Coal Combustion Residuals (CCR) Ash Monofill Groundwater Detection Monitoring Plan

Revision 0

Rawhide Energy Station
Laramie County, Colorado

Platte River Power Authority

Project Number: 60514655

October 10, 2017

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Prepared for
Platte River Power Authority
Fort Collins, CO

Submitted by
AECOM
Fort Collins, Colorado
October 2017

Coal Combustion Residuals (CCR) Ash Monofill Groundwater Detection Monitoring Plan

Rawhide Energy Station
Larimer County, Colorado

Revision 0

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List of Acronyms

AECOM	AECOM Technical Services, Inc.
ANOVA	analysis of variance
bgs	below ground surface
CBSGs	Colorado Basic Standards for Groundwater
CCR	coal combustion residuals
CDPHE	Colorado Department of Public Health and Environment
CFR	Code of Federal Regulations
COC	chain-of-custody
EDOP	Engineered Design and Operations Plan
EPA	U.S. Environmental Protection Agency
ft	feet
MS/MSD	matrix spike/matrix spike duplicate
PRPA	Platte River Power Authority
Site	Rawhide Energy Station
SOPs	Standard Operating Procedures
QA/QC	Quality assurance and quality control
RCRA	Resource Conservation and Recovery Act
TDS	total dissolved solids

Monitoring System Certification

Certification Statement 40 CFR § 257.91(f) – Design and Construction of a Groundwater Monitoring System for the existing Coal Combustion Residuals (CCR) Ash Monofill, Rawhide Energy Station, Larimer County, CO, managed by the Platte River Power Authority (PRPA).

I, Gregg Somermeyer, being a Registered Professional Engineer in good standing in the State of Colorado, do hereby certify, to the best of my knowledge, information, and in accordance with the accepted practice of engineering, for the above-referenced CCR unit, that the design and construction of the groundwater monitoring system, as included in Section 2.0 of the Groundwater Detection Monitoring Plan Revision 0, dated October 10, 2017, meets the requirements of 40 CFR § 257.91.

Gregg Somermeyer
October 10, 2017

Statistical Method Certification

Certification Statement 40 CFR § 257.93(f)(6) – Statistical Method for the Evaluation of Groundwater Monitoring Data for the existing Coal Combustion Residuals (CCR) Ash Monofill, Rawhide Energy Station, Larimer County, CO, managed by the Platte River Power Authority (PRPA).

I, Gregg Somermeyer, being a Registered Professional Engineer in good standing in the State of Colorado, do hereby certify, to the best of my knowledge, information, and in accordance with the accepted practice of engineering, for the above-referenced CCR Unit, that the statistical method selected for the groundwater monitoring system, as identified and described in Section 4.0 of the Groundwater Detection Monitoring Plan Revision 0, dated October 10, 2017, is appropriate for evaluating the groundwater monitoring data for the above-referenced CCR unit.

Gregg Somermeyer
October 10, 2017

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PROFESSIONAL ENGINEER

1 Introduction

This Coal Combustion Residuals (CCR) Ash Monofill Groundwater Detection Monitoring Plan (Plan) was developed by AECOM Technical Services, Inc. (AECOM) at the request of the Platte River Power Authority (PRPA). The objective of the Plan is to provide a description of the field, laboratory, and desktop activities that will be completed to perform the groundwater detection monitoring tasks at the CCR Ash Monofill facility located at the Rawhide Energy Station (Rawhide Station or “the Site”).

1.1 Background

The Site encompasses approximately 3,120 acres north of Wellington in Larimer County, Colorado. In addition to the plant buildings, the major feature of the facility is a 500-acre cooling water reservoir (Hamilton Reservoir) which contains approximately 15,000 acre-feet of water (**Figure 1**). The power block area contains the boiler and turbine buildings, the air quality control equipment and the administrative offices. A rail spur along the northern edge of the Site connects the Rawhide Facility with the mainline of the BNSF Railway Company and is used to deliver coal and construction materials for plant operations. Six generating units are located at the Rawhide Station. Units A, B, C, D, and F are fueled by natural gas, and Unit 1 is fueled by coalfrom the Powder River Basin in Wyoming.

CCR solid waste from Unit 1 operations is disposed in the Ash Monofill comprised of two cells (Cell 1 and Cell 2). Cell 1 (ca 1980-2007) is capped and no longer in use, but has not undergone final closure. Cell 2 is active, lies to the west of the closed Cell 1, and is progressively advancing northwards as further ash material is placed within the cell. The Ash Monofill is regulated under the CCR Rule promulgated by the U.S. Environmental Protection Agency (EPA) under 40 Code of Federal Regulations (CFR) Part §257, Subtitle D of the Resource Conservation and Recovery Act (RCRA).

1.2 Purpose

The purpose of this plan is to outline the groundwater detection monitoring program for the Ash Monofill in accordance with the CCR regulations specified in 40 CFR §257.94. Data developed using this plan will be used to evaluate whether operations at the Ash Monofill are protective of groundwater. The detection monitoring program is intended to:

- Establish background groundwater constituent concentrations that could leach from the ash material disposed in the Ash Monofill by collecting eight rounds of samples from the Ash Monofill monitoring well network and analyzing the samples for the constituents listed in Appendix III and Appendix IV of 40 CFR §257.
- Collect and analyze groundwater samples on a semi-annual basis from downgradient and upgradient monitoring wells installed around the Ash Monofill.
- Establish a methodology to evaluate whether a statistically significant increase of hazardous constituents above background has occurred from the Ash Monofill.

2 Detection Monitoring Program

2.1 Site Hydrogeology

The hydrogeology of the Rawhide Station is discussed in the Engineering Design and Operations Plan (EDOP; PRPA 1980) and in the "Final Report Investigation of the Groundwater Monitoring Program for the Bottom Ash Disposal Site," conducted by Lidstone and Anderson (1989). According to the 1980 EDOP, hydrogeology of the Rawhide Station site was originally investigated by drilling and installing twenty-three (23) piezometers in conjunction with the original geotechnical investigation of the site prior to construction of the facility. Data from the piezometers indicated that a groundwater table exists within the weathered Pierre Shale bedrock at some locations below the site and in surficial deposits along Coal Creek. The report indicated that the depth to groundwater varied across the site from 11 to 67 feet (ft) below ground surface (bgs) and generally flowed to the south-southeast. The shallow water table, as explained in the 1980 EDOP, was reported to be directly recharged by infiltration from precipitation and surface runoff.

Following construction and operation of the Rawhide Energy Station, Lidstone and Anderson (1989) concluded that sufficient groundwater data were collected to determine a mound had formed in the shallow, fractured, and weathered Pierre Shale in the vicinity of the cooling water reservoir. After a review of available groundwater level information for the Site, AECOM concluded that the Ash Monofill is hydraulically upgradient of any groundwater mound created by the cooling water reservoir.

The uppermost aquifer at the Ash Monofill is identified as the weathered and fractured Pierre Shale which lies approximately 19 to 39 feet below ground surface (ft bgs) and is recharged by precipitation. Groundwater in at the Ash Monofill is present under water table conditions. The depth to groundwater ranges from approximately 12 to 38 ft bgs. Groundwater flow is generally from northwest to south-southeast, from the Ash Monofill towards Hamilton Reservoir, generally following the topographic slope of the valley.

2.2 Monitoring Well Network

The groundwater detection monitoring network for the Ash Monofill is depicted on **Figure 2**. The Ash Monofill network includes one upgradient well, ASH-01, that will be used to establish background groundwater constituent concentrations, and three downgradient wells, ASH-03, ASH-04, and ASH-05, along the southern edge of the Ash Monofill. Monitoring well ASH-01 was installed in 1980 as MW-01 for a site-wide monitoring well network. Monitoring wells ASH-03, ASH-04, and ASH-05 were installed in 2016 to comply with the CCR Rule. The monitoring well system reflects the minimum requirements of the CCR Rule. This network satisfies the requirements of 40 CFR §257.91 because the ash monofill was constructed within a narrow valley that is sloped to the south that localizes groundwater that may have been affected by a release from the Ash Monofill. The downgradient monitoring wells extend across the width of the valley and allow detection of potentially contaminated groundwater from beneath the Ash Monofill.

Monitoring well ASH-01 was installed in a 7-inch borehole using 4-inch inner diameter (i.d.) Schedule 40 polyvinyl chloride (PVC) casing and screen. Bentonite clay was used as the annular sealant and pea gravel was used as the filter media around a 3-foot length of well screen set in the saturated zone. A concrete well pad was poured around the well and is secured with a locked steel protector cap. The new monitoring wells (ASH-03 through ASH-05) were drilled using a hollow-stem auger rig equipped with 8.25-inch augers. The wells were completed with 2-inch i.d. PVC casing and 0.01-inch factory slotted, 10-foot long screen. The well annulus was filled with 20/40 silica sand to approximately 2 feet above the top of screen, a 2-foot thick, 3/8-inch hydrated bentonite chip seal, and finished with neat cement grout. The wells were completed with above grade protective covers. The boring logs and well construction diagrams for the monitoring wells are included in **Appendix A**. **Table 1** summarizes well construction details for the Ash Monofill detection monitoring wells.

2.3 Sampling Frequency

To establish background and downgradient concentrations for the detection monitoring program, wells in the Ash Monofill monitoring well network were sampled approximately bi-monthly (every two months). The eight sampling rounds began on September 12, 2016 and were completed on July 13, 2017 prior to the October 17, 2017 deadline established in the CCR Rule (40 CFR §257.94). After October 17, 2017, the detection monitoring sampling frequency will be semi-annual (**Table 2**).

2.4 Analytical Parameters

During the eight rounds of baseline detection monitoring, samples were collected from the Ash Monofill wells and analyzed for the constituents listed in 40 CFR §257, Appendices III and IV. This list includes the general chemistry parameters pH and total dissolved solids (TDS); anions (chloride, fluoride, and sulfate); combined radium-226+228, and several metals as shown on **Table 2**. Groundwater samples will not be field-filtered so that reported metals concentrations represent “total recoverable metals” as required by the CCR Rule.

Since the initial detection monitoring has been completed, the analyte list will be reduced to the indicator parameters listed in Appendix III of 40 CFR §257. This shorter list, which includes boron, calcium, chloride, fluoride, sulfate, and TDS (Table 2), will remain the focus of detection monitoring until the Ash Monofill is closed or assessment monitoring is triggered. Groundwater pH will continue to be monitored as a field parameter.

2.5 Reporting

To comply with the CCR Rule, an Annual Monitoring and Corrective Action Report will be prepared for the Ash Monofill after the first eight (8) rounds of detection monitoring is completed. This initial report will be completed no later than January 31, 2018, and annually thereafter, and will prepared in accordance with the requirements of 40 CFR §257.90. The annual reports will document the status of the detection monitoring program for the Ash Monofill, summarize key actions completed, describe any problems encountered, discuss actions to resolve the problems, and identify key activities for the upcoming calendar year. The annual report will be considered complete when it is placed in the facility operating record. Other information required to be included in the annual report is listed in 40 CFR §257.90.

3 Groundwater Sampling and Analysis

This section describes procedures that will be used at the Site for groundwater monitoring, sampling, and analysis.

3.1 Field Procedures

Groundwater sampling and analysis will be conducted in general accordance with the following AECOM Standard Operating Procedures (SOPs) that are included in **Appendix B**:

- SOP No. 001 Chain-of-Custody Procedures
- SOP No. 002 Package and Shipment of Environmental Samples
- SOP No. 003 Decontamination of Field Equipment
- SOP No. 004 Water Level Measurements
- SOP No. 005 Low Flow Groundwater Sampling

Significant deviations from the SOPs will be recorded in the field notes. Field notes will be recorded by sampling personnel. The field notes will include sampler name(s), well identification numbers, the date and time, instrument calibration notes, water-level measurements, well purging volumes, deviations from the SOPs, and other notable site observations. These records are copied to the project file and included in the Annual Monitoring and Corrective Action Report.

3.2 Investigation Derived Waste

Groundwater monitoring sampling and analysis has been performed at Site wells for a number of years. The results for wells in the vicinity of the Ash Monofill have been reviewed relative to the Colorado Basic Standards for Groundwater (CBSGs). The results for analytes with associated CBSGs were reported at values below primary CBSGs for samples collected in 2014 and 2015. Therefore, based on this information, and as this characterization of the groundwater demonstrates compliance with CBSGs, purge water generated during sampling will be discharged to ground surface. The purge water will be discharged by pouring it on the ground in a flat area away from the well head. The field sampler will spread out the purge water as much as possible to promote evaporation and reduce the potential for the water to runoff or infiltrate into the subsurface.

3.3 Sample Preservation and Shipment

Samples will be preserved in the field as appropriate, and sample containers will be labeled and placed in appropriate shipping containers. **Table 2** lists the required preservative for each analytical constituent. Sample containers will be placed on ice following sample collection and during transport to the laboratory. Other sample preservatives include nitric acid for metals and hydrochloric acid for mercury analysis. The sample bottles for analysis of metals and mercury will be preserved by the laboratory prior to sample collection. Samples will be transported under chain-of-custody (COC) control to a certified analytical laboratory.

3.4 Analytical Program

The list of Appendices III and IV analytes, analytical methods, and sample preservatives are shown on **Table 2**. Analyses will be conducted by a certified analytical laboratory. Both Appendix III and IV analytes will be analyzed during the first eight sampling events of detection monitoring to establish background. After October 2017, when the detection monitoring sampling frequency changes to semi-annual, the Appendix III list of boron, calcium, chloride, fluoride, sulfate, and TDS will be analyzed and reported. If assessment monitoring is subsequently triggered, both the Appendix III and IV list of analytes will be analyzed. Groundwater pH will continue to be monitored as a field parameter.

3.5 Chain-of-Custody Control

Standard chain-of-custody (COC) procedures will be followed from sample collection and throughout the analytical process. Custody is recorded through a series of signatures on the COC form as sample possession changes from one person or organization to another. For each sample location, the sample name, date and time of collection, and requested analyses will be recorded on the COC form. COC records will be maintained and included in the Annual Monitoring and Corrective Action Report.

3.6 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) measures will be implemented to collect reliable and valid field and analytical data. The QA/QC program will include collecting field duplicate samples to assess error associated with sample methodology and analytical procedures. At a minimum, one field duplicate will be collected per 20 samples or individual sampling event. Equipment blanks will also be collected when sampling equipment is re-used at multiple wells to assess the efficacy of equipment decontamination techniques. At least one equipment blank will be collected for every 20 samples or per sampling event. In addition, matrix spike/matrix spike duplicate (MS/MSD) samples will be used to monitor lab performance and the degree to which matrix interferences affect the reported concentration of an analyte. At least one equipment blank and MS/MSD will be collected for every 20 samples or per sampling event. A laboratory quality control report for each detection monitoring event will be provided by the lab and included in the data validation packet.

The data quality will be assessed by conducting a data review and validation on the laboratory analytical data packages. For each sampling event, a technical memorandum will be prepared and included within the Annual Monitoring and Corrective Action Report. The technical memorandum will summarize the usability of the analytical data with respect to satisfying project data quality objectives.

4 Statistical Methodology

4.1 Regulatory Guidance

Regulatory guidance provided in 40 CFR §257.90 specifies that a CCR groundwater monitoring program include selection of the statistical procedures to be used for evaluating groundwater quality data as required by 40 CFR §257.93. Groundwater quality monitoring data will be collected under the detection monitoring program outlined in this plan and includes collection and analysis of a minimum of eight independent groundwater samples for the background and downgradient compliance wells as required by 40 CFR §257.94(b). The groundwater samples will be analyzed for the constituents listed in 40 CFR §257 Appendices III and IV.

After the initial eight rounds of groundwater samples are collected and analyzed, these data must be statistically evaluated to determine if there are any statistically significant increases over background for the Appendix III constituents. In determining whether a statistically significant increase has occurred, the constituent concentrations at the downgradient wells (ASH-03, ASH-04, and ASH-05) and the background well (ASH-01) will be compared using one or more of the statistical methods presented in Sections 4.2 and 4.3.

The rule text of 40 CFR §257.93(f) outlines the statistical methods available to evaluate groundwater monitoring data. The statistical test(s) chosen will be conducted separately for each constituent in each monitoring well and will be appropriate for the constituent data and their distribution. The available statistical methods include the following:

- A parametric analysis of variance (ANOVA) followed by multiple comparison procedures to identify statistically significant evidence of contamination. The method must include estimation and testing of the contrasts between each compliance well's mean and the background mean levels for each constituent;
- An ANOVA based on ranks followed by multiple comparison procedures to identify statistically significant evidence of impacts. The method must include estimation and testing of the contrasts between each compliance well's median and the background median levels for each constituent;
- A tolerance or prediction interval procedure, in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each compliance well is compared to the upper tolerance or prediction limit;
- A control chart approach that gives control limits for each constituent; or
- Another statistical test method that meets the performance standards outlined below in the paragraph regarding statistics.

