2018
ANNUAL ENVIRONMENTAL MONITORING REPORT
SAUK LANDFILL

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Concrete, Washington

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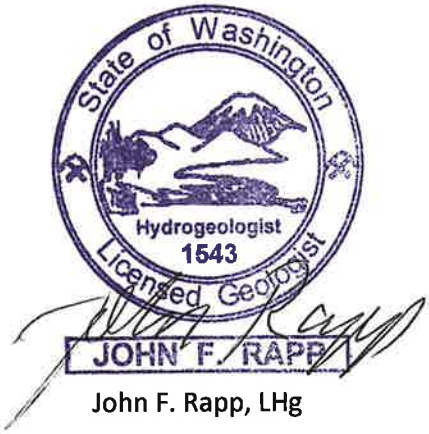
April 2019

2018 Annual Environmental Monitoring Report
Sauk Landfill
Skagit County, Washington

Prepared by:



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1.0 INTRODUCTION

This report presents a summary of environmental monitoring data collected during 2018 at the Sauk Landfill. Annual reporting of environmental monitoring data is required by the *Minimum Functional Standards for Solid Waste Handling* (Chapter 173-304 Washington Administrative Code [WAC]). This annual report includes a summary of groundwater quality and flow characteristics measured in on-site monitoring wells.

The Sauk Landfill (also known as the "Sauk-Faber" Landfill) is located in the NW ¼, NE ¼ of Section 28, Township 35 North, Range 9 East, approximately 2,000 feet north-northeast of the Skagit River and approximately 2 miles west of the town of Rockport (Figure 1). The landfill occupies an old gravel pit. The site began operation as a certified sanitary landfill in 1979. The landfill stopped receiving waste in 1988 and closure was completed in 1989 in accordance with Chapter 173-304 WAC requirements. Closure activities included the following:

- installation of an engineered cap over the landfill
- installation of four on-site monitoring wells
- implementation of environmental monitoring activities

Skagit County is currently conducting the post-closure monitoring and maintenance activities required by 173-304 WAC.

2.0 HYDROGEOLOGY

A previous investigation conducted by Hong West & Associates (HWA; 1990) reports that the Sauk Landfill site is underlain by glacio-fluvial deposits. Well-graded sand and gravel deposits are present from the surface to depths ranging from approximately 30 feet below ground surface (bgs) on the north side of the landfill to about 90 feet bgs on the southeast side of the landfill. This unit is underlain by poorly graded sand that varies from about 140 feet thick on the western site margin to about 65 feet thick on the eastern site margin. A thin (1 to 15 feet thick) silt unit underlies the sand layer. The silt unit is subsequently underlain by an approximately 10- to 20-foot thick silty gravel unit that hosts the uppermost aquifer. The overlying silt layer appears to act as a semi-confining layer for the uppermost aquifer. All four on-site monitoring wells are screened within this semi-confined aquifer. Beneath the silty gravel unit is a clayey silt to silty clay unit. Nearby domestic well logs indicate this unit is about 150 feet thick. Domestic well logs indicate a gravel deposit of unknown thickness underlies the clayey silt unit. This gravel deposit is host to a deep confined aquifer(s) that is the principal water supply in the area.

Previous groundwater measurements indicate that groundwater flow in the upper aquifer is generally from the north to the south. Based on this flow direction, Monitoring Well MW-3 is located upgradient of the landfill, while Wells MW-1, MW-2, and MW-4 are located downgradient of the landfill (Figure 2).

2.1. Water Level Monitoring

Groundwater elevations measured in 2018 for the shallow semi-confined aquifer are summarized below in Table 1. Groundwater elevations were measured during March (1st Quarter), June (2nd Quarter) and September (3rd Quarter), and December (4th Quarter) in 2018.

Table 1. 2018 Static Water Level Elevations

Well	March	June	September	December
MW-1	385.96	386.83	362.82	365.42
MW-2	384.77	385.37	368.87	368.67
MW-3	388.67	388.54	372.49	377.45
MW-4	386.87	387.44	369.94	369.54

Elevations are in feet above mean sea level (NGVD 29)

Table 1 shows that the lowest potentiometric surface elevation in 2018 occurred during the September monitoring event and the highest elevation occurred during the March event with a seasonal variation between 17.90 (MW-4) and 16.18 (MW-3) feet. A hydrograph showing the potentiometric surface elevation during the entire monitoring period is presented as Figure 3. Potentiometric surface maps of the shallow semi-confined aquifer prepared using the data in Table 1 are presented as Figures 4a, 4b, 4c, and 4d. The groundwater flow direction was generally north to south through the site towards the Skagit River. Based on the 2018 water level measurements, the measured gradient through the central portion of the site for the shallow semi-confined aquifer averaged approximately 0.007 feet/foot (ft/ft). Based on grain size distribution, average hydraulic conductivity is estimated at about 1.4 feet/day (ft/day), and porosity is estimated at about 25 percent (HWA, 1990).

