TETRA TECH

PROFESSIONAL CIVIL ENGINEER SCOTT K SCHMOKER E-8251 10/4/2016 STATE OF NEBRASKA

To: Mr. Tony Sedlacek

Cc: Tetra Tech Project File

From: Tamara Pelham

Date: October 5, 2016

Subject: Groundwater Monitoring System Assessment

The final rule to regulate the disposal of coal combustion residuals ("CCR") as solid waste under subtitle D of the Resource Conservation and Recovery Act ("RCRA") was published in the Federal Register, Volume 80, No. 74 on Friday, April 17, 2015 ("CCR Rule"). This final rule was effective on October 14, 2015 and is self-implementing. It is understood that the Fossil Fuel Combustion Ash ("FFCA") Monofill owned and operated by the City of Fremont's Department of Utilities ("FDU") and authorized by the Nebraska Department of Environmental Quality ("NDEQ") under Nebraska Solid Waste Permit No. NE0203777 will be regulated under this new rule as a CCR Landfill, by definition. CCR Landfills are collectively regulated by reference as "CCR Units".

Under the new CCR Rule, groundwater monitoring and corrective action requirements are codified under 40 Code of Federal Regulations ("CFR") 257.90 through 257.98, and owners or operators of CCR Units are required to be in compliance with these requirements on or before October 17, 2017. The stated groundwater monitoring requirements are, in summary:

1. Install a groundwater monitoring system (40 CFR 257.91);
2. Develop a groundwater sampling and analysis program, including statistical procedures for evaluating groundwater monitoring data (40 CFR 257.93);
3. Initiate detection monitoring to obtain at least eight (8) independent samples for each background and downgradient well for constituents listed in Appendix III and IV to Part 257 (40 CFR 257.94(b)) and at least semiannual during the active life of the CCR unit and the post-closure period; and
4. Begin evaluating the groundwater monitoring data for statistically significant indications of groundwater impacts (40 CFR 257.94).

If constituents listed in Appendix III are detected at a statistically significant increase over background levels, the groundwater monitoring program must progress from *detection monitoring* to *assessment monitoring*, which involves evaluating a larger suite of analytes to determine appropriate corrective action.

FDU had an on-going groundwater monitoring program established to comply with Nebraska Solid Waste Permit No. NE0203777, which incorporates data that dates back to 1997. It is unknown whether FDU operations prior to 1997 would have or could have impacted groundwater quality relative to or beneath the existing FFCA Monofill.

The following sections provide preliminary assessments and conclusions ascertained based on information and documentation provided by FDU (Attachment 1) and that directly respond to the four groundwater monitoring requirements established by the new CCR Rule (listed above). It should be recognized, however, that the review and conclusions rendered herein establish a working framework to complete this compliance assessment task.

As more information is obtained, compiled, and factored, e.g., additional groundwater constituent data or additional statistical results, the accuracy and defensibility of the conclusions rendered are expected to improve.

1.0 INSTALL A GROUNDWATER MONITORING SYSTEM

Groundwater monitoring systems under the new CCR Rule are subject to performance standards, requiring "a sufficient number of wells" to evaluate the upper-most aquifer environment beneath a CCR Unit. Wells must be positioned to establish groundwater quality at a minimum number of locations: one (1) upgradient and three (3) downgradient relative to the CCR Unit, augmented by "additional monitoring wells as necessary…". [40 CFR 257.91(c)(1) and (2)] The U.S. Environmental Protection Agency ("EPA") considers this *minimum* number of wells to be generally insufficient, and consequently an owner or operator of a CCR Unit whose system uses this minimum must demonstrate that data from the wells is sufficient to adequately characterize groundwater below a CCR Unit.

FDU uses five (5) groundwater monitoring wells to assess groundwater quality up and downgradient relative to the FFCA Monofill. Monitoring well MW-4 is designated as the upgradient monitoring well, while groundwater monitoring wells MW-1, 2, 3, and 5 are recognized as down-gradient wells; however, historic groundwater elevation data confirms there have been instances when groundwater elevations at downgradient wells have been higher than those measured at MW-4.