The chosen statistical method will comply with the performance standards outlined in 40 CFR §257.93(g), as appropriate, based on the statistical test method used. The performance standards include the following:

- The statistical method used to evaluate groundwater monitoring data will be appropriate for the constituent distribution (i.e., parametric or nonparametric).
- If an individual well comparison procedure is used to compare an individual compliance well constituent concentration with background constituent concentrations or a groundwater protection standard, the test shall be done at a Type I error level no less than 0.01 or 0.05, depending on the method chosen. This performance standard does not apply to tolerance intervals, prediction intervals, or control charts.
- If a control chart approach is used to evaluate groundwater monitoring data, the specific type of control chart and its associated parameter values shall be such that this approach is at least as effective as any of the other statistical analysis approaches previously specified.
- If a tolerance interval or a prediction interval is used to evaluate groundwater monitoring data, the levels of confidence and, for tolerance intervals, the percentage of the population that the interval must contain, shall be such that this approach is at least as effective as any of the other statistical analysis approaches previously specified.

- The statistical method must account for data below the limit of detection with one or more statistical procedures that shall be at least as effective as any of the other statistical analysis approaches previously specified.
- If necessary, the statistical method must include procedures to control or correct for seasonal and spatial variability as well as temporal correlation in the data.

Per 40 CFR §257.93(h)(2), statistical analysis of the first eight rounds of data must be completed within 90 days after completing the initial groundwater sampling and analysis to determine whether there has been a statistically significant increase over background for any constituent. The first eight rounds of groundwater sampling and analysis must be completed no later than October 17, 2017. In accordance with 40 CFR §257, the Rawhide Facility must obtain a certification from a qualified professional engineer stating that the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area. The certification must include a narrative description of the statistical method selected to evaluate the groundwater monitoring data.

Assessment monitoring is required per 40 CFR §257.95 whenever a statistically significant increase over background has been detected for one or more of the indicator parameters listed in 40 CFR §257 Appendix III. An assessment monitoring program also includes annual groundwater sampling and analysis for the constituents listed in 40 CFR §257 Appendix IV. The purpose of assessment monitoring is to determine if releases of CCR constituents have occurred to groundwater.

The facility can return to detection monitoring once assessment monitoring results are at or below background values for two consecutive assessment monitoring events. If the assessment monitoring demonstrates an exceedance of a groundwater protection standard for any of the CCR constituents specified in 40 CFR §257 Appendices III and IV, groundwater corrective action must be initiated.

4.2 Statistical Analysis Approach

There is no single method of statistical analysis that is appropriate for each groundwater constituent dataset. It is most prudent to use a suite of statistical methods that are dependent on the data and their distributions. The statistical analyses can be based on an interwell and/or an intrawell approach for the purpose of determining if the Ash Monofill has impacted groundwater quality. The statistical algorithms used for the interwell and intrawell approaches are chosen based on the groundwater constituent data and their distributions as well as consideration of natural seasonally- or spatially-varying groundwater constituent concentrations.

The initial eight rounds of baseline groundwater monitoring data were concurrently collected and analyzed for the 40 CFR §257 Appendices III and IV constituents. These data will be used to represent background groundwater quality for the Ash Monofill and to determine if the Ash Monofill has impacted downgradient groundwater quality. The initial eight rounds of detection monitoring sampling and analysis were completed prior to the October 17, 2017 deadline established in the CCR Rule (40 CFR §257.94).

A preliminary, exploratory statistical analysis was conducted after the initial eight rounds of baseline data were obtained to initially assess the constituent data and determine the most appropriate statistical approach(es) for the data. The data were examined for outliers and the percentage of non-detect values to verify that the data collected are suitable for statistical analysis. The data were also examined using goodness-of-fit tests to determine the most appropriate statistical distribution and time series plots and areal maps were used to determine if seasonal or spatial variations in constituent concentrations were present. Based on this preliminary evaluation of the data, an interwell statistical approach was selected as appropriate for evaluating groundwater at the Rawhide Facility, as described in Section 4.3.

Per 40 CFR §257.93(h)(2), statistical analysis of all eight rounds of the initial groundwater monitoring data must be completed within 90 days after completing groundwater sampling and analysis to determine whether there has been a statistically significant increase over background for any Appendix III constituent.

4.3 Interwell Statistical Approach

Interwell tests compare the statistical differences between (upgradient) background and downgradient compliance wells. An interwell statistical approach will be used during detection monitoring for the following reasons:

- Sufficient data are available in the upgradient background well to ensure adequate degrees of statistical power to detect real exceedances above background levels, and also reasonable control over the site-wide false positive rate so that spurious exceedances have little chance of being identified.
- Although there is evident spatial variation among most, if not all, of the Appendix III constituents, it is unclear to what extent the similarly evident variation among the downgradient wells is due strictly to natural differences in groundwater quality and/or other factors unrelated to management of the CCR ash. Because of this uncertainty, an interwell comparison strategy appears to be initially more appropriate for the Rawhide Facility.

As a caveat to this approach, for constituents that occur naturally and vary substantially in concentration across the Rawhide Facility due to natural hydrogeologic or geochemical factors — thus, exhibiting significant spatial variability — an interwell testing scheme will not always be helpful. Constituent concentrations greater than background might be attributed to anthropogenic contamination using an interwell approach, when the differences are actually natural and due to locally varying distributions of groundwater constituents. In such cases, an intrawell approach may be warranted.

Furthermore, there is no requirement either in RCRA or the CCR Rule to use exactly the same statistical method or approach for every constituent. Depending on characteristics of the Rawhide Facility and data that are collected, a mix of interwell and intrawell tests may be warranted. At this site, the initial statistical screening suggests that interwell comparisons are most appropriate despite evident spatial variability. However, that conclusion could change as additional data are collected during future detection monitoring. If new information indicates that constituent concentrations remain relatively stable and that the existing spatial variation is unrelated to the Ash Monofill, a modification of the statistical approach to intrawell testing may be recommended for one or more constituents.

Under an interwell statistical approach in detection monitoring, the actual statistical method(s) chosen will be determined based on the constituent data distribution (as outlined below), which in turn is influenced both by the percentage and pattern of non-detect measurements as well as the temporal stability of the concentration levels.

When (1) the percentage of non-detects is low to moderate (i.e., less than 50-60 percent), (2) the background data can be normalized (perhaps via a standard transformation), and (3) the results are stationary (i.e., stable over time), the following statistical methods are highly recommended by USEPA (2009):

- Parametric interwell prediction limit methods with retesting; or
- Interwell control charts with retesting.

When the background data cannot be normalized (perhaps due to a large percentage of non-detects), but the data are stationary (i.e., stable over time), the following statistical method is recommended by USEPA (2009):

- Non-parametric interwell prediction limits with retesting.

Note that the specific retesting method in each of these options will be chosen to account for the size of the well network, the amount of background data available, the number of constituents being monitored, the site-specific mix of intrawell and interwell tests, and the impact of these factors on the statistical power and accuracy of the test. At this site, the upgradient background wells relative to the number of downgradient wells to be tested on a semi-annual basis will enable use of a 1-of-2 retesting plan. This necessitates collection of a single independent resample at any location in which the initial routine measurement exceeds its respective statistical limit. A confirmed statistical exceedance will not be recorded unless both the initial measurement and resample value both exceed the statistical limit.

If the upgradient background data are non-stationary and thus exhibit a clear trend, it will suggest that factors unrelated to the Ash Monofill are impacting upgradient groundwater quality. Three general scenarios will be considered:

- Older background data may no longer be representative of current site conditions and may need to be excluded from statistical calculations. In this case, the interwell statistical limits will be updated to include only the most representative background data.
- The compliance wells will be examined to see if similar trends are occurring downgradient. If so, a common trend component will be estimated across the site and removed from every well. The residual data will then be used to construct revised statistical limits and tested as previously described.
- If the trend in upgradient background wells is not reflected in downgradient wells, further investigation may be needed to determine if the upgradient data still serve as a reasonable background with which to compare downgradient compliance measurements. If not, the statistical approach will be modified to an appropriate intrawell strategy.

Because of the decision matrix needed to establish the correct statistical approach, the background data for each constituent will be periodically screened prior to construction of new or revised statistical limits. This screening will examine the proportion and pattern of outliers and potential data anomalies (perhaps due to laboratory or field sampling factors), the presence or absence of statistically significant trends over time, the presence or absence of statistically significant outliers, and the identification of an appropriate statistical distribution. In particular, any confirmed background outliers will be excluded from statistical calculations, so as not to unduly bias the statistical limits.

5 Assessment Monitoring

5.1 Triggers and Timing

If through the statistical analyses discussed in Section 4.0, it becomes evident that a statistically significant increase over background has occurred for one or more of the detection monitoring 40 CFR §257 Appendix III constituents, documentation will be placed in the facility operating record indicating which constituents have shown an increase. The facility would then have two options for continued groundwater monitoring at the Ash Monofill.

- The first option would be to evaluate whether a source other than the Ash Monofill caused the statistically significant increase, or whether the increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.
- The second option would be to establish an assessment monitoring program for the Ash Monofill in accordance with 40 CFR §257.95. An assessment monitoring program also includes annual groundwater sampling and analysis for the constituents listed in 40 CFR §257 Appendix IV. The purpose of assessment monitoring is to determine if releases of CCR constituents have occurred from the Ash Monofill. If this option proves to be necessary, a notification will be placed in the facility operating record stating that an assessment monitoring program has been established. The facility is required to implement the assessment monitoring program within 90 days of confirming the statistically significant concentration increase.

Protocols that will be followed for each of these options are described below in Sections 5.2 through 5.4.

5.2 Verification Resampling

Verification resampling is an integral component of the statistical method outlined in Section 4.3. Verification resampling provides a way to evaluate unexpected or errant sample results and can help avoid unnecessary entry into assessment monitoring. A verification resample would only be collected from the well(s) where an outlier or statistically significant concentration increase was observed, and only for the relevant analyte(s). The same sampling procedures used for detection monitoring would also be used for verification resampling. The facility will take reasonable efforts to complete verification resampling within two weeks of identifying the need to resample. A statistically significant increase only is flagged when a verification sample confirms the initial result. A report documenting this action will be developed in accordance with requirements of 40 CFR §257.94.

5.3 Alternate Source Demonstration

In addition to verification resampling, the facility may also choose to evaluate whether the statistically significant concentration increase was derived from another source besides the Ash Monofill. Such an evaluation, if warranted, may require specialized sample analyses to identify concentration inputs from other potential sources. Any report prepared as a result of this evaluation or as a result of verification resampling will be placed into the facility operating record within 90 days of identifying the statistically significant concentration increase. The report will also be certified by a qualified groundwater scientist or professional engineer.

5.4 Assessment Monitoring Program

Assessment monitoring is required whenever a statistically significant increase over background has been detected for one or more of the constituents listed in 40 CFR §257 Appendix III. A routine monitoring sample result will only be considered valid if the verification sample result confirms a statistically significant increase over background values. If this situation occurs, the facility will implement an assessment monitoring program within 90 days of obtaining the verification resample result in accordance with 40 CFR §257.95. In assessment monitoring, the owner or operator of the CCR unit must sample and analyze the groundwater for all constituents listed in 40 CFR §257 Appendix IV (Table 2) within 90 days of a confirmed statistically significant increase over background, and annually thereafter. Within 90 days of obtaining the initial assessment monitoring results, and on at least a semiannual basis thereafter, resample all monitoring wells and conduct analyses for all parameters in 40 CFR §257 Appendix III and for those constituents in 40 CFR §257 Appendix IV that show a statistically significant increase above background in the initial assessment monitoring. All assessment monitoring results will be entered into the facility operating record as required by 40 CFR §257.95. The facility can return to detection monitoring once assessment monitoring results are at or below background values for two consecutive assessment monitoring events.

6 Limitations

The signature of Consultant's authorized representative on this document represents that, to the best of Consultant's knowledge, information, and belief in the exercise of its professional judgment, it is Consultant's professional opinion that the aforementioned information is accurate as of the date of such signature. Any opinion or decisions by Consultant are made on the basis of Consultant's experience, qualifications, and professional judgment and are not to be construed as warranties or guaranties. In addition, opinions relating to environmental, geologic, and geotechnical conditions or other estimates are based on available data, and actual conditions may vary from those encountered at the times and locations where data are obtained, despite the use of due care.

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Tables

Table 1
Monitoring Well Construction Details
Ash Monofill CCR Monitoring Program
PRPA Rawhide Facility

Well Name	Location Relative to CCR Unit	Top of Casing Elevation (ft amsl)	Ground Surface Elevation (ft amsl)	Total Depth (ft bgs)	Well Screen Interval (ft bgs)	Well Screen Lithology
ASH-01	Upgradient Well	5760.20	5759.26	31	26-29	Shale
ASH-03	Downgradient Well	5717.18	5714.21	49	39-49	Shale
ASH-04	Downgradient Well	5692.57	5689.58	29	19-29	Shale
ASH-05	Downgradient Well	5698.71	5696.68	29	19-29	Shale

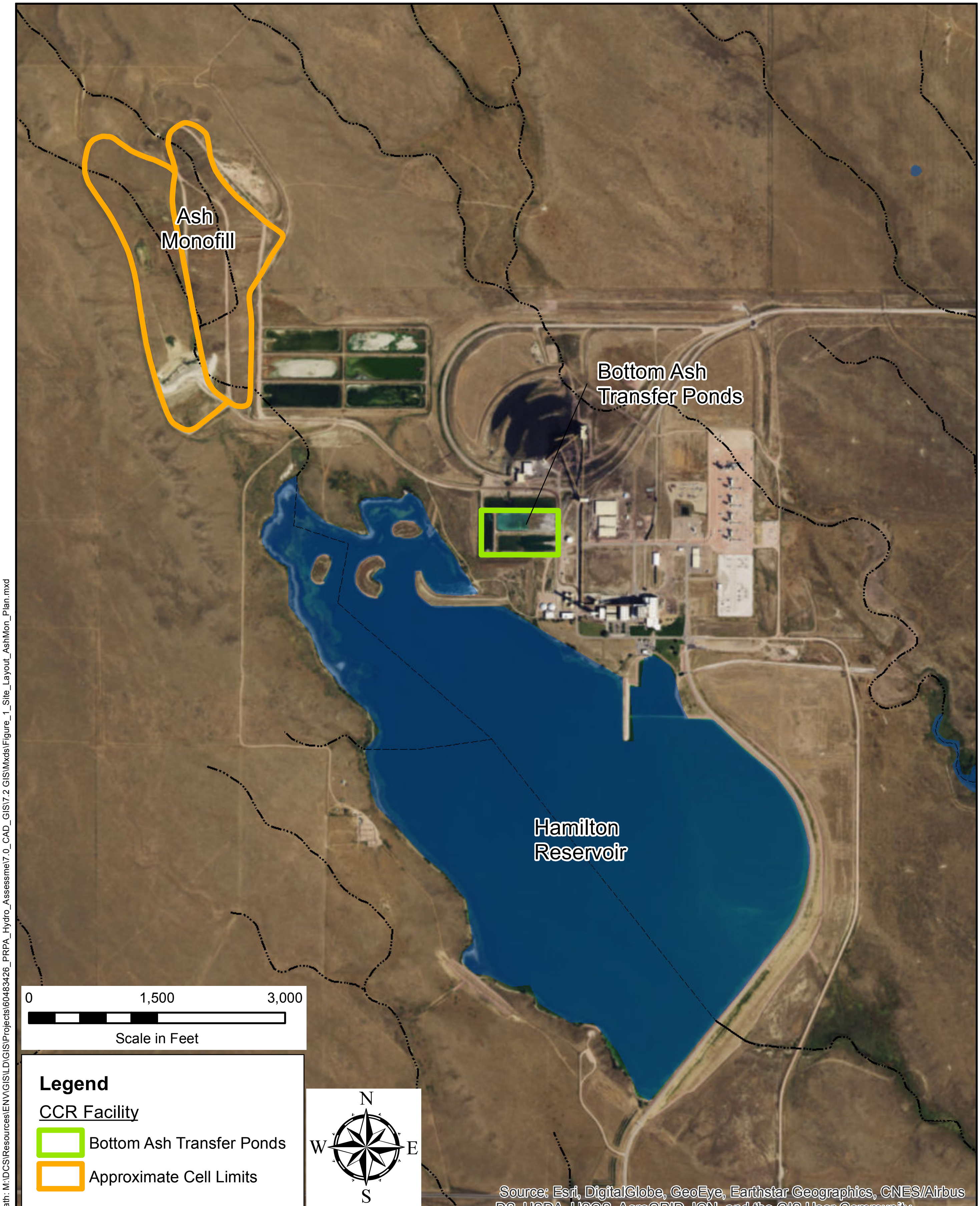
Notes:
ft amsl = feet above mean sea level
ft bgs = feet below ground surface
--- = Information not available
CCR = Coal Combustion Residuals
ASH-01 was installed in December 1980 as MW-1 by Black & Veatch

Table 2
Analytical Parameters, Methods, and Sampling Frequency
Ash Monofill CCR Monitoring Program
PRPA Rawhide Facility