Using these parameters, the average linear velocity of groundwater was calculated using Darcy's Law, where: **V = Ki/n,** and

V = average linear velocity,

K = hydraulic conductivity,

i = hydraulic gradient, and

n = porosity.

The calculated average rate of groundwater flow in the shallow semi-confined aquifer is approximately 0.04 ft/day.

A review of the hydrograph for the shallow semi-confined aquifer (Figure 3) shows typical seasonal fluctuation of the water levels, with the lowest water levels occurring in September to December, and the highest water levels occurring in June.

3.0 GROUNDWATER SAMPLING AND ANALYSIS

3.1. Sample Locations and Frequency

Quarterly groundwater samples were collected from each of the four on-site monitoring wells on a quarterly basis (MW-1, MW-2, MW-3, and MW-4) during 2018.

3.2. Sample Collection

Groundwater sampling was conducted using a low-flow sampling technique (in general accordance with that described in *Puls and Barcelona*, 1995). Monitoring wells were sampled and purged using dedicated bladder pumps. Groundwater parameters (pH, temperature, redox, dissolved oxygen, specific conductance, and turbidity) were measured every four minutes during the purging process utilizing a flow-through cell. Once these parameters stabilized, the well was then sampled. Parameters were considered stable when the last three readings of each parameter were within 3% difference of each other (for specific conductance) and 10% difference of each other for all other parameters.

3.3. Analytical Parameters

Groundwater samples were submitted to Edge Analytical of Burlington, Washington for analysis. Parameters analyzed consisted of those specified in the *Minimum Functional Standards for Solid Waste Handling* (Chapter 173-304 WAC) with the exception of total coliform, which was not analyzed per previous approval by the Skagit County Public Health Department and the Washington Department of Ecology. To accommodate state groundwater quality standards, concentrations of acrylonitrile, 1,2-dibromomethane (EDB), 1,4-dioxane, and vinyl chloride were analyzed with low-level detection limits using U.S. Environmental Protection Agency (USEPA) Method 8260 SIM. Beginning with the 2nd quarter sampling event of 2008, additional inorganic constituents were tested during each subsequent quarterly sampling event through the 1st quarter of 2010. These additional constituents were measured based on a request from the Washington Department of Ecology to further characterize groundwater at the landfill site. These additional constituents included total dissolved solids (TDS), alkalinity, bicarbonate, total calcium, total magnesium, total potassium, total sodium, and the following dissolved metals: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, and vanadium. The constituents that were never detected above practical quantitation limits were dropped from the sampling request. The additional constituents remaining on the current list include total dissolved solids, alkalinity, bicarbonate, total calcium, total magnesium, total potassium, total sodium and the following dissolved metals: barium and vanadium.

For quality assurance purposes, duplicate samples were collected from MW-2 during each sampling round.

4.0 GROUNDWATER QUALITY RESULTS

Assessment of water quality for the shallow semi-confined aquifer is based on analytical results from Monitoring Wells MW-1, MW-2, MW-3, and MW-4. Wells MW-1, MW-2, and MW-4 are located hydraulically downgradient of the landfill. MW-3 is located upgradient of the landfill and serves as the background monitoring well. Historical sampling results from these wells have shown possible low-level impacts from the landfill to groundwater quality in this aquifer. For this report, groundwater monitoring results have been compared to *Water Quality Standards for Groundwaters of the State of Washington* (Chapter 173-200 WAC).

All analytical groundwater monitoring results for 2018 are provided in Appendix A as tabulated data. To evaluate long-term trends, time-series plots were generated from data collected from 1990 through 2018 (108 sampling events). Fourteen long-term time-series plots (Appendix B) were generated from the analytical results. Time-series plots were not generated for analytes that were all or nearly all detected at concentrations that were below the laboratory practical quantitation limits (PQLs).

For quality assurance purposes, data validation reports were generated that reviews laboratory groundwater quality data from the first three quarter monitoring events at Sauk Landfill, and included with each of those three quarterly reports. The data validation report for the 4th quarter 2018 is included as Appendix C.

