Statistical Analysis Plan

Slag Pond Area

Big Stone Plant
Big Stone City, South Dakota

Prepared for:

Otter Tail Power Company
48450 144th Street
Big Stone City, SD 57216

October, 2017

15650 36th Ave N. Suite 110
Plymouth, MN 55446
Tel 952-346-3900
Fax 952-346-3901
www.carlsonmccain.com

ENVIRONMENTAL • ENGINEERING • LAND SURVEYING

TABLE OF CONTENTS

1.0 INTRODUCTION

This Statistical Analysis Plan describes the method(s) to be used in identifying statistically significant increases (SSIs) over the upgradient or background groundwater quality in the Slag Pond Area at Otter Tail Power Company's Big Stone Plant (Plant), in accordance with the requirements of the U.S. Code of Federal Regulations, Title 40, Parts 257 and 261 (CFR, 2015) regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments. In particular, this Plan satisfies applicable portions of §257.93, §257.94, and §257.95 pertaining to selection of a statistical method, detection monitoring, and assessment monitoring.

This Plan is included as Appendix B within the CCR Groundwater Sampling and Analysis Plan (SAP) for the Slag Pond Area (Carlson McCain, 2017) and the reader is referred to the SAP for additional information on the site-specific hydrogeologic setting, existing groundwater monitoring network, sampling and analysis procedures, and reporting requirements. The Plan specifically applies to the groundwater monitoring network for the Slag Pond Area, as described in the *Groundwater Monitoring System Report* (Barr, 2016).

2.0 STATISTICAL APPROACH

The statistical approach will generally follow applicable portions of the U.S. Environmental Protection Agency (EPA) Unified Guidance for Statistical Analysis of Groundwater Data at RCRA Facilities (Unified Guidance) (EPA, 2009). The Unified Guidance provides recommendations for statistical techniques used in detection and assessment monitoring, and is specifically referenced in the preamble for 40 CFR §257 as a guide for selecting a statistical method.

Statistical analysis will be completed using a commercially-available computer software program, such as Sanitas, developed by Sanitas Technologies. This program automatically incorporates many of the recommendations in the EPA Unified Guidance relating to statistical considerations such as background data, non-detects, and verification resampling.

2.1 Interwell vs. Intrawell Testing

The Unified Guidance describes two main strategies for comparison of background data to compliance data in monitoring wells. One strategy is known as "interwell" testing, which involves comparison of results in downgradient wells to the pooled upgradient well data for each parameter. The other strategy is known as "intrawell" testing, which involves comparison of recent observations to historical results within a single well. Interwell testing is the classical upgradient versus downgradient comparison, which is intuitive to many users, and can be a statistically powerful method in situations where the hydrogeologic conditions are relatively consistent and uniform, and the monitoring network is constructed such that wells are completed in the same aquifer and in the same relative stratigraphic position. Conversely, with intrawell testing, compliance data are compared to background samples collected from within the compliance well itself, as opposed to samples from upgradient wells, so it is not necessary to identify upgradient wells to use for background. Also, because the background and compliance data come from the same well, and therefore the same location, intrawell tests are not affected by spatial variability within the aquifer. This allows application of intrawell techniques at virtually any site, including sites with more complex hydrogeologic conditions.

Based on descriptions of the hydrogeologic setting and existing monitoring well network for the Slag Pond Area presented in Sections 2 and 3 of the SAP, intrawell testing will be the primary statistical method used for groundwater data evaluation, eliminating the influence of spatial variability. While intrawell analysis does not involve direct upgradient-to-downgradient comparisons, sampling and analysis of upgradient wells can provide valuable information and should be included in the intrawell testing program. Although upgradient wells do not provide the background data that compliance measurements are tested against for intrawell analysis, it is appropriate to discuss results of intrawell testing at compliance wells in the context of the overall site, including upgradient wells. For example, if SSIs in downgradient wells are associated with corresponding elevated concentrations or increasing trends in upgradient wells it may be an indication of natural changes in groundwater quality that are unrelated to the CCR unit. In this scenario, it may be appropriate to augment the primary intrawell method with additional analyses (e.g. trend testing and/or interwell analyses) in order to confirm or disconfirm an SSI.