Constituent	Analytical Method	Preservative	Background Detection Monitoring[1]	Continuing Detection Monitoring	Assessment Monitoring (if required)
Appendix III List					
Boron	6010C[2]	≤ 6°C, Nitric Acid	8 Events	Semi-Annual	Semi-Annual
Calcium	6010C[2]	≤ 6°C, Nitric Acid	8 Events	Semi-Annual	Semi-Annual
Chloride	9056A[2]	≤ 6°C	8 Events	Semi-Annual	Semi-Annual
Fluoride	9056A[2]	≤ 6°C	8 Events	Semi-Annual	Semi-Annual
pH	Field Measurement	Field Measurement	8 Events	Semi-Annual	Semi-Annual
Sulfate	9056A[2]	≤ 6°C	8 Events	Semi-Annual	Semi-Annual
Total Dissolved Solids	SM2540B[3]	≤ 6°C	8 Events	Semi-Annual	Semi-Annual
Appendix IV List					
Antimony	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual[4]
Arsenic	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Barium	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Beryllium	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Cadmium	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Chromium	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Cobalt	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Fluoride	9056A[2]	≤ 6°C	8 Events	N/A	Annual, Semi-Annual
Lead	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Lithium	6010C[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Mercury	7470A[2]	<6°C, HCl	8 Events	N/A	Annual, Semi-Annual
Molybdenum	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Selenium	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Thallium	6020A[2]	≤ 6°C, Nitric Acid	8 Events	N/A	Annual, Semi-Annual
Radium 226 and 228 Combined	9315/9320[2]	Nitric Acid	8 Events	N/A	Annual, Semi-Annual

Notes:
<6°C = Less than 6 degrees Celsius
HCl = Hydrochloric acid
CCR = Combustible Coal Residuals
N/A = Not Applicable. After October 17, 2017 this constituent will only be sampled as part of assessment monitoring (if required).
[1] = Eight (8) Background Detection Monitoring Events to be completed prior to October 17, 2017.
[2] = SW846, Test Methods for Evaluating Solid Waster, Physical/Chemical Methods
[3] = Standard Methods for the Examination of Water and Wastewater
[4] If assessment monitoring is triggered all Appendix IV constituents must be sampled annually. In addition, Appendix IV constituents that exceed background in the initial assessment monitoring sampling, must be sampled semi-annually, along with the Appendix III constituents
Metals will be reported as Total Recoverable Metals

Figures

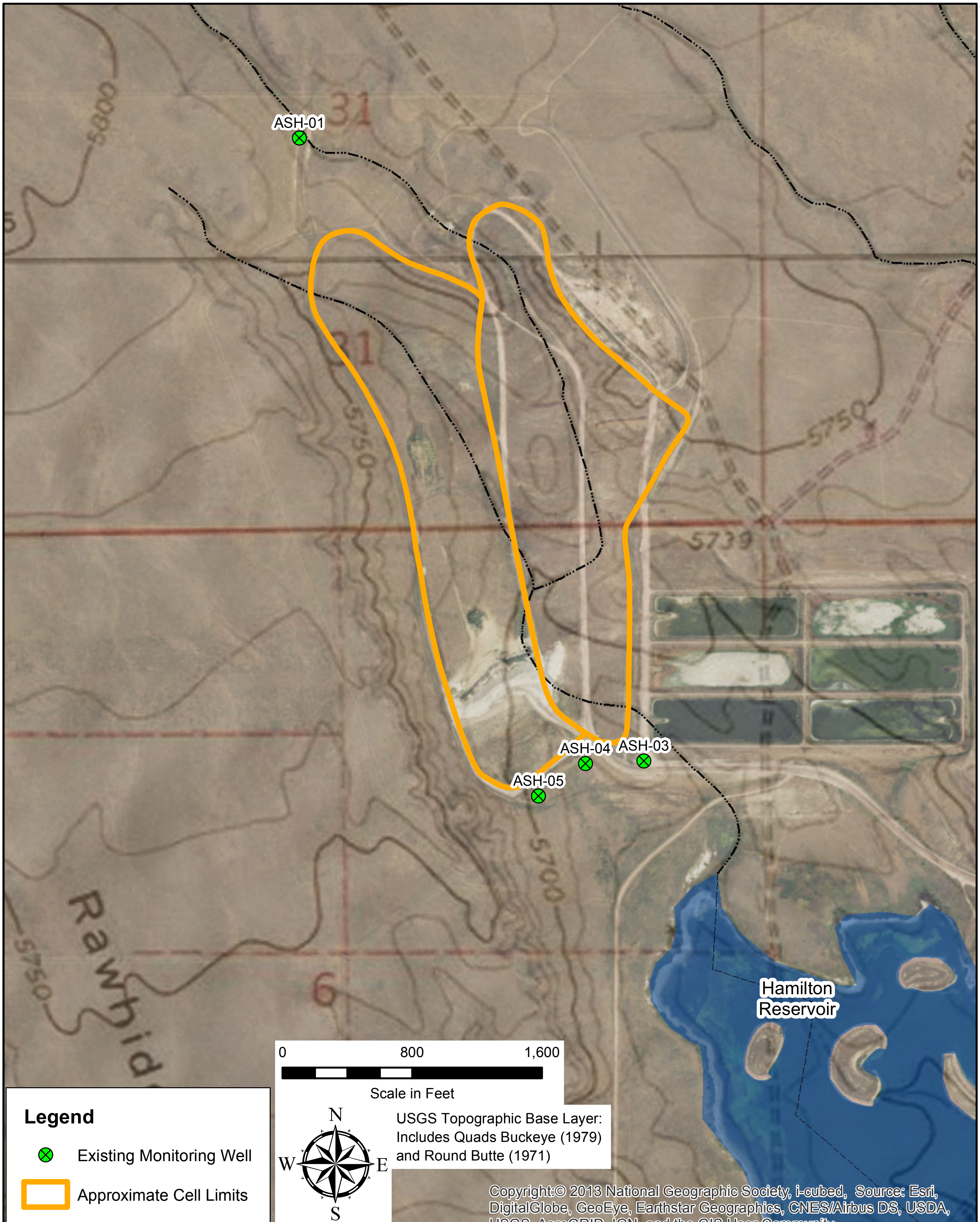


Coal Combustion Residuals (CCR)
Ash Monofill Groundwater Detection Monitoring Plan
Platte River Power Authority Wellington, CO
Project No.: 60431988 Date: 2017-10-12

RAWHIDE ENERGY STATION
SITE LAYOUT

AECOM

Figure 1



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Coal Combustion Residuals (CCR)
Ash Monofill Groundwater Detection Monitoring Plan
Platte River Power Authority Wellington, CO
Project No.: 60514657 Date: 2017-10-12

RAWHIDE ENERGY STATION
ASH MONOFILL MONITORING
WELL NETWORK

AECOM

Figure 2

Appendix A. Boring and Monitoring Well Completion Logs

AECOM Boring Log	**Project Name:** Rawhide Station **Client:** Platte River Power Authority **Project Number:** 60514655	**Boring ID:** ASH-01/MW-1

Date(s) Drilled	12/6/1980	Logged By	S. Roberts (Black and Veatch)	Checked By	Camille Littlefield (AECOM)
Drilling Method	-	Diameter of Borehole (in)	7		
Drill Rig Type	CME 55	Drilling Company	Drilling Engineers		
Driller's Name F. Schmidt	Sampler Type		-		
Description of Sample Location			Located far northwest, upgradient of monofill out in a bison pasture		

Total Depth of Borehole (ft)	32	Depth to Water (bgs)	
Ground Surface Elevation (ft-msl)	5755.6		
Groundwater Elevation (ft-msl)	TBD		
Measuring Point Elevation (ft-msl)	5757.1		
Northing	1562659.468		
Easting	3124781.188		

Depth (ft-bgs)	SAMPLES: Run Number	SAMPLES: Recovery (%)	SAMPLES: Sample ID	USCS Symbol	PID (ppm)	MATERIAL DESCRIPTION	Well Construction
0						0-5: silty clay, tan, trace to some sand, trace gravel	
5						5-25: shale, tan and olive, grading from olive to gray, grades hard	
10						gravel seam at 10'	
11						gravel seam at 11'	
20							

AECOM
Boring Log

Project Name:	Rawhide Station	Boring ID:	ASH-01/MW-1
Client:	Platte River Power Authority		
Project Number:	60514655		

Date(s) Drilled	12/6/1980	Logged By	S. Roberts (Black and Veatch)	Checked By	Camille Littlefield (AECOM)	Total Depth of Borehole (ft)	32	Depth to Water (bgs)	
Drilling Method	-	Diameter of Borehole (in)	7			Ground Surface Elevation (ft-msl)	5755.6		
Drill Rig Type	CME 55	Drilling Company	Drilling Engineers			Groundwater Elevation (ft-msl)	TBD		
Driller's Name F. Schmidt	Sampler Type		-			Measuring Point Elevation (ft-msl)	5757.1		
Description of Sample Location			Located far northwest, upgradient of monofill out in a bison pasture			Northing / Easting	1562659.468 / 3124781.188		

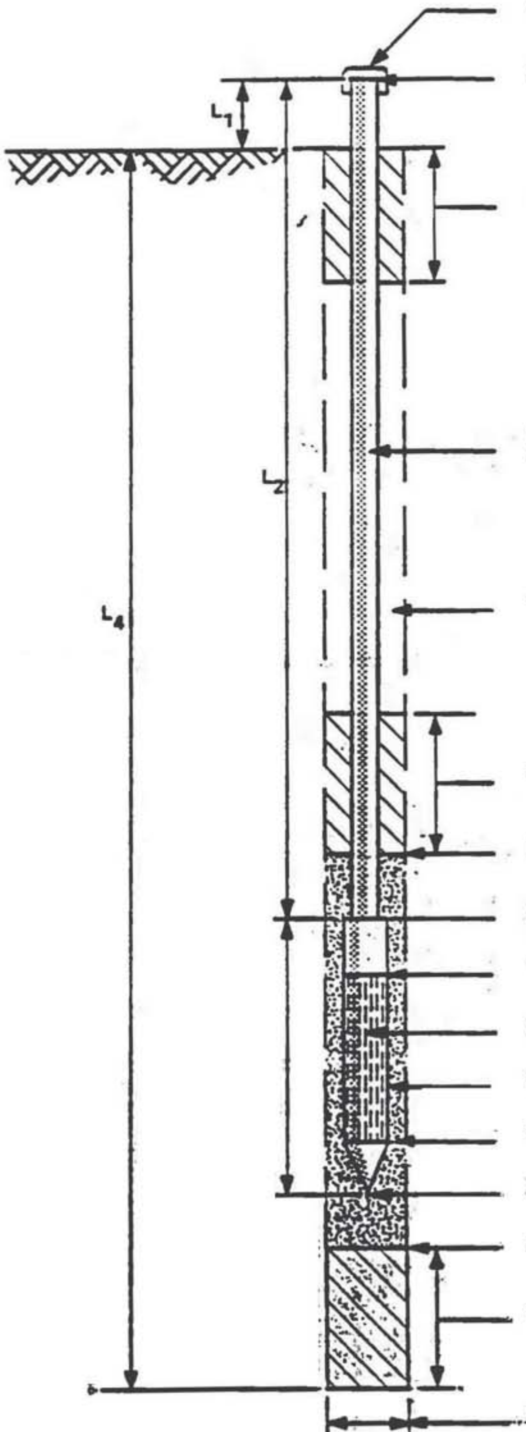
Depth (ft-bgs)	SAMPLES: Run Number	SAMPLES: Recovery (%)	SAMPLES: Sample ID	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Well Construction
21							
22							
23							
24							
25						25-26: gravel coarse	
26						26-32: shale olive to gray, hard	
27							
28							
29							
30							
31							
32						End of Boring at 32 ft	
33							
34						Notes: This boring log was adapted from the boring log done by Black and Veatch in 1980 as Piezometer 1. Northing and Easting are in NAD 1983 State Plane Colorado North	
35							
36							
37							
38							
39							
40							

RENAMED ASH-01/MW-1

BLACK & VEATCH
consulting engineers

PIEZOMETER NO. 1

GROUND ELEVATION AND DATUM 5755.6 FT AMSL



VENTED CAP

ELEVATION OF TOP OF RISER PIPE 5757.1

THICKNESS AND TYPE OF SEAL NO SEAL

I.D. OF RISER PIPE
TYPE OF RISER PIPE 4" ID PVC

TYPE OF BACKFILL AROUND RISER CEMENT GROUT

THICKNESS AND TYPE OF SEAL 2' BENTONITE

ELEVATION OF TOP OF FILTER SAND 5734.1

ELEVATION OF BOTTOM OF RISER 5729.1

TYPE OF PIEZOMETER 4 1/2" ID PVC

SCREEN GAUGE OR SIZE OF OPENINGS 1/8" DIA HOLES

DIAMETER OF PIEZOMETER TIP 4" ID

TYPE OF FILTER AROUND TIP PEA GRAVEL

ELEVATION OF BOTTOM OF PIEZOMETER 5726.1

ELEVATION OF BOTTOM OF FILTER SAND 5723.1

THICKNESS AND TYPE OF SEAL NO SEAL

DIAMETER OF BOREHOLE 7"

L1= 1.5

L2= 28

L3= 233

L4= 32

1/8" DIA HOLES DRILLED AT 4" CTRS AT 90 DEGS AROUND PIPE

NOTE: BLACK AND VEATCH DIAGRAM RESTORED BY CAMILLE LITTLEFIELD (AECOM)

AECOM	Client: Platte River Power Authority			Boring ID: ASH-03	
	Project Number:	60483426			
	Site Location:	Rawhide Station			
	Coordinates:	TBD	Elevation: TBD	Sheet: 1 of 3	
	Drilling Method:	Hollow Stem Auger		Monitoring Well Installed: Yes	
	Sample Type(s):	Continuous Core	Boring Diameter: 8 1/4 inch	Screened Interval:	39-49
Weather: sun, 40 degrees, windy		Logged By: Hurshman	Date/Time Started: 2/8/16 13:30	Depth of Boring:	49'
Drilling Contractor: Drilling Engineers		Ground Elevation: TBD	Date/Time Finished:	Water Level (drilling):	39.5'

Depth (ft)	Graphic Log	Sample Depth (ft)	Blows per 6"	Recovery (%)	PID Headspace (ppm)	U.S.C.S	**MATERIALS: Type (MAIN COMPONENT, minor component(s)), color, size, range, moisture content, structure, angularity, maximum grain size, odor/visual contamination, and Geologic Unit (If Known)**	Lab Sample ID	Lab Sample Depth (Ft.)
0	NA	NA	NA		NA		low recovery, fill material from v-trench pothole	No samples	
1									
2				25					
3									
4							fill continued to 8 ft		
5									
6									
7				80					
8							8-9: weathered shale with silty clay, tan in color, minor gravel interbedded from 8.5 to 9 ft, moist gravel on top of clay layer for 1 inch at 8 ft, slightly plastic silty clay		
9							9-14: silty clay with gravel, moist, poorly sorted, red granite gravels interbedded with silt and clay, appears to be fill, sandy gravel zone from 11-11.5 ft.		
10									
11									
12				100					
13									
14							14-19: continued as above, poorly sorted, light tan silty clay with gravel, dark brown streaks for 1 inch at 18.7 ft, moist		
15									
16							appears to be old monofill material in the area		
17				50					
18									
19									
20									

NOTES:

Checked by ___________________________ Date:________________

Date	Time	Depth to groundwater while drilling

AECOM	Client: Platte River Power Authority			Boring ID: ASH-03	
	Project Number:	60483426			
	Site Location:	Rawhide Station			
	Coordinates:	TBD	Elevation: TBD	Sheet: 2 of 3	
	Drilling Method:	Hollow Stem Auger		Monitoring Well Installed: Yes	
	Sample Type(s):	Continuous Core	Boring Diameter: 8 1/4 inch	Screened Interval:	39-49'
Weather: sun, 40 degrees, windy		Logged By: Hurshman	Date/Time Started: 2/8/16 13:30	Depth of Boring:	49'
Drilling Contractor: Drilling Engineers		Ground Elevation: TBD	Date/Time Finished:	Water Level (drilling):	39.5'

Depth (ft)	Graphic Log	Sample Depth (ft)	Blows per 6"	Recovery (%)	PID Headspace (ppm)	U.S.C.S	MATERIALS: Type (MAIN COMPONENT, minor component(s)), color, size, range, moisture content, structure, angularity, maximum grain size, odor/visual contamination, and Geologic Unit (If Known)	Lab Sample ID	Lab Sample Depth (Ft.)
	NA	NA	NA		NA		as above to 23.3 ft	No Samples	
21									
22				75					
23							23.3-24: light brown, extremely weathered shale, very crumbly, dry, no sand and gravel, few visible bedding planes, little silt, mainly clay/weathered shale		
24							continued as above to 29 ft weathered shale, crumbles easily		
25									
26				50					
27									
28									
29							28.5: 1 cm thick orange oxidized zone-dry, low angle (<20 degree) fracture continued as above to 31.1 ft		
30									
31				85			31.1-32.1: very hard almost slate like layer, light grey, dry back to weathered brown shale to 34 ft, dry, fracture 32.6 to 33 ft-oxidized (50-60 degrees) then back to horizontal laminated weathered shale, shell fragments		
32									
33									
34							34-36.5: as above, thinly bedded weathered shale, tan to brown, horizontal bedding, dry, oxidized 1cm thick zone at 35.5 ft, no major visible fractures, silt on bedding planes, crumbles moderately easily.		
35				100					
36									
37							36.5-39: as above 37.5: 40-50 degree angle fracture with small amount of water for 1 inch, oxidized orange in fracture, the remaining core crumbles easily, moist near 39 ft.		
38				100					
39							wet 39.5-40 ft, minor fracture below water.		
40									