4.1. On-site Wells

During 2018, pH was the only parameter that is outside of state groundwater standards (Chapter 173-200 WAC). Measured pH values were below the minimum secondary contaminant criterion of 6.5 during the first and third quarters at MW-3 and MW-4, and below the criterion during the third quarter at MW-1 and MW-2. A summary of the minimum and/or maximum pH values measured in each well during 2018 is presented in Table 2 below. While these data show that pH in downgradient wells is either below or above the minimum level; the exceedance of the pH criterion in downgradient wells does not necessarily indicate impact from the landfill since similar pH levels were measured in the upgradient well (MW-3).

Table 2. Summary of Analytes Exceeding Groundwater Quality Standards: 2018

Secondary Contaminant	GW Quality Standards	Minimum Level Detected			
		MW-1	MW-2	MW-3	MW-4
pH (standard units)	6.5-8.5	6.4	6.24	6.37	6.12

One dissolved metal was detected above its PQL during 2018. Dissolved barium was detected at all wells, including the upgradient background well MW-3, during every quarterly monitoring event. All detections were below the state groundwater standard (Chapter 173-200 WAC).

VOCs detected at the laboratory PQL during 2018 included Chloromethane and Trichlorofluoromethane (CFC-11). Both were detected at MW-2. However, the result is considered an estimated concentration and occurs when an analyte concentration is below the calibration curve but is above the method detection limit. No other VOCs were detected above the PQLs during 2018.

4.2. Piper Diagrams

Piper diagrams are a graphical display of the proportions of the major cations and anions in a sample. Piper diagrams are constructed by plotting the proportions of the major cations (calcium, magnesium, sodium and potassium) on one triangular diagram, the proportions of the major anions (alkalinity, chloride, sulfate) on another, and then combining the information from the two triangular plots onto a quadrilateral plot (Drever 2002).

A piper diagram was created using the data from each quarterly monitoring event in 2018 (Appendix C). The results show that the general chemistry does not significantly change each quarter. These piper diagrams indicated that MW-1, MW-2, and MW-3 all have a similar chemical signature and MW-4 has its own distinct chemical signature.

4.3. Cation-Anion Balance

Cation-anion balance is the ratio of cations to anions within the water sample. Since water samples are electrically neutral, the sum of the cations should equal the sum of the anions. The cations are magnesium, calcium, sodium and potassium. The anions are sulfate, chloride, carbonate and bicarbonate. The ratio would be determined as:

$$\text{Ratio} = (\text{sum of cations})/(\text{sum of anions})*100\%$$

Since water is electrically neutral, we would expect the ratio to be 1 or 100%. However the cation-anion balances calculated for each of the four quarterly monitoring events at Sauk Landfill are 15.92%, 4.603%, 7.875%, and 10.45%, respectively (Appendix D). This indicates that there are more anions than cations in the results. There could be a couple of reasons for this ratio imbalance. One is the fact that some analyte values are for dissolved metals and some analyte values are for total metals. Another reason could be that not all species were analyzed in the water sample, and were therefore not included in the cation-anion balance. The most common species were analyzed, but there could be less common species present in the water that were not included in the calculation.

4.4. Stiff Diagrams

A stiff diagram is another graphical representation of the major ion composition of a water analysis. A polygonal shape is created from three horizontal axes extending on either side of a vertical axis. The three major anions are plotted to the right of the center axis and the three major cations are plotted to the left of the center axis. The points are connected to create the polygonal shape. The larger the area of the polygonal shape, the greater the concentrations of the analytes (Drever 2002). Stiff diagrams were produced for each well during each of the three quarterly monitoring events in 2017 (Appendix D).

Generally, the polygons produced at each well are similar to each other, and are similar for each quarterly monitoring event. MW-2 has the largest polygonal shape, which indicates that it has the greatest concentration of analytes.

4.5. Domestic Wells

No domestic wells were sampled during 2018. Domestic wells located to the southwest and southeast of the landfill site have been sampled previously. The results of these analyses were presented in earlier annual reports. Refer to those reports for a discussion of domestic well results.

5.0 STATISTICAL EVALUATION OF GROUNDWATER RESULTS

Statistical analysis of groundwater monitoring data from Sauk Landfill is conducted using Microsoft Excel and WQStat Plus v.9 or equivalent software in accordance with the EPA guidance document (EPA 2009). Statistical analysis is conducted using data from the entire monitoring period (1990-2018) unless otherwise noted.

