsumersEnergy\DEKarn_JCWeadock_EssexvilleMI\290805

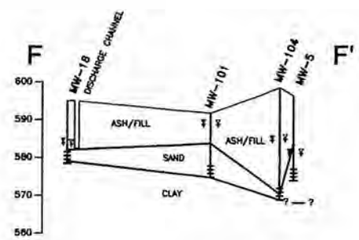


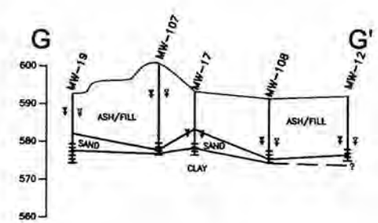


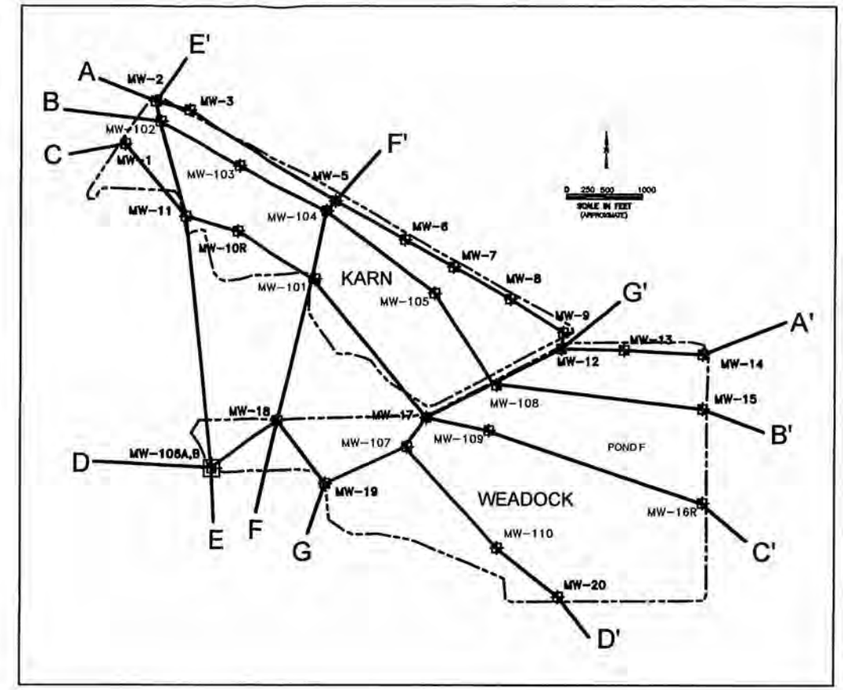












LEGEND

- WATER LEVEL ELEVATION ON SEPTEMBER 23, 2002
- WATER LEVEL ELEVATION ON OCTOBER 9, 2002
- WELL SCREEN

NOTES:
1. * WATER LEVEL FOR MW-106A IS FROM SEPTEMBER 24, 2002.
2. ELEVATIONS ARE UNITED STATE LAKE SURVEY (USLS), THE PRECURSOR TO IGLD 55 AND IGLD 85.
3. MATERIALS ADJACENT TO AND BENEATH THE DISCHARGE CHANNEL ARE NOT FULLY KNOWN. ALSO, WIDTH OF DISCHARGE CHANNEL ON A–A', B–B' AND C–C' IS NOT TO SCALE.

Natural Resource Technology
N R T

GEOLOGIC CROSS SECTIONS

PHASE I INVESTIGATION
CONSUMERS ENERGY
KARN/WEADOCK ASH STORAGE FACILITY
BAY CITY, MICHIGAN

DRAWN BY: TAS	CHECKED BY: EPK	APPROVED BY: BRH
DATE: 10/28/02	DATE: 11/07/02	DATE: 11/07/02

PROJECT NO. 1589/1.2
XREF: XS-SETUP
DRAWING NO. 1589-12-B10
FIGURE NO. 5

Table 3
Estimated Hydraulic Conductivity (K) Values
Consumers Energy Co.
D.E. Karn Generating Facility
Essexville, Michigan

Well ID	Test	H^0 (ft)	H^* (ft)	K (ft/d)	K (cm/sec)	Slug Test Solution
DEK MW-15004	3	2.106	2.31	9.5	3.4E-03	KGS Model (Hyder et. al, 1994)
DEK MW-15005	1	0.937	1.15	17	6.0E-03	KGS Model (Hyder et. al, 1994)
	3	1.917	2.31	11	3.9E-03	KGS Model (Hyder et. al, 1994)
	Average			*14*	*4.9E-03*	
DEK MW-15006	3	1.613	1.69	31	1.1E-02	KGS Model (Hyder et. al, 1994)
			Overall Average	***17***	***6.0E-03***	
			Overall Geometric mean	***15***	***5.4E-03***	
			Minimum	***9.5***	***3.4E-03***	
			Maximum	***31***	***1.1E-02***	

Notes:
H^0 = initial displacement
H^* = expected (calculated) displacement
cm/sec = centimeters per second
ft = feet
ft/d = feet per day

References

Butler, J.J., Jr., 1998. The Design, Performance, and Analysis of Slug Tests, Lewis Publishers, Boca Raton, 252p.

Hyder, Z, J.J. Butler, Jr., C.D. McElwee and W. Liu, 1994. Slug tests in partially penetrating wells, Water Resources Research, vol. 30, no. 11, pp. 2945-2957

LOG OF TEST BORING NO: PZ-2010-212 OW-10

Project Name: *D. E. Karn Barrier Wall Engineering*

Project Location: *Essexville, Michigan*

NTH Consultants, Ltd.
NTH Proj. No.: 62-100303-09
Checked By: ACE

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 589.5

Loose Dark Brown SILTY SAND with Trace of Organic Matter (roots)
586.5 — 3.0

Loose to Very Loose Dark Gray SILTY FINE TO MEDIUM SAND Trace of Clay & Organic Matter (roots)
572.0 — 17.5

Hard Brown SILTY CLAY with Little to Some Sand & Trace of Gravel
569.5 — 20.0

END OF BORING

SOIL SAMPLE DATA

SAMPLE TYPE/NO.	BLOWS / 6 inches	STD. PEN RESIST. (N)	REC (in)	HNu READING (ppm)	MOIST. CONTENT (%)	DRY DENSITY (pcf)	UNCONF. COMP ST (psf)
LS-1	1 2 3	5	10	--	25.1	97.5	--
LS-2	1 WOH 1	1	13	--	72.6	52.4	--
LS-3	WOH WOH 1	1	15	--	49.3	70.1	--
LS-4	WOH 2 4	6	16	--	28.8	97.2	--
LS-5	WOH WOH WOH	0	15	--	52.6	70.8	--
LS-6	10 17 20	37	17	--	8.7	135.7	16140

Total Depth: *20 FT*
Drilling Date: *05-20-2010*
Inspector: *N. Emery*
Contractor: *Rau Drilling Co.*
Driller: *G. Compeau*
Drilling Method:
CME-750 ATV-mounted drill rig with 4-1/4" inside-diameter, hollow-stem augers to end of boring

Plugging Procedure:
Piezometer No. PZ-2010-212 installed in borehole with screen tip set at 18.5 ft bgs.

Water Level Observation:
Groundwater encountered at 9.0 ft bgs during drilling.

Notes:
*[1] * - Pocket Penetrometer Value*
[2] WOH - Weight of Hammer (= 0 blow count)
[3] Coordinates and elevation surveyed by Rowe PSC (datum = NAVD88).

Coordinates:
N: 782738 E: 13263728

Figure No.

LOG OF TEST BORING 62-100303-09.GPJ NTH CORPORATE NEW.GDT 6/22/10

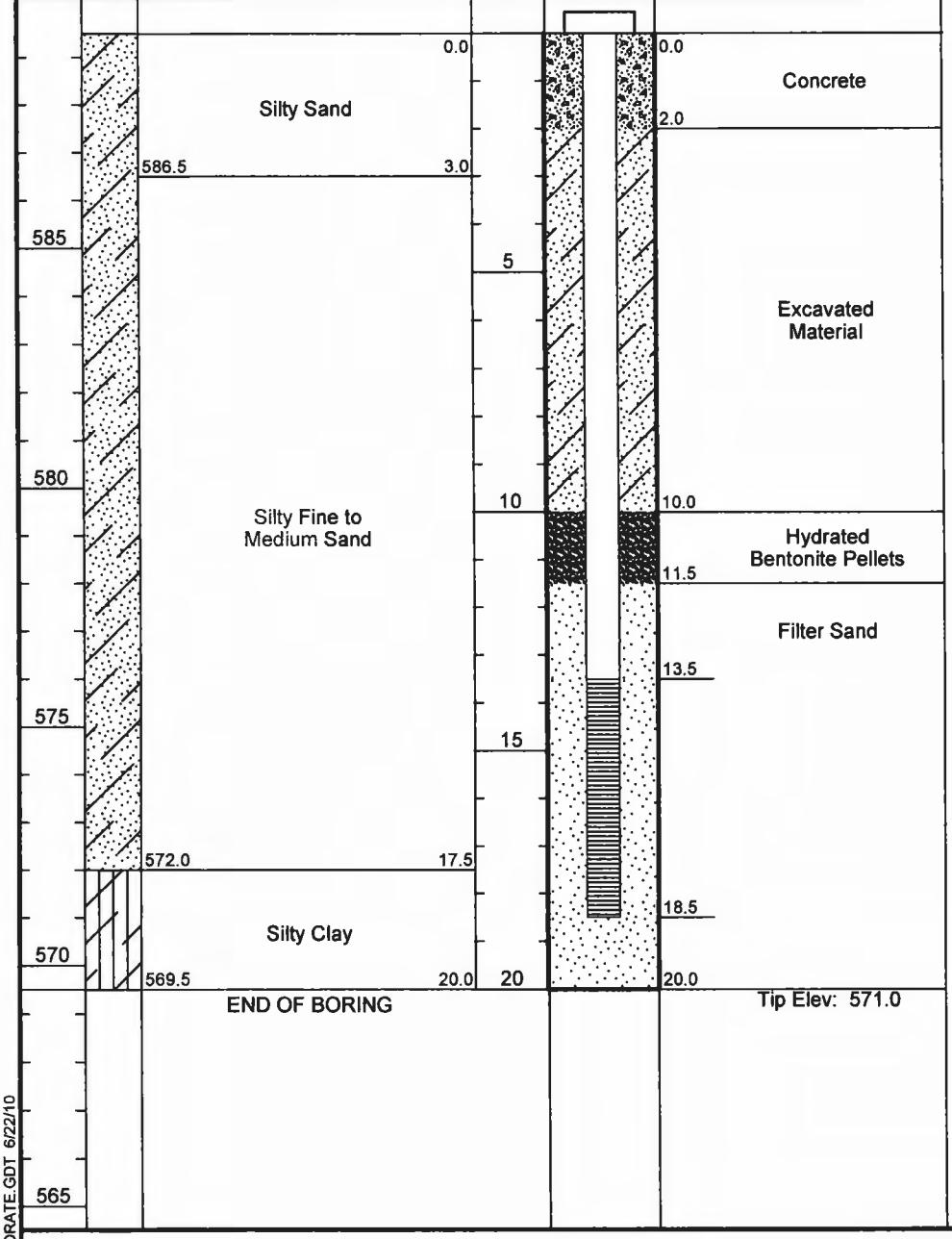
PIEZOMETER NO: PZ-2010-212 OW-10

Project Name: *D. E. Karn Barrier Wall Engineering*

Project Location: *Essexville, Michigan*

NTH Consultants, Ltd.
NTH Proj. No.: 62-100303-09
Checked By: ACE

SUBSURFACE PROFILE				INSTALLATION SCHEMATIC		GROUNDWATER DATA		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 589.5	DEPTH (FT)	WELL DETAIL	TOP OF CASING ELEVATION: 591.52	DATE	ELEV (FT)	COMMENTS
						6/7/2010	585.86	



Total Depth: *20.0 ft*
Drilling Date: *05-20-2010*
Inspector: *N. Emery*
Contractor: *Rau Drilling Co.*
Driller: *G. Compeau*
Equipment: *CME-750 ATV Drill Rig*

Casing Diameter: *2 in*
Casing Length: *15.5 ft*
Casing Type: *PVC*

Screen Diameter: *2 in*
Screen Length: *5 ft*
Screen Mesh: *0.007 in*
Screen Type: *PVC*

Protective Casing: *Steel*

Notes:

[1] For details of subsurface strata, see Log of Test Boring No. PZ-2010-212.
[2] Coordinates and elevation surveyed by Rowe PSC (datum = NAVD88).
[3] Well screen wrapped with filter fabric.

Coordinates: *N 782738 E 13263728*

FIGURE NO.

WELL LOG 62-100303-09.GPJ NTH CORPORATE.GDT 6/22/10

LOG OF TEST BORING NO: PZ-2010-208 OW-11

Project Name: *D. E. Karn Barrier Wall Engineering*

Project Location: *Essexville, Michigan*

NTH Consultants, Ltd.
NTH Proj. No.: 62-100303-09
Checked By: ACE

SUBSURFACE PROFILE / SOIL SAMPLE DATA

ELEV. (ft)	PRO-FILE	GROUND SURFACE ELEVATION: 602.5	DEPTH (ft)	SAMPLE TYPE/NO.	BLOWS / 6 inches	STD. PEN RESIST. (N)	REC (in)	HNu READING (ppm)	MOIST. CONTENT (%)	DRY DENSITY (pcf)	UNCONF. COMP ST (psf)
600		FILL (Fly Ash): Medium Compact Dark Gray FINE SAND		LS-1	4 6 9	15	15	--	43.2	70.8	--
		599.5 — 3.0	5	LS-2	3 3 3	6	17	--	43.8	72.7	--
595		FILL (Fly Ash): Loose to Very Loose Dark Gray SILTY FINE SAND		LS-3	1 2 3	5	17	--	51.4	64.9	--
			10	LS-4	WOH 1 1	2	17	--	48.5	66.4	--
590		590.0 — 12.5	15	LS-5	1 1 1	2	18	--	52.0	63.8	--
585		FILL (Fly Ash): Very Loose Gray SILT with Trace of Sand	20	LS-6	WOH WOH 1	1	18	--	33.4	81.7	--
		580.5 — 22.0									
580		Medium Gray FINE TO MEDIUM SAND with Trace of Silt	25	LS-7	3 6 7	13	17	--	23.3	101.0	--
		577.5 — 25.0									
		END OF BORING									
575			30								
570			35								

Total Depth: *25 FT*
Drilling Date: *05-18-2010*
Inspector: *N. Emery*
Contractor: *Rau Drilling Co.*
Driller: *G. Compeau*
Drilling Method:
CME-750 ATV-mounted drill rig with 4-1/4" inside-diameter, hollow-stem augers to end of boring

Plugging Procedure:
Piezometer No. PZ-2010-208 installed in borehole with screen tip set at 20.0 ft bgs.

Water Level Observation:
Groundwater encountered at 12.5 ft bgs during drilling.

Notes:
*[1] * - Pocket Penetrometer Value*
[2] WOH - Weight of Hammer (= 0 blow count)
[3] Coordinates and elevation surveyed by Rowe PSC (datum = NAVD88).

Coordinates:
N: 783194 E: 13263582

Figure No.

LOG OF TEST BORING 62-100303-09.GPJ NTH CORPORATE NEW.GDT 6/22/10

PIEZOMETER NO: PZ-2010-208 OW-11

Project Name: *D. E. Kam Barrier Wall Engineering*

Project Location: *Essexville, Michigan*

NTH Consultants, Ltd.
NTH Proj. No.: 62-100303-09
Checked By: ACE

SUBSURFACE PROFILE

ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 602.5	DEPTH (FT)
		Sand (Fly Ash)	0.0 – 3.0 (599.5)
600			
		Silty Fine Sand (Fly Ash)	3.0 – 12.5 (590.0)
595			
590			
		Silt (Fly Ash)	12.5 – 22.0 (580.5)
585			
580			
		Fine to Medium Sand	22.0 – 25.0 (577.5)
		END OF BORING	25

INSTALLATION SCHEMATIC

WELL DETAIL	TOP OF CASING ELEVATION: 604.27
	0.0 – 10.0: Excavated Material
	10.0 – 13.0: Hydrated Bentonite Pellets
	13.0 – 25.0: Filter Sand
	Tip Elev: 582.5

GROUNDWATER DATA

DATE	ELEV (FT)	COMMENTS
5/27/2010	588.67	
6/7/2010	589.32	

Total Depth: *25.0 ft*
Drilling Date: *05-18-2010*
Inspector: *N. Emery*
Contractor: *Rau Drilling Co.*
Driller: *G. Compeau*
Equipment: *CME-750 ATV Drill Rig*

Casing Diameter: *2 in*
Casing Length: *17 ft*
Casing Type: *PVC*

Screen Diameter: *2 in*
Screen Length: *5 ft*
Screen Mesh: *0.007 in*
Screen Type: *PVC*

Protective Casing: *4" dia. PVC extending 2 ft above ground*

Notes:

[1] For details of subsurface strata, see Log of Test Boring No. PZ-2010-208.
[2] Coordinates and elevation surveyed by Rowe PSC (datum = NAVD88).
[3] Well screen wrapped with filter fabric.

Coordinates: *N 783194 E 13263582*

FIGURE NO.

WELL LOG 62-100303-09.GPJ NTH CORPORATE.GDT 6/22/10

LOG OF TEST BORING NO: PZ-2010-206 OW-12

Project Name: *D. E. Karn Barrier Wall Engineering*

Project Location: *Essexville, Michigan*

NTH Consultants, Ltd.