NOTES:

Date	Time	Depth to groundwater while drilling

Checked by ___________________________ Date:_________________

AECOM	Client: Platte River Power Authority Project Number: 60483426 Site Location: Rawhide Station Coordinates: TBD Elevation: TBD Drilling Method: Hollow Stem Auger Sample Type(s): Continuous Core Boring Diameter: 8 1/4 inch	Boring ID: ASH-03 Sheet: 3 of 3 Monitoring Well Installed: Yes Screened Interval: 39-49'
Weather: sun, wind, 40 degrees	Logged By: Hurshman / Date/Time Started: 2/8/16 13:30	Depth of Boring: 49'
Drilling Contractor: Drilling Engineers	Ground Elevation: TBD / Date/Time Finished:	Water Level (drilling): 39.5'

Depth (ft)	Graphic Log	Sample Depth (ft)	Blows per 6"	Recovery (inches)	PID Headspace (ppm)	U.S.C.S	MATERIALS: Type (MAIN COMPONENT, minor component(s)), color, size, range, moisture content, structure, angularity, maximum grain size, odor/visual contamination, and Geologic Unit (If Known)	Lab Sample ID	Lab Sample Depth (Ft.)
41	NA	NA	NA	100	NA		39-42.5: continued weathered shale, water at 39.5 ft for 2-3 inches, oxidized orange zone with fractures in hard material, vertical fracture 40-40.5 ft with minor water, moist with gypsum at 41.5ft	No Samples	
42									
43				100			as above, weathered tan to brown shale to 44 ft		
44									
45				100			continued tan to brown weathered shale, horizontal laminations, outside of core is wet, inside of core wet along laminations/bedding planes and few fractures, mostly wet 45.5 to 46.4 ft, minor silt between bedding planes		
46									
47				100			47.5-49: dark grey shale, lightly weathered, horizontal bedding, shell fragments, moist, no visible fractures, thinly bedded, grey silt along bedding planes, outside of core is wet		
48									
49									
50							TD = 49 ft		
51									
52									
53									
54									
55									
56									
57									
58									
59									
60									

NOTES:
flushed with 200-250 gallons of water from driller's shop,
screened 39-49 ft, 20/40 sandpack from 35.5-49 ft, time released bentonite pellets from 33.5-35.5 ft, portland grout from surface to 33.5 ft, 0.01 slot screen, 2 inch schedule 40 PVC

Date	Time	Depth to groundwater while drilling

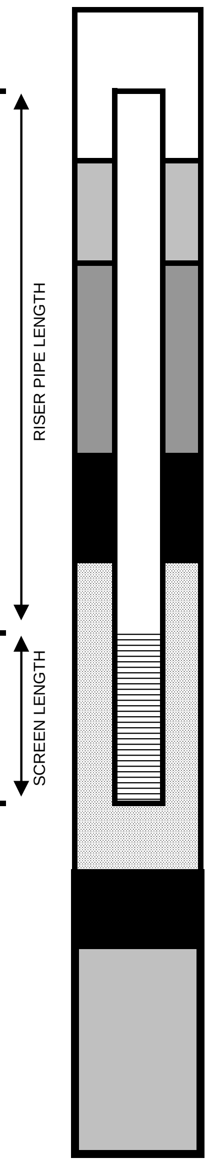
Checked by ______________________ Date:_______________

WELL CONSTRUCTION DATA

AECOM

PROJECT NAME: Platte River Power Authority - Rawhide Station		WELL ID: ASH-03	
PROJECT NO: 60483426	DATE INSTALLED: 2/8/2016	INSTALLED BY: JH	CHECKED BY: CL

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
	0	GROUND SURFACE
TBD	TBD	TOP OF CASING
	TBD	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: Portland grout mix
		GROUT/BACKFILL METHOD:
	33.5	GROUT
		BENTONITE SEAL MATERIAL: Time-released pellets
	35.5	BENTONITE SEAL
39	39	TOP OF SCREEN
		FILTER PACK MATERIAL: 20/40 sand
49	49	BOTTOM OF SCREEN
	49	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: NA
	49	HOLE BOTTOM



CASING AND SCREEN DETAILS

TYPE OF RISER:

PIPE SCHEDULE: sch. 40 PVC

PIPE JOINTS: threaded

SOLVENT USED: none

SCREEN TYPE: sch. 40 PVC

SCR. SLOT SIZE: 0.01 INCH

BOREHOLE DIAMETER 8.25 IN. FROM 0 TO 49 FT.
IN. FROM TO FT.

SURF. CASING DIAMETER 2 IN. FROM 0 TO 49 FT.
IN. FROM TO FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: see development form

TIME DEVELOPING: HOURS

WATER REMOVED: GALLONS

WATER ADDED: GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE:

COLOR BEFORE:

CLARITY AFTER:

COLOR AFTER:

ODOR (IF PRESENT):

WATER LEVEL SUMMARY

SWE MEASUREMENT		DATE	TIME
BEFORE DEVELOPING	T/PVC		
AFTER DEVELOPING:	T/PVC		
OTHER	T/PVC		
OTHER	T/PVC		

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☑ NO

NOTES:
"JH" = Jeremy Hurshman and Drilling Engineers
"CL" = Camille Littlefield
Flushed with 200-250 gallons of water from driller's shop

AECOM	Client: Platte River Power Authority			Boring ID: ASH-04
	Project Number:	60483426		
	Site Location:	Rawhide Station		
	Coordinates:	TBD	Elevation: TBD	Sheet: 1 of 2
	Drilling Method:	Hollow Stem Auger		Monitoring Well Installed: Yes
	Sample Type(s):	Continuous Core	Boring Diame 8 1/4 inch	Screened Interval: 19-29'
Weather: Partly cloudy, 32 degrees		Logged By: Hurshman	Date/Time Started: 2/8/16 08:30	Depth of Boring: 29'
Drilling Contractor: Drilling Engineers		Ground Elevation: TBD	Date/Time Finished: 2/8/16 13:00	Water Level (drilling): 19'

Depth (ft)	Graphic Log	Sample Depth (ft)	Blows per 6"	Recovery (%)	PID Headspace (ppm)	U.S.C.S	MATERIALS: Type (MAIN COMPONENT, minor component(s)), color, size, range, moisture content, structure, angularity, maximum grain size, odor/visual contamination, and Geologic Unit (If Known)	Lab Sample ID	Lab Sample Depth (Ft.)
1	NA	NA	NA		NA		low recovery, fill material from pothole, v trench 0-2 ft	No samples	
2				50			2-4: silty sand with clay, topsoil material, rootlets/organics, light tan to brown, dry		
3									
4							no recovery 4-5 feet		
5							5-9: light brown to tan weathered shale, dry, crumbles easily, thinly bedded, oxidized orange zones interbedded from 6-9 ft, small gypsum zones (< 1 cm) at 7.1, 7.8, 8.0, and 8.3 feet		
6				80					
7									
8									
9							as above to 13 ft, moist		
10									
11				50					
12									
13							13-14: light tan grey shale, tight, thinly bedded, oxidized orange layers (< 1 mm thick) interbedded, doesn't crumble as easily, no visible fractures, minor gypsum along oxidized bedding planes, dry		
14							light grey weathered shale, thinly bedded, crumbles easily 15-17.5 ft, moist from 16-16.5 ft and 17-17.5 ft, oxidized zones (1-2 cm thick) at 16.5, 17.2, 17.4, 17.7, and 18.1 ft,		
15									
16				85					
17									
18							tight compact shale, light grey from 18-19 ft, oxidized from 18.5-18.8 ft, thin 1-2 mm gypsum lenses in this zone, dry		
19							as above, wet from 19-19.7, then moist to 21 ft		
20									

NOTES:

Date	Time	Depth to groundwater while drilling

Checked by ________________________ Date:________________

AECOM			
Client: Platte River Power Authority			Boring ID: ASH-04
Project Number:	60483426		
Site Location:	Rawhide Station		
Coordinates:	TBD	Elevation: TBD	Sheet: 2 of 2
Drilling Method:	Hollow Stem Auger		Monitoring Well Installed: Yes
Sample Type(s):	Continuous Core	Boring Diameter: 8 1/4 inch	Screened Interval: 19-29'
Weather: Partly cloudy, 32 degrees	Logged By: Hurshman	Date/Time Started: 2/8/16 08:30	Depth of Boring: 29'
Drilling Contractor: Drilling Engineers	Ground Elevation: TBD	Date/Time Finished:2/8/16 13:00	Water Level (drilling): 19'

Depth (ft)	Graphic Log	Sample Depth (ft)	Blows per 6"	Recovery (%)	PID Headspace (ppm)	U.S.C.S	MATERIALS: Type (MAIN COMPONENT, minor component(s)), color, size, range, moisture content, structure, angularity, maximum grain size, odor/visual contamination, and Geologic Unit (If Known)	Lab Sample ID	Lab Sample Depth (Ft.)
	NA	NA	NA		NA		oxidized orange vertical fractures from 21-21.5 ft	No Samples	
21							thinly bedded shale, horizontal beds 21.5-23 ft, brown color, moist to dry, grey zone from 22.6-22.8'		
22				100					
23							23-24: thinly bedded grey weathered shale, tan wet zone 23.6-23.8 ft, no fractures, horizontal bedding		
24							24-29: thinly bedded grey shale, no visible fractures, wet from 24-25, 26-27.4, moist between, shell fragments in light grey shale zone between 26.6 and 26.8 ft, minor grey silt between bedding planes		
25									
26				100					
27									
28							appears dry 28-29 ft		
29							TD = 29 ft		
30									
31									
32									
33									
34									
35									
36									
37									
38									
39									
40									

NOTES:

screened 19-29 ft, well flushed with 75-100 gallons of water from Driller's shop
20/40 sandpack 17-29 ft, 50 lbs of time released bentonite pellets from 15-17 ft,
portland grout from surface to 15 ft.

Checked by ________________________ Date:________________

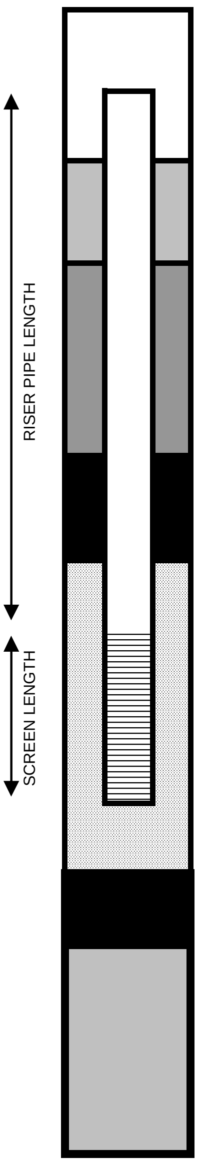
Date	Time	Depth to groundwater while drilling

AECOM

WELL CONSTRUCTION DATA

PROJECT NAME:	Platte River Power Authority - Rawhide Station	WELL ID:	ASH-04
PROJECT NO: 60483426	DATE INSTALLED: 2/8/2016	INSTALLED BY: JH	CHECKED BY: CL

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
	0	GROUND SURFACE
TBD	TBD	TOP OF CASING
	TBD	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: Portland grout mix
		GROUT/BACKFILL METHOD:
	15	GROUT
		BENTONITE SEAL MATERIAL: Time-released pellets
	17	BENTONITE SEAL
19	19	TOP OF SCREEN
		FILTER PACK MATERIAL: 20/40 sand
29	29	BOTTOM OF SCREEN
	29	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: NA
	29	HOLE BOTTOM



CASING AND SCREEN DETAILS

TYPE OF RISER:

PIPE SCHEDULE: sch. 40 PVC

PIPE JOINTS: threaded

SOLVENT USED: none

SCREEN TYPE: sch. 40 PVC

SCR. SLOT SIZE: 0.01 INCH

BOREHOLE DIAMETER 8.25 IN. FROM 0 TO 29 FT.
IN. FROM ___ TO ___ FT.

SURF. CASING DIAMETER 2 IN. FROM 0 TO 29 FT.
IN. FROM ___ TO ___ FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: see development form

TIME DEVELOPING: ___ HOURS

WATER REMOVED: ___ GALLONS

WATER ADDED: ___ GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE:

COLOR BEFORE:

CLARITY AFTER:

COLOR AFTER:

ODOR (IF PRESENT):

WATER LEVEL SUMMARY

SWE MEASUREMENT		DATE	TIME
BEFORE DEVELOPING	T/PVC		
AFTER DEVELOPING:	T/PVC		
OTHER	T/PVC		
OTHER	T/PVC		

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO

PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☑ NO

NOTES:
"JH" = Jeremy Hurshman and Drilling Engineers
"CL" = Camille Littlefield
Flushed with 200-250 gallons of water from driller's shop

AECOM
Boring Log

Project Name:	Rawhide Station
Client:	Platte River Power Authority
Project Number:	60514655

Boring ID: **ASH-05**

Date(s) Drilled	9/8/2016	Logged By	Jeremy Hurshman	Checked By	Camille Littlefield	Total Depth of Borehole (ft)	29
Depth to Water (bgs)							
Drilling Method	Hollow Stem Auger (HSA)	Diameter of Borehole (in)	8.25"			Ground Surface Elevation (ft-msl)	TBD
Drill Rig Type	Central Mine Equipment (CME)	Drilling Company	Drilling Engineers			Groundwater Elevation (ft-msl)	TBD
Driller's Name Rod G		Sampler Type	4" core barrel			Measuring Point Elevation (ft-msl)	TBD
Description of Sample Location			the foot of the Ash Monofill			Northing / Easting	1558621.76 / 3126285.639

Depth (ft-bgs)	Run Number	Recovery (%)	Sample ID	USCS Symbol	PID (ppm)	MATERIAL DESCRIPTION	Well Construction
0-4	1	50%	None	ML		0-4: topsoil 0-1, 1-4 silty with 5-10% rounded gravel, dry, tan, poorly-sorted, minor fine sand, more compact with depth, max gravel size = 1 cm	
4-6	2	100%	None	ML		4-6: continued as above	
6-9				weathered shale		6-9: grades into weathered shale, dry, brown, crumbles easily, thin bedding 0.5-2 cm thick, interbedded orange oxidized zones 7-9 ft, thicker bedding with depth, blocky 7-9 ft, oxidation mainly along bedding planes	
9-11.5	3	100%	None	weathered shale		9-11: continued as above 11-11.5: much harder shale/rock layer, oxidized, dry, horizontal 0.5 cm to 1 inch bedding, breaks easily along bedding	
11.5-14	4	100%	None	weathered shale		11.5-14: thinly bedded weathered shale, dry, brown at 11.5 ft grades into light to medium gray with orange oxidation, along bedding planes, silt along bedding planes, verticle fracture 13-14 ft - oxidized	
14-16.5	5	100	None	weathered shale		14-16.5: continued as above, minor gypsum lenses (1-2 mm) at 15, 15.5, 15.8 and 16.2 ft	
16.5-19	6	-	None	weathered (weath.) shale		16.5-19: continued as above, verticle oxidized fractures at 17.7-18.1 and 18.4-18.6, moist thinly bedded, wet at 19	
19-20	7	100%	None	weath. shale		19-21.5: continued as above, wet 19-19.5, then moist, gypsum lens at 19.5, blocky/thickly bedded shale, alternating gray to oxidized colors	

AECOM
Boring Log

Project Name:	Rawhide Station
Client:	Platte River Power Authority
Project Number:	60514655

Boring ID: ASH-05

Date(s) Drilled	9/8/2016	Logged By	Jeremy Hurshman	Checked By	Camille Littlefield	Total Depth of Borehole (ft)	29
Drilling Method	Hollow Stem Auger (HSA)	Diameter of Borehole (in)	8.25"			Ground Surface Elevation (ft-msl)	TBD
Drill Rig Type	Central Mine Equipment (CME)	Drilling Company	Drilling Engineers			Groundwater Elevation (ft-msl)	TBD
Driller's Name Rod G		Sampler Type	4" core barrel			Measuring Point Elevation (ft-msl)	TBD
Description of Sample Location			the foot of the Ash Monofill			Northing / Easting	1558621.76 / 3126285.639

Depth to Water (bgs):