Each of the existing wells is completed to a total depth of approximately 27 to 28 feet below grade surface ("bgs") and with a 20-foot, 0.010-inch slotted screen interval extending to within 1 to 1.5-feet of the total depth of the boring. Screen intervals intercept the upper most groundwater bearing zone encountered within soil generally described as silty clay to medium-grained sand. Data collected since 2010 indicates depth to first-encountered groundwater ranges from approximately 10 to 27 feet bgs, corresponding to elevations ranging between approximately 1,162.5 and 1,168.5 feet above mean sea level ("amsl") and yielding a geometric mean of 1,162.65 feet amsl.

Existing well placement to the northwest, southwest, north, and east of the constructed Monofill, and leachate collection system establish upgradient and downgradient monitoring locations given the observed, site-specific groundwater flow direction that exhibits a predominantly easterly vector. However, the relatively flat groundwater gradient combined with periodically irregular groundwater elevations creates the potential for upgradient versus downgradient or cross-gradient positions to arguably change.

For instance, April 2013 groundwater data exhibits a groundwater flow direction to the south-southeast, in which case, wells MW-1 and MW-2 are positioned downgradient, while wells MW-3, -4, and -5 are upgradient or cross-gradient of Monofill features. Although MW-1 is completed with three casings at this location, i.e., three wells (one monitoring well and two piezometers), only one casing is monitored for chemical constituents, and therefore, only two monitoring locations are positioned downgradient of the active Monofill area. In this case, FDU is reliant upon the argument that at least two of the casings at the MW-1 well location should count to satisfy the performance standard requiring three downgradient wells. But, if contested, the defensibility of the well network could be vulnerable in this instance.

Similarly, data from October 2014 exhibits a due east or slightly northeast groundwater flow direction that positions wells MW-1 and MW-2 downgradient of active Monofill features, but the location of MW-5 could be argued to be either downgradient, in which case compliance would be achieved, or cross-gradient, in which case compliance would not be achieved.

Recommendations:

While the current number of wells exceeds (by one well location) the *minimum* number of wells specified by regulation, irregularities and fluctuations observed in groundwater elevation data render the positions of existing monitoring wells inconsistent relative to designations as up-gradient, down-gradient, or cross-gradient. The interests of FDU are best protected by expanding the groundwater monitoring well network with additional well locations between MW-1 and MW-5 (and slightly east) and MW-1 and MW-2, and preferably also between MW-2 and MW-3 (See Attached Figure). In addition, since the construction integrity of the casing at background well MW-4 is questionable, it is recommended to abandon the existing MW-4 monitoring well and install a replacement groundwater monitoring well near this location.

2.0 GROUNDWATER SAMPLING AND ANALYSIS REQUIREMENTS

40 CFR 257.93 requires owners or operators of CCR Units to develop a sampling and analysis program that includes procedures and techniques for sample collection, preservation, and shipment; hydraulic/aquifer condition measurements; analytical procedures; chain of custody control; quality assurance/quality control ("QA/QC"); and statistical evaluation. The Groundwater Monitoring Plan updated in December 2010 included provisions addressing each of these requirements, although some aspects of the plan require amendment.

Based on the Detection Monitoring Analyte List included in Appendix III to Part 257, and given concurring guidance from the NDEQ, the list of analytes monitored in the Groundwater Sampling and Analysis Plan need only include the Appendix III constituents, which are: boron, calcium, chloride, fluoride, pH, Sulfate, and total dissolved solids ("TDS"). Detection Monitoring for only these constituents continues until one or more analyte concentrations exhibit statistically significant increases over background concentration(s).

Should statistical tools indicate likely groundwater impacts, the groundwater monitoring plan must include provisions to implement the expanded list of analytes required for Assessment Monitoring. EPA considers this escalation of groundwater monitoring provisions to be a "phased" approach to groundwater characterization at CCR Units. When or if Assessment Monitoring should be necessary, supplemental analytes specified to be *added* to the monitoring program include: antimony, arsenic, beryllium, cadmium, cobalt, lead, lithium, mercury, molybdenum, thallium, and radium 226 and 228 combined (Appendix IV to Part 257).

Per the CCR Rule, before Detection Monitoring protocols begin, 40 CFR 257.94(b) requires the collection and analysis of eight independent samples from each background and downgradient well to be analyzed for the constituents listed in Appendix III and Appendix IV. This initial sample schedule is required to be completed no later than October 17, 2017.