NTH Proj. No.: 62-100303-09

Checked By: ACE

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 591.7

ELEV. (ft)	PRO-FILE		DEPTH (ft)
590		FILL (Bottom Ash): Loose Gray SAND with Trace of Silt	
		588.7 — 3.0	
		FILL (Fly Ash): Medium Compact Gray SILTY SAND	5
		586.2 — 5.5	
585		Very Loose Gray SILTY SAND	
		583.7 — 8.0	
		Medium Compact Gray SILTY FINE SAND	10
580		579.2 — 12.5	
		END OF BORING	
			15
575			
			20
570			
			25
565			
			30
560			
			35

SOIL SAMPLE DATA

SAMPLE TYPE/NO.	BLOWS / 6 inches	STD. PEN RESIST. (N)	REC (in)	HNu READING (ppm)	MOIST. CONTENT (%)	DRY DENSITY (pcf)	UNCONF. COMP ST (psf)
LS-1	2 3 5	8	13	--	22.6	81.1	--
LS-2	5 6 6	12	12	--	12.6	115.7	--
LS-3	2 1 1	2	10	--	14.7	110.8	--
LS-4	4 5 6	11	12	--	43.4	74.4	--

Total Depth: *12.5 FT*
Drilling Date: *05-19-2010*
Inspector: *N. Emery*
Contractor: *Rau Drilling Co.*
Driller: *G. Compeau*
Drilling Method:
CME-750 ATV-mounted drill rig with 4-1/4" inside-diameter, hollow-stem augers to end of boring

Plugging Procedure:
Piezometer No. PZ-2010-206 installed in borehole with screen tip set at 12.5 ft bgs.

Water Level Observation:
Groundwater encountered at 7.0 ft bgs during drilling.

Notes:
*[1] * - Pocket Penetrometer Value*
[2] Coordinates and elevation surveyed by Rowe PSC (datum = NAVD88).

Coordinates:
N: 782858 E: 13263023

Figure No.

Sheet 1 of 1

PIEZOMETER NO: PZ-2010-206 OW-12

Project Name: *D. E. Karn Barrier Wall Engineering*

Project Location: *Essexville, Michigan*

NTH Consultants, Ltd.
NTH Proj. No.: 62-100303-09
Checked By: ACE

SUBSURFACE PROFILE				INSTALLATION SCHEMATIC		GROUNDWATER DATA		
ELEV. (FT)	PRO-FILE	GROUND SURFACE ELEVATION: 591.7	DEPTH (FT)	WELL DETAIL	TOP OF CASING ELEVATION: 594.19	DATE	ELEV (FT)	COMMENTS
						5/27/2010	587.79	
						6/4/2010	588.05	
590		Sand (Bottom Ash) 0.0 – 588.7 / 3.0			Excavated Material 0.0 – 3.0			
		Silty Sand (Fly Ash) 588.7 – 586.2 / 5.5	5		Hydrated Bentonite Pellets 3.0 – 5.5			
585		Silty Sand 586.2 – 583.7 / 8.0			Filter Sand 5.5 – 7.5			
		Silty Fine Sand 583.7 – 579.2 / 12.5	10		7.5 – 12.5			
580		END OF BORING			Tip Elev: 579.2			
575								
570								

Total Depth: *12.5 ft*
Drilling Date: *05-19-2010*
Inspector: *N. Emery*
Contractor: *Rau Drilling Co.*
Driller: *G. Compeau*
Equipment: *CME-750 ATV Drill Rig*

Casing Diameter: *2 in*
Casing Length: *10 ft*
Casing Type: *PVC*

Screen Diameter: *2 in*
Screen Length: *5 ft*
Screen Mesh: *0.007 in*
Screen Type: *PVC*

Protective Casing: *4" dia. PVC extending 2 ft above ground*

Notes:

[1] For details of subsurface strata, see Log of Test Boring No. PZ-2010-206.
[2] Coordinates and elevation surveyed by Rowe PSC (datum = NAVD88).
[3] Well screen wrapped with filter fabric.

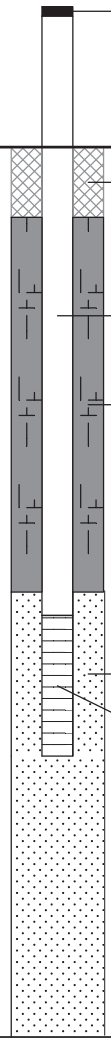
Coordinates: *N 782858 E 13263023*

FIGURE NO.

Date Start: 10/09/15 **Date Finish:** 10/09/15 **Drilling Company:** Stock Drilling **Driller's Name:** Austin Goldsmith **Drilling Method:** Hydrovac/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 10.0 **Water Level Finish (ft. btoc.):** 4.79	**Northing:** 782690.6 **Easting:** 13262816.8 **Casing Elevation:** 590.87 **Borehole Depth (ft. bgs.):** 19.0 **Surface Elevation:** 588.3 **Descriptions By:** L. Rogers	**Well/Boring ID:** **DEK MW-15002** **Client:** Consumers Energy **Location:** DE Karn Facility 2742 Weadock Highway Essexville, MI 48732 **Weather Conditions:** 64 F Sunny

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	590								
0								(0.0 - 6.0') Hydrovac; no lithology recorded.	
	585	1	0.0-6.0'	0.0	NA				
5									
								(6.0 - 6.8') Bottom ASH.	
	580	2	6.0-9.0'	3.0	NA			(6.8 - 9.0') SAND, very fine to fine; little medium sand; trace coarse sand; well sorted; moist; dark grayish brown (10YR 4/2).	
10								(9.0 - 10.0') SILT, medium to low plasticity, high dilatancy; some clay; little very fine to fine sand; moist to wet; dark olive gray (5Y 3/2).	
								(10.0 - 13.0') SAND, very fine to fine; little medium sand; trace coarse sand to granule, subrounded to subangular; well sorted; moist to wet; dark grayish brown (10YR 4/2).	
	575	3	9.0-19.0'	10.0	NA			(13.0 - 19.0') CLAY, medium to low plasticity; trace silt; trace fine to medium sand; trace granule to large pebbles, subrounded to subangular; dry; stiff to very stiff; dark grayish brown (10YR 4/2). NOTE: Till.	
15									
	570								
20								End of boring 19.0' bgs.	

Well/Boring Construction



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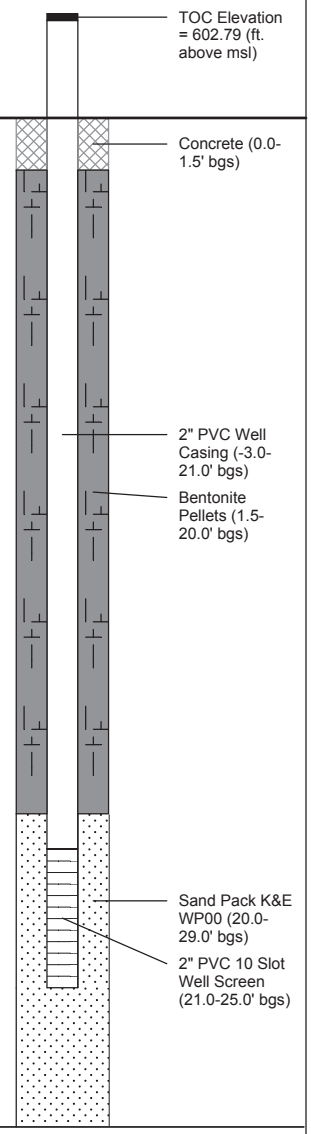
Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 10.0' bgs during drilling.
Water level at development was 4.79' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 586.02 feet above mean sea level.

Date Start: 10/12/15 **Date Finish:** 10/12/15 **Drilling Company:** Stock Drilling **Driller's Name:** Austin Goldsmith **Drilling Method:** Hydrovac/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 7.0 **Water Level Finish (ft. btoc.):** 12.08	**Northing:** 783112.8 **Easting:** 13263202.1 **Casing Elevation:** 602.79 **Borehole Depth (ft. bgs.):** 29.0 **Surface Elevation:** 599.9 **Descriptions By:** L. Rogers	**Well/Boring ID:** **DEK MW-15003** **Client:** Consumers Energy **Location:** DE Karn Facility 2742 Weadock Highway Essexville, MI 48732 **Weather Conditions:** 60 F Windy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	600								
		1	0.0-7.0'	0.0	NA			(0.0 - 7.0') Hydrovac; no lithology recorded.	
5	595								
								(7.0 - 8.0') Fly ASH; wet; black (10YR 2/1). NOTE: Fill material.	
		2	7.0-9.0'	2.0	NA	X		(8.0 - 9.5') PEAT and ASH; little roots; little organics; wet; black (10YR 2/1).	▼
10	590							(9.5 - 19.5') ASH, mix of bottom and fly; wet; black (10YR 2/1). NOTE: Fill material.	
		3	9.0-19.0'	7.5	NA	X			
15	585					X		NOTE: Trace clay from 16.0' to 19.5' bgs.	
20	580							(19.5 - 21.0') SAND, very fine to fine; little silt and clay; trace medium sand; well sorted; moist to wet; dark olive gray (5Y 3/2).	
						X		(21.0 - 25.0') SAND, very fine to medium; trace coarse sand; trace silt; well sorted; moist to wet; dark gray (10YR 4/1).	
		4	19.0-29.0'	10.3	NA				
25	575					X		(25.0 - 29.0') CLAY, medium to low plasticity; little granule to large cobbles, subrounded to subangular; trace silt; dry; stiff to very stiff; brown (10YR 4/7). NOTE: Till.	
30	570							End of boring 29.0' bgs.	

Well/Boring Construction



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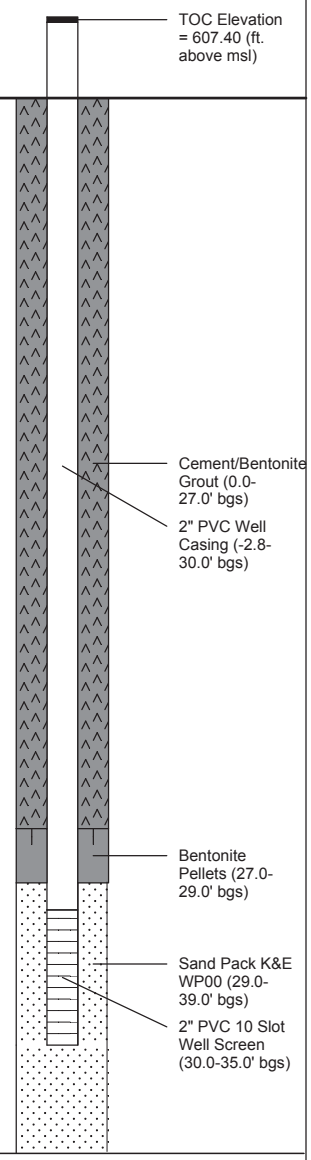
Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 7.0' bgs.
Groundwater encountered at 7.0' bgs during drilling.
Water level at development was 12.08' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 588.82 feet above mean sea level.

Date Start: 10/12/15 **Date Finish:** 10/12/15 **Drilling Company:** Stock Drilling **Driller's Name:** Austin Goldsmith **Drilling Method:** Hydrovac/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 13.0 **Water Level Finish (ft. btoc.):** 17.99	**Northing:** 783407.4 **Easting:** 13262642 **Casing Elevation:** 607.4 **Borehole Depth (ft. bgs.):** 39.0 **Surface Elevation:** 604.9 **Descriptions By:** L. Rogers	**Well/Boring ID:** **DEK MW-15004** **Client:** Consumers Energy **Location:** DE Karn Facility 2742 Weadock Highway Essexville, MI 48732 **Weather Conditions:** 65 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
0	605								
		1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
5	600								
		2	6.0-9.0'	4.7	NA	X		(6.0 - 15.0') Fly ASH; dry to moist; black (10YR 2/1). NOTE: Fill material. NOTE: Moist from 7-8.5' bgs. NOTE: Add little very fine to fine sand at 8.5' bgs.	
10	595								
		3	9.0-19.0'	8.2	NA			NOTE: Wet at 13.0' bgs.	▼
15	590							(15.0 - 26.0') Bottom ASH; wet; black (10YR 2/1). NOTE: Fill material.	
20	585								
		4	19.0-29.0'	9.6	NA				
25	580								
						X		(26.0 - 27.0') Fly ASH; wet; black (10YR 2/1). NOTE: Fill material.	
								(27.0 - 27.5') PEAT; little organics.	
30	575							(27.5 - 38.5') SAND, very fine to medium; trace coarse sand; well sorted; moist; gray (10YR 5/1).	
35	570	5	29.0-39.0'	7.6	NA				
						X		(38.5 - 39.0') SILT, no plasticity, slow dilatancy; little very fine sand; dry; soft; very dark grayish brown (10YR 3/2).	
40	565							End of boring 39.0' bgs.	

Well/Boring Construction



Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 13.0' bgs during drilling.
Water level at development was 17.99' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 588.86 feet above mean sea level.

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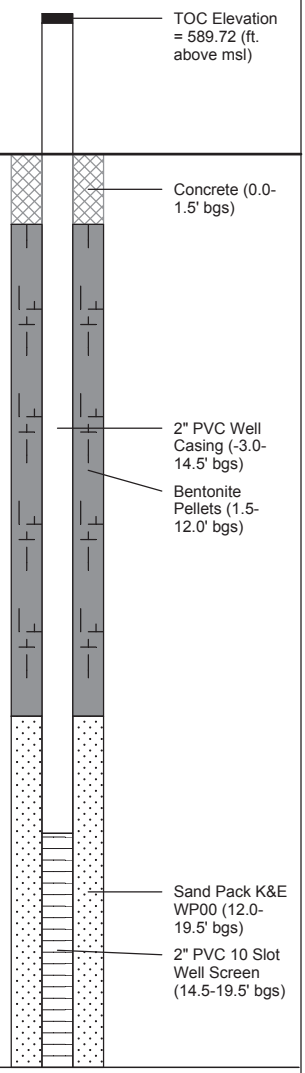
Date Start: 10/13/15 **Date Finish:** 10/13/15 **Drilling Company:** Stock Drilling **Driller's Name:** Austin Goldsmith **Drilling Method:** Hydrovac/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 15.0 **Water Level Finish (ft. btoc.):** 11.40	**Northing:** 783163 **Easting:** 13262105.3 **Casing Elevation:** 589.72 **Borehole Depth (ft. bgs.):** 19.5 **Surface Elevation:** 586.8 **Descriptions By:** L. Rogers	**Well/Boring ID:** **DEK MW-15005** **Client:** Consumers Energy **Location:** DE Karn Facility 2742 Weadock Highway Essexville, MI 48732 **Weather Conditions:** 52 F Cloudy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	590								
0								(0.0 - 6.0') Hydrovac; no lithology recorded.	
	585	1	0.0-6.0'	0.0	NA				
5								(6.0 - 6.5') Bottom ASH and TOPSOIL; trace roots. NOTE: Fill material.	
	580	2	6.0-9.5'	5.0	NA	X		(6.5 - 19.5') SAND, very fine to medium; trace coarse sand; well sorted; dry to moist; dark grayish brown (10YR 4/2). NOTE: Moist to wet at 8.5' bgs.	
10								NOTE: Color change to dark gray (10YR 4/1) at 10.0' bgs.	
	575	3	9.5-19.5'	10.6	NA	X			
15								NOTE: Wet at 15.0' bgs. NOTE: Trace very coarse sand and trace shell fragments at 16.0' bgs.	
	570					X			
20								End of boring 19.5' bgs.	
	565								

Well/Boring Construction



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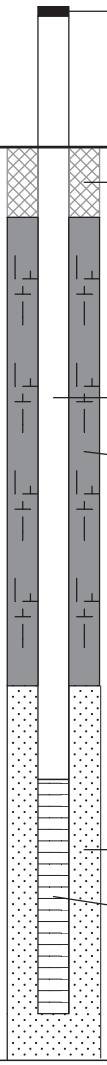
Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 15.0' bgs during drilling.
Water level at development was 11.40' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 579.72 feet above mean sea level.

Date Start: 10/13/15 **Date Finish:** 10/13/15 **Drilling Company:** Stock Drilling **Driller's Name:** Austin Goldsmith **Drilling Method:** Hydrovac/Sonic **Sampling Method:** Continuous **Rig Type:** Sonic **Water Level Start (ft. bgs.):** 14.0 **Water Level Finish (ft. btoc.):** 9.33	**Northing:** 782812.9 **Easting:** 13262180.2 **Casing Elevation:** 589.24 **Borehole Depth (ft. bgs.):** 19.5 **Surface Elevation:** 586.5 **Descriptions By:** L. Rogers	**Well/Boring ID:** **DEK MW-15006** **Client:** Consumers Energy **Location:** DE Karn Facility 2742 Weadock Highway Essexville, MI 48732 **Weather Conditions:** 57 F Windy

DEPTH (feet bgs.)	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	Geologic Column	Stratigraphic Description	Water Level (ft. bgs.)
	590								
0									
	585	1	0.0-6.0'	0.0	NA			(0.0 - 6.0') Hydrovac; no lithology recorded.	
5									
	580							(6.0 - 6.5') SAND, very fine to coarse; trace granule to large pebbles, subrounded to subangular; poorly sorted; dry; brown (10YR 4/3).	
		2	6.0-9.5'	3.0	NA	X		(6.5 - 19.5') SAND, very fine to fine; little medium sand; trace coarse sand; well sorted; dry; dark yellowish brown (10YR 3/6).	
10								NOTE: Moist; change to very dark gray (10YR 3/1) at 9.0' bgs.	
	575					X			
15		3	9.5-19.5'	10.3	NA			NOTE: Wet at 14.0' bgs.	
	570					X			
20								End of boring 19.5' bgs.	
	565								



Remarks: bgs = below ground surface btoc = below top of casing

Hydrovac to 6.0' bgs.
Groundwater encountered at 14.0' bgs during drilling.
Water level at development was 9.33' btoc.
No odor or staining observed.
Groundwater elevation measured on December 8, 2015 was 579.65 feet above mean sea level.