5.1. Box Plots

Box plots are useful in providing a visual display of the distribution of a data set (EPA 2009). The central box of the plot shows the interquartile range from the 25th to the 75th percentiles. A line (whisker) is drawn to the minimum and maximum values from the 25th and 75th percentiles, respectively. The 50th percentile is drawn within the box. The mean value of the data set is plotted within the box as a separate mark. Significantly staggered boxes could be an indication of spatial variability.

Box-plots were created of all analytes with significant detections (Appendix E). The box plots were visually analyzed to see if there were significant differences between the upgradient well (MW-3) and the downgradient wells (MW-1, MW-2, and MW-4) (Table 3).

Table 3. Box Plot Visual Analysis: 2018

Significantly Staggered Analyte	Distribution of Boxes
Alkalinity	MW-2 is higher
Barium	MW-2 is higher
Bicarbonate	MW-2 is higher
Calcium, total	MW-2 is higher
Magnesium	MW-2 is higher
Nitrate-N	MW-2 is higher
Potassium, total	MW-2 is higher
Sodium, total	MW-2 and MW-4 are higher
Specific conductance	MW-2 is higher
Total dissolved solids	MW-2 and MW-4 are higher

Ten out of the fourteen analytes plotted showed some degree of spatial variability. In 8 of the 10 analytes, the values measured in MW-2 were significantly higher than the values measured in MW-1, MW-3, and MW-4. In 2 of the analytes, the values measured in MW-2 and MW-4 were significantly higher than the values measured in MW-1 and MW-3.

These results indicate that with some analytes, there may be significant differences between the concentrations measured in the most downgradient well (MW-2) as compared to the other downgradient wells (MW-1 and MW-4) and the upgradient well (MW-3).

5.2. Mann-Kendall Trend Test

The presence of significant increasing or decreasing trends was determined using the Mann-Kendall test. The Mann-Kendall test evaluates possible trends by comparing random pairs of data within the data set. The test statistic will increase if the later value is greater than the earlier value, and decrease if the later value is less than the earlier value. After the test statistic is determined, the Z-score is calculated from the test statistic. The farther the Z-score is from zero, the more significant the trend (EPA 2009).

A long-term (1990-2018) and short-term (2014-2018) Mann-Kendall test was run on each well with a time-series plot (Appendix F). Some results state the presence of a statistically significant increasing or decreasing trend in the data, but there were either no or very few detections within the data set. These trends are not considered statistically significant since they are the result of a change in laboratory detection limit of the analyte, and not an actual change in detected concentrations.

Overall, the Mann-Kendall results indicate that each well shows some improvement in water quality (Table 4). Most of the statistically significant decreasing trends have been found in the long-term data set.

Table 4. Mann-Kendall Significant Long-term and Short-term Trends: 2018

Well	Analytes with increasing trend	Analytes with decreasing trend
MW-1		Bicarbonate Nitrate-N Sodium Specific Conductance **Sulfate**
MW-2	Nitrate-N Sulfate	Alkalinity Barium Bicarbonate Calcium, total Magnesium Specific Conductance Total Organic Carbon
MW-3		*Alkalinity* Bicarbonate Nitrate-N Specific Conductance Sulfate
MW-4	Chloride Sodium	Alkalinity Bicarbonate Sulfate

Regular text denotes a long-term trend only
Italicized text denotes a short-term trend only
Bold text denotes both a long-term and short-term trend

As seen in Table 4, several inorganic analytes are decreasing in all wells at the landfill. Bicarbonate, sulfate, specific conductance, and nitrate-N were both found to be decreasing in more than one well at the site. All of these analytes were found to be decreasing in the upgradient well, so this might indicate site-wide conditions rather than landfill impact.

Four inorganic analytes are found to be increasing in long-term at the landfill including chloride, nitrate, sodium, and sulfate. The most increasing analytes are present at MW-2 and MW-4. Three of the increasing analytes have groundwater quality standards, but most of the analyte concentrations remain significantly below the groundwater quality standard. The one analyte with concentrations close to its standard is nitrate-N in MW-2. In 2018, nitrate-N was detected at concentrations ranging from 1.37 to 1.99 mg/L, below the primary groundwater quality standard of 10 mg/L. While nitrate-N shows a definite increase in MW-2 in the long-term plot, in the short-term plot the concentration of nitrate-N appear to have leveled off.