Recommendations:

It is recommended to begin compiling constituent concentrations to satisfy the eight independent sample requirements as soon as practicable in order to obtain and evaluate the preliminary data required by October 17, 2017. If compliance with the CCR Rule is demonstrated in conjunction with the compliance requirements specified by the state-issued monofill permit, the Groundwater Monitoring Plan developed for the state permit should be amended to include provisions for escalating groundwater sampling that accommodates Assessment Monitoring specified by the CCR Rule, including an expanded list of analytical parameters.

2.1 STATISTICS

The statistical methods specified in the Groundwater Monitoring Plan were designed to comply with NDEQ Title 132, Chapter 7 and are eligible to be used to comply with the new CCR Rule because they are also cited in the EPA "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance, March 2009." However, the statistical methods prescribed in the Groundwater Monitoring Plan updated in 2010 referenced and/or relied on the 1992 version of the EPA guidance document. Consequently, statistical methods prescribed should be updated and the methods amended, as necessary, in accordance with contemporary guidance.

Based on the First Quarter 2015 Annual Groundwater Monitoring Report, it appears that FDU predominantly relies on three statistical tools: Levene's Test for Homogeneity of Variance (parametric), Shapiro-Francia Test of Normality, and the Kruskal-Wallis Non-Parametric Analysis. Levene's Test and the Shapiro-Francia Test are categorized as distributional statistical methods, while the Kruskal-Wallis Non-Parametric Analysis is an inter-well, alternative analysis of variation ("ANOVA") based on rank. Brief conclusions interpreting inter-well parametric and intra-well non-parametric tolerance tests were also mentioned. These tests are discussed in the March 2009 Unified Guidance document[1]; however, certain discrepancies in the use and application of these methods may warrant review and the use of additional statistical methods, as discussed below.

2.1.1 Levene's Test for Homogeneity of Variance (Distributional Statistic)

Interpretation of first quarter 2015 groundwater sampling results concludes, in part, "Parametric Analysis of Variance indicates barium, calcium, selenium, sulfate, TDS and vanadium were flagged as displaying a significant difference [unequal variance] when reviewing an inter-well comparison, but were not flagged on intrawell." Based on this statement, it appears that results of the *parametric* (versus non-parametric) Levene's test for homogeneity of variance are being presented, and while this test is reasonably robust to non-normally distributed data, the degree of non-normality to be accommodated (as recognized by the Shapiro-Francia Test of Normality) may contribute to less probable results or conclusions. Reference to "intrawell" comparisons suggest that additional Levene's Test results were not presented for review.

Recommendations:

Data that does not exhibit a normal distribution pattern should not prohibit the use of Levene's Test for Homogeneity; however, a more descriptive narrative explaining the uses and limitations of results is warranted. A general recommendation is that data or statistical results relied on for purposes of drawing conclusion(s) should be included with presented reports and results.

2.1.2 Shapiro-Francia Test of Normality (Distributional Statistic)

The Shapiro-Francia Test of Normality is a diagnostic tool that provides a numerical goodness-of-fit test of normality that is most applicably used for evaluation of data populations greater than 50.

Recommendations:

Continue the use of the Shapiro-Francia Test of Normality. Provide a clear indication whether or not the Shapiro-Francia Test of Normality results pertain to intra- or inter-well analyses, i.e., data populations pertaining to a single well location versus data populations compared between well locations.

2.1.3 Kruskal-Wallis Non-Parametric Analysis (non-parametric alternative to ANOVA)

The Kruskal-Wallis non-parametric analysis ("Kruskal-Wallis") compares population medians at multiple wells against the background population median. It is useful for evaluation of data that does not follow a normal distribution or cannot be normalized and for data populations containing concentrations that were reported below the method detection limits (non-detect data). However, the Kruskal-Wallis test assumes the population variances across all wells are equal, which is not the case according to the Levene's Test for Homogeneity of Variance.

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[1] 2009. "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance," Environmental Protection Agency. March

Recommendations:

Relegate the priority of the inter-well Kruskal-Wallis test results in favor of the inter-well, Non-Parametric Tolerance Limit Analysis results. Presentation of future Kruskal-Wallis Non-Parametric Analysis remains viable; however, results should be noted as reliant upon data populations exhibiting unequal variance, and the significance of the results should be clarified against the null hypothesis, which is that population medians across all tested wells are equal. The significance of results described in reference to "no wells selected" should also be clarified.

Basic Statistics data attached to the First Quarter 2015 Groundwater Monitoring Report appear to rely on Rank(ed) Means versus medians. Inter-well diagnostic tests based on mean values at multiple wells is an example of One-Way Analysis of Variance versus the Kruskal-Wallis Test, which relies on the non-parametric evaluation of medians. Validation and/or clarification of the results contained in the statistical program reports is recommended.

