STATISTICAL METHOD ASSESSMENT and CERTIFICATION

JAMES RIVER POWER STATION (JRPS)

Prepared for:

City Utilities of Springfield
301 E. Central Street
Springfield, Missouri

Prepared by:

JACOBS
125 Broadway Avenue
Oak Ridge, Tennessee, 37830

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In April 2015, the United States Environmental Protection Agency (USEPA) issued new regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments under 40 CFR 257, Subpart D. Facilities regulated under the CCR Rule are required to develop a groundwater monitoring system to evaluate if CCR materials are affecting groundwater quality. As a part of the evaluation, the analytical data collected during the sampling events must undergo statistical analysis to identify statistically significant increases in analyte concentrations above background levels. The detailed procedures for sampling and analysis required under 257.93(a)-(e) are documented in the SAP dated December 21, 2016 and the QAPP dated January 25, 2017 incorporated herein by reference and included in the CCR operating record as set forth in section 257.105.

To comply with the CCR Rule, statistical analyses will be performed on the JRPS groundwater analytical results. The data consist of analytical laboratory results from eight (8) rounds of samples collected from the JRPS groundwater monitoring network that have been validated by the project chemist. Constituent concentration levels in the downgradient monitoring wells will be compared to the constituent concentration(s) of the upgradient monitoring well(s) to determine if a statistically significant increase is present. This is intended to show if any elevated constituent concentrations could be a result of CCR materials or if constituent amounts from the monitoring wells are simply due to normal random variation.

The calculations to test for a statistically significant difference from background groundwater data will be performed for each constituent using the Sanitas statistical analysis software using the prediction interval module. The prediction interval approach for determining statistical significance is included in 40 CFR 257.93(f)(3) of the CCR Rule, as one of five acceptable statistical approaches. The prediction interval approach is well suited to using the Sanitas software.

Once the groundwater samples have been collected by the field staff and sent to an approved certified analytical laboratory, the concentration results for each constituent are validated by the project chemist. The validated laboratory data are then joined with the field chain of custody information and loaded into a database. If during the data verification/validation process, the project chemist determines that some lab data results need to be flagged as rejected or estimated, then the industry standard validation qualifiers of "R" for rejected and "J" for estimated will be applied to the data. If the laboratory determines that the constituent concentration is below the detection limit of the lab instrument these non-detections are flagged with a "U" qualifier. The validation qualifiers are saved in the database and any further data queries will filter out the rejected data flagged with the "R" qualifier. In order to maintain a consistent unit of measure, all data are converted to the same unit of measure (mg/L). All data are reported in the format of the standard acceptable to the regulatory agency.

The laboratory results are loaded along with the well location name and a flow relationship code. The flow relationship codes are either "upgradient" or "downgradient" of the CCR unit. These flow relationship codes are identified in the tables below for each well at JRPS. The table below shows an abbreviated version of the monitoring well names that must be used in the Sanitas statistical software due to a location name length limitation.

JRPS Monitoring Wells and Flow Relationship to the Landfill		
Well Name	Abbreviated Sanitas Well Name Alias	Flow Relationship to the Landfill
JRPS-MW-SA-1	JR-MWSA1	Upgradient
JRPS-PZ-SA-U-2	JR-PZSAU2	Upgradient
JRPS-MW-2	JR-MW2	Downgradient
JRPS-MW-SA-4	JR-MWSA4	Downgradient
JRPS-MW-SA-5	JR-MWSA5	Downgradient
JRPS-PZ-SA-U-1	JR-PZSAU1	Downgradient
JRPS-PZ-SA-U-4	JR-PZSAU4	Downgradient
JRPS-PZ-SA-U-5	JR-PZSAU5	Downgradient

The groundwater data include field duplicate groundwater samples that were collected at the same monitoring well on the same date. The relative percent difference between these field duplicate samples and the associated original samples are examined as part of the chemistry data validation process. Beyond this use of the field duplicate results, however, the constituent concentrations from the field duplicate samples are just as valid as the associated original samples. Therefore, it is generally suggested by USEPA to use a conservative approach and use the higher of the concentrations between the field duplicate sample and the associated original sample that is obtained on a constituent by constituent basis. In the case where the result from a constituent from one of the samples is a detection and the other sample result is a non-detection, then the measurable detection result will be used. In the cases where one of the two samples is rejected as part of the validation/verification process, then the acceptable result will be used. Note, to avoid skewing the statistics with an extra sample from one monitoring well, both values cannot be used so the higher value is used for each constituent and is treated as a single sample.