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WELL CONSTRUCTION LOG

WELL NO. DEK-MW-18001

Facility/Project Name:	Date Drilling Started:	Date Drilling Completed:	Project Number:
Consumers Energy DE Karn CCR Monitoring	5/21/18	5/21/18	290804.0000

Drilling Firm:	Drilling Method:	Surface Elev. (ft)	TOC Elevation (ft)	Total Depth (ft bgs)	Borehole Dia. (in)
Stearns Drilling	Hollow Stem Auger	590.7	593.47	18.0	8.0

Boring Location: Approximately 70 feet south and 30 feet west of decommissioned monitoring well DEK-MW-15001.
N: 782780.00 E: 13263320.00

Personnel
Logged By - Jacob Krenz
Driller - Gary Geerligs

Drilling Equipment: CME LC 60

Civil Town/City/or Village:	County:	State:
Essexville	Bay County	Michigan

Water Level Observations:
While Drilling: Date/Time 5/21/18 00:00 Depth (ft bgs) 7.0
After Drilling: Date/Time 5/22/18 07:08 Depth (ft bgs) 5.49

SAMPLE NUMBER AND TYPE	RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
1 SS	100	3 5 5 5	1	**TOPSOIL** black (10YR 2/1).				
				CLAY WITH SAND mostly clay, few to little fine to medium sand, trace fine gravel, low plasticity, yellowish brown (10YR 5/4), stiff, moist.	CL			
2 SS	100	4 5 6 7	2 3	**SAND** mostly medium sand, yellowish brown (10YR 5/6), dry, loose.	SP			
				CLAY WITH SAND mostly clay, few to little fine to medium sand, trace fine gravel, low plasticity, yellowish brown (10YR 5/4), stiff, moist.	CL			
				SAND mostly fine to medium sand, pale brown (10YR 6/3, dry, loose.	SP			
				CLAY WITH SAND mostly clay, few to little fine to medium sand, trace fine gravel, low plasticity, yellowish brown (10YR 5/4), stiff, moist.	CL			
3 SS	80	3 3 4 4	4 5	**SAND** mostly fine to medium sand, dark yellowish brown (10YR 4/4), moist, loose.	SP			
				CLAY WITH SAND mostly clay, few to little fine to medium sand, trace fine gravel, low plasticity, yellowish brown (10YR 5/4), stiff, moist.	CL			
				SAND mostly fine to medium sand, dark yellowish brown (10YR 3/6), moist, loose.	SP			
4 SS	80	3 1 1 1	6 7	**CLAY** mostly clay, trace fine sand, trace silt, low to medium plasticity, gray (10YR 5/1), moist, medium stiff.	CL			
				SAND mostly medium to coarse sand, very dark gray (10YR 3/1), saturated, loose.	SP			
5 SS	80	0 1 2 4	8 9	Change to fine to medium sand, trace silt at 9.0 feet.				

Signature:

Firm: TRC Environmental Corporation
1540 Eisenhower Place Ann Arbor, MI 48108
734-971-7080
Fax 734-971-9022

SOIL BORING WELL CONSTRUCTION LOG 290804P1T6.CEC.FLUORIDEASSESSMENT.GPJ TRC_CORP.GDT 290804.0000 1/22/19

WELL CONSTRUCTION LOG

WELL NO. DEK-MW-18001

SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (%)	BLOW COUNTS	DEPTH IN FEET	LITHOLOGIC DESCRIPTION	USCS	GRAPHIC LOG	WELL DIAGRAM	COMMENTS
6 SS	70	5 9 7 6	11 12	Change to mostly fine sand, trace ash at 11.0 feet.				
7 SS	60	4 6 9 7	13 14	Change to mostly medium sand, saturated, trace shell fragments, no ash at 13.0 feet.	SP			
8 SS	60	5 5 9 7	15 16					
9 SS	75	5 9 12 14	17 18	**CLAY** mostly clay, trace to few sand, trace gravel, low plasticity, gray (10YR 5/1), moist, very stiff.	CL			
				End of boring at 18.0 feet below ground surface.				
			19 20 21 22 23					

SOIL BORING WELL CONSTRUCTION LOG 290804P1T6.CEC.FLUORIDEASSESSMENT.GPJ TRC_CORP.GDT 290804.0000 1/22/19

WELL CONSTRUCTION DIAGRAM

PROJ. NAME: CONSUMERS ENERGY DE KARN CCR MONITORING		WELL ID:	**DEK-MW-18001**
PROJ. NO: 290804.0000	DATE INSTALLED: 5/21/2018 INSTALLED BY: J.KRENZ		CHECKED BY: M. Brehob

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
593.47	2.77	TOP OF CASING
590.70	0.0	GROUND SURFACE
	1.5	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: NA
		GROUT/BACKFILL METHOD: NA
14.27		
	NA	GROUT
		BENTONITE SEAL MATERIAL: MEDIUM CHIPS
	9.5	BENTONITE SEAL
579.20	11.5	TOP OF SCREEN
5.00		FILTER PACK MATERIAL: MEDIUM, WASHED SAND
574.20	16.5	BOTTOM OF SCREEN
	16.5	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: NATURAL COLLAPSE
572.70	18.0	HOLE BOTTOM

RISER PIPE LENGTH

SCREEN LENGTH

NOTES:

CASING AND SCREEN DETAILS

TYPE OF RISER: 2-INCH PVC

PIPE SCHEDULE: 40

PIPE JOINTS: THREADED O-RINGS

SCREEN TYPE: 2-INCH PVC

SCR. SLOT SIZE: 0.01-INCH

BOREHOLE DIAMETER: 8.00 IN. FROM 0 TO 16.5 FT.
2.00 IN. FROM 16.5 TO 18.0 FT.

SURF. CASING DIAMETER: ____ IN. FROM ____ TO ____ FT.
____ IN. FROM ____ TO ____ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: SURGE AND PUMP

TIME DEVELOPING: 0.5 HOURS

WATER REMOVED: 67.5 GALLONS

WATER ADDED: 0 GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE: VERY TURBID

COLOR BEFORE: LIGHT BROWN

CLARITY AFTER: CLEAR

COLOR AFTER: NONE

ODOR (IF PRESENT): NONE

WATER LEVEL SUMMARY

MEASUREMENT (FEET)			DATE	TIME
DTB BEFORE DEVELOPING:	19.71	T/PVC	5/22/2018	7:08
DTB AFTER DEVELOPING:	19.65	T/PVC	5/24/2018	15:53
SWL BEFORE DEVELOPING:	8.49	T/PVC	5/22/2018	7:08
SWL AFTER DEVELOPING:	8.35	T/PVC	5/24/2018	15:53
OTHER SWL:		T/PVC		
OTHER SWL:		T/PVC		

PROTECTIVE CASING DETAILS

PERMANENT, LEGIBLE WELL LABEL ADDED? ☑ YES ☐ NO

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

LOCK KEY NUMBER: NEW LOCK NOT YET ADDED BY CEC

Appendix C
Groundwater Sampling SOP

Title: **Groundwater Sampling**	Procedure Number: **ECR 009**
	Revision Number: **4**
	Effective Date: **August 2020**

Authorization Signatures			
Darby Litz		Elizabeth Denly	
Technical Reviewer Darby Litz	Date 8/4/20	Environmental Sector Quality Director Elizabeth Denly	Date 8/4/20

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Attachment C SOP Fact Sheet
Attachment D SOP Modifications for PFAS

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) was prepared to provide TRC personnel with general guidance in performing groundwater sampling activities. This SOP details equipment and sampling procedures for low-flow sampling, multi-volume purge sampling and passive diffusion bag sampling from monitoring wells. Various regulatory agencies and project-specific work plans may have specific requirements (e.g., equipment/instrument, flow rate, etc.) that may be applicable and take precedence, depending on the program.

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

1.2 Summary of Method

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling.

For low-flow and multiple well volume removal, there are various types of equipment available to perform groundwater sampling. The most common of these are the submersible pump, peristaltic pump, and bailer. However, the equipment selected and the purge method used, if any, will depend on project goals, data quality objectives (DQOs), hydrogeologic conditions, and regulatory requirements. Care should be taken when choosing the sampling procedures and device(s), as some procedures have the potential to affect the representativeness of the sample more than others. For repeated monitoring events, the sampling methodology and operating equipment employed should be consistent to minimize potential variability due to sampling procedures. The type of sampling method utilized is dependent upon site-specific conditions and it is not within the scope of this document to recommend a specific methodology. For specialized sampling programs involving per- and polyfluorinated alkyl substances (PFAS), refer to Attachment D for further details. Information on applicability of sampling methods can be found on Interstate Technology & Regulatory Council (ITRC) and United States Environmental Protection Agency (EPA) websites.

1.3 Equipment

The following equipment is commonly used to collect groundwater samples from a monitoring well. Site-specific conditions may warrant the use of additional equipment or deletion of items from this list.

- Appropriate level of personal protective equipment (PPE) as specified in the site-specific Health and Safety Plan (HASP)
- Electronic water level indicator capable of measuring to 0.01 foot accuracy
- Oil/water interface probe
- Extra batteries for water level/interface probe
- Submersible pump with low-flow capabilities (less than 1 liter/min) constructed of inert materials (e.g., stainless steel and Teflon®), such as a bladder pump (with sufficient quantity of bladders, o-rings, grab plates, etc.)
- Peristaltic pump
- Source of power for use with submersible or peristaltic pump (e.g., 12-volt battery, compressor, generator, compressed gas tanks, etc.)
- Flow controller for use with submersible pump (varies depending on type of pump used)
- Bottom-filling bailer constructed of inert materials (i.e., polyethylene, polyvinyl chloride [PVC], stainless steel or Teflon®)
- Bailer cord or wire (recommended Teflon®-coated, stainless steel cable; bailer wire; or contaminant-free rope with a Teflon®-coated stainless steel leader to connect bailer and rope)
- Tubing (Teflon®, Teflon®–lined polyethylene, or high density polyethylene [HDPE], type dependent upon project objectives)
- Silicone tubing (only used for peristaltic pump head and/or flow-through cell connections)
- Water quality meter(s) capable of measuring parameters, such as pH, temperature, specific conductivity, oxidation-reduction potential (ORP), and dissolved oxygen (DO)
- Flow-through cell
- T-connector
- Turbidity meter
- Passive sampling device (and any device-specific accessories)
  - Passive diffusion bags (PDBs)
  - Tether (stainless steel cable or marine-grade polyethylene rope), well cap, and weights, unless already installed
  - Funnel (Fill kit)
  - PVC cable ties
  - Tool to cut cable ties
  - PVC discharge tubes
  - Tether reel
- Well lock keys
- Bolt cutters

- Appropriate tools for equipment and to open well box (e.g., socket wrench, pry bar, etc.)
- Containers with lids for purge water (i.e., 5-gallon buckets, drums, etc.)
- Stopwatch or timer
- Graduated measuring container appropriately sized to measure flow rate
- Sample bottle labels
- Laboratory-grade water (can request from lab – for equipment blanks)
- Chain-of-custody (COC) forms
- Sample cooler(s)
- Photoionization detector (PID) or flame ionization detector (FID) for well head monitoring
- Sample containers (may be supplied by the laboratory depending upon the regulatory program): The proper containers should be determined in conjunction with the analytical laboratory in the planning stages of the project. If not included in sample containers provided by laboratory, sample preservatives will need to be kept with sample containers, and added to sample containers prior to sample collection.
- Field book and/or Groundwater Field Data Record (multiple copies)
- Filtration equipment
- In-line filter (0.45 micron [µm]) or as otherwise required by the project-specific work plan.
- Bubble wrap/Bubble wrap bags
- Lint-free, non-abrasive, disposable towels (e.g., Kimwipes®)
- Indelible marking pens
- Plastic bags (e.g., Ziploc®)
- Ice
- Teflon® tape
- Plastic sheeting or large trash bags which can be cut open
- Umbrella, tent, or equivalent for shading equipment (particularly the flow-through cell) from sunlight or blocking rain
- Equipment decontamination supplies
- Container for bailing water out of water-logged road boxes or well vaults
- Map of well locations and well construction data
- Copy of field notes from previous sampling event for reference
- Project-specific work plan

1.4 Definitions

Bailer	A cylindrical device suspended from a rope or cable, which is used to remove water, non-aqueous phase liquid (NAPL), sediment or other materials from a well or open borehole. Usually equipped with some type of check valve at the base to allow water, NAPL, and/or sediment to enter the bailer and be retained as it is lifted to the surface. A bailer may be made in varying diameters; however a bailer that fits in a two-inch well is the most common. In some instances a < 1-inch diameter bailer (a.k.a. pencil bailer) is used for small diameter wells.
Borehole	A hole drilled into the soil or bedrock using a drill rig or similar equipment.
Dense Non-aqueous Phase Liquid (DNAPL)	Separate-phase product that is denser than water and, therefore, sinks to the bottom of the water column.
Depth To Water (DTW)	The distance to the groundwater surface from an established measuring point.
Drawdown	The response to purging/pumping a well resulting in the lowering of groundwater within the water column in the well or in a water-bearing zone.
FID	An instrument that uses a flame to break down volatile organic compounds (VOCs) into ions that can be measured.
Flow-Through Cell	The container used to immerse the multi-parameter probes in well purge water during pre-sampling well purging. The flow-through cell is usually made of transparent acrylic and is connected to the end of the discharge tubing creating an in-line, sealed container in which purge water circulates around the measurement probes. The discharge from the pump prior to the flow-through cell may be fitted with a check valve or T-connector for collection of water for turbidity measurement.
Flush Mount	The type of well completion where the riser terminates at or below grade. Flush-mounted wells are typically completed with a “curb box” which is an “at-grade” enclosure designed to protect the well riser.
Light Non-aqueous Phase Liquid (LNAPL)	Separate-phase product that is less dense than water and therefore floats on the surface of the water.

Monitoring Well	A well made from a PVC pipe, or other appropriate material, with slotted screen installed across or within a saturated zone. A monitoring well is typically constructed with a PVC or stainless steel pipe in unconsolidated deposits and with steel casing in bedrock.
PID	An instrument that uses an ultraviolet light source to break down VOCs into ions that can be measured.
Piezometer	A well made from PVC or metal with a slotted screen installed across or within a saturated zone. Piezometers are primarily installed to monitor changes in the potentiometric surface elevation.
Potentiometric Surface	A surface representing the hydraulic head of groundwater.
Protective Casing	The pipe installed around the well riser that sticks up from the ground (above-grade completions) or is flush with the ground (at-grade completions, e.g., curb box) in order to protect the well integrity. Protective casings are typically constructed of steel or aluminum and usually closeable with a locking cover/hasp to maintain well integrity between sampling events.
Recharge Rate	The rate at which groundwater returns to the water column in the well.
Separate-Phase Product	A liquid that does not easily dissolve in water. Separate-phase product can be more dense (i.e., DNAPL) or less dense (i.e., LNAPL) than water and, therefore, can be found at different depths in the water column.
Static Water Level	Level at which water resides in a well when the water level is at equilibrium with atmospheric pressure.
Well Cover	The cap or lid constructed at the end of the protective casing (above-grade completions) or flush-mounted curb box (ground surface completions) to secure access to the well. Well covers for stick-up wells are often equipped with a hasp to accommodate a padlock. Well covers for flush-mounted road boxes or vaults are opened and closed using a threaded bolt.
Well Filter Pack	A material composed of clean silica sand or sand and gravel of selected grain size and gradation that is placed in the annulus between the screened interval and the borehole wall in a well for the purpose of retaining and stabilizing the formation material.

Well Plug/Expansion Plug	The plug fashioned into a cap placed into the top of the well riser (e.g., J-Plug). Well plugs are usually designed with an expandable gasket that is activated by turning a locking wing nut or removable key latch, closing a snap cap or engaging a magnetic clutch cap to seal the well riser.
Well Riser	Sections of blank (non-slotted) pipe that extend from the well screen to or above the ground surface.
Well Screen	Pipe (typically PVC or stainless steel) used to retain the formation or filter pack materials outside of the well. The pipe has openings/slots of a uniform width, orientation, and spacing. The openings/slots can vary based on formation and filter pack material specifications.

1.5 Health & Safety Considerations

TRC personnel will be on site when implementing this SOP. Therefore, TRC personnel shall follow the site-specific HASP. TRC personnel will use the appropriate level of PPE as defined in the HASP.

The well head should be pre-screened using a PID/FID to avoid inhalation of contaminants venting from the well. If monitoring results indicate sustained elevated concentrations of organic contaminants, the level of PPE may need to be increased in accordance with the HASP or work could be conducted upwind of the well.

When present, special care should be taken to avoid contact with LNAPL or DNAPL. The use of an air monitoring program, as well as the proper PPE designated by the site-specific HASP, can identify and/or mitigate potential health hazards.

Implementing this SOP may require the use of reagents and/or compressed gases for the calibration and operation of field equipment. These substances may be hazardous and TRC personnel must appropriately handle, store, and dispose of them at all times. Skin contact with liquid from preserved sample bottles must be avoided as they may contain strong acids or bases. When filling bottles pre-preserved with acid (e.g., hydrochloric acid, nitric acid, sulfuric acid), vapors may be released and should not be inhaled. Do not allow bottles with acid to be exposed to elevated atmospheric temperatures or sunlight as this will facilitate fumes from the acids.

1.6 Cautions and Potential Problems

The following sections highlight issues that may be encountered and should be discussed with the Project Manager prior to mobilization into the field. Special care should be taken when sampling for PFAS. Please refer to Attachment D for details.

1.6.1 Pre-Sampling Issues

(a) Selection of equipment for groundwater sampling should consider multiple factors, including: DTW, well specifications (e.g., depth and length of well screen intervals), desired flow rate, possible weather conditions, type and concentration of contaminant(s), and remoteness/accessibility to the site. The benefits and limits of each type of groundwater

sampling equipment should be fully reviewed during project planning or prior to mobilization if the project-specific work plan does not identify the required equipment. For example, peristaltic pumps are incapable of withdrawing water in wells in which the depth to water is greater than approximately 20-25 feet below ground surface (bgs).

(b) If the screen or open borehole is greater than 10 feet in length, consult the project-specific work plans for the target sampling interval. Generally, pumps are either placed in the middle of the saturated zone if the water level is below the top of the screen or in the middle of the screen interval if the water level is above the top of the screen.