2.1.4 Parametric and Non-Parametric Tolerance Interval\Limit

Tolerance limits can be constructed to test whether a compliance point population is identical or similar to background data population(s) (i.e., the null hypothesis), which is an inter-well comparison (i.e., compliance point data compared to background data). Compliance can then be substantiated based on comparison of compliance data to the upper value of the tolerance interval derived based on background data, the upper value then representing the *tolerance limit*. Both Parametric and Non-Parametric Tolerance Interval/Limit testing can be used with data sets containing reported concentrations less than method detection levels.

Parametric tolerance limits assume normality of the sample background data, which may be a valid observation with respect to the FFCA Monofill data. Further statistical analysis of background data is necessary to substantiate this condition.

The non-parametric tolerance interval (or limit when evaluating against the upper end of the interval) is not dependent upon data distribution or variability. The assumption in this case is that the compliance-point data follow the same or similar distribution as background, which is also a reasonable assumption in the absence of groundwater impacts originating from known or unknown potential contaminant sources.

Current statistical test procedures include both Parametric and Non-Parametric Tolerance Interval evaluations. However, the results of these tests presented in the First Quarter 2015 Annual Groundwater Monitoring Report may be confused or are confusing because:

1. Non-Parametric Tolerance Intervals are primarily an inter-well assessment technique (i.e., a compliance point compared to background)[2], yet results and conclusions reference non-parametric tolerance results for intra-well analyses; and,
2. P*arametric* (inter-well) tolerance analysis assumes a normal distribution of data but was used to assess data populations, including vanadium, that do not exhibit a normal distribution.

Consequently, the conclusion that "the detection of vanadium is not indicative of landfill impact" because it is a common constituent in soil is not well supported by the data presented, nor does it appear to be a logical conclusion of fact. Further, "water quality standards that have been established by the EPA" are represented by discrete Maximum Contaminant Levels ("MCL"), which, in some cases, may be valid limits to evaluative comparison. However, the contention that, "it does not appear the tested parameters exceed any statistical levels for water quality standards that have been established by the EPA" is not clear, and inter-well statistical

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[2] 2010. Unified Guidance. EPA. Pg 17-15

comparisons to background concentrations are confusing given the analysis(es) provided for review. Under these conditions, FDU may be vulnerable to contest should opposition groups or organizations become aware.

Recommendations:

Further use of parametric tolerance interval/limit testing should be validated against recommendations provided in current EPA Unified Guidance. In instances where data populations exhibit a normal distribution, parametric tolerance interval/limit testing may support helpful *inter-well* comparisons and conclusions. However, if data populations do not exhibit normal distribution tendencies, this statistical tool should be omitted in favor of non-parametric tolerance interval/limit testing.

Non-parametric tolerance interval/limit testing should continue to be conducted as an inter-well detection monitoring procedure, and an interpretation of results should clearly explain how statistical results are compared to background data, i.e., typically the maximum background value observed for a given constituent.[3]

2.1.5 Recommendations for Additional Intra-well Statistical Test Methods

The age of the facility, the potential for historic groundwater contamination, and observed variations or discrepancies between groundwater elevations measured in wells assigned as upgradient versus downgradient are conditions that may erode the reliability, validity, or certain defensibility of inter-well statistical analyses. Consequently, it is recommended to continue to analyze data using the historic methods reported, but expand the statistical suite to include additional intra-well trend analysis to assess analyte tendencies or characteristics at each individual well location.

Of the three intra-well tests for evaluating potential trends specified in EPA's Unified Guidance, Linear Regression and Mann-Kendall statistics summaries are regarded as powerful and interpretable parametric and nonparametric statistical test methods, respectively. Furthermore, while these statistical test methods are incorporated into a wide variety of commercially-available statistics programs, the Air Force Center for Environmental Excellence ("AFCEE") has made publicly available (free on-line) the Monitoring and Remediation Optimization System ("MAROS") software that is capable of producing Linear Regression and Mann-Kendall statistical results for groundwater monitoring data (up to 40 data sets). A brief explanation of how results are processed, reported, and interpreted is included in Attachment 2.