Depth (ft-bgs)	Run Number	Recovery (%)	Sample ID	USCS Symbol	Graphic Log	MATERIAL DESCRIPTION	Well Construction
21	7	100%	None	weath. shale		19-21.5: continued as above, wet 19-19.5, then moist, gypsum lens at 19.5, blocky/thickly bedded shale, alternating gray to oxidized colors	
22–24	8	100%	None	weathered shale		21.5-24: continued as above, 45° fracture at 23.7-23.8, oxidized, wet at 24, moist to dry above, gypsum lens at 23.9 (2 mm thick)	
25–26	9	100%	None	weathered shale		24-26.5: Thinly bedded shale, dark gray to dark brown with minor oxidized zones near 25 and 26. wet 24-25, then moist/dry, thin wet oxidized zone at 25.5 and 26, silt along bedding planes	
27–29	10	100%	None	weathered shale		26.5-29: continued as above, weathered shale, increased silt content along bedding planes, silt is light brown in color, moist, wet at 28.8 ft.	
30–40						End of Boring at 29 ft	

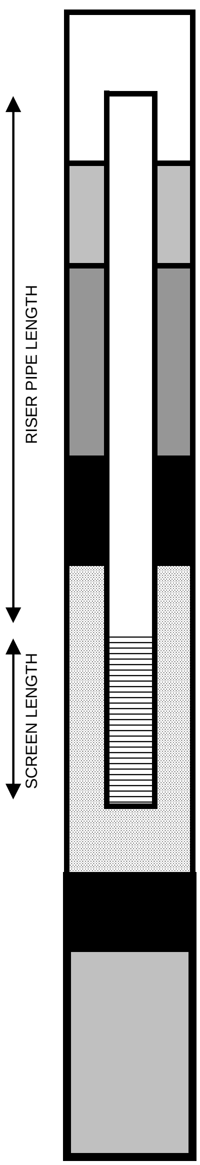
Notes:
grout seal: 2-15 ft
bentonite seal: 15-17 ft, 3/8" inch bentonite chips
sandpack: 17-19 ft, 20/40 sand
screen: 19-29 ft, 10 slot 2-in sch. 40 PVC
Northing and Easting are in NAD 1983 State Plane Colorado North

AECOM

WELL CONSTRUCTION DATA

PROJECT NAME: Platte River Power Authority - Rawhide Station		WELL ID: ASH-05	
PROJECT NO: 60514655	DATE INSTALLED: 9/8/2016	INSTALLED BY: JH	CHECKED BY: CL

ELEVATION (BENCHMARK: USGS)	DEPTH BELOW OR ABOVE GROUND SURFACE (FEET)	
+2.5	TBD	TOP OF CASING
	0	GROUND SURFACE
	2	CEMENT SURFACE PLUG
		GROUT/BACKFILL MATERIAL: Portland grout mix
		GROUT/BACKFILL METHOD:
	15	GROUT
		BENTONITE SEAL MATERIAL: 3/8" chips
	17	BENTONITE SEAL
19	19	TOP OF SCREEN
		FILTER PACK MATERIAL: 20/40 sand
29	29	BOTTOM OF SCREEN
	29	BOTTOM OF FILTER PACK
	NA	BENTONITE PLUG
		BACKFILL MATERIAL: NA
	29	HOLE BOTTOM



NOTES:
"JH" = Jeremy Hurshman and Drilling Engineers
"CL" = Camille Littlefield
Surface completion = stickup with 3 bollard posts

CASING AND SCREEN DETAILS

TYPE OF RISER:
PIPE SCHEDULE: sch. 40 PVC
PIPE JOINTS: threaded
SOLVENT USED: none
SCREEN TYPE: sch. 40 PVC
SCR. SLOT SIZE: 0.01 INCH

BOREHOLE DIAMETER 8.25 IN. FROM 0 TO 29 FT.
IN. FROM TO FT.

SURF. CASING DIAMETER 2 IN. FROM 0 TO 29 FT.
IN. FROM TO FT.

WELL DEVELOPMENT

DEVELOPMENT METHOD: see development form
TIME DEVELOPING: HOURS
WATER REMOVED: GALLONS
WATER ADDED: GALLONS

WATER CLARITY BEFORE / AFTER DEVELOPMENT

CLARITY BEFORE:
COLOR BEFORE:

CLARITY AFTER:
COLOR AFTER:

ODOR (IF PRESENT):

WATER LEVEL SUMMARY

SWE MEASUREMENT		DATE	TIME
BEFORE DEVELOPING	T/PVC		
AFTER DEVELOPING:	T/PVC		
OTHER	T/PVC		
OTHER	T/PVC		

PROTECTIVE COVER AND LOCK INSTALLED? ☑ YES ☐ NO
PERMANENT, LEGIBLE WELL LABEL ADDED? ☐ YES ☑ NO

Appendix B. Standard Operating Procedures (SOPs)

Standard Operating Procedure

Chain-of-Custody Procedures

Procedure Number: 001

Revision No.: 0

Revision Date: October 2017

Date: October 10, 2017

SOP Author, Camille Littlefield

Date: October 10, 2017

SOP Reviewer, Geoff Webb

Contents

1.0 Scope and Applicability

1.1 Chain of custody (COC) is defined as the unbroken trail of accountability for the physical security of samples, data, and records (USEPA Glossary of Quality-Related Terms). This Standard Operating Procedure (SOP) describes COC procedures applicable to environmental samples collected by AECOM during field sampling and analysis programs. Custody procedures within the laboratories analyzing the samples are not addressed.

1.2 Samples are physical evidence. The objective of COC procedures is to provide sufficient evidence of sample integrity to satisfy data defensibility requirements in legal or regulatory situations.

1.3 The National Enforcement Investigations Center (NEIC) of the United States Environmental Protection Agency (USEPA) defines custody of evidence in the following manner:

- It is in your actual possession;
- It is in your view, after being in your physical possession;
- It was in your possession and then you locked or sealed it up to prevent tampering; or
- It is in a secure area.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in a site-specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Interferences

3.1 The following may impact the legal or regulatory defensibility of the data:

- The samples are not accompanied by a COC form; or
- The information recorded on the COC form is incomplete, inaccurate, or differs from the information recorded on the sample containers.

4.0 Equipment and Materials

4.1 The following materials are relevant to this procedure:

- COC Form (Figure 1);
- Sample labels;
- COC tape or seal (Figure 2);
- Indelible pen or Sharpie™; and

- Clear plastic sealing tape.

4.2 Materials identified in related SOPs may also be needed.

5.0 Procedures

5.1 Pre-Sample Collection Activities

5.1.1 Some measurement methods require preparation of sample collection media or special treatment of sample containers prior to sample collection. In these cases, COC procedures should be initiated with the media preparation or container treatment. This requires that sample identification numbers or media/container identification numbers be assigned. These numbers should be entered on the COC form, leaving room for the subsequent recording of the associated sample numbers. In this variation, the custodian responsible for media preparation or container treatment has the responsibilities outlined in Section 5.2, and the sampler or field sample custodian has the responsibilities stated in Section 5.3 when he or she receives the prepared media or treated containers. There are a number of acceptable approaches to this variation, and the detailed procedures should be documented in the associated work plan.

5.2 Sample Collection Phase

5.2.1 As few people as possible should handle the samples. For certain programs, it is helpful if a single person is designated as the sample custodian (the person responsible for the care and custody of the samples until they are transferred to the laboratory for analysis).

5.2.2 While in the field, sampling personnel should be able to testify that tampering of the samples could not occur without their knowledge. Examples of actions taken may include sealing the sample containers with COC tape or locking the samples in a secure area.

5.2.3 If samples are to be shipped by commercial overnight carrier, the field sampler or sample custodian completes a COC form for each cooler/package of samples and places the original completed form inside the associated cooler/package before the package is sealed (a copy is retained and kept in the field record files). Each completed COC form should accurately list the sample identification numbers of the samples with which it is packaged, and should contain the identification number of the COC tape on the cooler/package. Representatives of commercial carriers are not required to sign the COC form.

5.2.4 If samples are hand carried to a laboratory, the person hand carrying the samples is the sample custodian. If the carrier is a different person than the one who filled out the COC form and packaged the samples, then that person transfers custody to the carrier by signing and dating each form in the "Relinquished By" section. The carrier then signs and dates each form in the adjacent "Received By" section. When the carrier transfers the samples to the laboratory, he or she signs and dates each form in the next "Relinquished By" section, and the laboratory sample custodian signs and dates each form in the adjacent "Received By" section.

5.2.5 If samples are transmitted to the laboratory by courier, the procedures described in either Section 5.2.3 or 5.2.4 are followed, depending on whether the courier is a commercial courier or laboratory representative, and whether the cooler has been secured by COC seals prior to pick up by a laboratory courier.

5.3 Sample Labeling

5.3.1 Labeling of samples occurs at the time of sample collection.

5.3.2 Waterproof, adhesive labels are preferred. Labels should be applied to the container, not the lid whenever possible. Additional interior labels may be required for certain biological samples.

5.3.3 Sample tags may be required for certain samples. If tags are utilized, their use will be addressed in a site-specific work plan.

5.3.4 Labels should be completed in waterproof, indelible ink. Covering the label with clear plastic tape is recommended to protect the legibility of the label and to prevent the label from detaching from the sample container.

5.3.5 The following information should be recorded on the sample label:

- Project identification (project name and number/client/site);
- Field sample identification code (exactly as it appears on the COC form);
- Sampler's initials;
- Date and time of sample collection;
- Analyses requested; and
- Preservation.

5.4 Documentation of Sample History

5.4.1 Sample history includes, but is not limited to, preparation of sample containers or collection media (e.g., wipes), collection, handling (i.e., subsampling or compositing), storage, shipment, analytical preparation and analysis, reporting, and disposal.

5.5 Documentation of Custody

5.5.1 It is recommended that a COC form be initiated upon sample collection. If this is not feasible for a particular event, the COC form may be initiated at the time of sample packaging. If this is the case, the sample collection records will serve as the initial custody document and will document the collection of the sample (outlined in Section 5.3.5).

5.6 The following information is recorded on the COC form:

- Project identification (AECOM project number, client, site name and location);
- Page number (for example, 1 of 2, 2 of 2);
- Field sample identification code (must be unique to the sampling event and program, and must agree exactly with the field sample identification code recorded on the bottle label);
- Sampling point location (optional if recorded elsewhere in field records);
- Date and time of sample collection;
- Sample matrix (e.g., soil, water, air, etc…);
- Preservative;
- Analysis requested;

- Number of containers;
- Type of sample (i.e., grab or composite) (identifying if aqueous samples have been filtered in the field is recommended);
- Signature(s) of sampling personnel and signatures of all personnel handling, receiving, and relinquishing the samples;
- Date(s) and time(s) of each sample transfer;
- Sampler remarks (these comments may serve to alert the laboratory to highly impacted samples or identify quality control (QC) sample requirements);
- Airbill number (if shipped by overnight commercial carrier); and
- Laboratory name and address.

5.7 COC Tape Numbers

5.7.1 The COC is filled out completely and legibly in indelible ink. There should be no unexplained blank spaces. Blank lines should be lined out and initialed and dated.

5.7.2 Corrections are made, if necessary, by drawing a single line through and initialing and dating the error. The correct information is recorded with indelible ink.

5.7.3 Information on the COC should agree exactly with that recorded on the sample containers. Discrepancies may result in the samples being incorrectly logged into the laboratory or delays in initiating sample analysis.

5.8 Sample Receipt and Inspection

5.8.1 Upon sample receipt, the coolers or packages are inspected for general condition and COC tape condition. The coolers or boxes are then opened and each sample is inspected for damage.

5.8.2 Sample containers are removed from packing material and sample label information is verified against the COC form.

5.8.3 The condition upon receipt, including any discrepancies or problems, is documented and the COC form is completed by signing and recording the date and time of receipt.

5.8.4 Receipt and inspection of samples by subcontractor analytical laboratories will adhere to written procedures established by the laboratory.

6.0 Quality Assurance / Quality Control

6.1 The records generated in this procedure are subject to review by the sampling team leader, project manager, or designee.

6.2 The field team leader is responsible for reviewing the chain-of-custody forms for completeness and accuracy prior to sample shipment.

7.0 Data and Records Management

7.1 The records generated in this procedure are part of the permanent record supporting the associated measurements and may include, as applicable, the COC forms, sample tags, carrier waybills, and field and laboratory records of sample history (i.e., collection, handling, storage, analysis, etc…).

7.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) should be appropriately, thoroughly documented in the project records.

7.3 Records associated with the activities described in this SOP should be maintained according to the project-specific document management policy.

8.0 Personnel Qualifications and Training

8.1 Qualifications and Training

8.1.1 The individual executing these procedures should have read, and be familiar with, the requirements in this SOP.

8.1.2 No specialized skills are necessary in order to implement these procedures; however, an understanding of the concept of custody is useful.

8.2 Responsibilities

8.2.1 The Project Manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

8.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP, and in project-specific work plans.

8.2.3 For certain sampling programs, the Project Manager, sampling team leader or designee may assign an individual to serve as sample custodian. This individual is responsible for supervising the implementation of COC procedures in accordance with this SOP and project-specific work plans.

9.0 References

American Society for Testing and Materials (ASTM). 2004. Standard Guide for Sample Chain-of-Custody Procedures. D 4840-99 (Reapproved 2004).ENSR SOP 1009 − Data Validation.

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). USEPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

10.0 Revision History

Revision	Date	Changes
0	October 2017	Initial Version

Figure 1: Example of Chain-of-Custody

AECOM

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

Cooler #________

Laboratory: TESTAMERICA - DENVER

Project Name:	Project Number:
AECOM Contact:	TA Project Manager:
Company: AECOM	TA Project Number:

ANALYSIS REQUESTED *(Include Method Number, Container and Preservative)*

FIELD SAMPLE ID	**SAMPLING DATE**	**SAMPLING TIME**	**MATRIX**	Total Number of Containers										**Comments (e.g.- extra Volume MS/MSD)**

SAMPLE RECEIPT: CONDITION/COOLER TEMP:________________ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
Signature	Signature	Signature	Signature
Printed Name	Printed Name	Printed Name	Printed Name
Firm	Firm	Firm	Firm
Date/Time	Date/Time	Date/Time	Date/Time

SPECIAL INSTRUCTIONS:

- Circled analyses represent those analyses for which bottles are contained in this cooler.
- Level IV package required.
- See Site-Specific QAPPs for Metals, VOC, SVOC, and PAH lists.
- Report soils on a dry weight basis.
- Dissolved Metals and Dissolved Organic Carbon are field filtered.
- DoD 5.0, Full Spike Lists are required

Figure 2: Example Chain-of-Custody Tape

Standard Operating Procedure

Package and Shipment of Environmental Samples

Procedure Number: 002

Revision No.: 0

Revision Date: October 2017

Date: October 10, 2017

SOP Author, Camille Littlefield

Date: October 10, 2017

SOP Reviewer, Geoff Webb

Contents

1.0 Scope and Applicability

1.1 Purpose and Applicability

1.1.1 This Standard Operating Procedure (SOP) describes the procedures associated with the package and shipment of environmental samples. Two general categories of samples exist: 1) environmental samples consisting of water and soil submitted for routine environmental testing, and 2) waste material samples which include non-hazardous solid wastes and/or hazardous wastes, as defined by 40 CFR Part 261, submitted for environmental testing or bench/pilot-scale treatability testing. Packaging and shipping procedures will differ for the two sample categories.

1.1.2 This SOP is applicable to the package and shipment of environmental samples submitted for routine environmental testing. Environmental samples are not considered a hazardous waste by definition; therefore, the Department of Transportation (DOT) regulations regarding sample transportation do not apply. Environmental samples do, however, require stringent packaging and shipping measures to confirm sample integrity and safety of the individuals handling and transporting the samples.

1.1.3 This SOP is designed to provide a high degree of certainty that environmental samples will arrive at their destination intact. This SOP assumes that samples will often require shipping overnight by a commercial carrier service; therefore, the procedures are more stringent than may be necessary if a laboratory courier is used, or if samples are transported directly to their destination by a sampling team member. Should the samples be transported directly to the laboratory by a laboratory courier or a sampling team member, the procedures may be modified to reflect a lesser degree of packaging requirements.

1.1.4 Respective state or federal agency (regional office) protocols may require or recommend specific types of equipment to use in sample packaging, or a specific method of shipment that may vary from the indicated procedures in this SOP. Deviations from this SOP to accommodate other regulatory requirements should be reviewed in advance of the field program, should be explained in the project work plan, and must be documented in the field project notebook when they occur.

1.2 General Principles

1.2.1 Sample package and shipment generally involves the placement of individual sample containers into a cooler, or other similar shipping container, and placement of packing materials and coolant in order to isolate the samples, maintain the required temperature, and limit the potential for damage to sample containers during transportation.

2.0 Health and Safety Considerations

2.1.1 Sampling personnel should be aware that packaging and shipment of samples involves potential physical hazards primarily associated with the ocassional handling of broken sample containers and the lifting of heavy objects. Adequate health and safety measures must be taken in order to protect sampling personnel from these potential hazards. A project Health and Safety Plan (HASP) generally addresses physical, and other potential, hazards. A project HASP must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing sampling, and must be adhered to as field activities are performed. In the absence of a project HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Interferences

Not applicable.