5.3. Wilcoxon Rank-Sum Test

A more formal tool to compare downgradient and upgradient wells is through a two-sample t-test. The Wilcoxon rank-sum test (also known as the Mann-Whitney test) was conducted on the Sauk data. The

Wilcoxon rank-sum test was selected because it is non-parametric, and it can also handle the presence of some non-detect values in the data set by treating them as ties (Gilbert 1987).

The Wilcoxon rank-sum test compares a single compliance well or group of wells against the background well(s) values. All of the concentrations from the upgradient and downgradient wells are ranked according to data value. The Wilcoxon test statistic (*W*) is calculated from the summation of ranks for both the upgradient and downgradient populations (Gilbert 1987). Large values of *W* indicate a significant difference between upgradient and downgradient wells, therefore suggesting the possibility of contamination in the downgradient well. Small values of *W* indicate that there is little difference between the upgradient and downgradient well concentrations (EPA 2009).

The Wilcoxon rank-sum test does make some assumptions that if not met in the data set, could affect the robustness of the results. While the data distributions do not need to be normal, the test assumes that the upgradient and downgradient concentrations follow the same underlying distribution with an equal amount of variance. The side-by-side box plots are a useful tool to compare population distribution and variability. The Wilcoxon rank-sum test also assumes that the tested populations are stationary over time and that concentrations are not trending upward or downward (EPA 2009). The Mann-Kendall test can be used to find significant trends. If there are analytes that met one or both of these criteria, the robustness of the Wilcoxon rank-sum test for that analyte will be discussed.

The Wilcoxon rank sum test was performed on all analytes with a long-term time-series plot (Appendix G). The Wilcoxon rank-sum test compared each downgradient well to the upgradient well, individually. The full results are included in Appendix H. Fourteen inorganic analytes and 2 VOCs were found to show significant differences between upgradient and downgradient concentrations (Table 5). In all 15 analytes, MW-2 was found to have a significant difference from the upgradient well. In 5 of the analytes, all 3 downgradient wells were found to have significant differences between the upgradient well.

Table 5. Wilcoxon Rank-Sum Test Results: 2018

Analyte	Significant Result	Similar data distribution	Significant trends	Robust
Alkalinity	MW-2	Yes	MW-2 decreasing	Yes
Barium, dissolved	MW-2, MW-4	Yes	MW-2 decreasing	Maybe
Bicarbonate	MW-2	Yes	MW-1, MW-2, & MW-4 decreasing	Yes
Calcium	MW-2	Yes	MW-2 decreasing	Yes
Chloride	MW-1, MW-2, MW-4	Yes	MW-4 increasing	Maybe
Magnesium	MW-1, MW-2, MW-4	Yes	MW-2 decreasing	Yes
Nitrate-N	MW-2, MW-4	Yes	MW-2 increasing	Maybe
pH	MW-2, MW-4	Yes		Yes
Potassium	MW-1, MW-2, MW-4	Yes		Maybe
Sodium	MW-1, MW-2, MW-4	Yes	MW-1 decreasing; MW-4 increasing	Maybe
Specific conductance	MW-1, MW-2, MW-4	Yes	MW-1, MW-2 & MW-3 decreasing	Maybe
Sulfate	MW-2	Yes	MW-2 increasing;. MW-3 & MW-4 decreasing	Maybe
Total dissolved solids	MW-2, MW-4	Yes		Maybe

Not all of these analytes met the assumptions in the Wilcoxon rank sum test. Several analytes found to have significant results from the Wilcoxon rank sum test also have either increasing or decreasing trends. The Wilcoxon rank sum test assumes that there are no trends in the data. Therefore, the Wilcoxon rank sum results may not be as robust for these analytes. The robustness of the results is noted in the table above (Table 5). Five analytes (alkalinity, bicarbonate, calcium, and magnesium) meet both of these assumptions, so their results can be considered robust and acceptable.

Though the Wilcoxon rank sum test may not be ideal for this data set, it is a helpful tool in recognizing that significant differences are present between the upgradient (MW-3) and downgradient (MW-1, MW-2, and MW-4) in this data set.

5.4. Prediction Limits

Prediction limits offer another method to determine if significant differences exist between upgradient and downgradient wells. The prediction limit is constructed using the upgradient (background) well values. The prediction limit (PL) is generally calculated by:

$$PL = \bar{x} + ks$$

where $\bar{x}$ is the upgradient well mean, s is the upgradient well standard deviation, and k is the multiplier depending on the type of prediction limit in use (i.e. parametric, non-parametric). Downgradient values are then compared to the prediction limit. If a downgradient well is found to exceed the prediction limit, it is considered significantly different than the upgradient well. Prediction limits can also be used to test future concentrations. Once a prediction limit is established, a new individual value can be compared to the prediction limit. A new value exceeding the established prediction limit could suggest possible contamination.