(c) The need for redevelopment of the monitoring wells should be evaluated periodically in accordance with the project-specific requirements. This is assessed by comparing the measured total depth of the well with the constructed depth. If the measured depth is less than the constructed depth, this may indicate siltation of the well and/or the presence of an obstruction in the well. If it is determined that redevelopment is necessary, it should be performed in accordance with ECR SOP 006, *Well Development.* The time necessary for a well to restabilize after redevelopment will be determined on a project-specific basis and may depend on regulatory requirements.

(d) During the total well depth measurement, there is the potential for sediment, if present at the bottom of the well, to be disturbed, thereby increasing the turbidity of the groundwater. Therefore, the total well depth measurement should be collected the day prior to collecting groundwater samples, if possible.

(e) Use caution if using compressed gas cylinders (e.g., nitrogen, carbon dioxide) for purging/sampling of groundwater. Check for leaks around regulator connections by spraying soapy water on the connections. If a leak is discovered, the connection to the regulator should be disassembled, wrapped with Teflon® tape, and reconnected to the cylinder. If the leak continues, the regulator should be replaced. It should be noted that Department of Transportation (DOT) regulations apply to the transportation and handling of compressed gas cylinders (see 49 Code of Federal Regulations [CFR] 171). Never transport cylinders with the regulator attached. Replace the cylinder valve cover on the compressed gas cylinder before transport.

(f) All field personnel must be made aware of the water level measurement reference point being used for each well at a site (i.e., must be clearly marked) in order to ensure collection of comparable data between events.

(g) Bolt cutters may be necessary to remove rusted locks. Dipping rusted locks in a soapy solution may help with opening difficult locks. Oils and other products containing VOCs (e.g., WD-40) should not be used on locks as these compounds may cause contamination of water samples collected at the well. Replace cut locks and note in the field book.

(h) Prior to accessing the well, physical conditions around the well head should be assessed for situations that might result in cross-contamination or the introduction of foreign material/debris into the well. For example, flush-mounted wells may have water or road sand/salt/debris inside the curb box. Rodents and insects (e.g., bees, wasps) have been known to construct nests within the protective casing of a well. If bees, wasps, or other insects are

encountered, insecticides should be used with caution as the chemicals may cause contamination of water samples collected at the well. If water or foreign material is introduced into the well, the Project Manager should be immediately notified.

1.6.2 General Purging and Sampling Issues

(a) Prior to installation of a submersible pump into a well, ensure that the tubing is properly sealed to the pump to avoid losing the pump down the well and to prevent escape of air or water from the pump, which could result in poor pump performance and the aeration of the well water. Do not do this by tugging on tubing. Never lower pumps into the well using only tubing; instead a security line attached to the pump is required to prevent potentially losing the pump down the well.

(b) A submersible pump should not be lowered to the bottom of the well to avoid stirring up any sediment at the bottom of the well and prevent getting the pump stuck (fine sediment accumulation in the bottom of the well can create a strong suction with a flat bottom pump such as a bladder pump, which may require jetting to retrieve the pump).

(c) Start with the lowest pumping rate possible and increase until a sustainable rate is reached. Avoid high pumping rates (> 1 liter/min), as this could lead to damage of the well filter pack, if present. Where practical and/or possible, refer to previous sampling events to establish consistent flow rates.

(d) Some regulatory agencies may have concern about the use of peristaltic pumps when sampling for VOCs due to the potential for loss of VOCs during sampling and alteration of other water quality parameters such as pH and alkalinity. Samplers should review the requirements in the project-specific work plan and/or regulatory guidelines prior to performing the work. Explicit approval to use a peristaltic pump for the collection of VOCs may be required by the governing regulatory agency. An option may be to use the "soda straw" method to collect the VOC sample which does not allow the water to go through the pump head:

(1) After purging the well with the peristaltic pump, collect all fractions <u>except VOCs</u> from the outlet side of the pump (i.e., VOCs will be collected last instead of first).
(2) Turn the pump off.
(3) Change into clean gloves.
(4) Disconnect the tubing coming out of the well from the inlet side of the pump and <u>immediately</u> put a finger over the end of this tubing to prevent water from draining out of the tubing.
(5) Retrieve tubing from the well, coiling it in one hand as it is being retrieved (maintain finger over end of tubing).
(6) Open VOC vials. Briefly remove finger from end of tubing to allow water to flow into vial. Replace finger on end of tubing to stop flow. Do this for remaining VOC vials.

(e) In the event that a well cannot be purged and sampled with a pump, the alternative to pumping may be the use of a bottom-filling bailer. The applicable regulatory agency requirements and the Project Manager should be consulted if in doubt about the appropriateness of using a bailer at a site or during a particular sampling event.

(f) During purging and sampling, the tubing should remain filled with water to minimize possible changes in water chemistry due to contact with the atmosphere. All flow-through cells should be shaded from direct sunlight to minimize the potential for off-gassing and temperature fluctuations.

(g) Ensure monitoring instruments (i.e., multi-parameter water quality instrument, turbidity meter, water level measuring device) are maintained in good condition and properly calibrated to ensure accurate readings. Be sure to have appropriate-sized extra batteries on hand.

(h) Adverse weather conditions may present challenges that need to be dealt with on a case-by-case basis. For example, air temperatures below 32°F may cause ice formation in the tubing, flow-through cell, and on the sampling equipment, or heavy rain could cause standing water issues with flush-mounted wells. Heavy rain can also impact electronic sampling equipment; preventative measures should be taken to keep electronic equipment dry.

(i) Observe and avoid any uncontrolled ambient/surrounding air conditions that could affect analytical results (e.g., truck/vehicle exhaust nearby, industrial building vents). Always ensure that vehicles are turned off during sampling to avoid introducing vehicle exhaust into the sample. If uncontrolled ambient/surrounding air conditions cannot be avoided, contact the Project Manager for further instruction; collection of a field blank sample may be warranted in this situation.

(j) Procedures should be established to minimize potential cross-contamination. For example:

- Wrap monitoring and sampling equipment with protective material (e.g., aluminum foil, polyethylene sheeting, Ziploc® bags) after decontamination and between sampling locations to minimize the potential for cross-contamination between well purging events at different locations.
- Use dedicated or disposable sampling equipment or new tubing at each sampling point when appropriate to minimize the need for decontamination.
- Protect sampling equipment and/or the open well head from blowing soil and dust by covering with plastic sheeting as needed.
- If a bailer and rope are used to purge and/or sample the well, then there is the possibility of contamination from the rope used to lower the bailer. New or dedicated rope should be used when appropriate. Alternatively, a decontaminated, Teflon®-coated stainless steel leader can be attached between the rope and the bailer. The leader acts as an extension to the rope and allows for the top of the bailer to enter the water column without immediately placing the rope into the water. It is important to keep the rope clean and not allow contact with the ground surface during bailing.

(k) Disposal of the groundwater collected during purging must be performed in accordance with all applicable regulations and the project-specific work plan.

(l) Clear tape should not be used to cover labels on containers used for certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

(m) In cases where it is difficult to obtain sufficient sample volume for multiple analytical fractions as well as required quality control (QC) analyses (*e.g.*, field duplicates, matrix spike/matrix spike duplicate [MS/MSD] analyses), discuss this situation with the Project Manager and laboratory prior to sample collection. Laboratories can often "make do" with less volume, especially for inorganic parameters, or increase the reporting limit proportional to the sample volume obtained.

1.7 Personnel Qualifications

Since this SOP will be implemented at sites or in work areas that entail potential exposure to toxic chemicals or hazardous environments, all TRC personnel must be adequately trained. Project- and client-specific training requirements for samplers and other personnel on site should be developed in project planning documents, such as the sampling plan or project-specific work plan. These requirements may include:

- OSHA 40-hour Health and Safety Training for Hazardous Waste Operations and Emergency Response (HAZWOPER) workers
- 8-hour annual HAZWOPER refresher training.

2.0 PROCEDURES

Procedures for collecting groundwater samples from monitoring wells are described below. The project-specific work plan should also be consulted for specific details regarding sampling.

When possible, sampling should always begin at the monitoring well with the least contaminated groundwater and systematically proceed to the well with the most contaminated groundwater, including sites which may have nested wells.

2.1 Pre-sampling Activities

(a) It should be determined if there is the requirement to determine static water level measurements on <u>all</u> wells at the site prior to sampling, regardless if the well is being sampled.

(b) Prior to field activities, review historical groundwater sampling logs (if available) to maintain consistency for the current sampling event (e.g., equipment type, pump intake depth setting, flow rate, etc.)

(c) Organize monitoring, purging, and sampling equipment taking care not to allow cross-contamination. This can be accomplished by laying new polyethylene sheeting near the well or using new buckets, etc.

(d) Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

(e) Unlock the well cover on the well.

(f) Record the sample location, time, and date in the field book and/or on the Groundwater Field Data Record.

(g) On the Groundwater Field Data Record, note the physical condition of the well, including damage, deterioration, and signs of tampering, if any. Collect photographic documentation of serious damage to present to the Project Manager.

(h) Open the well cap and expansion plug, and stay upwind of and not directly over the well. Note any unusual odors, sounds, or difficulties in opening the well and, if required, measure the organic vapor reading at the rim of the well with a suitable organic vapor screening device (e.g., PID or FID), and record the reading in the field book and/or on the Groundwater Field Data Record. If pressure or vacuum is noted or suspected in the well, allow sufficient time for the water level elevation in the well to equilibrate.

(i) Gently lower a clean, decontaminated water level measuring device into the well to determine the static water level. If appropriate for site conditions, check for the presence of LNAPL or DNAPL using an oil/water interface probe (refer to ECR SOP 004, *Water Level and Product Measurements*). If LNAPL or DNAPL is detected, contact the Project Manager before proceeding with purging and sampling activities. Record the information on depth to groundwater to the nearest 0.01 feet, depth to LNAPL or DNAPL, and/or thickness of NAPL in the field book and/or the Groundwater Field Data Record. Refer to ECR SOP 004, *Water Level and Product Measurements*, for proper procedures in performing these measurements.

(j) If required in the project-specific work plan, measure the depth to the bottom of the well to assist in calculating the well volume of the well. If possible, avoid making total well depth measurements on the same day as sampling due to the tendency to disturb sediment during this measurement. If NAPL is suspected, use a decontaminated oil/water interface probe. If the measured depth is less than the constructed depth, this may indicate that the well needs to be redeveloped (see ECR SOP 006, *Well Development*). Consult the project-specific work plan or Project Manager for further instructions.

2.2 Groundwater Purging Activities

Purging is conducted to ensure that representative groundwater is obtained from the water-bearing unit for analysis. The multiple-volume or low-flow purging approach may be used to remove water from the well and monitor the water in order to determine when a well has been adequately purged (i.e., stabilized); at a minimum, the pH, specific conductance and temperature of the groundwater removed during purging should be monitored and recorded in the field notes. Other parameters may be required in some regulatory jurisdictions (e.g., turbidity). Additionally, the purge volume should be monitored and recorded. In some instances, such as when monitoring at solid waste disposal facilities, simply removing an adequate volume of water (e.g., three well volumes) may be suitable for adequate purging, and sampling can commence. Check with the project-specific work plan and appropriate regulatory guidance to determine any specific purging requirements.

If the well has been previously sampled consistent with this SOP, then the prior purging strategy (e.g., method, pump intake depth and the flow rates) should be followed during subsequent sampling events to maintain consistency and minimize potential variability due to the sampling procedure.

2.2.1 Multiple-Volume Purging Approach

The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization. The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough (e.g., every 3 to 5 minutes) to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes may be sufficient.

Purge Volume

Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. The specific methodology for obtaining these measurements is included in ECR SOP 004 *Water Level and Product Measurements*.

Once this information is known, the well volume can be calculated using Equation 1:

Well Volume (V) = πr^2 h (cf) **Equation 1**

where:
π = pi (3.14)
r = radius of well in feet (ft)
h = height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf = conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3.

The volume in gallons/linear foot (gal/ft) and liters/linear foot (L/ft) for common-size wells are as follows:

Well Inside Diameter (inches)	Volume (gal/ft)	Volume (L/ft)
1	0.0408	0.1529
2	0.1631	0.6174
3	0.3670	1.3892
4	0.6524	2.4696
6	1.4680	5.5570

If the volumes for the common-size wells above are utilized, Equation 1 is modified as follows:

Well volume = (h)(f) **Equation 2**

where:
h = height of water column (feet)

f = the volume in gal/ft or L/ft

For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed. The field notes should reflect the single-well volume calculations or determinations according to one of the above methods and a reference to the appropriate multiplication of that volume, (i.e., a minimum of 3 well volumes) clearly identified as a purge volume goal.

For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.

If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. If, after 3 well volumes have been removed, the field parameters have not stabilized (see discussion in Section 2.2.3), additional well volumes (up to a total of 5 well volumes), should be removed. If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging. If, after 5 well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible with respect to turbidity. The conditions of sampling should be noted in the field book.

2.2.2 Low-flow Purging Approach

The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample. The term low-flow refers to the low velocity with which water enters the pump intake during purging and sampling. The objective is to draw representative saturated zone water through the well screen to the pump intake while avoiding disturbance of the stagnant water above the well screen through minimizing drawdown of the water column in the well. To achieve this, the flow rate should be adjusted to less than 1 L/min (usually, this will be a rate less than 500 ml/min and may be as low as 100 ml/min). Once drawdown stabilizes, the sampled water is isolated from the stagnant water in the well casing, thus eliminating the need for its removal. This sampling method is based on the principle that water within the screened zone passes through continuously and does not mix with water above the screen. Water entering the pump can be considered representative of water in the formation after drawdown and indicator parameters have stabilized.

When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval (or center of the water column within the well screen if the water level is below the top of the well screen) to help prevent disturbance of any sediment at the bottom of the well. If known, the pump can be placed adjacent to the areas with the highest hydraulic conductivity or highest level of contaminants. Dedicated pumps can be utilized to minimize disturbance of the water column. Subsequent sampling events should duplicate as closely as possible the pump intake depth and the stabilized flow rate from the previous events.

To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.

The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings. Note any flow rate adjustments on the Groundwater Field Data Record. Once an appropriate purge rate has been achieved, record this information, continue purging until water quality indicator parameters have stabilized (see Section 2.2.3), and then sample the well.

Attempts should be made to avoid pumping a well dry. If drawdown cannot be maintained at less than 0.3 feet and the falling water level is approaching the top of the screened interval (or the top of the pump for sampling that began with the water level below the top of the screen), perform the following steps:

1. Reduce the flow rate, or turn the pump off and allow for recovery. (The pump must have a check valve to prevent backflow if it is shut off).
2. Begin pumping again at a lower flow rate.
3. If water draws down to the top of the screened interval again (or the top of the pump for sampling that began with the water level below the top of the screen), turn the pump off and allow for recovery.
4. If two tubing volumes (including volume of water in the pump and flow-through cell) have been removed during purging, sampling can proceed the next time the pump is turned on without waiting for indicator field parameters to stabilize. The project-specific work plan or Project Manager should be consulted for guidance.
5. If this procedure is used, this should be recorded in the field book and/or on the Groundwater Field Data Record.

2.2.3 Field Parameter Stabilization During Purging

Stabilization criteria may depend on project objectives or regulatory-specific requirements. Refer to Appendix A for some of the regulatory-specific requirements for field parameter stabilization. Generally, an adequate purge with respect to the ground water chemistry is achieved when, stability for at least three consecutive measurements is as follows:

- pH ± 0.1 standard unit (SU)
- specific conductance within 3%
- turbidity within 10% for values greater than 5 nephelometric turbidity units (NTUs). If three turbidity readings are less than 5 NTUs, the values are considered as stabilized

Other parameters, such as DO, may also be used as a stabilization parameter. Typical stabilization goals for DO are within 0.2 mg/L or 10% saturation, whichever is greater. DO measurements should be conducted using either a flow-through cell or an over-topping cell to minimize or reduce potential oxygenation of the sample.

Because groundwater temperature is generally not very sensitive in distinguishing between stagnant casing water and formation water and is subject to rapid changes during purging, its usefulness is subject to question for the purpose of determining parameter stability. Even if temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters, during well purging, as it may be needed to interpret other parameter results.

ORP is not always used as a stabilization parameter since it may also be subject to rapid changes during the purging process; however, it may be measured and recorded during well purging.

2.2.4 Special Considerations During Purging

Wells Purged Dry/Purge Adequacy

For wells with slow groundwater recovery, attempts should be made to avoid purging the well dry. This may be accomplished by slowing the purge rate. As water enters a well that has been purged dry, the water may cascade down the sand pack and/or the well screen, potentially stripping VOCs that may be present and/or potentially mobilizing soil fines into the re-accumulating water column.

However, even with slower purge rates, in some situations, a well may be pumped or bailed dry (evacuated) during the purging process. In these situations, evacuation generally constitutes an adequate purge and the well may be sampled following sufficient recovery (enough volume to allow filling of all sample containers). **It is not necessary that the well be evacuated three times before it is sampled.** Purging parameters should be measured and recorded during sample collection to serve as the measurements of record for the sampling event.

It is particularly important that wells be sampled as soon as possible after purging to maintain sample representativeness. If adequate volume is available upon completion of purging, the well should be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells that have a slow recovery should be scheduled so that they can be purged and sampled in the same day after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

Temporary Monitoring Wells

Procedures used to purge temporary groundwater monitoring wells may differ from permanent wells, because temporary wells are installed with different DQOs for immediate sample acquisition. Wells of this type may include standard well screens and risers placed in boreholes created by hand augering, power augering, or by drilling. Alternatively, they may consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler, or a Hydropunch® sampler.

Purging to address stagnant water may not necessarily apply to temporary wells, because stagnant water is not typically present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column may become, and the more appropriate it may be to apply, to the extent possible, standard permanent monitoring well purging criteria.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing saturated conditions, resulting primarily in increased turbidity. Therefore, the goal of purging, if conducted, may be to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low-stress purging techniques using variable-speed peristaltic pumps.