Any one of the following statistical analyses can be used to comply with the requirements of the CCR Rule 40 CFR 257.93(f):

- Levene's Test for Homogeneity (Parametric Analysis of Variance) – 40 CFR 257.93(f)(1);
- Kruskal-Wallis Non-Parametric Analysis - 40 CFR 257.93(f)(2); and
- Parametric and Non-Parametric Tolerance Interval\Limit – 40 CFR 257.93(f)(3);
- A control chart approach or another statistical method that meets performance standards – 40 CFR 257.93(f)(4) and 257.93(f)(5).

Given the history of monitoring and statistical analyses conducted for the FDU Monofill to date, it is recommended to continue to assess data using the Levenes Test for Homogeneity, the Shapiro-Francia Test of Normality, and the Kruskal-Wallis Non-Parametric Analysis. In addition, it is also recommended to validate statistical conclusions using Parametric and Non-Parametric Tolerance Interval/Limit tests and Linear Regression and Mann-Kendall statistical methods. Based on the conclusions generated by this expanded suite of statistical tests, a comprehensive interpretation of data should be derived for the initial eight sets of data collected for Detection

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[3] IBID, Pg 17-18

Monitoring, and then the selection of an appropriate, applicable, and defensible suite of statistical methods should be finalized in the first Annual Groundwater Monitoring Report prepared for publication by October 17, 2017.

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Attachment 1

List of Documents/Information Provided by the City of Fremont

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The following list of documents was received from FDU for review:

1. Permit Renewal Application for Fossil Fuel Combustion Ash Disposal Area, December 2010
2. Quarterly Groundwater Monitoring Reports:
    a. 1st Quarter 2013
    b. 3rd Quarter 2013
    c. 1st Quarter 2014
    d. 3rd Quarter 2014
    e. 1st Quarter 2015
    f. 3rd Quarter 2015
3. Excel databases
    a. Water Levels 2010 to 2015
    b. 7.9.2004 through 7.6.2009
    c. 7.21.2009 through 7.13.2010 (field parameters)
    d. Ash Monofill
4. Contour Maps:
    a. 1998
    b. 1999
    c. 2000
    d. 2001
    e. 2002
    f. 2003
    g. 2004 (#1 and #2)
    h. 2005
    i. 2006
    j. 2007
    k. 2008
    l. 2009
    m. 2010
    n. 2Q2011_3Q2011
    o. 2Q2012_3Q2011
    p. 4Q2011_1Q2012

Attachment 2

Summary Describing Linear Regression and Mann Kendall Statistical Analyses

The Linear Regression analysis is intended to identify the trend in data through estimation of the log slope, to place confidence limits on the log slope of the trend (the fit of predicted values to observed values), and to determine the standard error of the slope (standard deviation). Positive log slopes indicate an increase in constituent concentrations over time, whereas negative values indicate a decrease in constituent concentrations over time. The Coefficient of Variation (COV) is the statistical measure of how the individual data points vary about the mean value. Values less than 1.00 indicate data are relatively clustered about the mean value and stable, while values larger than 1.00 indicate a greater degree of scatter that exhibits 'no trend,' at 90 to 95% confidence.

The Confidence in Trend is the statistical probability that the constituent concentration is increasing (ln slope >0) or decreasing (ln slope <0). Results may be inconclusive if data or trend residuals do not exhibit a normal or normalized distribution.

Mann-Kendall is a non-parametric statistical procedure for analyzing trends in data over time, suitable for analyzing data that do not follow a normal distribution and that may include irregular sampling intervals and missing data. Analytical results reported to be below method detection limits are assigned values at one-half the minimum detection level. Results of non-parametric test methods are not biased by the overall magnitude of outlier data points, but depend on the ranking of individual data points. Positive Mann-Kendall statistic values (S) indicate an increase in constituent concentrations over time, whereas negative values indicate decreasing concentrations. Larger positive or negative values indicate the strength or confidence in the trend.