4.0 Equipment and Materials

- Sample coolers
- Sample containers
- Sample labels
- Shipping labels
- Chain of custody (COC) records
- COC tape
- Bubble wrap
- Wet ice
- Packing tape
- 2-gallon Ziploc® brand freezer bags for ice
- Health and Safety supplies
- Equipment decontamination materials
- Field project notebook and water-proof ink pen

5.0 Procedures

5.1 General Information

5.1.1 Regulatory Information

- The extent and nature of sample containerization will be governed by the type of sample, and a reasonable projection of the sample's hazardous nature and constituents. The EPA regulations (40 CFR Section 261.4(d)) specify that samples of solid waste, water, soil or air, collected for the sole purpose of testing, are exempt from regulation under the Resource Conservation and Recovery Act (RCRA) when any of the following conditions are applicable:
- Samples are being transported to a laboratory for analysis;

- Samples are being transported to the collector from the laboratory after analysis; and
- Samples are being stored (1) by the collector prior to shipment for analyses, (2) by the analytical laboratory prior to analyses, (3) by the analytical laboratory after testing but prior to return of sample to the collector or pending the conclusion of a court case.

5.1.2 Sample Information

- Sample information to be provided on the COC will follow the Chain of Custody SOP 001.

5.1.3 Laboratory Notifications

- Prior to sample collection the Project Manager, or designated alternative, must notify the laboratory manager of the number of samples, type of samples, approximate collection dates, and approximate shipment dates for the samples. If the number, type or date of sample shipment significantly changes due to program changes, which may occur in the field, the Project Manager or alternate must notify the laboratory of the changes. Additional notification from the field is often necessary when shipments are scheduled for Saturday deliveries.

5.2 General Site Preparation

5.2.1 Small Projects

- Small projects consisting of a one or two day duration may require package and shipment of samples using the field vehicle as the sample preparation area. If sample coolers are to be sent via a third party commercial carrier service, adequate sample packaging materials should be sent to the project location in prior to sampling, or purchased from stores located near the site.

5.2.2 Large Projects

- Multi-day or week long sampling programs usually require the rental of an office trailer or the use of existing office/storage facilities for storage of equipment and sample preparation. If possible, a designated area should be selected for storage of unused sample containers/coolers, and another area for sample handling, packaging, and shipping. Handling of environmental samples are preferably to be conducted in a clean area away from unused sample containers in order to minimize the potential for cross contamination. Large quantities of packaging materials may require advance special ordering. Shipping forms/labels may be preprinted to facilitate shipping.

5.2.3 Cooler Inspection and Decontamination

- Laboratories will often re-use coolers. Every cooler received at a project location should be inspected for general condition and cleanliness. Any coolers that have cracked interior or exterior linings/panels or hinges should be discarded because their insulating properties are now compromised. Any coolers missing one or both handles should also be discarded, if replacement handles (e.g., knotted rope handles) cannot be fashioned in the field. Replacement coolers may be purchased in the field if necessary.
- The interior and exterior of each cooler should be inspected for general condition and cleanliness upon arrival, before use. Excess packing tape and old shipping labels should be removed. If the cooler interior exhibits visible impacts or odors it should be

decontaminated in accordance with the Decontamination of Field Equipment SOP 003. Drain plugs should be sealed on the inside with duct tape.

5.2.4 Other Considerations

- Volatile Organic Compound (VOC) Samples - Sample containers used for VOC analysis may be grouped into a single cooler, with a separate COC, to limit the number of trip blanks required for transportation and analysis. Individual VOC samples may also be placed into Zipper-lock bags in order to further protect the samples.
- Impacted Samples - Sample containers with presumed high analyte concentrations should be isolated within their own cooler with each sample container placed in a sealed Zipper-lock bag, in order to prevent cross contamination and for health and safety reasons.

5.3 Sample Packaging Method

5.3.1 Place plastic bubble wrap matting over the base of each cooler or shipping container as needed to create a cushion of the samples.

5.3.2 Check that each sample container is properly sealed, correctly and legibly labeled, and is externally clean. Re-label and/or wipe bottles clean if necessary. Wrap each large glass sample container (250 milliliter (ml) or greater) individually with bubble wrap secured with tape. Small glass sample containers (i.e., 40 ml vials) can be wrapped in bubble wrap in groups of two or three containers if they are collected from the same sampling location. Plastic sample containers do not need to be wrapped in bubble wrap. Place bottles into the cooler in an upright single layer. Do not stack bottles or place them in the cooler lying on their sides. If plastic and glass sample containers are used, alternate the placement of each type of container within the cooler so glass bottles are not placed side by side.

5.3.3 Place additional bubble wrap in any voids between sample containers.

5.3.4 Insert cooler temperature blanks as required.

5.3.5 Double-bag wet ice in 2-gallon Ziploc® brand freezer bags and distribute them in a layer over the top of the samples.

5.3.6 Add additional bubble wrap or other packing materials to fill the balance of the cooler or container.

5.3.7 Obtain a piece of COC tape and enter the COC tape number in the appropriate place on the COC form. Sign and date the COC tape.

5.3.8 Complete the COC form. Do not forget to sign it. If shipping the samples involves the use of a third party commercial carrier service, sign the COC record thereby relinquishing custody of the samples. Shippers should not be asked to sign COC records. If a laboratory courier is used, or if samples are transported directly to the laboratory, the receiving party should accept custody and sign the COC records. Remove the last copy from the form and retain it with other field notes. Place the original COC form (with remaining copies) in a Zipper-lock type plastic bag, and tape the bag to the inside lid of the cooler or shipping container. Refer to the Chain of Custody SOP 001 for more specific information.

5.3.9 Close the top or lid of the cooler or shipping container.

5.3.10 Place the COC tape over the seal between the cooler and the lid and overlap with transparent packaging tape, taping the cooler shut and protecting the COC tape.

5.3.11 Packaging tape should be placed entirely around the sample shipment containers in order to seal the lid down. A minimum of three full wraps of packaging tape will be placed in at least two locations on the cooler. A minimum of one full wrap will be placed around the base of the cooler over the drain plug to prevent leakage.

5.3.12 Repeat the above steps for each cooler or shipping container.

5.4 Sample Shipping Method

5.4.1 Hand Delivery

- When a project member is transporting samples by automobile to the laboratory, the COC will be maintained by the person transporting the sample and COC tape need not be used. COC records should be relinquished upon delivery, and a copy of the record retained in the project file.

5.4.2 Laboratory Courier

- Laboratory couriers are usually employees of the analytical laboratory who recieve the samples. They will accept custody of the samples, and must sign the COC records before acquiring custody. COC records do not need to be sealed in the cooler although it is recommended that the coolers be sealed with tape. All other packaging requirements generally apply unless otherwise specified in the project specific Quality Assurance Project Plan (QAPP).
- If the laboratory courier is not authorized to accept custody of the samples, or if the requirements of the project plan prevent transfer to the laboratory courier, samples will be handled as described below in Section 5.4.3.

5.4.3 Third Party Courier

- If overnight shipment is required, a third party package delivery service should be used. Transport the cooler to the package delivery service office or arrange for package pick-up at the site. Fill out the appropriate shipping form or airbill and affix it to the cooler. Some courier services may use multi-package shipping forms where only one form needs to be filled out for all packages going to the same destination. If not, a separate shipping form should be used for each cooler. Keep the receipt for package tracking purposes should a package become lost. Please note that each cooler also requires a shipping label which indicates point of origin and destination. Shipping labels on the coolers will aid in recovery of a lost cooler if a shipping form gets misplaced. Never leave coolers unattended while waiting for package pick-up. Airbills or waybills must be maintained as part of the custody documentation.

5.5 Sample Receipt

- Upon receipt of the samples, the analytical laboratory will open the cooler or shipping container and will sign "received by laboratory" on each COC form. The laboratory will verify that the COC tape has not been broken previously and that the tape number corresponds with the number on the COC record. The laboratory will note the condition of the samples upon receipt and will identify any discrepancies between the contents of the cooler and the COC. The analytical laboratory will then forward the signed back copy of the COC record to the project manager to indicate that sample transmittal is complete.

6.0 Quality Assurance / Quality Control

6.1 Sampling personnel should follow specific quality assurance guidelines as outlined in the site-specific work plan. Proper quality assurance requirements should be provided which will specify sample package and shipment requirements if variations to the indicated procedures are necessary on a particular project.

6.2 The potential for samples to break during transport increases greatly if individual containers are not snugly packed into the cooler or properly wrapped as applicable. Completed coolers may be lightly shake-tested to check for any loose bottles. The cooler should be repacked if loose bottles are detected.

6.3 Environmental samples are generally shipped so that the samples are maintained at a temperature of 4 ± 2°C. Temperature blanks may be required for some projects as a quality assurance check on shipping temperature conditions. These blanks are usually supplied by the laboratory and consist of a plastic bottle filled with tap water. Temperature blanks should be placed near the center of the cooler to provide an accurate reading of the internal temperature of the cooler upon arrival.

7.0 Data and Records Management

7.1 Documentation supporting sample package and shipment generally consists of COC records and shipping records. All documentation will be retained in the project files following project completion.

8.0 Personnel Qualifications and Training

8.1 Sample package and shipment is a relatively simple procedure requiring minimal training and a minimal amount of equipment. It is, however, recommended that initial attempts be supervised by more experienced personnel. Sampling technicians should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous waste materials are considered to be present.

8.2 Sampling Technician

- It is the responsibility of the sampling technician to be familiar with the procedures outlined within this SOP and with specific sampling, quality assurance, and health and safety requirements outlined within the project-specific plans. The sampling technician is responsible for proper package and shipment of environmental samples and for proper documentation of sampling activities for the duration of the sampling program.

8.3 Sampling Coordinator

- Large sampling programs may require additional support personnel such as a sampling coordinator. The sampling coordinator is responsible for providing management support such as maintaining an orderly sampling process, providing instructions to sampling technicians regarding sampling locations, and fulfilling sample documentation requirements, thereby allowing sampling technicians to collect samples in an efficient manner.

8.4 Field Team Leader

- The field team leader is responsible for ensuring that project-specific requirements are communicated to the sampling team and for providing the materials, resources, and guidance necessary to perform the activities in accordance with the project plan and this SOP. The field team leader is also responsible for ensuring that proper arrangements have been made with the designated analytical laboratory. These arrangements include, but are not necessarily limited to, subcontractor agreements, analytical scheduling, and bottle/cooler orders. The field team leader may delegate some of these responsibilities to other project staff at his/her discretion.

9.0 References

None

10.0 Revision History

Revision	Date	Changes
0	October 2017	Initial Version

Standard Operating Procedure

Decontamination of Field Equipment

Procedure Number: 003

Revision No.: 0

Revision Date: October 2017

Date: October 10, 2017

SOP Author, Camille Littlefield

Date: October 10, 2017

SOP Reviewer, Geoff Webb

Contents

1.0 Scope and Applicability

1.1 Purpose and Applicability

1.1.1 This Standard Operating Procedure (SOP) describes the methods to be used for the decontamination of field equipment used in the collection of environmental samples. The list of field equipment may include a variety of items used in the collection of soil and/or water samples, such as split-spoon samplers, trowels, scoops, spoons, bailers and pumps. Heavy equipment such as drill rigs and backhoes also require decontamination, usually in a specially constructed temporary decontamination area.

1.1.2 Decontamination is performed as a quality assurance measure and a safety precaution. Improperly decontaminated sampling equipment can lead to misinterpretation of environmental data due to interference caused by cross-contamination. Decontamination protects field personnel from potential exposure to hazardous materials. Decontamination also protects the community by preventing transportation of contaminants from a site.

1.1.3 This SOP emphasizes decontamination procedures to be used for decontamination of reusable field equipment. Occasionally, dedicated field equipment such as well construction materials (e.g., well screen, riser pipe) or disposable field equipment (e.g., bailers) may also require decontamination prior to use. A project-specific work plan should provide additional specific decontamination requirements for the particular project.

1.1.4 Respective state or federal agency (regional office) regulations may require specific types of equipment or procedures for use in the decontamination of field equipment. The project manager should review the applicable regulatory requirements, if any, prior to the start of the field investigation program.

1.2 General Principles

1.2.1 Decontamination is accomplished by manually scrubbing, washing, or spraying equipment with detergent solutions, tap water, distilled/deionized water, steam and/or high pressure water, or solvents.

1.2.2 Generally, decontamination of non-dedicated equipment is accomplished at each sampling location between collection points. Waste decontamination materials, such as spent liquids and solids, will be collected and managed as investigation-derived waste (IDW) for later disposal. All decontamination materials, including wastes, should be stored in a central location so as to maintain control over the quantity of materials used or produced throughout the investigation program.

2.0 Health and Safety Considerations

2.1 Decontamination procedures may involve chemical exposure hazards associated with the type of contaminants encountered in the field or solvents employed, and may involve physical hazards associated with decontamination equipment. When decontamination is performed on equipment that has been in contact with hazardous materials or when the quality assurance objectives of the project require decontamination with chemical solvents, the measures necessary to protect personnel must be addressed in a project specific Health and Safety Plan (HASP). This plan must be approved by the project Health and Safety Officer before work commences, must be distributed to all personnel performing equipment decontamination, and must be adhered to as field activities are performed.

3.0 Interfaces

Not applicable.

4.0 Equipment and Materials

- Decontamination agents (per work plan requirements):
    - LIQUI-NOX, ALCONOX, or other phosphate-free biodegradable detergent;
    - Tap water;
    - Distilled/deionized water; and
    - Methanol and/or hexane, acetone, isopropanol.
- Health and Safety equipment
- Chemical-free paper towels
- Waste storage containers (e.g., drums, carboys, 5-gallon pails with covers, plastic bags)
- Cleaning containers (e.g., plastic buckets or tubs, galvanized steel pans, pump cleaning cylinder)
- Cleaning brushes
- Pressure sprayers
- Squeeze bottles and/or spray bottles
- Plastic sheeting
- Aluminum foil
- Field project notebook and waterproof ink pen

5.0 Procedures

5.1 General Preparation

5.1.1 It should be assumed that all sampling equipment, even new items, are impacted until the proper decontamination procedures have been performed on them or unless a certificate of analysis is available which demonstrates the items cleanliness.

5.1.2 Field equipment that is not frequently used should be wrapped in aluminum foil, shiny side out, and stored in a designated "clean" area. Small field equipment can also be stored in plastic bags to eliminate the potential for contamination. Field equipment should be inspected and decontaminated prior to use if the equipment appears impacted and/or has been stored for long periods of time. Unless customized procedures are stated in the project-specific work plan for decontamination of equipment, the standard procedures specified in this SOP shall be followed.

5.1.3 Establish the decontamination station within an area that is convenient to the sampling location. If single samples will be collected from multiple locations, then a centralized decontamination station or a portable decontamination station should be established.

5.1.4 An IDW containment station should also be established at this time. The project-specific work plan should specify the requirements for IDW containment. In general, decontamination solutions are discarded as IDW between sampling locations. Solid waste is disposed of as it is generated.

5.2 Decontamination for Organic and Inorganic (Metals) Analyses

5.2.1 This procedure applies to soil sampling and groundwater sampling equipment used in the collection of environmental samples submitted for organic constituent analysis. Examples of relevant items of equipment include split-spoons, trowels, scoops/spoons, bailers, and other small items. Bladder and submersible pump decontamination procedures are outlined in Section 5.4.

5.2.2 Decontamination is to be performed before sampling events and between sampling points.

5.2.3 After a sample has been collected, remove all impacts from the equipment or material by brushing and then rinsing with available tap water. This initial step may be completed using a 5-gallon pail filled with tap water. Steam or a high-pressure water rinse may also be conducted to remove solids and/or other impacts.

5.2.4 Wash the equipment with a phosphate-free detergent and tap water solution. This solution should be kept in a 5-gallon pail with its own brush.

5.2.5 Rinse with tap water or distilled/deionized water until all detergent and other residue is washed away. This step can be performed over an empty bucket using a squeeze bottle, spray bottle, or pressure sprayer.

5.2.6 Wash the equipment a second time with a phosphate-free detergent (e.g., liquinox) and tap water solution. This solution should be kept in a 5-gallon pail with its own brush.

5.2.7 Rerinse with deionized water to remove any residual solvent. Rinsate should be collected in the solvent waste bucket.

5.2.8 Allow the equipment to air-dry in a clean area or blot with chemical-free paper towels before reuse. Wrap the equipment in tin foil and/or seal it in a plastic bag if it will not be reused for a while.

5.2.9 Dispose of soiled materials and spent solutions in the designated IDW disposal containers.

5.3 Decontamination of Submersible Pumps

5.3.1 This procedure will be used to decontaminate submersible pumps before and between groundwater sample collection points. This procedure applies to both electric submersible and bladder pumps. Tubing will not be decontaminated and reused. Tubing will either be dedicated and stored individually for each well or new tubing will be used.