2.2.5 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The pump of choice is usually a function of the purging approach (e.g., multiple-volume vs. low-flow), well diameter, the DTW, the total depth of the well, the amount of water that is to be removed during purging, the specific analytical testing program for the well, and the equipment previously used during purging and sampling of the well. A peristaltic pump is appropriate for purging whenever the head difference between the sampling location and the water level is less than the limit of suction (approximately 25' to 30') and the volume to be removed is reasonably small. For wells where the water level is below the limit of suction, and/or where there is a large volume of water to be purged, the variable-speed electric submersible pump or adjustable-rate bladder pumps would be appropriate. Bailers may also be used for purging in appropriate situations (e.g., shallow wells with small purge volumes); bailers are not suitable for low-flow purging.

The following subsections describe well evacuation devices that are most commonly used. Other devices are available but are not discussed in this SOP due to their limited use. Site-specific operating procedures should be developed in the case that an uncommon purge device is used.

2.2.5.1 Purging with a Suction Pump

There are many different types of suction pumps. They commonly include: centrifugal, peristaltic and diaphragm. Diaphragm pumps can be used for well evacuation at a fast pumping rate and sampling at a low pumping rate. The peristaltic pump is a low-volume pump that incorporates a roller to squeeze flexible tubing, thereby creating suction. This tubing can be dedicated to a well for re-use or discarded. It is recommended that 1/4 inch or 3/8 inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2 (applicable to peristaltic pumps only).
(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.
(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications.
(d) Ensure that the pump tubing is set at the pre-determined pump intake depth.
(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for

collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Do not allow the pump to run dry. If the pumping rate exceeds the well recharge rate, adjust the rate accordingly or, if consistent with the purging and sampling objectives, lower the tubing further into the well and continue pumping.

(g) Using the water quality meter, take an initial reading of the required indicator parameters. All measurements, except turbidity, must be obtained using a transparent flow-through cell unless an unforeseen situation makes this impractical or inadvisable. Initially, turbidity may be elevated. Once turbidity has decreased to a measurable range, begin monitoring indicator parameters at approximately every 3-5 minutes, or as appropriate. Please note that flow-through cell size should be taken into account in conjunction with the flow rate to determine the length of time between water quality parameter readings. At least one flow-through cell volume should be turned over between readings. For example, if the flow through cell size is 500 mL and the flow rate is 100 mL/min, then it would be appropriate to measure water quality parameters every 5 minutes.

(h) Record the readings on the Groundwater Field Data Record. The monitoring probes must be submerged in water at all times. Record the indicator parameters, along with the water level, as described in Step (g) above. If removing a specified volume of water (e.g., 3-5 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume. In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection. Stabilization criteria are discussed in Section 2.2.3.

Particulate build-up in the flow-through cell may impact indicator parameters. If the cell must be cleaned during pumping operations, continue pumping and disconnect the cell for cleaning, then reconnect and continue monitoring. Record the start and stop times, and describe the cleaning steps in the field book.

If indicator parameter stabilization is required and parameters have not stabilized after 2-hours of purging (or other pre-determined length of time), one of three options may be taken after consultation with the Project Manager:

1) continue purging until stabilization is achieved;
2) discontinue purging, do not collect any samples, and record in the field book and/or on the Groundwater Field Data Record the stabilization conditions and steps taken to attempt to achieve stabilization; or,
3) discontinue purging, collect samples and document attempts to achieve stabilization.

NOTE: If parameters do not stabilize, or turbidity remains greater than 5 NTU within the project-determined time range (EPA recommends up to 2 hours), contact the Project Manager to develop a modified sampling approach.

(i) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(j) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.2.5.2 Purging with a Submersible Pump

Submersible pumps generally use one of two types of power supplies, either electric or compressed gas. Electric pumps can be powered by a 12-volt DC rechargeable battery, or a 110- or 220-volt AC power supply. Those units powered by compressed gas (e.g., bladder pump) normally use a small electric controller that also needs a 12-volt DC battery or 110-volt AC power. They may also utilize compressed gas from bottles. Pumps differ according to the depth and diameter of the monitoring wells and the height of the potentiometric surface/water table (e.g., pressure head). It is recommended that 1/4-inch or 3/8-inch (inner diameter) tubing be used to help ensure that the sample tubing remains filled with water and to prevent water from being aerated as it flows through the tubing. Purging procedures are as follows.

(a) Determine the volume of water to be purged as described in Section 2.2.1 or follow the low-flow approach described in Section 2.2.2.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of pumps, tubing or other purging/sampling equipment with foreign materials.

(c) Assemble the pump, tubing and power source, if necessary, in accordance with manufacturer's specifications. If the pump itself is being lowered into the well, ensure a safety line is attached.

(d) Non-dedicated purge/sampling vs. dedicated purge/sampling systems.

<u>Dedicated systems:</u> Pump has already been installed. Refer to historical monitoring well information, and record the depth of the pump intake in the field book and/or on the Groundwater Field Data Record.

<u>Non-dedicated systems:</u> Determine the target depth of the pump intake. Note that this may be a historical intake depth; see well construction data or the project-specific work plan. If there is not an established intake depth, the center of the screened interval should be targeted. If the measured water level is lower than the top of the well screen, position the pump intake at the midpoint of the water column. The intake should be generally 1 to 2 feet above the bottom of the well to minimize potential mobilization of any settled sediment, the risk of the pumping suction being broken, or the entrainment of air in the pump tubing and resulting sample. Slowly lower the pump, safety line, and tubing into the well to the pre-determined pump intake depth. The tubing should be cut to the desired length to assist in installing the pump. Measure the depth of the pump intake while lowering the tubing/pump into location. Record the pump intake depth in the field book and/or on the Groundwater Field Data Record. For deeper wells and large diameter wells, two staff members may be necessary to accomplish this task.

(e) Connect the discharge line from the pump to the flow-through cell for parameter measurements. Use a T-connection or valve prior to the flow-through cell to allow for collection of water for turbidity measurements. Direct the discharge line from the flow-through cell to a 5-gallon bucket (or equivalent) to contain the purge water for proper disposal. Verify the end of the tubing is not submerged in the purge bucket. Manage purge water as specified in the project-specific work plan.

(f) Measure the flow rate of the pump with a graduated container and stop watch. The pump pressure may need to be increased for discharge to occur. Record the volume of water collected for a period of 1 minute and calculate the flow rate as follows.

$$Flowrate\,(mL\,/\,min) = \frac{volume\ collected\ (mL)}{1\ minute}$$

(g) Measure the water level and record the flow rate and the water level. This should be performed every 3 to 5 minutes during purging. For low-flow purging, the flow rate should be adjusted to result in a rate between 100 to 500 mL/min; however, if drawdown of the well is observed, a slower flow rate may be necessary. If using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 mL volatile organic analysis (VOA) vial, if possible.

(h) Prior to recording the water quality indicator parameters, a minimum of one tubing volume should be purged. Note that this includes the volume of the flow-through cell.

(i) Proceed to steps (g) through (j) in Section 2.2.5.1.

2.2.5.3 Purging with a Bailer

(a) Determine the volume of water to be purged as described in Section 2.2.1.

(b) Take necessary precautions (e.g., laying plastic sheeting around the well) to prevent contamination of tubing or other purging/sampling equipment with foreign materials.

(c) Use a well-dedicated bailer (i.e., used exclusively for that well only), a decontaminated bailer or an unused, disposable bailer.

(d) Attach an appropriate length of (a) bailing line, (b) Teflon®-coated bailing wire or (c) rope with Teflon®-coated stainless steel leader to reach the bottom of the well. Secure a knot or series of knots to the top of the bailer. Be sure to have additional length of line to facilitate handling of the bailer at the surface (typically 10 ft).

(e) Lower the bailer gently into the well until it reaches the water column and fills with water from the bottom. Note: It is recommended that the bailer be lowered into the water to a depth that prevents the water from entering the top of the bailer. This is done to prevent excess turbulence caused by filling from the bottom and the top simultaneously. Controlling the line attached to the bailer as it is lowered into the well is also important to prevent degassing of the water as the bailer impacts the water. In shallow wells, controlling the line is not too difficult; however, for wells of greater depths it is common to utilize a hand-over-hand (windmill) approach using both hands to control longer lengths of line and prevent the loops in the line from tangling with one another. This procedure is simple to learn and saves a good deal of time by preventing tangles. Do not allow the bailing line or rope to become contaminated by surface soil.

(f) Once the bailer is full of water, gently withdraw the bailer from the well until it comes out of the top of the well. Be sure to control excess line in your hands to prevent the rope and bailer from touching the ground, and then grasp the bailer as it appears at the top of the well.

(g) Immediately pour the water into a vessel for water quality measurements, and record the measurements in the field book or on the Groundwater Field Data Record (at the project-required frequency). Otherwise, pour water into a 5-gallon bucket or other vessel to track the volume purged. As a general rule, standard 2-inch bailers are able to hold about 1 liter of water when full. This process will have to be repeated several times to complete adequate purging of the well (e.g., three to five well volumes).

(h) Record the volume of water purged on the Groundwater Field Data Record. Record the disposal method used for purge water in the field book.

(i) Once the required volume of water is removed (typically 3 to 5 well volumes) from the well and/or parameters are stabilized to the satisfaction of the project-specific work plan, proceed to Section 2.3, Post-purging Groundwater Sample Collection.

2.3 Post-purging Groundwater Sample Collection

(a) New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.

(b) If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell or sample from the T-connector, if used. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.

(c) If using bottom-filling bailers,

- Slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling).
- Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.

2.3.1 Sample Collection Order

Fractions of the groundwater sample should be collected in the following order (i.e., decreasing volatility) unless otherwise specified in the project-specific work plan:

1. VOCs;
2. Semivolatile organic compounds (SVOCs);
3. Other organic parameters;
4. Unfiltered inorganic constituents (e.g., total metals);
5. Filtered inorganic constituents (e.g., dissolved metals); and
6. Other constituents.

During sample collection, allow the water to flow directly down the side of the sample container without allowing the tubing to touch the inside of the sample container or lid in order to minimize aeration and turbulence and maintain sample integrity. The tubing should remain filled with water.

2.3.2 VOC Sample Collection

<u>Collection of VOCs/Volatile Petroleum Hydrocarbons (VPH):</u> Samples for VOCs will be collected first unless they are being collected by the "straw" method described in Section 1.6.2 (d), and the sample vial must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, the vial should be topped off using a minimal amount of sample to re-establish the

meniscus. Care should be taken to not flush any preservative out of the vial when topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected. Note: Extra VOC vials should be obtained prior to the sampling event in case this situation occurs.

Note: When using a bladder pump, it is recommended that the pump be set to deliver long pulses of water so that one pulse will fill a 40 ml VOA vial, if possible.

When acid preservation is used for the collection of VOCs, the acid must be added to the vials before sample collection. However, in most cases 40-ml VOA vials come pre-preserved. If a pre-preserved vial effervesces upon the addition of sample, the acid preservative can be rinsed out of the vial with sample water and then used to collect the sample. The laboratory should be made aware that the affected sample will not be acid-preserved as this may affect the sample holding time. Note effervescence in the field book for future reference.

2.3.3 Non-VOC Sample Collection

Completely fill the remaining sample containers for all non-VOC analyses.

Preserve the non-VOC samples in accordance with method and project-specific requirements following sample collection if the sample containers are not pre-preserved. (**NOTE:** Pre-preserved vials may be supplied by the laboratory, depending on the program).

2.3.4 Field Filtering

Depending upon project requirements, field filtering may be performed for non-VOC analyses. An in-line filter should be fitted at the end of the discharge tubing and the sample should be collected after the filter. Pre-rinse the in-line filter by allowing a minimum of 0.5 to 1 liter of groundwater from the well to pass through the filter prior to sampling. Ensure the filter is free of air bubbles prior to collecting samples. Preserve the filtered water sample immediately or directly fill pre-preserved containers (if provided). Clearly note “filtered” or “dissolved” on sample label and COC document.

2.4 Groundwater Sample Collection Without Purging (Passive Sampling)

Passive sampling can be defined as the free flow of contaminants from the media being sampled to a receiving phase in a sampling device. Depending upon the sampler, the receiving phase can be a solvent (e.g., water), chemical reagent, or porous adsorbent (e.g., activated carbon). While there are many different types of passive samplers, most have a barrier between the medium being sampled and the receiving phase. The barrier determines the sampling rate that contaminants are collected at a given concentration and can be used to selectively permit or restrict various classes of chemicals from entering the receiving phase.

There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers.

Passive samplers are deployed down a well to the desired depth within the screened interval or open borehole to obtain a discrete sample without using pumping or a purging technique. Most

samplers are able to be stacked to obtain samples at multiple depths. Some samplers can also be used to measure contaminants in groundwater as it enters a surface water body.

Diffusion, or equilibrium, samplers are devices that rely on diffusion of the analytes to reach equilibrium between the sampler fluid and the well water. Samples are time-weighted toward conditions at the sampling point during the latter portion of the deployment period. The degree of weighting depends on analyte and device-specific diffusion rates. Typically, conditions during only the last few days of sampler deployment are represented. Depending upon the contaminant of concern, equilibration times range from a few days to several weeks. Diffusion samplers are less versatile than grab samplers as they are not generally effective for all chemical classes.

Both the diffusion and integrating samplers depend upon permeation or diffusion through barriers that hold the receiving phase. This diffusion process is chemical and barrier specific. Diffusion samplers are commonly known as PDBs or rigid porous polyethylene (RPP) samplers. PDBs may be used to sample for VOCs, and RPPs may be used to sample for various organic and inorganic constituents. PDBs must be allowed to remain in the well for a sufficient period of time to allow the deionized water in the sampler to come into equilibrium with the constituents in the ambient groundwater.

Some regulatory agencies allow groundwater samples to be collected without purging the well. This may be accomplished by suspending a passive sampler in the well for a period of time appropriate for the type of passive sampler being used. It is important to confirm that the chosen sampler is compatible with the contaminants of concern including all VOCs of interest at the site.

Diffusion passive samplers are used most commonly and the procedure for their use is as follows:

(a) Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.

(b) New passive samplers are attached via PVC cable ties to a tether (a pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well. There should be sufficient well screen saturation within the well to completely cover the passive sampler. For VOCs, it is recommended that there should be several feet of groundwater above the top of the PDB.

(c) The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers). Longer equilibration times may be necessary in lower permeability formations. Once sufficient time for equilibration has passed, the PDB samplers can be retrieved when convenient.

(d) Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.

(e) Detach the passive sampler from the tether.

(f) Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

(g) Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. Tilting the passive sampler will control the flow rate. The VOA vials must be filled within the first several minutes of passive sampler retrieval. (Note that sample vials should be prepared and opened on a stable surface or holding device such as a foam pack. Decanting sample from passive samplers into containers requires techniques that may require some practice and patience.) Refer to Section 2.3.2 for special circumstances regarding the filling of VOA vials.

(h) A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.

(i) Dispose of the passive sampler after use.

2.5 Post-sampling Activities

(a) Cease pumping and, if system is non-dedicated, disassemble and decontaminate the purging and sampling equipment. Verify the end of the tubing is not submerged in the purge bucket prior to turning off the pump.

(b) Dispose of the bailer (if disposable) and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the bailer in a plastic bag for transport to the site decontamination area.

(c) Dispose of the empty passive sampler and/or rope and/or other disposable equipment in accordance with the project-specific work plan, or store the empty passive sampler in a plastic bag for transport to the site decontamination area

(d) Replace the well cap and well cover on the well and lock the outer casing (if present).

(e) Label each sample. If the labels are covered with clear tape, ensure this is not performed for VOA vials.

(f) Place all samples in a cooler with ice.

(g) Ensure samples are delivered to the laboratory well before the required holding time expires.

(h) Consult the project-specific work plan to determine if a calibration check is required at the end of the day for the water quality parameters.

3.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Field personnel should discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager.

Each project must consider investigation-derived waste disposal methods and have a plan in place prior to performing the field work. Provisions must be in place as to what will be done with investigation-derived waste. If investigation-derived waste cannot be returned to the site, consider material containment, such as a composite drum, proper labeling, on-site storage by the client, testing for disposal approval of the materials, and ultimately the pickup and disposal of the materials by appropriately licensed vendors.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The collection of QC samples is dependent upon the DQOs. Project-specific work plans should be consulted to determine the required frequency of QC sample collection.

4.1 Field Duplicates

The following procedures should be used for collecting field duplicates of groundwater samples:

(a) For QC purposes, each duplicate sample will be typically submitted to the laboratory as a "blind" duplicate sample, in that a unique sample identification not tied to the primary sample identification will be assigned to the duplicate (e.g., DUP-01). Standard labeling procedures used for groundwater sampling will be employed. However, a sample collection time will not be included on the sample label or the COC form. The actual source of the duplicate sample will be recorded in the field book and/or on the Groundwater Field Data Record.

(b) Each duplicate sample will be collected simultaneously with the actual sample by alternately filling sample and duplicate bottles. Following the order of collection specified for each set of containers (VOCs, SVOCs, other organic parameters, unfiltered inorganic constituents, and filtered inorganic constituents), the duplicate sample containers will be alternately filled with groundwater for each parameter.

(c) All collection and preservation procedures outlined for groundwater sampling will be followed for each duplicate sample.

4.2 Equipment Blanks

Equipment blanks include reagent water that is run through the bailer (if not disposable), rope, leader line, decontaminated pump, a representative section of the pump's tubing, or any other piece of sampling equipment that may have come in contact with the sample. The equipment blanks are collected and preserved in the same sample containers as field samples. If dedicated or disposable systems are used, equipment blanks are not required, although an initial blank could be performed to demonstrate that the dedicated equipment is clean prior to use. If only dedicated tubing is used, the equipment blank will include only the pump in subsequent sampling events. A passive sampler is considered a dedicated device and no equipment blank is required.

Ideally, the reagent water should come from the laboratory and be certified clean. If not certified and/or if not from the laboratory performing the analyses, a separate water blank that has not run through the sampling equipment should be sent to the laboratory for analysis.