The prediction limit calculation does make assumptions about the data set. If these assumptions are not met the prediction limit results may not be considered robust. It is assumed that the upgradient and downgradient sample measurements have the same distribution. As with the Wilcoxon rank sum test,

the box plots will provide this with a visual analysis. The sample data must also not exhibit any trends. The Mann-Kendall results will show any trends that exist. The prediction limit calculation also assumes that the background data come from a common parent population with no statistical outliers in the upgradient data. The WQStat program tests each data population for normality. If the data is normal, it will apply a parametric prediction limit calculation to the data. If the data set is not normally distributed, the WQStat program will apply a nonparametric prediction limit calculation.

Prediction limits were calculated for every analyte that had been graphed in a time-series plot. The full results are included in Appendix H, and the results are summarized below (Table 6).

Table 6. Prediction Limit Results: 2018

Analyte	Over prediction limit	Similar data distribution	Significant trends	Outliers in MW-3	Robust
Alkalinity	MW-2	Yes	MW-2 decreasing	None	Yes
Bicarbonate	MW-2	Yes	MW-2 decreasing	None	Yes
Calcium	MW-2	Yes	MW-2 decreasing	None	Yes
Chloride	MW-2, MW-4	Yes	MW-4 decreasing	None	Yes
Magnesium	MW-1, MW-2	Yes	MW-2 decreasing	None	Yes
Nitrate-N	MW-2	Yes	MW-2 increasing	None	Yes
Potassium	MW-2	Yes		None	Maybe
Sodium	MW-2, MW-4	Yes	MW-4 increasing	None	Yes
Specific conductance	MW-2	Yes	MW-1, MW-2 decreasing	None	Yes
Total dissolved solids	MW-2, MW-4	Yes		None	Yes

Ten inorganic analytes were found to have downgradient values exceed their prediction limits. MW-2 was found to exceed the prediction limit for every one of these analytes.

Not all of these analytes met the assumptions of the prediction limit calculations. Several analytes found to have downgradient values over their respective prediction limits also had either increasing or decreasing trends. However, all analytes had similar data distributions between the upgradient and downgradient wells, and no outliers were found in the upgradient data set (MW-3). Four analytes (alkalinity, bicarbonate, magnesium, and total dissolved solids) meet all of the assumptions, therefore their results can be considered robust and acceptable. Though the results from the analytes may not be as robust, the results of the prediction limit calculations can be helpful in assessing potential impacts from the landfill.

The statistical analysis of Sauk Landfill shows that there are some significant differences between the upgradient well (MW-3) and the down-gradient wells (MW-1, MW-2, and MW-4). These significant differences could indicate impacts from the landfill. Well MW-2, the most down-gradient well, shows the greatest potential impacts from the landfill. While there are potential impacts from the landfill, only one analyte (pH) was detected at levels outside of the state groundwater quality criteria range.

6.0 LANDFILL GAS MONITORING ACTIVITIES

Section (2)(b)(i) of Chapter 173-304-460 WAC specifies minimum functional air quality standards for landfills. These standards limit the concentration of explosive gases in the subsurface at the property boundary to the lower explosive limit (LEL) for that gas. The most common explosive landfill gas is methane, which has an LEL at a concentration of approximately 5 percent by volume. Methane is typically monitored at closed landfills in LFG monitoring probes; however, there are currently no LFG monitoring probes located at the Sauk Landfill. Therefore, it is not possible to monitor compliance with the air standard as part of the current environmental monitoring program. However, Skagit County did conduct a LFG investigation at the site in August 2005. The complete results of the LFG investigation are included in a separate report (Skagit County 2008). The results of this investigation indicated that LFG has not migrated beyond the landfill perimeter. Based on this investigation, it can be concluded that the Sauk Landfill is in compliance with the air quality standard.

7.0 OPERATIONS AND MAINTENANCE ACTIVITIES

A detailed survey of the landfill was conducted in January 2017. The survey found that the landfill cover was in good shape, with no apparent settling or sinking.