5.3.2 Prepare the decontamination area if pump decontamination will be conducted next to the sampling point. If decontamination will occur at another location, the pump and tubing may be removed from the well and placed into a clean trash bag for transport to the decontamination area.

5.3.3 Once the decontamination station is established, the pump should be removed from the well and the discharge tubing and power cord coiled by hand as the equipment is removed. If any of the equipment needs to be put down temporarily, it should be placed on a plastic sheet (around well) or in a clean trash bag. If a disposable discharge line is used it should be removed and discarded at this time.

5.3.4 As a first step in the decontamination procedure, use a pressure sprayer with tap water to rinse the exterior of the pump, discharge line, and power cord as necessary. Collect the rinsate and handle as IDW.

5.3.5 Place the pump into a pump cleaning cylinder or bucket containing a detergent solution (detergent in tap water). Holding the tubing/power cord, pump solution through the pump system. A minimum of one gallon of detergent solution should be pumped through the system. Collect the rinsate and handle as IDW.

5.3.6 Place the pump into another cylinder/bucket containing a phosphate-free detergent (e.g., liquinox) in distilled/deionized water. Pump until the detergent solution is removed. Collect the rinsate and handle as IDW.

5.3.7 Place the pump into another cylinder/bucket containing distilled/deionized water. Pump a minimum of 3 to 5 pump system volumes of water through the system (pump and discharge line). Collect the rinsate and handle as IDW.

5.3.8 Remove the pump from the cylinder/bucket and if the pump is reversible, place the pump in the reverse mode to discharge all removable water from the system. If the pump is not reversible the pump and discharge line should be drained by hand as much as possible. Collect the rinsate and handle as IDW.

5.3.9 Using a pressure sprayer with distilled/deionized water, rinse the exterior of the pump, discharge line, and power cord thoroughly, shake all excess water, and then place the pump system into a clean storage container. If the pump system will not be used again right away, the pump itself should also be wrapped with aluminum foil before placing it into the bag.

5.4 Decontamination of Large Equipment

5.4.1 Consult the project-specific work plan for instruction on the location of the decontamination station and the method of containment of the wash solutions. For large equipment, usually a temporary decontamination facility (decontamination pad) is required which may include a membrane-lined and bermed area large enough to drive heavy equipment (e.g., drill rig, backhoe) onto it with enough space to spray other equipment and to contain overspray. Usually a small sump with a pump is necessary to collect and contain rinsate. A water supply and power source is also necessary to run steam cleaning and/or pressure washing equipment.

5.4.2 Upon arrival and prior to leaving a sampling site, all heavy equipment (e.g., drill rigs, trucks, backhoes) should be thoroughly cleaned and then the parts of the equipment which come in contact or in close proximity to sampling activity should be decontaminated. This can be accomplished in two ways, steam cleaning or high pressure water wash and manual scrubbing. Following this initial cleaning, only those parts of the equipment which come in close proximity to the sampling activities (i.e., auger stems, rods, backhoe bucket) must be decontaminated in between sampling events.

5.4.3 Occasionally, well construction materials (e.g., well screen, riser pipe) may require decontamination before the well materials are used. These materials may be washed in the decontamination pad, preferably on a raised surface above the pad (i.e., on sawhorses), with clean plastic draped over the work surfaces. Well materials usually do not require a multistep cleaning process as they generally arrive clean from the manufacturer. Usually, a thorough steam-cleaning of the interior/exterior of the well materials will be sufficient. The project-specific work plan should provide guidance regarding decontamination of well materials.

6.0 Quality Assurance / Quality Control

6.1 General Considerations

6.1.1 The decontamination method, solvent type, decontamination frequency, decontamination location on site, amd the method of containment and disposal of decontamination wash solids and solutions are dependent on site logistics, site-specific chemistry, the nature of the impacted media to be studied, and the objectives of the study. Each topic must be considered and addressed during development of a decontamination strategy.

6.2 Equipment Blank Sample Collection

6.2.1 General guidelines for quality control check of field equipment decontamination usually require the collection of one equipment blank from the decontaminated equipment per day. The project-specific work plan should specify the type and frequency of collection of each type of quality assurance sample.

6.2.2 Equipment blanks are generally collected by pouring laboratory-supplied deionized water into, over, and/or through the freshly decontaminated sampling equipment and then transferring this water into a sample container. Equipment blanks should then be labeled as a sample and submitted to the laboratory to be analyzed for the same parameters as the associated sample. Equipment blank sample numbers, as well as collection method, time and location should be recorded in the field notebook.

7.0 Data and Records Management

7.1 Specific information regarding decontamination procedures should be documented in the project-specific field notebook. Documentation within the notebook should thoroughly describe the construction of each decontamination facility and the decontamination steps implemented in order to show compliance with the project-specific work plan. Decontamination events should be logged when they occur with the following information documented:

- Date, time and location of each decontamination event;
- Equipment decontaminated;
- Method;
- Solvents/acids;
- Notable circumstances;
- Identification of equipment blanks and decontamination rinsates;

- Method of blank and rinsate collection;
- Date, time and location of blank and rinsate collection; and
- Disposition of IDW.

7.2 Repetitive decontamination of small items of equipment does not need to be logged each time the item is cleaned.

8.0 Personnel Qualifications and Training

8.1 All sampling technicians performing decontamination must be properly trained in the decontamination procedures employed, the project data quality objectives, health and safety procedures and the project quality assurance procedures. Specific training or orientation will be provided for each project to confirm that personnel understand the special circumstances and requirements of that project. Field personnel should be health and safety certified as specified by OSHA (29 CFR 1910.120(e)(3)(i)) to work on sites where hazardous materials may be present.

8.2 Sampling Technician

8.2.1 It is the responsibility of the Sampling Technician to be familiar with the decontamination procedures outlined within this SOP and with specific quality assurance, and health and safety requirements outlined within project-specific work plan. The sampling technician is responsible for decontamination of field equipment and for proper documentation of decontamination activities. The sampling technician is also responsible for ensuring decontamination procedures are followed by subcontractors when heavy equipment requires decontamination.

8.3 Field Project Manager

8.3.1 The Field Project Manager is responsible for confirming that the required decontamination procedures are followed at all times. The Project Manager is also responsible for confirming that subcontractors construct and operate their decontamination facilities according to project specifications. The project manager is responsible for collection and control of IDW in accordance with project specifications.

9.0 References

Not Applicable

10.0 Revision History

Revision	Date	Changes
0	October 2017	Initial Version

Standard Operating Procedure

Water Level Measurements

Procedure Number: 004

Revision No.: 0

Revision Date: October 2017

Date: October 10, 2017

SOP Author, Camille Littlefield

Date: October 10, 2017

SOP Reviewer, Geoff Webb

Contents

1.0 Scope and Applicability

1.1 This Standard Operating Procedure (SOP) defines the methods to be used for measuring the depth to groundwater and total depth of groundwater monitoring wells and piezometers. Similar procedures can also be used to measure the depth to water in other structures such as catch basins or cisterns, or in surface water bodies from fixed structures such as bridges, culverts, or piers.

1.1.1 Water level and well depth measurements collected from monitoring wells or piezometers may be used for the following purposes, among others:

- To evaluate the well condition (e.g., silt accumulation, height of water column);
- To establish sampling requirements (e.g., purge volumes, drawdown during purging);
- To calculate the horizontal hydraulic gradient and the direction of groundwater flow;
- To calculate the vertical hydraulic gradient, if well nests are used (i.e., the direction of groundwater flow in the vertical plane);
- To evaluate the effects of manmade and natural stresses on the groundwater system; and
- To calculate other important hydrogeologic characteristics (e.g., measuring drawdown during slug tests, aquifer pumping tests).

1.1.2 This information, when combined with other location-specific information, is important in understanding the current distribution of constituents in groundwater and their potential for migration in the future. Hydrogeologic characterization is important not only in evaluating potentially impacted groundwater, but also in evaluating non-impacted groundwater resources.

1.2 Some wells may contain light non-aqueous phase liquid (LNAPL) floating on the water surface or dense non-aqueous phase liquid (DNAPL) that sinks to the bottom. The procedures outlined in this SOP may be used to measure fluid levels in such wells, but the results may not be representative of the hydraulic head/potentiometric level.

1.3 There are other methods for measuring water depths than those described in this SOP such as using a weighted tape with or without a sounding device ("plopper"), pressure transducers, air line pressure, strip recorders, etc. This SOP addresses the methods in most common and regular use.

2.0 Health and Safety Considerations

2.1 The health and safety considerations for the work associated with this SOP, including both potential physical and chemical hazards, will be addressed in the site-specific Health and Safety Plan (HASP). In the absence of a site-specific HASP, work will be conducted according to the AECOM Health and Safety Policy and Procedures Manual and/or direction from the Regional Health and Safety Manager.

3.0 Interferences

3.1 Potential interferences could result in inaccurate readings if the sensor on the water level meter is wet or dirty, or if the cable cannot be kept vertically upright (e.g., due to a well that is not plumb or a bridge in windy conditions). Care shall be taken to keep the probe clean, and to take appropriate measures to reduce these interferences when measuring water levels. The probe may also be shaken to remove water or other fluids that may adhere to the probe. If there is any concern that a particular reading may not be accurate, it shall be noted in the field log book.

3.2 If LNAPL is present in a well, the measured depth to water may not be representative of the hydraulic head/potentiometric level. If the LNAPL thickness and specific gravity are known, an accurate hydraulic head can be calculated.

3.3 Some water level meters (especially oil/water interface probes) may rely on optical technology for readings. In these cases, the readings may be influenced by the presence of light. While this is not an issue in wells, it may be for surface water bodies.

3.4 The measured depth to water is not always representative of the hydraulic head in the aquifer. Interferences may include barometric pressure effects, timing during tidal cycles, well construction details, confined/artesian aquifers, well efficiency, etc. Where such influences may be important, the project-specific work plan should specify any corrective measures or additional data to be collected. Interpretation and use of water level data should be performed by a trained specialist.

4.0 Equipment and Materials

4.1 Electronic Water Level Meter - Electronic water level meters consist of a spool of small-diameter cable (or tape) with a weighted probe attached to the end. The cable (or tape) is marked with measurement increments in feet (ft) or meters (m) (accurate to 0.01 ft/0.01 m), with the zero point being the sensor of the probe. When the probe comes in contact with the water, an electrical circuit is closed, and a light and/or buzzer within the spool will signal the contact. The cable must be of a sufficient length to reach the expected depth of the water to be measured. The probe shall be tested (using water containing dissolved ions) at the start of the field program to confirm proper operation.

4.2 An oil/water interface probe may be used to measure water depths; however, in some cases there may be increased risk of cross-contamination using a probe that is regularly placed in separate phase liquids. Where such risks are considered significant, project-specific requirements will specify that oil-water interface probes are not to be used in wells where no separate-phase liquids are expected.

4.3 Other materials that may be required:

- Health and safety supplies (as required by the site-specific HASP);
- Equipment decontamination materials, including absorbent pads if appropriate;
- Plastic sheeting or bucket for resting instrument off the ground;
- Water level field form (if applicable);
- Well construction records;
- Appropriate hand tools and keys to access monitoring wells; and

- Field project logbook and waterproof ink pen.

5.0 Procedures

5.1 Summary of Method

Measurements will involve measuring the depth to water and/or total well depth to the nearest 0.01 ft/0.01m using an electronic water level meter. The depths within wells will be measured from the top of casing (typically the inner casing) at the surveyed elevation point. This reference point should be marked so that readings are consistently taken from the same reference point. Depths to surface water may be similarly measured from a marked reference point on the fixed structure (e.g., bridge, culvert, pier, wharf) passing over or bordering the surface water body.

5.2 General Preparation

5.2.1 Well records review: Well completion diagrams should be reviewed to determine well construction characteristics, including the location of the reference point and the total depth of the well. Historic static water level measurements and survey information may also be reviewed.

5.2.2 Well access: Many wells may be locked for security reasons. The necessary procedures and equipment to access the wellhead shall be identified prior to entering the site.

5.2.3 Equipment: There are many different water level meters available. Field personnel should make sure the appropriate equipment is used based on well construction details (e.g., well diameter, anticipated depth to water). The specific equipment to be used should be inspected. Field personnel should be sure the equipment is in proper working order, and the measurement increment marks are legible. The type of power supply (e.g., type of batteries) should be determined so that an appropriate back-up supply can be obtained if needed. Sometimes water level meters may be repaired by removing a length of cable near the sensor and resplicing the cable to the sensor. If this kind of repair has taken place, the measurement markings on the cable are no longer accurate. This condition should be observed and noted, and if appropriate, a replacement water level meter may be obtained as an alternative to correcting the water level measurement for the length of the splice.

5.2.4 Calibration: Manufacturer’s instructions, if any, for calibrating or maintaining the accuracy of the instrument shall be followed.

5.2.5 Equipment decontamination: All down-hole equipment will be decontaminated prior to use, after use, and between well locations in accordance with project-specific requirements. Note that some water level probes may be made of materials that are incompatible with certain decontamination solvents.

5.2.6 Order of measurement: For some projects, there may be a specific order in which measurements are to be collected, for example, from the least to most impacted wells. Any such requirements will be specified in the project-specific plans.

5.2.7 Opening the well: Prior to accessing the well, the wellhead should be cleared of debris and/or standing water. For example, it is common to find standing water in flush mount wellheads that, if not removed, will enter the monitoring well, potentially causing inaccurate water level measurements and/or impacting the groundwater. Nothing from the ground surface should be allowed to enter the well (except for the decontaminated measuring device). Once the wellhead is clear, open the well to obtain the measurements. In some cases, it may be necessary to allow the water level to equilibrate prior to measurement (e.g., wells with fully submerged screened intervals).

5.3 Measurement Procedures

5.3.1 At each location (i.e., well, piezometer, bridge/culvert, pier/wharf, etc…), determine the location of the surveyed elevation mark. For wells, general markings may include either a notch in the riser pipe or a permanent ink mark on the riser pipe. Some projects may specify a consistent reference point for all wells, for example, the highest or northern most point on the riser. For monitoring surface water levels, either there is a painted mark on an existing structure, the reference point is be known and not marked or the reference point is not yet defined and not marked.

5.3.2 If the reference point is not defined and marked, a point may be selected and clearly and permanently marked to be used for future measurements. Typically, in the absence of a marked measuring point, the measurement is collected from the top of the interior casing on the north side and noted as such in project documentation. If this is done, the project manager must be notified to arrange for the elevation of the new reference point to be surveyed.

5.3.3 To obtain a water level measurement, lower the probe of the water level meter down into the water in the well until the audible sound of the unit is detected or the light on an electronic sounder illuminates. In wells, the probe shall be lowered slowly into the well to avoid disruption of formation water and creation of turbulent water within the well. At this time, the precise measurement should be determined (to the nearest 0.01 ft/0.01m) by repeatedly raising and lowering the tape to converge on the exact measurement. Obtain the reading from the stadia-marked cable where it crosses the surveyed reference point. If the cable is not marked to the nearest 0.01ft/0.01m, a manual rule may be used to interpolate between marked measurements as specified in the site-specific work plan.

5.3.4 Record the water level measurement as well as the location identification number, measuring point (surveyed elevation point), date, time, and weather conditions in the field logbook and/or field form. Any problems with the condition of the well should be noted so that appropriate maintenance can be performed.

5.3.5 To measure the total depth of a well, lower the probe slowly to the bottom of the well (turn down signal as appropriate). For deep wells or wells with a soft or silty base, the depth may be difficult to determine. It may be helpful to lower the probe until there is slack in the tape, and gently pull up until it feels as if there is a weight at the end of the tape. Obtain the depth reading (to the nearest 0.01 ft/0.01m) from the cable where it crosses the surveyed reference point. If the cable is not marked to the nearest 0.01ft/0.01m, a manual rule may be used to interpolate between marked measurements as specified in the site-specific work plan.

5.3.6 Record the total well depth in the field logbook and/or field form.

5.3.7 The meter will be decontaminated in accordance with appropriate project-specific requirements and equipment use and care requirements. If the probe was in contact with separate-phase liquids, the potential for cross-contamination is greater, so appropriate care should be taken during decontamination, as specified in the project-specific work plan. It is important to avoid placing the measuring tape and probe directly on the ground surface (to minimize potential cross-contamination) or allowing the cable to become kinked (which affects the accuracy of the measured depths).

5.4 Special conditions

5.4.1 Wells containing pumps or other equipment: It may be difficult to obtain accurate water level depths in wells where down-hole equipment is present. There may not be sufficient space within the well for the water level meter, or the meter cable may become bound up in the tubing, cables, or other equipment in the well. It is preferable to remove down-hole equipment when feasible. If removal of the equipment is not feasible and there is a reasonable chance of getting the meter caught in the well and not being able to remove it, it may be preferable to avoid collecting water level data.

5.4.2 Drinking water wells: The water level meter represents a potential source of surface contamination when introduced into drinking water wells, particularly for bacteriological impacts. If it is necessary to measure water level depths in drinking water wells using the procedures in this SOP, appropriate disinfection procedures should be performed.