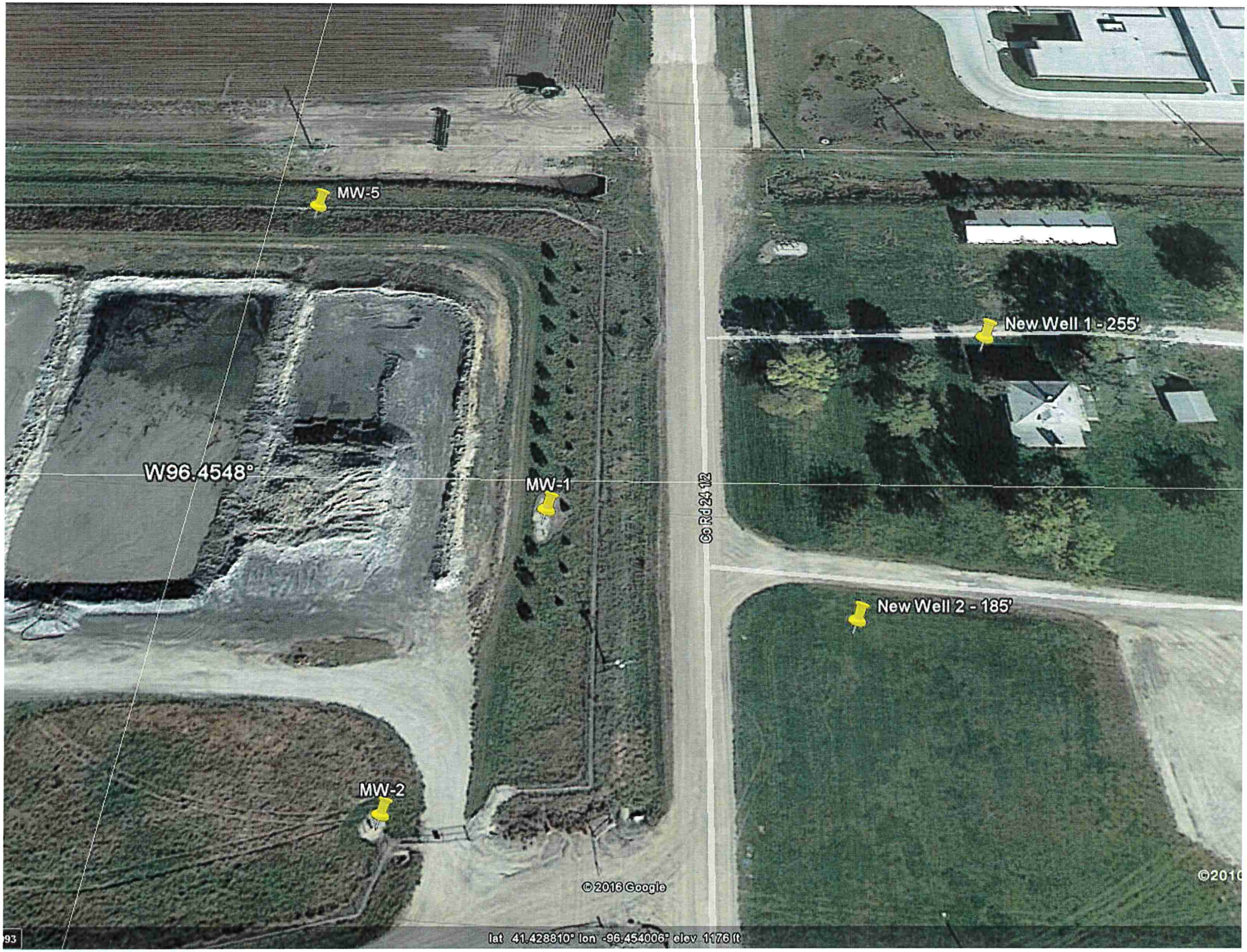
Concentration trends assessed using both the Linear Regression and Mann-Kendall statistical tests that are assigned "probably increasing" or "probably decreasing" trends (rejecting the null hypothesis [H_0] of a stable condition) are assigned at a 90% or better confidence level. Increasing (I) or decreasing (D) trend assessments are assigned at a 95% confidence level.

Mann-Kendall trends may also be assigned as stable (S) or designated as no trend (NT). These designations occur when the confidence in the trend (confidence level) is less than 90%. Stable trend assignments are used when the S value is at or below 0 (decreasing trend) and the COV is less than 1, indicating values closely grouped around the mean, thus providing statistical support to accept the H_0 that the trend is, indeed, stable.