All eight (8) rounds of data have been collected in the field, analyzed by the laboratory, validated by the chemist, and loaded in the database. The next step is to perform statistical analysis on the data. First, the prediction interval module in the Sanitas software will include the data from all eight (8) rounds from the upgradient background wells to calculate the prediction limit - a value to which all concentrations from the downgradient wells will be compared. By default, the prediction interval module in Sanitas first performs a Shapiro-Wilk/Francia test to determine if the data have a normal distribution. If the data have a normal distribution, then a parametric prediction interval will be calculated. If the data do not have a normal distribution, then a non-parametric prediction interval will be calculated.

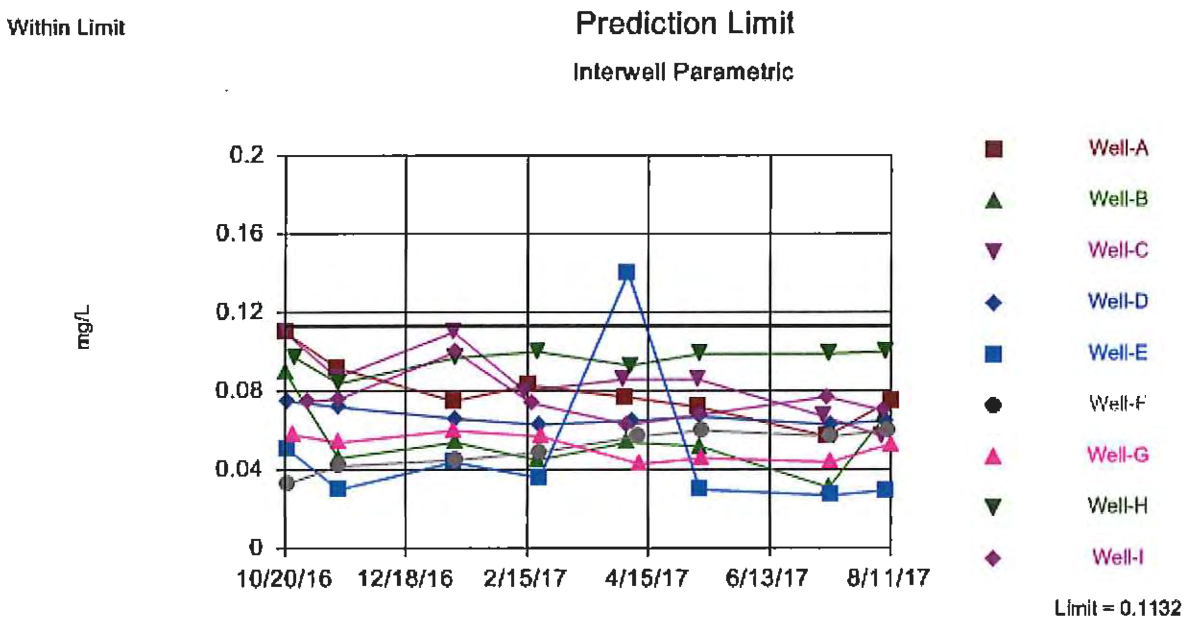
The laboratory analysis will be performed on the gronndwater samples using analytical methods that will have detection limits as low as practical to ensure that the statistical evaluation is defensible. Keeping the detection limits low will result in the least amount of concentration levels that the lab will only report as "below the detection limit." Without knowing a numerical concentration level on all data, the ability to perform accurate statistics is weakened with these samples without detections which are called censored data. Since the statistics require a numerical concentration level to be available for all samples, the Sanitas software uses the following approach to handling censored data:

1) If less than 15% of the background data are non-detects, then the numerical result value used on the non-detect samples is ½ the detection limit.

2) If the number of samples that are non-detects is between 15% and 50% on the data, then the sample mean and standard deviation are adjusted according to the Cohen's method

3) If the number of samples that are non-detects are over 50%, a non-parametric prediction limit will be calculated