There were no operation and maintenance activities conducted at Sauk Landfill in 2018.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Groundwater monitoring at the Sauk Landfill site consists of measuring water levels and sampling four on-site monitoring wells screened in a shallow semi-confined aquifer on a quarterly basis. One well is located hydraulically upgradient of the landfill (MW-3); the remaining three wells are located downgradient of the landfill (MW-1, MW-2, and MW-4). Water level measurements indicate that groundwater generally flows to the south beneath the site toward the Skagit River. Analytical results from sampling conducted in 2018 indicate that only one parameter was out of compliance with state water quality criteria. No VOCs were detected above laboratory PQLs in 2018.

Trend analysis indicates that concentrations of most typical landfill contaminants have decreased during the past twenty-five years. The statistical analysis of Sauk Landfill shows that there are some significant differences between the upgradient well (MW-3) and the down-gradient wells (MW-1, MW-2, and MW-4). Well MW-2, the most down-gradient well, shows the greatest potential impacts from the landfill. Overall, the lack of detected VOCs and the fact that only pH was detected at levels outside of the state groundwater quality criteria range indicate that the impact from the landfill to the uppermost aquifer is, at most, minimal. Groundwater quality in the shallow semi-confined aquifer remains generally good and has improved during the last twenty-eight years of monitoring.