An important assumption for intrawell comparisons is that the monitoring locations are not currently impacted by the CCR unit. With intrawell analysis the background data set is comprised of analytical results from within the compliance wells themselves, so if the groundwater is already contaminated it will not be identified as an SSI unless concentrations continue to increase. Groundwater Monitoring has historically not been required for the Slag Pond Area, so a series of new monitoring wells were installed in 2015 and 2016 as described in the *Groundwater Monitoring System Report* (Barr, 2016) for the purpose of developing the CCR monitoring network.

In situations where a new monitoring system is being installed around an existing facility, pre-development background data is not available from within individual wells, so interwell methods are typically preferred. However, the hydrogeology of the Slag Pond Area is better suited for intrawell methods, so a review of the background data was conducted to investigate the assumption that the compliance wells do not show adverse impacts to groundwater. A review of background samples collected to date shows that multiple parameters listed in Appendix III of 40 CFR 257 (i.e. detection monitoring parameters) are elevated in one or more upgradient wells relative to downgradient wells, indicating that there is neither a clear distinction between upgradient and downgradient water quality, nor a pattern of consistently elevated parameters in downgradient wells. Additionally, for the Appendix IV (i.e. assessment monitoring) parameters with primary EPA Maximum Contaminant Levels (MCLs), concentrations are consistently below the MCLs, which demonstrates that downgradient water quality meets applicable federal standards for drinking water. As such, intrawell testing appears appropriate for the Slag Pond Area given the constraints of the site hydrogeology and background data time frame.

3.0 DETECTION MONITORING

3.1 Statistical Method

The use of the selected statistical method, and the selected general statistical approach (interwell vs. intrawell), is subject to ongoing review and assessment to ensure its continued suitability for groundwater monitoring at the site. As the background data set changes over time, modifications to the statistical methods are expected. Otter Tail Power Company reserves the right to employ different statistical methods in place of, or in addition to, the initially selected methods if future analysis of the dataset indicates that alternate methods are more appropriate. Any changes to the statistical method will be documented in the annual monitoring report, and if changes will carry forward into future events a revised Statistical Analysis Plan will be prepared and placed into the Plant's operating record.

Each detection monitoring constituent listed in Table 2 of the SAP will be analyzed to determine whether any of the compliance well data exhibit an SSI over background data. The primary statistical method used for detection monitoring for the Slag Pond Area will be intrawell control charts. A control chart is one of the specified methods listed in §257.93 (f)(4) and compares future observations to a control limit calculated using the mean and standard deviation of the background measurements. Control charts have the benefit of allowing visual identification of potential trends in the data because the compliance data are displayed graphically over time. The Shewart-CUSUM control chart is an example of a type of control chart that may be utilized, and governing equations for this type of control chart are presented in Chapter 20 of the Unified Guidance (EPA, 2009). Control chart parameters will be chosen such that testing achieves appropriate false positive rates and statistical power as recommended by the Unified Guidance.

If the control chart utilized is a parametric procedure, the original or transformed data must fit a normal distribution. Normality testing is discussed further in Section 3.3, below. If the data cannot be normalized, then a non-parametric procedure will be substituted. Non-parametric prediction limits will be the primary alternative method used is such cases. Non-parametric prediction limits are constructed by setting the limit as a large "order statistic" from the background data set, for example the highest detected value.

3.2 Background Data

The Unified Guidance recommends a minimum of eight background samples for intrawell analysis. To date, Otter Tail Power Company has conducted eight sampling events at each well in the Slag Pond Area monitoring network. Each background sample has been analyzed for each of the parameters in Appendix III and Appendix IV of 40 CFR 257. These eight samples will be used to construct the initial detection monitoring background data sets for the Slag Pond Area.

An important assumption of intrawell control chart analysis is that the background data are statistically independent. To check independence between consecutive sampling events, the background measurements were tested for first-order autocorrelation using the autocorrelation function presented in Chapter 14 of the Unified Guidance. No pattern of significant autocorrelation was identified, indicating the background sampling frequency was adequate to ensure independence between consecutive samples.

As monitoring progresses and additional samples are collected and analyzed, the background data set should be updated periodically (in the absence of SSIs) to allow long-term, natural changes in groundwater quality to be incorporated into the monitoring program. Background data will be updated every two years, unless an SSI is noted at a particular well or statistical testing indicates that the proposed new background data exhibit significant differences from the existing background data set. This is consistent with the recommendations in the Unified Guidance for semi-annual sampling.