4.3 Trip Blanks

Trip blanks will be used to check for potential contamination of VOCs via migration during storage and shipping. Trip blanks typically consist of two to three 40 mL VOA vials filled with analyte-free water and preserved with hydrochloric acid (HCl) to pH <2 SU. Trip blank containers are usually supplied pre-filled by the laboratory. Trip blanks are typically submitted to the laboratory at a frequency of one per cooler for coolers that contain samples for VOC and/or VPH analysis. Trip blanks are analyzed by the laboratory for VOCs and/or VPH, depending on field sample analyses.

4.4 Field Blanks

Field blanks consists of analyte free water exposed to the atmosphere during field sample collection. The water is containerized in an appropriate bottle and preservative for the analytical suite and shipped to the laboratory with the other field samples. The results are used to assess whether or ambient/surrounding air conditions may have influenced analytical results.

4.5 MS/MSDs and MS/Duplicates

MSs are an additional analysis of a sample spiked by the laboratory with a subset or all of the target analytes and are used to demonstrate the accuracy of analytical methods for a given matrix. MSDs are an additional analysis of a sample spiked with a subset or all of the target analytes and are also used to demonstrate the accuracy of analytical methods for a given matrix. MS/MSDs also provide a measure of analytical precision for a given matrix. Duplicates are an additional analysis of a sample and are used to demonstrate the precision of analytical methods for a given matrix.

Triplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform the MS/MSD analyses for organic parameters. Duplicate volumes of a field sample must be collected in order for the laboratory to have enough volume to perform MS/Duplicate analyses for inorganic parameters. The sample designated for MS/MSD or MS/Duplicate analyses should be noted in the Comments column of the COC document.

4.6 Temperature Blanks

Temperature blanks consist of a sample container filled with non-preserved water (potable or distilled) and typically are included in all coolers that contain samples that require temperature preservation. These may be added to the coolers by the field team if not provided by the laboratory. Temperature blanks must remain inside the coolers on ice during the sampling process.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

Record the sample location, sample identification, and date and time of collection in the field book and/or the Groundwater Field Data Record. The Groundwater Field Data Record (Attachment B) should be used to record the following information:

- Volume of each sample

- Sample identification number
- Sample location (sketch of the sample point)
- Time and date sample was collected
- Personnel performing the task
- Volume of water removed
- Purging time
- Flow rate during purging and sampling
- Weather conditions during sampling (e.g. temperature, wind)
- Field parameters such as water level, pH, temperature, conductivity, turbidity, ORP, and DO
- Sample collection equipment and method used
- Decontamination procedures
- Analytical parameters
- Preservation method and amount of preservative

All sample numbers must be documented on the COC form that accompanies the samples during shipment. Any deviations from the records management procedures specified in the project-specific work plan must be approved by the Project Manager and documented in the field book.

6.0 REFERENCES

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USEPA. September 2004. Field Sampling Guidance Document #1220: Groundwater Well Sampling. USEPA Region 9 Laboratory Richmond, California.

USEPA, January 19, 2010. *Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. USEPA Region 1, Rev. 3.

USEPA. March 6, 2013. *Groundwater Sampling.* SESDPROC-301-R3. USEPA Region 4, Science and Ecosystem Support Division. Athens, Georgia.

USEPA. April 22, 2014. Passive (No Purge) Samples. http://www.clu-in.org/characterization/technologies/default.focus/sec/Passive_%28no%20purge%29_Samplers/cat/Overview/

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	AUGUST 2014	NOT APPLICABLE
1	JULY 2016	ADDED ATTACHMENT D TO ACCOMMODATE SOP MODIFICATIONS REQUIRED WHEN SAMPLING FOR PFCS; CHANGED NAMING CONVENTION FOR SOP FROM RMD TO ECR.
2	NOVEMBER 2016	ADDED ADDITIONAL INFORMATION REGARDING PFAS.
3	JANUARY 2020	TRC RE-BRANDING; ADDED FIELD BLANKS TO SECTION 4
4	AUGUST 2020	ADDITIONAL PFAS-SPECIFIC INFORMATION INCLUDED

Attachment A:

Groundwater Field Parameter Stabilization Criteria for Selected Jurisdictions

Jurisdiction	Information Source	Applicable Stabilization Criteria
USEPA Region 1	Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells; U.S. Environmental Protection Agency Region 1, January 19, 2010. http://www.epa.gov/region1/lab/qa/pdfs/EQASOP-GW001.pdf (for low flow PDF) http://www.epa.gov/region1/lab/qa/qualsys.html (for EPA's Quality System Documents)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% if >5 NTUs; if three Turbidity values are <5 NTU, consider the values as stabilized Dissolved Oxygen: ±10% if >0.5 mg/L, if three Dissolved Oxygen values are <0.5 mg/L, consider the values as stabilized Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 2	Groundwater Sampling Procedure: Low Stress (Low Flow) Purging and Sampling, SOP # SST-7, Revision No. 1, November 2010.	Same as above
USEPA Region 4	USEPA Region 4 SOPs: http://www.epa.gov/region4/sesd/fbqstp/index.html See Chemical Parameter Stabilization Criteria (section 3.2.1.1.2 of Groundwater Sampling SOP, revision 3/6/2013: http://www.epa.gov/region4/sesd/fbqstp/Groundwater-Sampling.pdf	pH: ±0.1 unit Specific Conductance: ±5% Temperature: Not used Turbidity: "Stabilized" (no criteria specified) if >10 NTUs ; if three Turbidity values are <10 NTUs, consider the values as stabilized Dissolved Oxygen (optional parameter): ±0.2 mg/L or ±10% of saturation, whichever is greater Oxidation/Reduction Potential: Not used
USEPA Region 5	Ground Water Forum Issue Paper (May 2002, Yeskis and Zavala) http://www.epa.gov/superfund/remedytech/tsp/download/gw_sampling_guide.pdf A minimum set of parameters would include pH, conductivity, and turbidity or DO. Puls and Barcelona, 1996 (pH, specific conductance, ORP, turbidity) Wilde et al., 1998 (pH, turbidity, DO)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: Not used Turbidity: ±10% if >10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
USEPA Region 9	See USEPA Region 1 (above)	
USEPA Region 10	See USEPA Region 5 (above)	
Alabama	Alabama Environmental Investigation and Remediation Guidance (section C.3.1) http://www.adem.state.al.us/MoreInfo/pubs/AEIRGInvestigation.pdf	pH: ±0.1 unit Specific Conductance: ±10% Temperature: "Constant" (no criteria specified) Turbidity: Stabilized (no criteria specified), or <10 NTUs Dissolved Oxygen: No criteria specified Oxidation/Reduction Potential: No criteria specified

Jurisdiction	Information Source	Applicable Stabilization Criteria
Indiana	Indiana Department of Environmental Management The Micro-Purge Sampling Option http://www.in.gov/idem/files/remediation_tech_guidance_micro-purge.pdf The parameters normally measured for stability (listed in increasing order of sensitivity) are pH, temperature, specific conductivity, oxidation-reduction potential, DO and turbidity. At least one of the last three listed must be used.	pH: ±0.1 unit Specific Conductance: ±3% Temperature: ±3% Turbidity: ±10% Dissolved Oxygen: ±10% Oxidation/Reduction Potential: ±10 millivolts (document says microvolts, but that may be an error)
Michigan	MDEQ Part 201 Op Memo 2, Attachment 5 http://www.michigan.gov/documents/deq/deq-rrd-OpMemo_2_Attachment5_249853_7.pdf	No specific values to determine stabilization are listed, but the Op Memo lists several other groundwater sampling guidance documents. If a valid reference exists, then it can be used to justify a sampling approach and stabilization parameters.
New Jersey	New Jersey Department of Environmental Protection http://www.state.nj.us/dep/srp/guidance/fspm/	pH: ± 0.1 unit Specific Conductance: ± 3% Temperature: ± 3% Dissolved Oxygen: ± 10% Turbidity: ± 10% for values greater than 1 NTU ORP/Eh: ± 10 millivolts
Ohio	Ohio EPA SOPs: http://www.epa.state.oh.us/portals/30/rules/FSOPs.pdf See Purging Stabilization Criteria (SOP 2.2.4, dated January 2, 2007, review in progress)	pH: ±0.1 unit Specific Conductance: ±3% Temperature: No criteria specified Turbidity: Below 10 NTUs ideal; ±10% if greater than 10 NTUs Dissolved Oxygen: ±0.3 mg/L Oxidation/Reduction Potential: ±10 millivolts
This table was last updated in July 2014.		

Attachment B:

Example Groundwater Field Data Records

TRC

Groundwater Field Data Record

Project: Project No.: Date/Time: Sheet ___ of ___

TRC Personnel: Well ID:

WELL INTEGRITY

	YES	NO
Protect. Casing Secure	☐	☐
Concrete Collar Intact	☐	☐
PVC Stick-up Intact	☐	☐
Well Cap Present	☐	☐
Security Lock Present	☐	☐

Sampling Equipment: _____

Flow-thru Cell Volume: _____

PID SCREENING MEAS.

Background	
Well Mouth	

Protective Casing Stick-up _____ ft. (from ground)

Riser Stick-up (from ground) _____ ft.

WELL DIAMETER ☐ 2 inch ☐ 4 inch ☐ 6 inch

Other: _____

WELL MATERIAL

☐ PVC ☐ SS

Other: _____

Well Depth _____ ft. ☐ top of riser ☐ top of casing ☐ _____ ☐ measured ☐ historical

Water Depth _____ ft.

Well Volume _____

LNAPL/DNAPL Depth = _____

NAPL Thickness = _____

Depth of pump intake: _____

Static water level after pump put into well:

Initial purge Rate/ Water Level (100-400 ml/min):

Adjusted purge Rates/time/WL(record changes)

Flow rate at time of sampling:

Total volume of water purged:

FIELD WATER QUALITY MEASUREMENTS (record at appropriate intervals)

Time									
Temp. (°C)									
Conduct. (µmhos/cm)									
DO (mg/L)									
pH (su)									
ORP (millivolts)									
Turbidity (NTU)									
Flow (ml/min)									
Depth To Water (ft)									
Cumulative Purge Vol. (gal or L)									

Time						
Temp. (°C)						
Conduct. (µmhos/cm)						
DO (mg/L)						
pH (Std. Units)						
Eh/ORP (millivolts)						
Turbidity (NTU)						
Flow (ml/min)						
Depth To Water (ft)						
Cumulative Purge Vol. (gal or L)						

Stabilization Criteria*
(3 consecutive readings)
- Temperature: ± 3 %
- Conduct. (µmhos/cm): ± 3 %
- DO (mg/L): ± 10 % (for values >0.5 mg/L)
- pH (Std. Units): ± 0.1 SU
- ORP (millivolts): ± 10 mV
- Turbidity (NTU): +/- 10 % (for values >5.0 NTUs)
- Drawdown: < 0.3 ft (can be greater as long as water level stabilizes above well screen)

	Purge	Sample
Peristaltic Pump	☐	☐
Submersible Pump	☐	☐
Bladder Pump	☐	☐
Bailer	☐	☐
Other: _____	☐	☐

Comments: _____

Analytical Parameter	Filtered (Y/N)	Preservation	# Bottles	Size/Type Bottles	Time Collected	QC	Sample #

* Consult the applicable regulatory guidance for the specific criteria.

Signed: _____

Rev: April 2014

PAGE _____ OF _____

TRC

WATER SAMPLE LOG

PROJECT NAME:	PREPARED		CHECKED	
PROJECT NUMBER:	BY:	DATE:	BY:	DATE:

SAMPLE ID:	WELL DIAMETER: ☐ 2" ☐ 4" ☐ 6" ☐ OTHER _____
WELL MATERIAL:	☐ PVC ☐ SS ☐ IRON ☐ GALVANIZED STEEL ☐ OTHER _____
SAMPLE TYPE:	☑ GW ☐ WW ☐ SW ☐ DI ☐ LEACHATE ☐ OTHER _____

PURGING	TIME:	DATE:	SAMPLE	TIME:	DATE:
PURGE METHOD:	☐ PUMP _____ ☐ BAILER _____		PH: _____ SU	CONDUCTIVITY: _____ umhos/cm	
			ORP: _____ mV	DO: _____ mg/L	
DEPTH TO WATER: _____ T/ PVC	FLOW-THRU CELL VOLUME		TURBIDITY: _____ NTU		
DEPTH TO BOTTOM: _____ T/ PVC			☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY		
PUMP INTAKE DEPTH: _____ T/ PVC	_____ LITERS		TEMPERATURE: _____ °C	OTHER: _____	
WELL VOLUME: _____ ☐ LITERS ☐ GALLONS			COLOR: _____	ODOR: _____	
VOLUME REMOVED: _____ ☐ LITERS ☐ GALLONS			FILTRATE (0.45 um) ☐ YES ☐ NO		
COLOR: _____ ODOR: _____			FILTRATE COLOR: _____	FILTRATE ODOR: _____	
TURBIDITY			QC SAMPLE: ☐ MS/MSD ☐ DUP- _____		
☐ NONE ☐ SLIGHT ☐ MODERATE ☐ VERY			COMMENTS:		
DISPOSAL METHOD: ☐ GROUND ☐ DRUM ☐ OTHER					

TIME	PURGE RATE (ML/MIN)	PH (SU)	CONDUCTIVITY (umhos/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	TEMPERATURE (°C)	WATER LEVEL (FEET)	CUMULATIVE PURGE VOLUME (GAL OR L)
									INITIAL

NOTE: STABILIZATION TEST IS COMPLETE WHEN 3 SUCCESSIVE READINGS ARE WITHIN THE FOLLOWING LIMITS:

pH: +/- **10 %** COND.: +/- **10 %** ORP: +/- **10 %** D.O.: +/- **10 %** TURB: +/- **10 %** or <= **5** TEMP.: +/- **0.5°C**

BOTTLES FILLED			PRESERVATIVE CODES A - NONE B - HNO3 C - H2SO4 D - NaOH E - HCL F - _____						
NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED	NUMBER	SIZE	TYPE	PRESERVATIVE	FILTERED
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N
				☐ Y ☐ N					☐ Y ☐ N

SHIPPING METHOD: _____	DATE SHIPPED: _____	AIRBILL NUMBER: _____
COC NUMBER: _____	SIGNATURE: _____	DATE SIGNED: _____

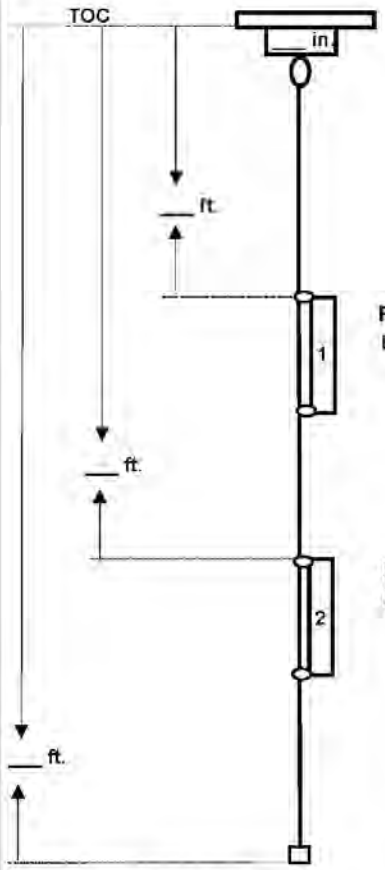
REVISED 06/2011

Groundwater Sampling Record for Organics (For Wells with Passive Diffusion Bags)

Project Name/No:

Well ID:

Installation of PDBs:	Sampling of PDBs:
TRC Personnel: _____	TRC Personnel: _____
Date: _____	Date: _____
Time: _____	DTW (ft): _____
DTW (ft): _____	



PDB #1
Length: ___ in.

Sample ID: _____
Sample Time: _____
Evidence of algae, iron or other coatings?: _____

PDB #2
Length: ___ in.

Sample ID: _____
Sample Time: _____
Evidence of algae, iron or other coatings?: _____

Measured well depth during tether installation: ___ ft.

Field Notes:

Rev: April 2014

Attachment C: SOP Fact Sheet

GROUNDWATER SAMPLING

PURPOSE AND OBJECTIVE

The objective of groundwater sampling is to obtain a representative sample of water from a saturated zone or groundwater-bearing unit (i.e., aquifer) with minimal disturbance of groundwater chemistry. This requires that the sample being collected is representative of groundwater within the formation surrounding the well bore as opposed to stagnant water within the well casing or within the filter pack immediately surrounding the well casing.

There are three general approaches to groundwater purging/sampling that can be used to obtain a representative groundwater sample for analysis: 1) the low-flow or micropurge method where the mixing of the stagnant water is minimized using low-flow pumping rates during the collection of the groundwater sample; 2) the multiple well volume removal approach in which the stagnant water is removed from the well and the filter pack prior to sample collection; and 3) the passive sampler procedure where water quality equilibration with the surroundings is achieved through deployment of the passive sampler for a sufficient amount of time prior to sampling. All three approaches are summarized in this document.