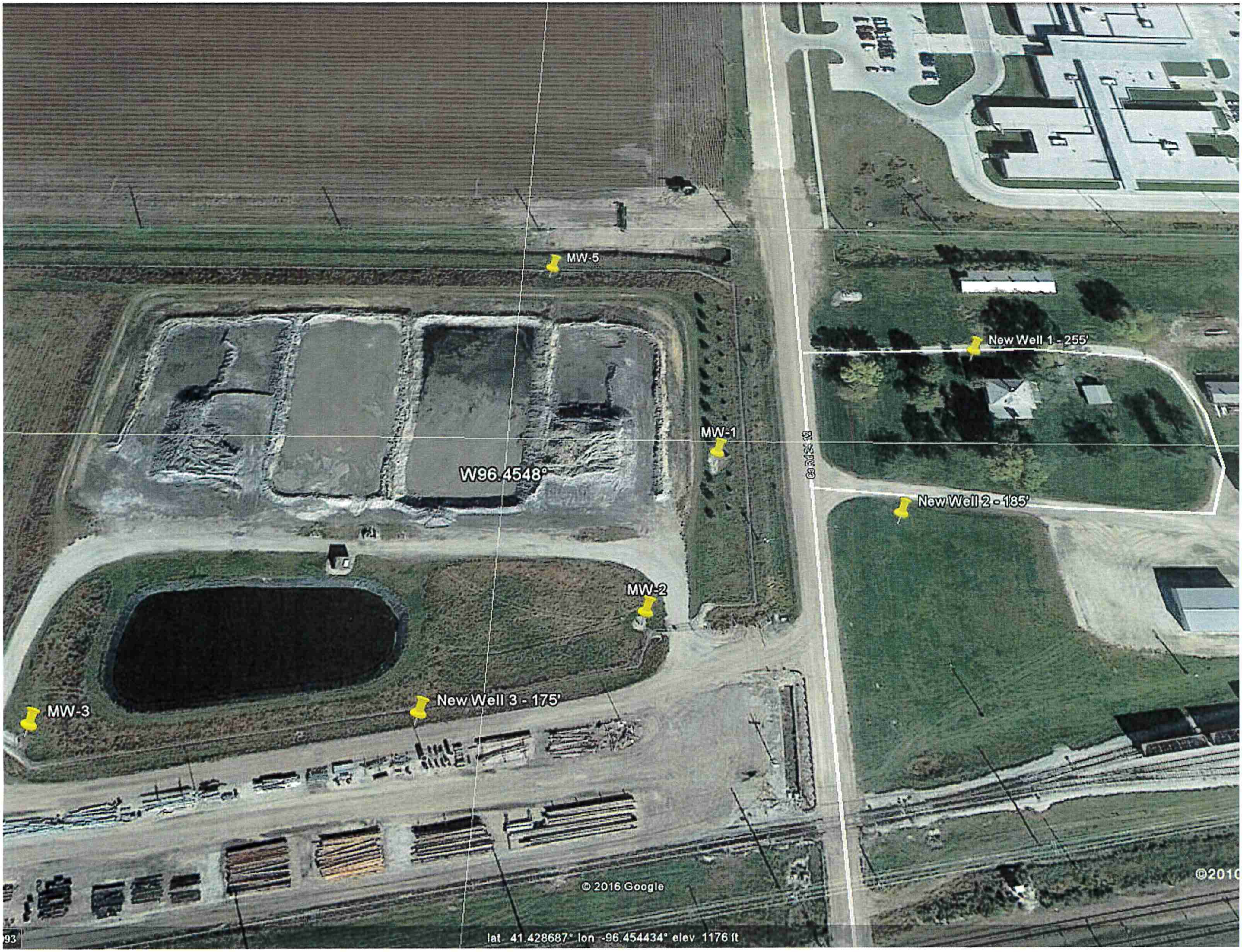
A value of S equal to or below 0 and a COV greater than 1 indicate insufficient statistical evidence to describe a trend, i.e. no trend. If the value of S exceeds 0 (increasing trend), but the statistical confidence in the trend is less than 90%, even if the COV is less than 1, the decision matrix defaults to no trend, which means statistical evidence is insufficient to reject or accept H_0.

Attachment 3

Proposed Areas for Additional Groundwater Monitoring Well Installation



MW-5
New Well 1 - 255'
W96.4548°
MW-1
Co Rd 24 12
New Well 2 - 185'
MW-2
© 2016 Google
©2010
lat 41.428810° lon -96.454006° elev 1176 ft



MW-5
New Well 1 - 255'
MW-1
W96.4548°
New Well 2 - 185'
MW-2
MW-3
New Well 3 - 175'
© 2016 Google
©2010
lat 41.428687° lon -96.454434° elev 1176 ft