5.4.3 Wells potentially containing DNAPL: Slowly lower an oil/water interface probe to the bottom of the well and listen for the indication of DNAPL (i.e., a solid tone). If DNAPL is detected, the probe should be slowly lowered to the bottom of the well to confirm that DNAPL extends from the water/DNAPL interface to the bottom of the well. The thickness of DNAPL gauged in the well will be calculated from the depth of the start of the NAPL to the bottom of the well and recorded where appropriate.

6.0 Quality Assurance / Quality Control

6.1 Field personnel will follow site-specific quality assurance guidelines. A list of monitoring well construction total depths and the previous year’s measured total depths and water levels will be taken to the field for comparison during well gauging activities, as available. Where measured depths are not consistent with well records or previously measurements, the depths should be re-measured, verified, and documented in the field records.

6.2 Field duplicates of the depth-to-water measurements will be obtained if required by, and at the frequency specified in, project-specific requirements. To collect a field duplicate measurement, the water level probe will be fully withdrawn from the well, then re-lowered to obtain a second reading of the depth to water. No more than a few minutes should elapse between the two measurements. Field duplicates will not be obtained if water levels are changing rapidly, for example, during pumping tests.

6.3 Manufacturer’s instructions, if any, for calibrating or maintaining the accuracy of the instrument shall be followed.

7.0 Data and Records Management

7.1 All field information will be recorded in the field logbook or on a field collection form by field personnel.

7.2 Unanticipated changes to the procedures or materials described in this SOP (deviations) will be appropriately documented in the project records.

7.3 Records associated with the activities described in this SOP will be maintained according to the document management policy for the project.

8.0 Personnel Qualifications and Training

8.1 Qualifications and training

8.1.1 The individual executing these procedures must have read, and be familiar with, the requirements of this SOP.

8.1.2 Collecting water level measurements is a relatively simple procedure requiring minimal training and a relatively small amount of equipment. It is recommended that the collection of water level measurements be initially supervised by more experienced personnel.

8.1.3 Field personnel must be health and safety trained as required by the project conditions and local/national standards.

8.2 Responsibilities

8.2.1 The project manager is responsible for providing the project team with the materials, resources and guidance necessary to properly execute the procedures described in this SOP.

8.2.2 The individual performing the work is responsible for implementing the procedures as described in this SOP and any project-specific work plans.

8.2.3 Field personnel are responsible for the proper use, maintenance, and decontamination of all equipment used for obtaining water level measurements, as well as proper documentation in the field logbook or field forms, as appropriate.

9.0 References

American Society for Testing Materials. 1993. ASTM Standard D4750, Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).

Driscoll, Fletcher G. 1986. Groundwater and Wells. St. Paul Minnesota: The Johnson Division.

United States Environmental Protection Agency. 2001. Guidance for Preparing Standard Operating Procedures (SOPs). EPA QA/G-6. EPA/240/B-01/004. USEPA Office of Environmental Information, Washington, DC. March 2001.

10.0 Revision History

Revision	Date	Changes
0	October 2017	Initial Version

Standard Operating Procedure

Low Flow Groundwater Sampling

Procedure Number: 005

Revision No.: 0

Revision Date: October 2017

Date: October 10, 2017

SOP Author, Camille Littlefield

Date: October 10, 2017

SOP Reviewer, Geoff Webb

Contents

1.0 Scope and Applicability

1.1 Standard Operating Procedure (SOP) 005 describes methods used to obtain the collection of valid and representative groundwater samples from monitoring wells utilizing a low flow sampling technique. This technique is designed to reduce the influx of particulate matter into the monitoring well and groundwater sample to produce a more representative analysis of groundwater quality and to reduce aeration that can affect geochemical parameters. Low flow groundwater sampling also reduces the volume of purge water generated.

1.2 Specific project requirements as described in an approved Site-Specific Work Plan, Sampling Plan, Task Hazard Analysis (THA), or Health & Safety Plan (HASP) will take precedence over the procedures described in this document.

2.0 Health and Safety

2.1 This section presents the generic hazards associated with low flow groundwater sampling and is intended to provide general guidance in preparing site-specific health and safety documents. The site-specific HASP and THA will address additional requirements and will take precedence over this document. Note that low flow groundwater sampling usually requires Level D personal protection unless there is a potential for exposure to airborne site contaminants. All maintenance and servicing of instrumentation should be performed in a safe area, away from hazardous locations.

2.2 Health and safety hazards include but are not limited to the following:

- Slip, trips, and falls in tall grasses over obstacles and/or berms near well locations (Review terrain hazards prior to conducting these operations. Confirm there is a safe means of access/egress to the wellhead.);
- Dermal exposure to potentially impacted groundwater (Confirm that proper personal protective equipment (PPE) is used to mitigate the impact of splashes of groundwater to skin and/or eyes.);
- Exposure to site contaminants (If there is product in the well (especially gasoline) take all precautions necessary to prevent fire/explosion and/or exposure to airborne vapors.); and
- Ergonomics (Use appropriate ergonomic techniques when inserting or retrieving equipment for the wells to preclude injury to the arms, shoulders or back.).

3.0 Interferences

3.1 Contaminants that are known to adsorb to particulates (e.g., metals, polychlorinated biphenols (PCBs)) will be impacted by elevated turbidity (>25 NTU). Although filtering would help to reduce the amount of particulates suspended in the sample, groundwater samples should not be filtered prior to analysis unless an unfiltered sample will be submitted for the same analysis as the filtered sample. Decisions to sample when turbidity remains above 5 NTU shall be made in consideration of the analyses that will be performed and the project objectives.

3.2 Oxidation reduction potential (ORP) is a difficult parameter to measure in the field because the length of time which is necessary for the probe to obtain an accurate measurement is too long to be conducive to use during low-stress monitoring. Consequently, ORP readings may continue to increase or decrease slowly over the purging period.

4.0 Equipment and Materials

4.1 Project-specific equipment will be selected based upon project objectives and site conditions (e.g., the depth to water, purge volumes, analytical parameters, well construction, and physical/chemical properties of the analytes). The following section includes basic types of materials and equipment necessary to complete groundwater sampling activities.

4.2 Purging/Sample Collection

4.2.1 In general equipment that will contact the water must be made of inert materials, preferably stainless steel or fluorocarbon resin. Other materials may also be allowed by the project–specific sampling plan. The properties of purging/sampling equipment should be carefully considered as well as the constituents of interest (COIs). Purging/sampling equipment may include the following:

- Peristaltic pump;
- ¼ inch Teflon and polyethylene tubing;
- Water level measurement equipment;
- In-line water quality meter (e.g., flow-through cell);
- Water quality meter with individual temperature, pH, specific conductance, dissolved oxygen (DO), turbidity, salinity, and oxidation reduction potential (ORP) probes;
- Turbidity meter;
- Safety Data Sheets (SDS) for any chemicals or site-specific contaminants; and
- Field data sheets, log book and waterproof ink pen.

4.3 Decontaminate equipment in accordance with Decontamination of Field Equipment SOP 003.

4.4 Sample Collection

- Preservation solutions (as necessary)
- Sample containers
- Coolers

4.5 Miscellaneous

- Disposable nitrile gloves
- Tubing cutters
- Plastic sheeting
- Personal protective equipment (PPE)
- Cloth towels or other suitable insulating material to insulate the flow-through the cell
- Buckets and intermediate containers

5.0 Procedures

5.1 Water-Level Measurement

After unlocking and/or opening a monitoring well, the first task will be to obtain a water level measurement. A static water level will be measured in the monitoring well prior to purging and collecting samples. The water level is needed for estimating the purge volume and may also be used for mapping the potentiometric surface of the groundwater. Whenever possible, water level measurements will be collected at all of the wells on-site within 24 hours of each other, or a period reasonable to site conditions. Water level measurements will be collected using an electronic or mechanical device following the methods described in Water Level Measurements SOP 004.

The location of the measurement point for water level measurements for each well should be clearly marked or identified in previous sample collection records. This point is usually established on the well casing itself, but may be marked on the protective steel casing in some cases. In either case, it is important that the marked point coincide with the same point of measurement used by the surveyor. If the measuring point from previous investigations is not marked, the water level measuring point should be marked on the north side of the well casing and noted in the groundwater sampling form (**Figure 1**). The location should be described on the groundwater sampling form.

After opening the well, the field sampler will check for indications of an airtight seal resulting in a pressure difference within the well compared to ambient conditions. If this is the case, the field sampler will allow a minimum of five minutes for the water level to stabilize before collecting a down-hole measurement. To obtain a water level measurement, the field sampler should lower a decontaminated mechanical or electronic sounding unit into the monitoring well until the audible sound of the unit is detected or indicates water contact. At this time the precise measurement should be determined by repeatedly raising and lowering the tape or cable to converge on the exact measurement. The water level measurement should be entered on the groundwater sampling form. The water level measurement device shall be decontaminated immediately after use following the procedures outlined in Water Level Measurements SOP 004.

5.2 Low Flow Purging and Sample Collection Procedures

- Prior to purging, confirm that equipment is operating properly and calibrated by following the equipment manuals provided by the equipment manufacturer. Record this information as well as the monitoring well number, site, date, time, weather conditions, and well condition on the groundwater sampling log and in the field logbook. Also note the condition of the inner well seal/cap on the groundwater sampling log and measure depth to water and total well depth with a decontaminated electronic water level meter.
- If the monitoring well is newly installed and developed, or has been recently redeveloped, sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, and the water quality parameters have stabilized. Since site conditions vary, a general rule-of-thumb is to wait 24 hours after well development to sample a new monitoring well. Monitoring wells developed with stressfulmeasures (e.g., backwashing, jetting, compressed air, etc…) may require as long as 7 days before sampling.

5.2.1 Low Flow Purging via Peristaltic Pump

- The inlet of the pump tubing will be lowered into the monitoring well slowly and carefully to a depth corresponding with the approximate midpoint of the screened interval of the aquifer at least 2 feet from the bottom of the well, to prevent disturbance of sediment present at the bottom of the well. A depth-to-water measurement device will be lowered into the monitoring well to monitor drawdown. The water level meter can be left in the well during purging.
- The peristaltic pump will be turned on at a flow rate between 0.2 and 0.5 liters per minute (L/min). Ideally, a steady flow rate should be maintained resulting in a stabilized water level with drawdown of 0.3 feet or less from the static water level. Record each adjustment made to the pumping rate and water level. If the monitoring well recharge is not adequate enough to maintain proper water levels, the monitoring well will be pumped dry and the monitoring well will be sampled after the water level in the monitoring well has recovered.

5.2.2 Low Flow Purging via Dedicated Bladder Pump

- A depth-to-water measurement device will be lowered into the monitoring well to monitor drawdown. The water level meter can be left in the well during purging.
- The air pressure within the dedicated bladder pump will be turned on at a low rate to maintain a stabilized water level with drawdown of 0.3 feet or less from the static water level. Record each adjustment made to the air pressure and water level. If the monitoring well recharge is not adequate enough to maintain proper water levels, the monitoring well will be pumped dry and the monitoring well will be sampled after the water level in the monitoring well has recovered.

5.2.3 Collection of Field Parameters

- Field personnel should familiarize themselves with the field parameters to be monitored. If available, historical sampling forms should be reviewed and available in the field for an initial understanding of the range of values previously obtained at each sample location.
- The water quality meter will be calibrated according to the procedures identified in the instrument manual.Calibration procedures and results must be documented in the site field notebook.
- Groundwater will be pumped from the monitoring well into a sealed and insulated flow-through assembly containing probes to measure the water temperature, pH, turbidity, conductivity, ORP, and DO using a water quality meter.
- The flow-through assembly must be placed as close as possible to the monitoring well to be sampled. The tubing that connects the monitoring well discharge to the flow-through cell must be as short as possible. The flow-through assembly must be insulated with a cloth towel or other suitable insulating material to minimize fluctuations in the water quality readings. In addition, the insulated flow-through assembly and monitoring well discharge tubing connected to the cell must be shaded from direct sunlight at all times.
- Field parameter values will be recorded on the Groundwater Sampling Form or in the site field notebook along with the corresponding purge volume. After passing through the flow-through chamber, the water will be discharged into a container of known volume where the pumping rate will be measured with a watch. When the

container is full, the water will be properly disposed of following site protocols.

5.2.4 Groundwater Sample Collection

- Field personnel should contact the laboratory prior to going out into the field to confirm necessary lab containers are available. Sample receiving dates should also be discussed with the laboratory.
- Groundwater samples will be collected for laboratory analysis when the indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, collected 3 to 5 minutes apart, are within the following approximate limits (EPA 1996, 2010):
    - **Turbidity** (10% for values greater than 5 NTU, if three Turbidity values are less than 5 NTU, consider the values as stabilized);
    - **Dissolved Oxygen (DO)** (10% for values greater than 0.5 mg/L, if three DO values are less than 0.5 mg/L, consider the values as stabilized);
    - **Specific conductance** (3%);
    - **Temperature** (3%);
    - **pH** (±0.1 unit);
    - **Oxidation/Reduction Potential (ORP)** (±10 millivolts).
- The tubing will be disconnected from the “t” connected to a valve and the flow-through cell. Samples will be collected directly from the pump tubing. VOC samples are normally collected first and directly into the pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow slowly into the inside of the container with minimal turbulence.
- In general, groundwater samples will need to be placed on ice and inside coolers to protect the samples from the sun and to decrease their temperature to or below 4 ± 2°C.
- Each sample container will be slowly filled by pouring sample water gently down the inside of the container with minimal turbulence.

5.3 Purge Water Management

- Purge water will be handled in accordance with site-specific requirements (e.g., containerized and disposed of off-site, discharged to the ground next to the well sampled).

6.0 Quality Assurance / Quality Control

6.1 Quality assurance (QA)/quality control (QC) requirements dictated by the project specific sampling plan include, but are not limited to, blind field duplicates, equipment rinsate blanks (ERB), and field blanks. These samples will be collected at the following frequencies:

- Field Duplicate – one (1) per every ten (10) samples;
- ERB – one (1) per day of sample collection activities, or per type of field equipment used to collect samples;
- Field Blank – as determined for the project; and
- Trip Blanks – shall be included with all VOCs, methane, and other samples that consist of dissolved gas phase compounds.

7.0 Data and Records Management

7.1 Various documents will be completed and maintained as part of groundwater sample collection. These documents will provide a summary of the sample collection procedures and conditions, shipment method, analyses requested, and custody history. These documents may include:

- Site field book;
- Groundwater sampling forms;
- Sample labels;
- Chain of Custody (COC);
- Shipping receipts; and
- Sample nomenclature protocol.

All documentation will be stored in the project files. Sample nomenclature protocol should be discussed with the project data management personnel to confirm consistency between sampling events.

8.0 Personnel Qualifications and Training

8.1 Qualifications and training requirements for field samplers are described in the project-specific HASP.

8.2 The field sampling coordinator will have the responsibility of confirming that all groundwater sampling is performed in accordance with the project-specific sampling program and this SOP. In addition, the field sampling coordinator must confirm that all field workers responsible for conducting groundwater sampling activities are fully acquainted with this SOP and other pertinent project documents.

9.0 References

Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, EPA 600/4-89/034, published by National Water Well Association, 1989.

RCRA Ground Water Monitoring Technical Enforcement Guidance Document, published by National Water Well Association, 1986.

A Compendium of Superfund Field Operations, EPA 540/P-87/001, published by the Office of Emergency and Remedial Response, Office of Waste Programs Enforcement, US EPA, 1987.

10.0 Revision History

Revision	**Date**	**Changes**
0	October 2017	Initial Version

Figure 1: Groundwater Sampling Form

AECOM

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Greenwood Village, CO 80111
Tel: 303.694.2770

Groundwater Sample Collection Form

Well Identification ______________

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Project Name:		**Sampled By:**	
Project Number:		**Sample ID:**	
Site ID:		**Sample Date:**	
Date:		**Sample Time:**	

Equipment

Purging Method/Equipment		Filtering Equipment	
Sampling Equipment		Flow Rate	

Purging Information

Casing I.D. [a] (in.):		Length of Static Water Column [e] = [d] - [c] (ft):	
Unit Casing Volume [b] (gal/ft)		Casing Water Volume [f] = [b] x [e] (gal)	
Depth to Water [c] (ft, bgs):		Total Purged Volume [g] (gal):	*See below*
Depth to Bottom of Well [d] (ft, bgs):		Number of Purged Volumes [h] = [g] / [f]:	

Time	Volume *(gallons)*	Temp *(°C)*	pH	ORP *(mV)*	Conductivity *(mS/cm) or (uS/cm)*	DO *(mg/L)*	Turbidity *(NTU)*	Comments

Total Volume Removed (gallons): _______ **Time:** _________ **Purged Dry (Y/N):** __________

Casing Volume

Casing I.D. (in.)	Unit Casing Volume Gal/Lin. Ft.)
1.0	0.04
2.0	0.16
4.0	0.65
5.0	1.00
6.0	1.55
8.0	2.60

Additional Remarks

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