WHAT TO BRING

- Site-specific HASP and field book
- Project-specific work plan
- Figure or site map showing well locations and table showing well construction details
- Field data sheets from previous sampling event
- Well wrenches, ratchet set, and turkey baster to remove standing water from flushmount manholes
- Bolt cutters, padlocks and keys
- Water level meter of sufficient length
- Decontaminated pump, control box, power source (i.e., battery, generator, etc.)
- Tubing (Teflon®, Teflon®-lined polyethylene, or HDPE, type dependent upon project objectives)
- Multi-parameter instrument and flow-through cell (typically should include: pH, temperature, conductivity, ORP, and DO)
- Turbidity meter
- Equipment decontamination supplies (refer to ECR SOP 010, *Equipment Decontamination*)
- Appropriate PPE
- Field book
- Sample bottleware, labeled cooler, ice, temperature blank and blank COC forms; may also need field blank bottles and reagent-grade water
- Zip-loc® plastic bags
- Groundwater field data records
- Graduated cylinder and stop-watch
- Rope for tying off pump at desired intake
- Indelible marking pens
- Bubble wrap
- 5-gallon bucket(s)

As Needed:

- Calibrated PID or FID for well mouth readings
- Oil/water interface probe of sufficient length
- Drums for purge water, grease pen and adhesive drum labels; appropriate crescent or socket wrench
- Filtration equipment, if required (0.45 micron filters, or as otherwise required for the project)
- Other non-routine PPE such as Tyvek coveralls or respirators
- Traffic cones
- Field calibration sheets and calibration solutions

OFFICE

- Prepare/update the site-specific HASP; make sure the field team is familiar with the most recent version.
- Review the project-specific work plan with the Project Manager and/or the field team leader. Discuss the following:
  - Communication procedures;
  - Sampling order and designation;
  - Collection and sample method;
  - Analytical parameters, holding times and turn-around times;
  - Laboratory (contact/shipping info, COC, billing references);
  - Purge water management (Drums? Discharge to ground?);
  - QC sample collection; and
  - Decontamination procedures.
- Verify that monitoring wells will be accessible and/or coordinate to have a site contact available to assist.
- Make sure that monitoring well sample designations and QC sample designations/frequency are understood.
- Confirm that all necessary equipment is available in-house or has been ordered. Rental equipment is typically delivered the day before fieldwork is scheduled. Prior to departure or mobilization to site, test equipment and make sure it is in proper working order. Have rental equipment supplier contact information available for use in field.
- Review sample bottle order for accuracy and completeness and damaged bottles.
- Discuss specific documentation and containerization requirements for investigation-derived waste disposal with the Project Manager

ON-SITE

GROUNDWATER SAMPLING

- Review the HASP with all field personnel, sign acknowledgement form and conduct Health & Safety tailgate meeting. Check in security, site contact, or designated person per project-specific work plan or Project Manager.
- Make sure appropriate PPE is worn by all personnel and work area is safe (i.e., utilize traffic cones; minimize interference with on-site activities and pedestrian traffic, etc.)
- Calibrate equipment (if applicable) and record all rental equipment serial numbers in the field book.
- Open wells to allow equilibration and collect full round of water level gauging before sampling is started (unless otherwise noted in project-specific work plan). Record the following:
  - Well mouth PID/FID reading (if necessary);
  - Depth to product and water;
  - Total well depth (not required if free product is measured unless otherwise noted in project-specific work plan); and
  - Condition of wells (i.e., lid broken, pad cracked, rusted lock) and collect photographs if site allows camera use.

SAMPLING PROCEDURES: PRE-PURGE

- Decontaminate pump.
- Take water level measurements prior to pump installation.
- Connect sampling tubing to pump outlet and lower to sample depth; **ALWAYS USE ROPE TO SECURE PUMP TO SURFACE.**
- The pump intake depth(s) for each well should be specified in the project-specific work plan (either specific depth or mid-point of saturated well screen).
- For wells with screened or open borehole intervals greater than 10 feet in length, sampling of multiple intervals may be required.
- If samples are to be collected from multiple depths from an individual well, always collect a sample from the shallowest depth first and leave enough extra tubing coiled at the surface so the pump can be lowered to the next interval; always try to cover excess tubing present at the surface to prevent the air temperature from influencing the measurements and exposure to contaminants on the ground;
- Be careful not to let the pump hit the bottom of the well.
- If using Teflon®-lined tubing, be sure that the lining does not bunch up around the connection. This will restrict water flow and make the pump work harder than it has to.
- Calibrate (or perform a calibration check on) all field monitoring equipment on the same day before collecting groundwater samples. Refer to TRC SOPs and manufacturer's equipment calibration instructions. A calibration check may also be required during or at the end of each sampling day. Consult the project-specific work plan.

SAMPLING PROCEDURES: MULTIPLE-VOLUME PURGING

- The multiple-volume purging approach is typically performed using bailers or submersible or peristaltic pumps. In the multiple-volume purging approach, there are two measurements used to determine adequate purge volume removal prior to sample collection: 1) purge volume and 2) field parameter stabilization.
- The field parameters should be recorded at regular volumetric intervals. There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters.
- Prior to purging a well, the amount of water inside the well riser and well screen (i.e., water column) should be determined, if possible. Once this information is known, the well volume can be calculated using the following equation:

  Well Volume (V) = $\pi r2\ h$
- For volumetric purging, an adequate purge is typically achieved when 3 to 5 well volumes have been removed.
- For volumetric purging, it is suggested that field readings are collected every ½ well/well screen volume after an initial 1 to ½ well volumes are purged. The volume removed between readings can be adjusted as well-specific information is developed.
- If removing a specified volume of water (e.g., 3 well volumes) has been determined to be suitable for purging, sampling can commence immediately upon achieving the required purge volume.
- In other cases, where specified in the project-specific work plan, stabilization of field parameters must be documented prior to sample collection.
- If, after 3 well volumes have been removed, the field parameters have not stabilized, additional well volumes (up to a total of 5 well volumes), should be removed.
- If the parameters have not stabilized within five well volumes, it is at the discretion of the Project Manager whether or not to collect a sample or to continue purging.

SAMPLING PROCEDURES: LOW-FLOW PURGING

- The low-flow purging approach is typically performed using peristaltic pumps or submersible pumps. Low-flow purging (also referred to as low-stress purging, low-volume purging, or Micropurging®) is a method of well purging/sampling that minimizes the volume of water withdrawn from a well in obtaining a representative sample.
- When performing low-flow purging and sampling, it is recommended that the pump intake be set in the center of the well screen interval to help prevent disturbance of any sediment at the bottom of the well.

GROUNDWATER SAMPLING

- To begin purging, the pump should be started at the lowest pressure/power flow rate setting (e.g., 100 mL/min) and then slowly increased until water begins discharging. Monitor the water level and slowly adjust the pump speed until there is little or no drawdown or drawdown has stabilized. The pump pressure/power may need to be increased for discharge to occur.
- The stabilization of drawdown should be documented. Measure and record the flow rate and water level every 3 to 5 minutes during purging. The flow rate should be reduced if drawdown is greater than 0.3 feet over three consecutive 3 to 5 minute interval readings.
- Attempts should be made to avoid pumping a well dry.

Field Parameter Stabilization During Purging

- Generally, an adequate purge with respect to the groundwater chemistry is achieved when stability for at least three consecutive measurements is achieved. See stability requirements in Appendix A of this SOP.

POST-PURGE GROUNDWATER SAMPLE COLLECTION

- New, disposable gloves should be donned immediately prior to sample collection and should be changed at any point that their cleanliness becomes compromised during sample collection.
- If using a submersible or peristaltic pump, maintain the same flow rate as used during purging. Disconnect the pump tubing from the flow-through cell. Samples must be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. This is critically important to avoid cross-contamination between wells.
- If using bottom-filling bailers, slowly lower the bailer into the well until it is submerged to the point where water does not enter the top (i.e., bottom-filling). Retrieve the bailer. The first bailer recovered after well purging must be used for sample collection.
- Collect groundwater samples in the following order:
  - VOCs;
  - SVOCs;
  - Other organic parameters;
  - Unfiltered inorganic constituents; and
  - Filtered inorganic constituents.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Preserve the non-VOC samples in pre-preserved vials supplied by the laboratory or if the sample containers are not pre-preserved, preserve the non-VOC samples in accordance with method and project-specific requirements.
- Depending upon project requirements, filtering may be performed. See procedures listed in Section 2.3.4 of this SOP. Clearly note "filtered" on the sample label and the COC.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.
- Decontaminate non-disposable sampling equipment between uses.

PASSIVE SAMPLING

- There are three generic forms of passive (no purge) samplers: thief (grab) samplers, diffusion (equilibrium) samplers, and integrating (kinetic) samplers. However, this SOP focuses on the more commonly used diffusion (equilibrium) samplers. Be aware of sample holding times, and arrange for samples to be in the laboratory's possession accordingly.
- Passive samplers are deployed at a predetermined depth across the well screen. Typically, the initial sampling event may deploy multiple passive samplers across 5-foot intervals of saturated well screen to observe any potential stratification. Long-term sampling depths typically target a zone of higher concentration, if present.
- New passive samplers are attached via PVC cable ties to a tether (pre-made marine-grade polyethylene rope or stainless steel cable with a weight at the bottom) that is then suspended within the well.
- The passive sampler should be allowed to equilibrate with groundwater for an appropriate period of time (e.g., at least 2 weeks for PDB samplers).
- Raise the passive sampler to the surface using a tether reel. Examine the surface of the passive sampler for evidence of algae, iron, or other coatings, and for tears to the membrane. Note observations in the field book. If tears are present and water is leaking out, the sample is not considered viable. Contact the Project Manager.
- Detach the passive sampler from the tether.
- Remove excess beaded water from the passive sampler with a clean gloved hand, running top to bottom; this is to minimize the contact of beaded water with water in the passive sampler.

GROUNDWATER SAMPLING

- Use a small diameter discharge tube (<0.15 inch diameter to reduce volatilization) and pierce near the bottom, allowing water to smoothly flow into the VOA vial. The VOA vials must be filled within the first several minutes of passive sampler retrieval.
- A small amount of water may remain within the passive sampler after filling the VOA vials and can be used for field parameter measurements if required.
- Dispose of the passive sampler after use.
- Note that sample vials for VOCs must be filled so a meniscus forms over the mouth of the vial. This ensures no air bubbles or headspace will be formed after it has been capped. Ensure the lack of air bubbles and headspace by turning the vial upside down and tapping it lightly. If any bubbles are observed, see Section 2.3.2 of this SOP.
- Make sure all sample bottles are appropriately labeled.
- Package the samples with bubble wrap and/or organic absorbent, as necessary. Place into shipping container and cool to 4°C and complete the COC.

DOs AND DO NOTs OF GROUNDWATER PURGING AND SAMPLING

DOs:

- DO have the following items when going into the field: site-specific work plan; site-Specific HASP; appropriate PPE (steel-toed boots, safety glasses, etc.) as required by the Site-Specific HASP; field book and a water-proof ball-point pen; business cards; nitrile gloves; well keys; copies of well installation forms and field data forms from previous sampling event.
- DO make sure that the equipment is set up properly and the bottleware is nearby and ready to be filled. There is little time between taking parameters.
- DO look at the water quality parameters from the previous round of sampling. If there is a large deviation from the previous round's measurements, make sure the meters are properly calibrated and the parameter units are the same. Otherwise, consult the Project Manager or field team leader.
- DO fill sample bottles slowly to make sure that they are not overfilled and that preservative does not become diluted. If collecting filtered samples, fill all non-filtered first, then fill filtered samples - if water is very silty, more than one filter might be required to fill sample bottles.
- DO record the time that purging begins and ends. "Purge Stop" and sample start time are the same.
- DO call your Project Manager or field team leader if unexpected conditions are encountered or at least daily to update them. It is also recommended to call when sampling is winding down for the day to make sure that the project-specific work plan has been fully implemented and there are no additional tasks to complete. Provide shipping tracking numbers to the Project Manager and laboratory contact.
- DO have the numbers for laboratory, vehicle rental and equipment rental providers readily available while in the field.
- DO record sample locations and parameters in the field book and the Groundwater Field Data Records as you purge.
- DO check on the purging setup frequently to make sure proper equipment function is maintained.
- DO bring ice to the site in the morning so that samples are kept cool throughout the entire event. Storing samples in a warm cooler can invalidate sample results and may result in re-sampling on your own time.

DO NOTs:

- DO NOT sign anything in the field. This includes disposal documentation, statements, etc.; call the Project Manager if this is an issue.
- DO NOT allow the pump or sampling equipment to hit the bottom of the well - If the pump hits the bottom of the well, it can stir up mud. Remember, the goal of low-flow sampling is to collect non-turbid samples.
- DO NOT use non-indelible ink to label samples or record field notes – if the field book gets wet, notes become illegible.
- DO NOT leave air bubbles in VOA vials.
- DO NOT pour any extracted water back down into the well.
- DO NOT lean over wells with pens, keys, cell phones, tools, etc. in your pocket.
- DO NOT use clear tape to cover labels on certain analyses (e.g., 40-mL vials for VOC analysis) due to potential interference with analytical equipment.

Attachment D: SOP Modifications for PFAS

Due to the pervasive nature of PFAS in various substances routinely used during sampling and the need to mitigate potential cross-contamination or sampling bias to ensure representative data are collected, special care should be taken when sampling for PFAS. The following table highlights the required modifications to this SOP when sampling for PFAS.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
1.3	• Do not use equipment utilizing Teflon® or low density polyethylene (LDPE)[1] during sample handling or mobilization/demobilization. This includes bailers, tubing, bladders, bailer cord/wire, waterproof/resistant paper products, certain personal protective equipment (PPE) (see below), and Teflon® tape. High density polyethylene (HDPE) or silicone tubing should be used in lieu of Teflon® or Teflon®-lined tubing. • Passive diffusion bags (PDBs) should not be used due to the presence of LDPE material in PDBs. • Blue Ice® (chemical ice packs) must not be used to cool samples or be used in sample coolers. Regular ice in Ziploc® bags can be used. • Do not use LDPE or glass sample containers or containers with Teflon-lined lids. HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable. • Do not use aluminum foil. • Field notes should be recorded on loose paper field forms maintained in aluminum or Masonite clipboards. Waterproof field books, plastic clipboards and spiral bound notebooks should not be used. • Do not use Post-It Notes during sample handling or mobilization/demobilization. • Refer to TRC's SOP ECR-010 Equipment Decontamination for PFAS-specific decontamination protocols. Ensure that PFAS-free water is used during the decontamination procedure.
1.5	Always consult the Site Specific Health and Safety Plan prior to conducting field work. The following considerations should be made with regards to field preparation during PFAS sampling: • Tyvek® suits should not be worn during PFAS sampling events. Cotton coveralls may be worn. • Boots and other field clothing containing Gore-Tex™ or other waterproof/resistant material should not be worn. This includes rain gear. Boots made with polyurethane and polyvinyl chloride (PVC) are acceptable. • Stain resistant clothing should not be worn. • Food and drink should not be allowed within the exclusion area. Pre-wrapped food or snacks should not be in the possession of sampling personnel during sampling. Bottled water and hydration drinks (e.g., Gatorade®) may be consumed in the staging area only.

PFAS Sampling Protocols	
SOP Section Number	**Modifications to SOP**
	• Personnel involved with sample collection and handling should wear nitrile gloves at all times while collecting and handling samples or sampling equipment. Avoid handling unnecessary items with nitrile gloves. A new pair of gloves must be donned prior to collecting each sample. • Wash hands with Alconox or Liquinox and deionized water after leaving vehicle before setting up to sample a well.
1.6.1	• Avoid wearing clothing laundered with fabric softeners. • Avoid wearing new clothing (recommended 6 washings since purchase). Clothing made of cotton is preferred. • Avoid using cosmetics, moisturizers, hand creams, or other related products as part of cleaning/showering on the day of sampling. • Avoid using sunscreens or insect repellants that are not natural or chemical free.
1.6.2	• Consider collecting samples for total suspended solids which will become important for fate and transport and treatment considerations. Floc accumulates high concentrations of PFAS and specifically some of the longer-chain PFAS; when this floc settles out, concentrations can decrease by an order of magnitude. • Low-flow sampling is preferred for PFAS sampling. Bailers should be avoided due to the potential for PFAS to accumulate at the air/water interface. If bailers need to be used, purging of at least one well volume should be performed to remove static surface conditions. • If sampling for parameters other than PFAS, perform PFAS sampling first. Schedule PFAS sampling at the beginning of the work day to avoid other sources of contamination.
2.0	• Monitoring wells should always be sampled from the lowest contamination to the highest contamination, when possible. In source areas, if deep wells are anticipated to be less contaminated, the deep wells should be sampled prior to sampling the shallow wells to avoid cross-contamination from sampling equipment.
2.2.5	Tubing used to purge and sample groundwater for PFAS must not be LDPE or Teflon®. HDPE and silicone are acceptable.
2.3 and 2.3.3	LDPE and/or glass containers should not be used for sampling. Teflon®-lined caps should also not be used during sample collection. Instead, HDPE or polypropylene containers are acceptable for sample storage. HDPE or polypropylene caps are acceptable.
2.4	Due to LDPE material in PDBs, PDBs cannot be used for PFAS sampling.
2.5 (e)	Avoid using waterproof labels for sample bottles. The use of paper labels covered with clear tape or placed in Ziploc® bags to avoid moisture on the sample label is acceptable.
2.5 (f)	Samples for PFAS analysis must be shipped at <10°C. Standard coolers are acceptable. Keep high-concentration PFAS samples in separate coolers from low-concentration PFAS samples.

Notes:

[1] – PFAS have been used as an additive in the manufacturing of LDPE to smooth rough surfaces and, in the case of LDPE tubing, to allow for less turbulent flow along the surface of the tubing.

Appendix D
Chain-of-Custody Procedures SOP

Title: **Chain-of-Custody Procedures**	Procedure Number: **ECR 002**
	Revision Number: **1**
	Effective Date: **January 2020**

Authorization Signatures	
Technical Review James Peronto — Date 1/1/20	Environmental Sector Quality Director Elizabeth Denly — Date 1/1/20

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FIGURES

Figure 1: Example Sample Label and Custody Seal
Figure 2: Example Chain-of-Custody Form
Figure 3: Example Federal Express Air Bill

ATTACHMENTS

Attachment A: SOP Fact Sheet

1.0 INTRODUCTION

1.1 Scope & Applicability

This Standard Operating Procedure (SOP) guides TRC personnel in proper Chain-of-Custody practices.

This SOP was prepared to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and will be followed, if applicable. Sample custody procedures are an important part of the field investigation program in order to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law or other evidentiary venue. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. An overriding consideration essential for the validation of environmental measurement data is the necessity to demonstrate that samples have been obtained from the locations stated and that they have reached the laboratory without alteration (i.e., representative of the identified sample media).

1.2 Summary of Method

Evidence of the sample tracking from collection to shipment, laboratory receipt, and laboratory custody (until proper sample disposal and the introduction of field investigation results as evidence in legal proceedings when pertinent) must be properly documented.