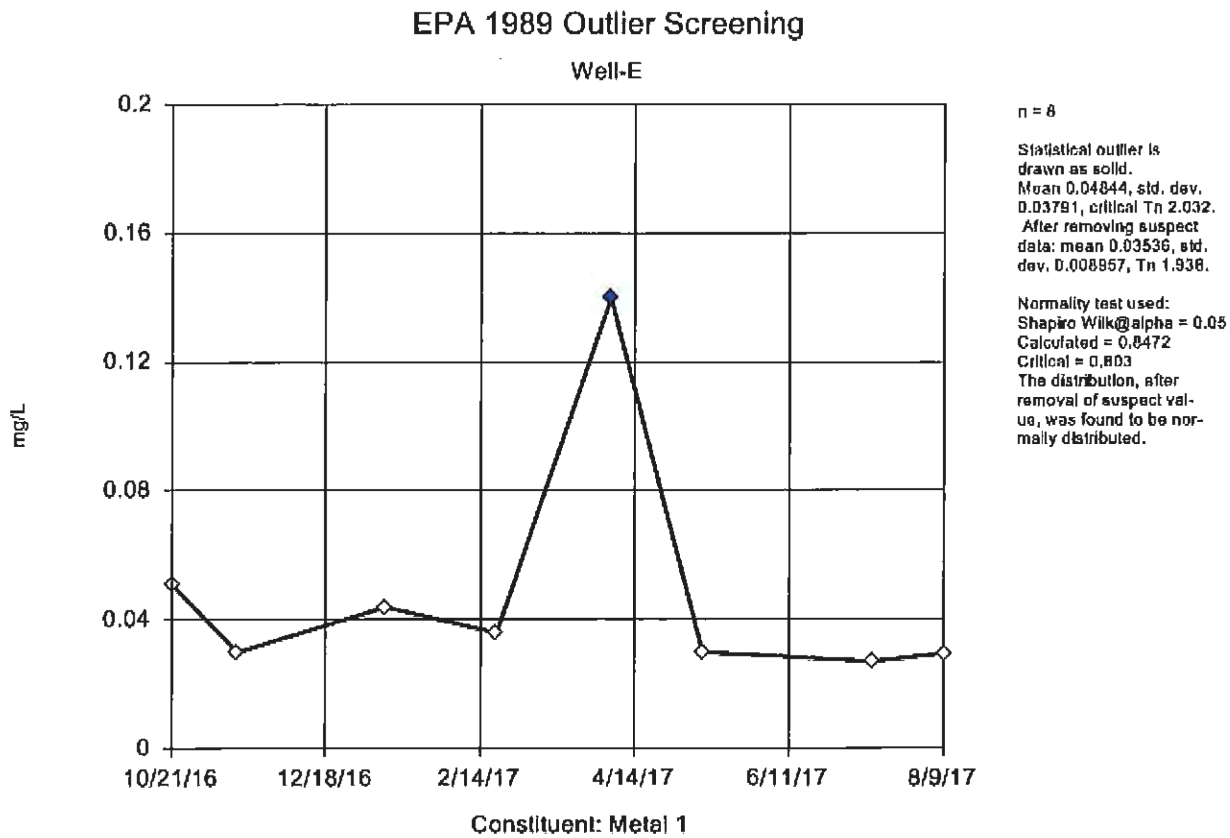
An example of the prediction limit statistic for a constituent using the Sanitas software is shown below. In the initial analysis of this example, the downgradient concentrations for the Well-E include one result in April 2017 that exceeded the 0.1132 mg/L statistical prediction limit.



Background Data Summary: Mean=0.06681, Std. Dev.=0.01728, n=16. Seasonality was not detected with 95% confidence. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9258, critical = 0.887. Report alpha = 0.08648. Individual comparison alpha = 0.01. Most recent point for each compliance well compared to limit.

Constituent: Metal 1

For any groundwater well that includes one or more concentrations that exceed the statistical significant limit, the concentrations at the well will also be analyzed in Sanitas using the outlier module if there are any obvious spikes in the constituent concentrations for each groundwater well. An example of the Sanitas outlier analysis is shown in the figure below. In this example, the single unusually high concentration for the constituent at Well-E qualifies as a statistical outlier which is highlighted in the figure with a solid filled symbol. In some cases, other statistical methods or professional judgment might be used to ideutify constituent concentrations as statistical outliers. Any qualifying outliers will be omitted, and the prediction limit analysis will be repeated.



The prediction limit statistics and graphs using the Sanitas software will be run for every required constituent, and the outlier analysis will be performed when appropriate. After completing the statistics using the Sanitas software, any constituents that have downgradient concentrations exceeding the prediction interval limits will be reported as exceedances. Also, graphs of the individual data results for the upgradient wells will be presented.

For more detailed information on the mathematics behind the prediction interval module and the outlier module in the Sanitas software, refer to the "Statistical Analysis Procedures" documentation for the Sanitas software and the associated bibliography references. This is available online using the link: http://www.sanitastech.com/sanitas/stats87.pdf

If any problems emerge in the statistical analysis when using the defaults in the prediction interval module in the Sanitas software, refinements to the software defaults will be examined. Also, if any problems emerge when using the prediction interval approach to calculate the statistical significance, one of the four other acceptable statistical approaches included in section 40 CFR 257.93(f) could be considered for use in calculating statistical significance. As long as the groundwater data set is established and defensible, the details of the statistical approach can be modified if necessary.

James River Power Station

Statistical Method Profession Engineer Certification

By means of this certification and in accordance with 40 CFR Part 257.93(f)(6), I certify that I am a qualified professional engineer as defined in 40 CFR 257.53, that I have reviewed the statistical methods used for City Utilities of Springfield, Missouri CCR units at JRPS, and that these statistical methods are appropriate and meet all the requirement under 40 CFR 257.93.

Printed name of Qualified Professional Engineer Gary J. Pendergrass, PE, RG

Signature

Registration No. E-19636 Registration State Missouri Date October 12, 2017