3.3 Normality Testing and Non-detects

In parametric tests a key assumption is that the background data are normally distributed. The data set will be tested for normality using the Shapiro-Wilk, Shapiro-Francia, or another appropriate test. If the data do not follow a normal distribution or cannot be normalized, for example if the data set contains a high percentage of non-detects, then a non-parametric prediction limit will be generated in lieu of a control chart. For data sets with up to 15% non-detects, the non-detect values will be substituted with the value of the laboratory reporting limit. For data sets with greater than 50% non-detects, a non-parametric prediction limit will be generated in lieu of a control chart. If all results are non-detect the double-quantification rule should be used, meaning that two consecutive detections above the highest laboratory reporting limit constitute an SSI. If reported, estimated results less than the reporting limit (i.e. "J-flagged") data will be used in place of non-detect values.

3.4 Outlier Testing

Outliers are extreme high or low values within a data set which can disproportionally effect the background statistics, e.g. mean and standard deviation, used in generating applicable limits and determining SSIs. These anomalous values must be identified, evaluated, and removed from the data set if found to be not representative of natural conditions. The background data set will be screened for outliers using Dixon's test if background data set is less than 25 samples, and Rosner's test if greater than 25 samples. Time series graphs and box and whisker plots may also be generated to help visually identify outliers.

3.5 Duplicate Data

As discussed in Section 4 of the SAP, duplicate samples will be collected for QA/QC purposes. For statistical analysis of parameters with duplicate samples, only the original sample will be used for statistical comparisons, assuming that review of all QA/QC data indicates that the original sample is valid.

3.6 Determination of Statistically Significant Increases (SSIs)

For parameters statistically monitored using control charts, observations exceeding the control limit will be flagged as an initial exceedance and the well will be subject to verification resampling, as recommended in the Unified Guidance. Similarly, with prediction limits, if the original observation exceeds the prediction limit it will signal an initial exceedance subject to resampling. The resampling strategy used will be pass 1-of-2, meaning one resample will be collected and if either the initial sample or the resample are below the control limit (i.e. they "pass" the test) then the SSI is not verified. In practice, resampling is only conducted when there is an exceedance in the initial sample, so pass 1-of-2 can be thought of simpler terms: if the resample exceeds the limit, then there is a verified SSI; otherwise there is not an SSI. The resample will be collected at least 30 days after the initial sample and at least 30 days prior to the next scheduled sampling event.

If the initial exceedance is not verified, and is subsequently not flagged as erroneous or unrepresentative, the sample result will remain in the database, but will not be used for additional analysis or added to the background data set before being evaluated to determine whether it is a statistical outlier.

3.7 Response to a Verified SSI

If an SSI is determined to have occurred for one of the detection monitoring parameters, Otter Tail Power Company will take the following actions in accordance with §257.94 (e):

1. Except as provided for in (2), below, within 90 days of identifying a verified SSI establish an assessment monitoring program in accordance with §257.95
2. Within 90 days, demonstrate that a source other than the CCR Unit caused the SSI
    - If it is determined within 90 days of detecting the SSI that a source other than the CCR Unit caused the SSI, the groundwater monitoring system will return back to detection monitoring.
    - If, within 90 days of detecting the SSI, it cannot be determined that a source other than the CCR Unit is causing the SSI, assessment monitoring will be initiated at the groundwater monitoring system with SSI.
    - Any report indicating that the CCR Unit is not the source of the SSI, regardless of whether the groundwater monitoring system is in assessment monitoring or not, will be included in the annual groundwater monitoring and corrective action report in accordance with §257.90 (e).
3. Prepare a notification of assessment monitoring and place in Plant's operating record.

3.8 Demonstrations

If an SSI is observed, Otter Tail Power Company may complete a demonstration identifying that a source other than the CCR Unit caused the SSI, or that the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Otter Tail Power Company must complete the written demonstration within 90 days of detecting an SSI and obtain a certification from a qualified professional engineer verifying the accuracy of the information in the report.

4.0 ASSESSMENT MONITORING

If an SSI is detected for one or more detection monitoring constituents and Otter Tail Power Company is unable to demonstrate that a source other than the CCR Unit is the source of the SSI within 90 days of detecting the SSI, Otter Tail Power Company will begin assessment monitoring in accordance with §257.95.