A sample or evidence file is considered to be in a person's custody if the item is:

- In a person's possession
- In the view of the person after being in a person's possession
- Secured and preserved so that no one can tamper with it after having been in a person’s possession
- In a secured area, restricted to authorized personnel

The Field Team Leader or designee is responsible for overseeing and supervising the implementation of proper sample custody procedures in the field. The Field Team Leader or designee is also responsible for ensuring sample custody until the samples have been transferred to a courier or directly to the laboratory. Once received by the laboratory, the samples proceed through an orderly processing sequence specifically designed to ensure continuous integrity of both the sample and its documentation.

1.3 Equipment

The following list is an example of items that may be utilized when implementing sample custody procedures in the field. Project-specific conditions or requirements may warrant the use of

additional items or deletion of items from this list. Many of these items may be provided by the selected analytical laboratory for a given project.

- Chain-of-Custody forms
- Sample labels
- Sample tags
- Custody seals
- Computer
- Indelible/waterproof ink
- Printer

2.0 PROCEDURES

Sample custody and transfer procedures are summarized below. These procedures are intended to ensure that the samples will arrive at the laboratory with the Chain-of-Custody intact. The Chain-of-Custody procedures are initiated in the field immediately following sample collection. The procedures consist of four main components: (1) preparing and attaching a unique sample label to each sample collected, (2) completing the Chain-of-Custody (COC) form, (3) reviewing the COC form for accuracy and (4) preparing the samples for shipment and transfer of custody.

2.1 Specific Chain-of-Custody Procedures

2.1.1 Sample Labels

Field personnel are responsible for uniquely identifying and labeling all samples collected during a field investigation program. All labeling must be completed in indelible/waterproof ink and securely affixed to the sample container. Individual sample containers may be pre-labeled or labeled in the field at the time of collection. Sufficient sample information should be cross-referenced in the field documentation for tracking purposes.

Sample labels typically contain the following information:

- Unique sample identification
- Sample location and/or depth/description number, if different from above
- Sample matrix
- Type of analysis to be performed
- Type of chemical preservation used
- Grab or composite designation
- Filtered or unfiltered
- Sampling date and time
- Sampler's affiliation and initials
- Site and/or client name

An example of a sample label is provided in Figure 1.

2.1.2 Custody Seals

Custody seals may be secured across the shipping container to ensure content integrity. The seals contain both the date and the signature of the person affixing them and must be completed in indelible/waterproof ink. Custody seals are attached to the cover seal of the cooler and can be covered with clear plastic tape after being signed and dated by field personnel. An example of a custody seal is shown in Figure 1. The use of custody seals will be determined on a project-specific basis by the Project Manager.

2.1.3 Chain-of-Custody Form

For all analyses, COC forms must be completed for each sample set submitted. COC forms are initiated by the samplers in the field and maintained until samples are analyzed by the laboratory. If multiple laboratories are being used, a separate set of COC forms must be completed for each laboratory receiving samples to ensure proper transfer of custody from the time of sample collection to analysis. These forms serve as a record of sample collection, transfer, shipment, and receipt by the laboratory. These forms typically contain the following pertinent information:

- Project/site name and/or project number
- Carrier name, if applicable
- Air bill numbers(s), if known and applicable
- Laboratory name and address
- Sample identifications
- Sample matrix (e.g., soil, water)
- Type of sample (i.e., grab or composite)
- Date/time sample collected
- Size, type, and number of containers
- Preservative used
- Required analysis or method
- Turnaround time
- Names of individuals responsible for custody of samples
- Date shipped or otherwise transferred

Figure 2 provides an example COC form. It should be noted that this is an example format only. Laboratories typically provide their own laboratory-specific COC form. Other COC formats may be used as long as all of the applicable information is included. COC forms will be initiated in the field.

All entries on the COC form must be legible and must be made in blue or black permanent ink. No erasures or obliterations can be made. If an incorrect entry is made, the information must be crossed out with a single strike mark which is signed or initialed and dated by the person recording the information. The correction must be written adjacent to the error. The original entry should still be legible even though crossed out.

2.1.4 Transfer of Custody

Samples will be accompanied by a properly completed COC form during each step of custody transfer and shipment. When physical possession of samples is transferred, both the individual relinquishing the samples and the individual receiving them will sign, date, and record the time of transfer on the COC form.

All samples will be shipped directly to the laboratories by a TRC employee, an overnight commercial carrier, or a laboratory-supplied courier service.

In the case of sample shipment by an overnight commercial carrier, a properly prepared air bill, including the project number (Figure 3), will serve as an extension of the COC form while the samples are in transit. The COC forms will be sealed inside the sample cooler within a clear plastic bag and the custody seals, if used, will be completed on the outside of the cooler prior to shipment. Commercial carriers are not required to sign off on the custody forms since the forms are sealed inside the cooler prior to shipment so any custody seal remains intact. The original COC form will accompany the samples at all times. A copy of all COC forms submitted to the laboratory will be retained by the sampler along with field records/logbooks documenting sample collection and will be placed in the project files.

If at the completion of sampling the samples are not shipped directly from the field or point of collection to the analytical laboratory, the samples will be temporarily stored in an iced cooler at a secure location (e.g., locked vehicle, residence, office) or in a locked refrigerator at the TRC office. Access to the secure location and transfer of the sample containers for laboratory delivery shall only be provided by a TRC employee and such sample transfer shall be recorded on the COC form.

3.0 QUALITY ASSURANCE/QUALITY CONTROL

Following sample collection, all samples will be brought to a location for batching and paperwork checks. At this location, labels and logbook information are cross-checked to ensure there is no error in sample identification or sample collection time and that all samples are accounted for. The sample information is transferred to the COC form. The samples are packaged to prevent breakage and/or leakage, and the shipping containers are labeled for transport.

The Field Team Leader has the responsibility of maintaining the COC and air bill documentation. Individual responsibilities may be delegated to other field staff, as appropriate. Quality control procedures will place emphasis on ensuring that appropriate samples were collected and submitted to the laboratory for the correct analyses. The COC forms will also be reviewed by the Field Team Leader or designee to ensure that all required information is clearly presented.

Many laboratories will provide a sample receipt confirmation via electronic mail upon request. COC forms should be cross-checked with laboratory sample receipt confirmations, if applicable, to ensure that all samples were received and logged-in correctly by the laboratory.

4.0 INVESTIGATION-DERIVED WASTE DISPOSAL

Not applicable.

5.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

The Project Manager or Field Team Leader will maintain an inventory of all COC forms completed during the program and will be responsible for ensuring that they are archived in the project files following the completion of the field work.

It is good practice to scan all completed COC forms at the conclusion of field activities and store the resulting electronic PDF files in the project directory.

6.0 REFERENCES

A Compendium of Superfund Field Operations Methods EPA/540/P-87/001. December 1987.

U.S. Environmental Protection Agency (EPA) Office of Enforcement and Compliance Monitoring – National Enforcement Investigations Center (NEIC) requirements (NEIC, 1986)

7.0 SOP REVISION HISTORY

REVISION NUMBER	REVISION DATE	REASON FOR REVISION
0	MARCH 2013	NOT APPLICABLE
1	JANUARY 2020	TRC RE-BRANDING AND SOP RE-NUMBERING

Figure 1 Example Sample Label and Custody Seal

Sample Label

CLIENT/SOURCE	☐ GRAB ☐ COMPOSITE OTHER
SITE NAME	DATE
SAMPLE #	TIME
ANALYSIS	PRESERVATIVE
	COLL. BY

Custody Seal

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

CUSTODY SEAL

Date

Signature

Figure 2 Example Chain-of-Custody Form

TRC

Boott Mills South, Foot of John Street • Lowell, Massachusetts 01852
Telephone 978-970-5600 • Fax 978-453-1995

Chain-of-Custody Record

Page ____ of ____

Project Name _____
Project No.: _____
Sampling Date(s): _____
Laboratory Name: _____
Laboratory Location: _____
Sampler Name(s): _____

Shipping Carrier ❑ FED EX ❑ COURIER
Date Shipped _____
Airbill No. _____

MCP Work Only: Have the appropriate number of field samples been collected for this program?
❑ YES ❑ NO

Turnaround Time (Circle One)
15 Day 10 Day 5 Day 3 Day Other: _____

ANALYSIS AND PRESERVATIVE

SAMPLE ID	DATE/TIME SAMPLED	COMPOSITE OR GRAB	MATRIX	VOLUME / CONTAINER TYPES	NUMBER OF CONTAINERS
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	
	/			/	

COMMENTS

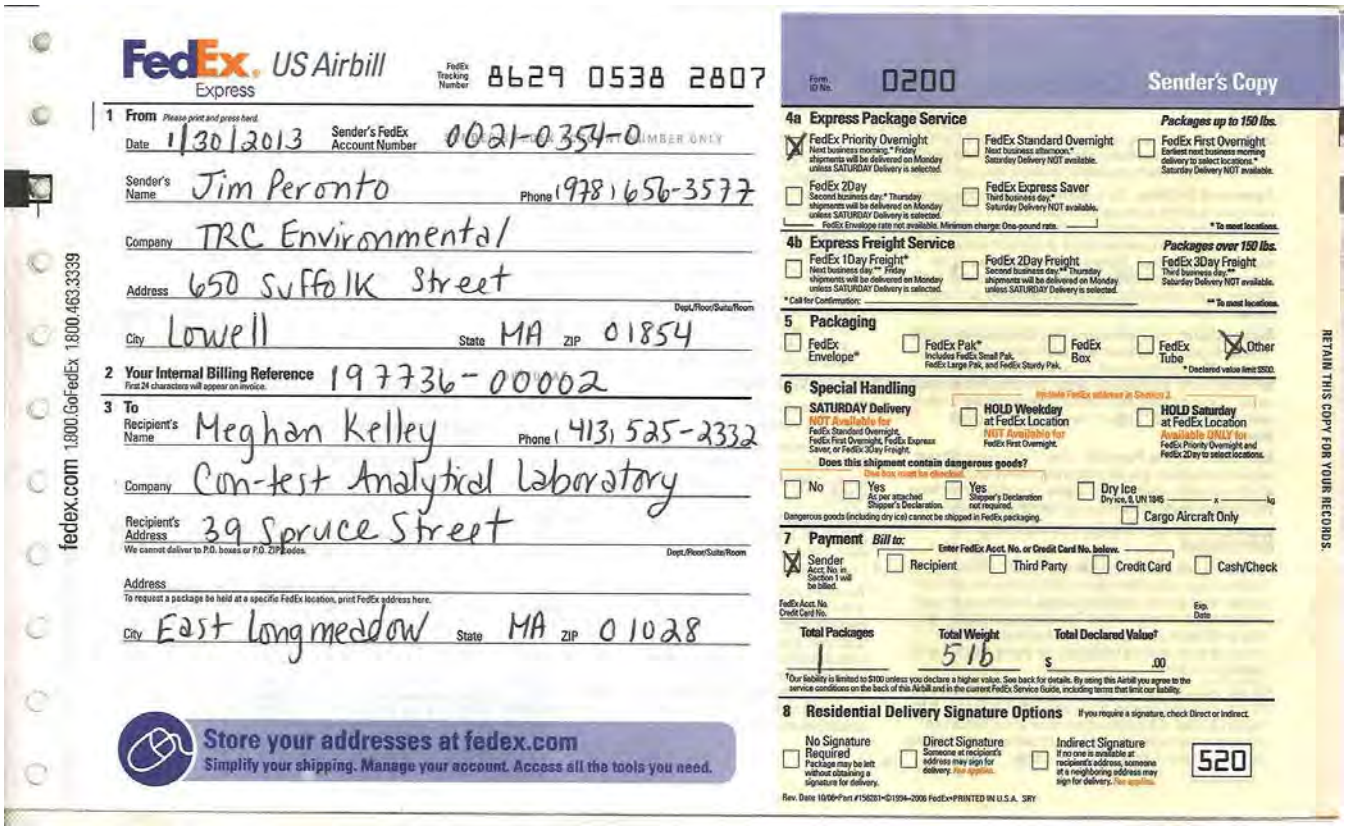
Send results to: _____
Cooler temperature: _____

Relinquished By:(Signature)	Date/Time	Received By:(Signature)	Date/Time
	/		/
Relinquished By:(Signature)	Date/Time	Received By:(Signature)	Date/Time
	/		/

№ 0020

WHITE – LABORATORY YELLOW – LABORATORY COPY PINK – OFFICE COPY GOLD – FIELD COPY

Figure 3 Example Federal Express Air Bill



FedEx Express US Airbill — FedEx Tracking Number 8629 0538 2807

1 From — Date 1/30/2013 — Sender's FedEx Account Number 0021-0354-0
Sender's Name Jim Peronto — Phone (978) 656-3577
Company TRC Environmental
Address 650 Suffolk Street — Dept./Floor/Suite/Room
City Lowell — State MA — ZIP 01854

2 Your Internal Billing Reference 197736-00002

3 To — Recipient's Name Meghan Kelley — Phone (413) 525-2332
Company Con-test Analytical Laboratory
Recipient's Address 39 Spruce Street — Dept./Floor/Suite/Room
Address
City East Longmeadow — State MA — ZIP 01028

Store your addresses at fedex.com
Simplify your shipping. Manage your account. Access all the tools you need.

fedex.com 1.800.GoFedEx 1.800.463.3339

Form ID No. 0200 — Sender's Copy

4a Express Package Service — Packages up to 150 lbs.
[X] FedEx Priority Overnight — Next business morning.* Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
[ ] FedEx Standard Overnight — Next business afternoon.* Saturday Delivery NOT available.
[ ] FedEx First Overnight — Earliest next business morning delivery to select locations.* Saturday Delivery NOT available.
[ ] FedEx 2Day — Second business day.* Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
[ ] FedEx Express Saver — Third business day.* Saturday Delivery NOT available.
FedEx Envelope rate not available. Minimum charge: One-pound rate.
* To most locations.

4b Express Freight Service — Packages over 150 lbs.
[ ] FedEx 1Day Freight* — Next business day.** Friday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
[ ] FedEx 2Day Freight — Second business day.** Thursday shipments will be delivered on Monday unless SATURDAY Delivery is selected.
[ ] FedEx 3Day Freight — Third business day.** Saturday Delivery NOT available.
* Call for Confirmation:
** To most locations.

5 Packaging
[ ] FedEx Envelope* [ ] FedEx Pak* — Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak. [ ] FedEx Box [ ] FedEx Tube [X] Other
* Declared value limit $500.

6 Special Handling
[ ] SATURDAY Delivery — NOT Available for FedEx Standard Overnight, FedEx First Overnight, FedEx Express Saver, or FedEx 3Day Freight.
[ ] HOLD Weekday at FedEx Location — NOT Available for FedEx First Overnight.
[ ] HOLD Saturday at FedEx Location — Available ONLY for FedEx Priority Overnight and FedEx 2Day to select locations.
Does this shipment contain dangerous goods? (One box must be checked.)
[ ] No [ ] Yes — As per attached Shipper's Declaration. [ ] Yes — Shipper's Declaration not required. [ ] Dry Ice — Dry ice, 9, UN 1845 ____ x ____ kg
[ ] Cargo Aircraft Only
Dangerous goods (including dry ice) cannot be shipped in FedEx packaging.

7 Payment — Bill to: Enter FedEx Acct. No. or Credit Card No. below.
[X] Sender — Acct. No. in Section 1 will be billed. [ ] Recipient [ ] Third Party [ ] Credit Card [ ] Cash/Check
FedEx Acct. No. / Credit Card No. — Exp. Date

Total Packages: 1 — Total Weight: 5 lb — Total Declared Value†: $ .00
†Our liability is limited to $100 unless you declare a higher value. See back for details. By using this Airbill you agree to the service conditions on the back of this Airbill and in the current FedEx Service Guide, including terms that limit our liability.

8 Residential Delivery Signature Options — If you require a signature, check Direct or Indirect.
[ ] No Signature Required — Package may be left without obtaining a signature for delivery.
[ ] Direct Signature — Someone at recipient's address may sign for delivery. Fee applies.
[ ] Indirect Signature — If no one is available at recipient's address, someone at a neighboring address may sign for delivery. Fee applies.
520

Rev. Date 10/06 Part #156281 ©1994–2006 FedEx PRINTED IN U.S.A. SRY

RETAIN THIS COPY FOR YOUR RECORDS.

Attachment A: SOP Fact Sheet

CHAIN-OF-CUSTODY PROCEDURES

PURPOSE AND OBJECTIVE

Chain-of-Custody procedures have been developed to direct TRC personnel in the sample custody procedure requirements associated with field sample collection. Other state or federal requirements may be above and beyond the scope of this SOP and should be followed, if applicable. Sample custody procedures are an important part of the field investigation program to maintain data quality and to be able to document proof of proper handling. Sample custody begins at the collection of the samples and continues until the samples have been analyzed. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

WHAT TO BRING

- Chain-of-Custody (COC) forms
- Sample Labels
- Custody Seals (if required)
- Indelible/waterproof ink

ON-SITE

- Complete all sample labels with indelible/waterproof ink.
- At a minimum, sample labels should include: site name; unique sample identification; sample date and time.
- COC forms must be completed for each sample set and must be initiated in the field by the sampler.
- COC forms must be completed in blue or black permanent ink.
- At a minimum, the COC forms should include: site name; sample identification; sample matrix; type of preservative; type of analysis; sampling date; and sampler's name.
- Once sampling activity is completed and the COC form is filled out, place samples in sample coolers.
- Package samples to prevent breakage and/or leakage.
- The COC forms will be reviewed by the Field Team Leader or designee prior to relinquishing the samples.
- The original COC form must accompany samples to the laboratory.
- When samples are transferred from one person to another, both the relinquisher and the person receiving the samples should sign, date and record the date of transfer on the COC form.
- If samples are not sent directly to laboratory, samples need to remain on ice and be stored in a secure location.

Appendix E
Laboratory QA/QC Plans

(Consumers Energy Laboratory Services to Provide Separately)