The steps to be followed for assessment monitoring are as follows:

1. Within 90 days of beginning assessment monitoring, the groundwater monitoring system with the detected SSI will be sampled for the parameters listed as "assessment monitoring" as found on Table 2.
2. 90 days after receiving results of the initial assessment monitoring parameters analysis, all wells will be resampled for detection monitoring parameters plus detected (i.e. concentration above the reporting limit) assessment monitoring parameters. Groundwater sampling thereafter will be semi-annual and consist of sampling for the entire suite of assessment monitoring parameters during one event and detection monitoring parameters plus detected assessment monitoring parameters during the other event.
3. If the concentration of an assessment or detection monitoring parameter continues to be above background concentrations but below the applicable groundwater protection standard (see Section 5.4.1), assessment monitoring will continue.
4. If one or more assessment monitoring parameters are detected at significant levels above the groundwater protection standard, the following actions will be taken:
    - Place a notification of the exceedance in the Plant's operating record;
    - The nature and extent of the release will be determined;
    - Notify the owners or residents of land beneath which the plume is migrating offsite, and place notification in operating record;
    - Within 90 days:
        - Initiate an assessment of corrective measures as required by §257.96, or
        - Demonstrate that a source other than the CCR Unit caused the SSI

Once the concentrations of all parameters listed in Table 2 are shown through statistical analysis to be below background concentrations through for two consecutive monitoring events, detection monitoring may resume. A notice of resuming detection monitoring will be placed in the Plant's operating record.

4.1 Groundwater Protection Standards

Groundwater protection standards (GWPS) must be established for each detected assessment monitoring constituent. The GWPS shall be either the MCL, or the background concentration for the constituent, whichever is higher.

Comparing assessment monitoring data to the GWPS will be done using confidence intervals. In assessment monitoring, the comparison is made to determine whether constituent concentrations have increased above the GWPS. Therefore, the lower confidence limit (LCL) is of primary interest. If the LCL exceeds the GWPS at the 95% confidence level then the constituent has been detected at a statistically significant level above the GWPS and an assessment of corrective measures must begin pursuant to §257.96.

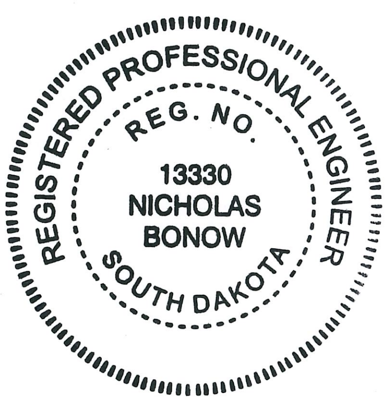
Development of statistical methods for corrective action measures is beyond the scope of this Plan. Such methods should be developed as part of a corrective action monitoring program, if necessary.

5.0 CERTIFICATION

I hereby certify under penalty of law that this report was prepared under my direction or supervision under a system designed to assure that qualified personnel gather and evaluate the information submitted. Based upon my inquiry of the persons or person who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. Furthermore, I certify that I am a duly Licensed Professional Engineer under the Laws of the State of South Dakota.

In addition, I certify that the selected statistical methods identified in this Plan are appropriate for evaluating the groundwater monitoring data at Otter Tail Power Company's Big Stone Plant Slag Pond Area, and meet the requirements of §257.93, Groundwater sampling and analysis requirements, as included in 40 CFR Part 257, Subpart D, Disposal of Coal Combustion Residuals from Electric Utilities.

Nicholas Bonow, PE	October 16, 2017
License No. 13330	Date



6.0 REFERENCES

ASTM, 2012. D6312-98 (2012) Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detecting Monitoring Programs; ASTM Book of Standards, Vol. 4.09. www.astm.org/

Barr, 2016. Groundwater Monitoring System Report; Slag Pond Area, Big Stone Plant, Big Stone City, South Dakota. Prepared for Otter Tail Power Company. December, 2016.

Carlson McCain, 2017. CCR Groundwater Sampling and Analysis Plan. Slag Pond Area; Big Stone Plant, Big Stone City, South Dakota. October, 2017.

CFR, 2015. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule, 40 CFR, Parts 257 and 261.

EPA, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance. Environmental Protection Agency Office of Resource Conservation and Recovery. March, 2009.