9.0 REFERENCES

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FIGURES

Figure 1. Landfill Location Map

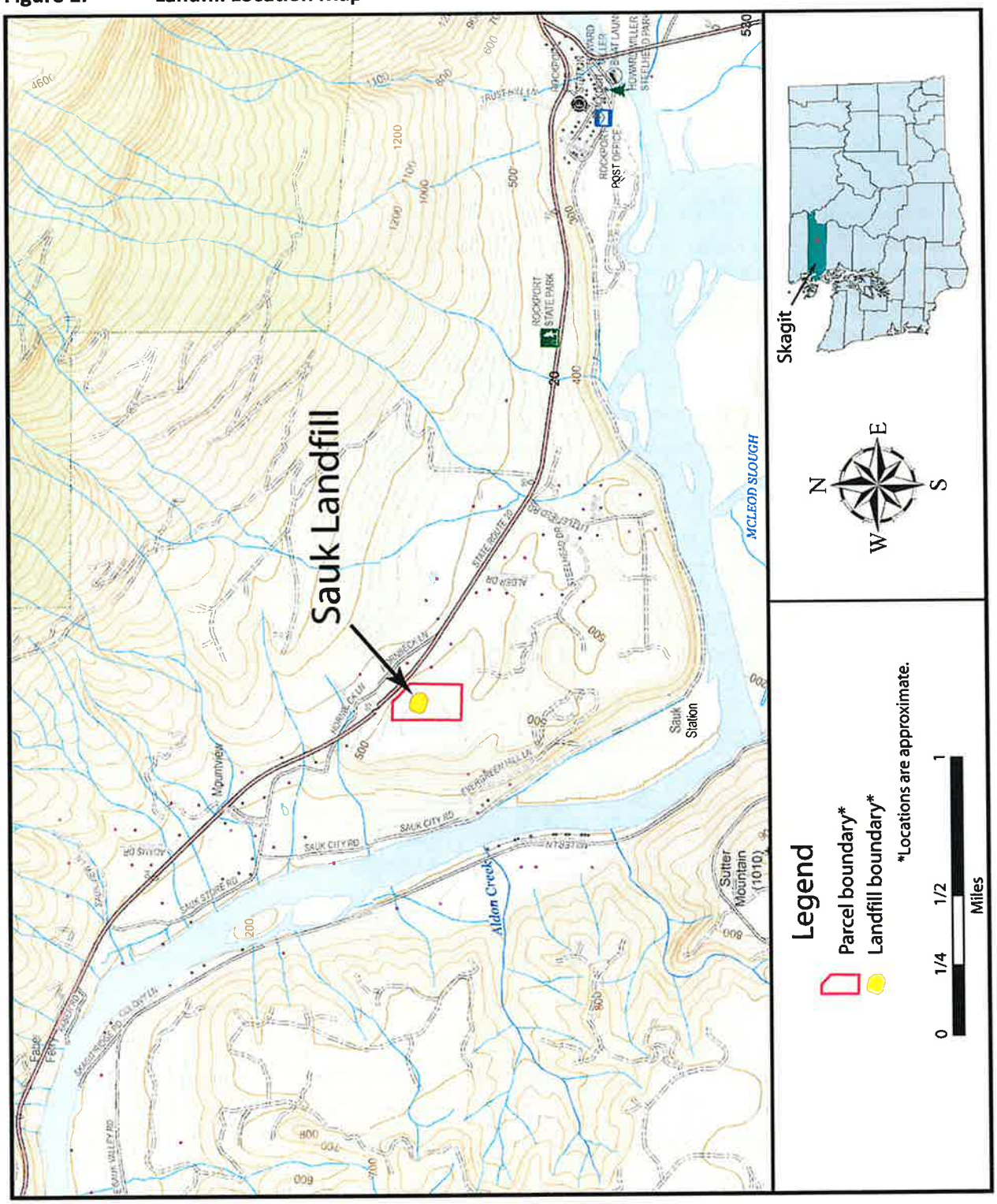


Figure 2. **Monitoring Well Location Map.**

LEGEND

MW-1 ● Monitoring Well

Approximate Landfill Boundary

Figure 3. **Sauk Landfill Hydrograph 1990 – 2018**

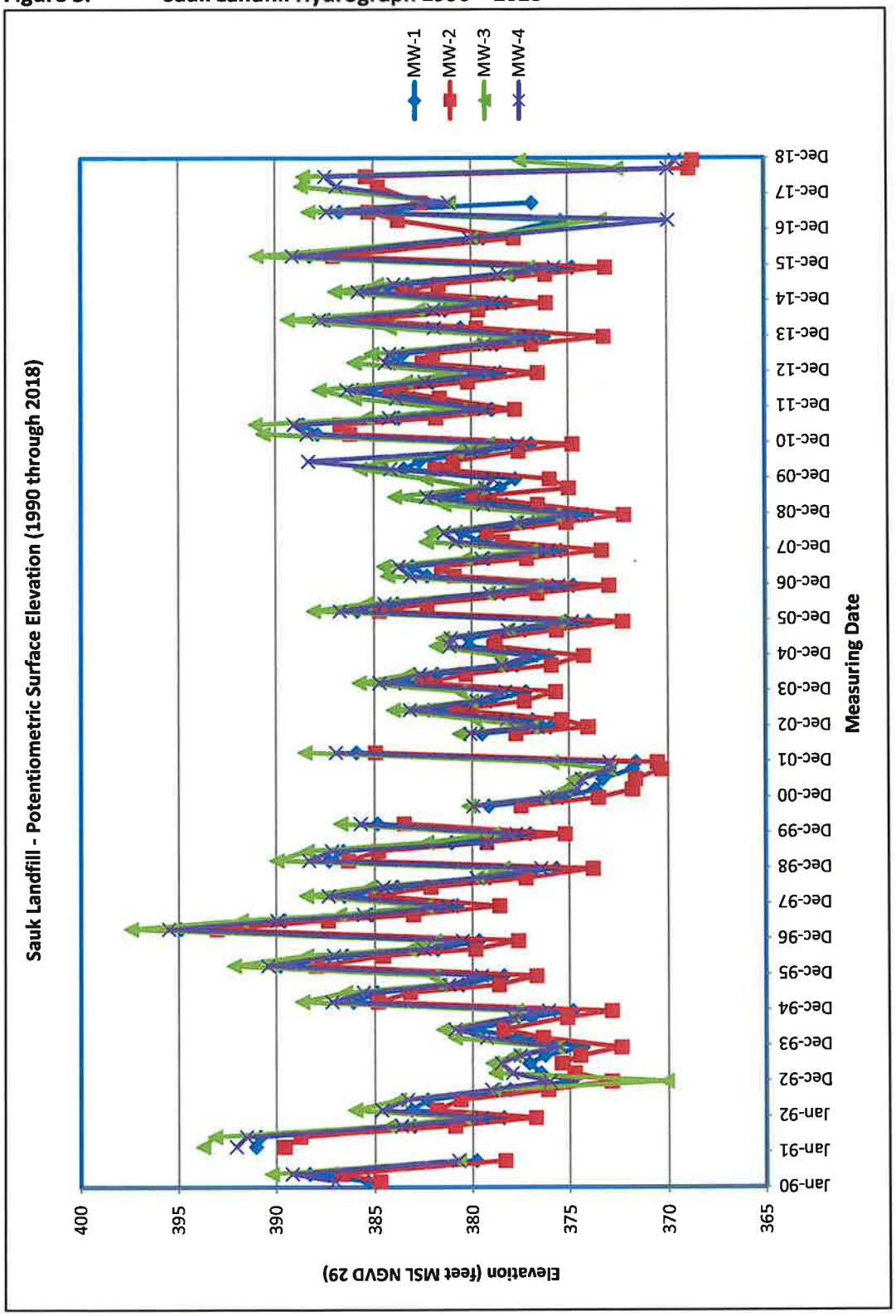
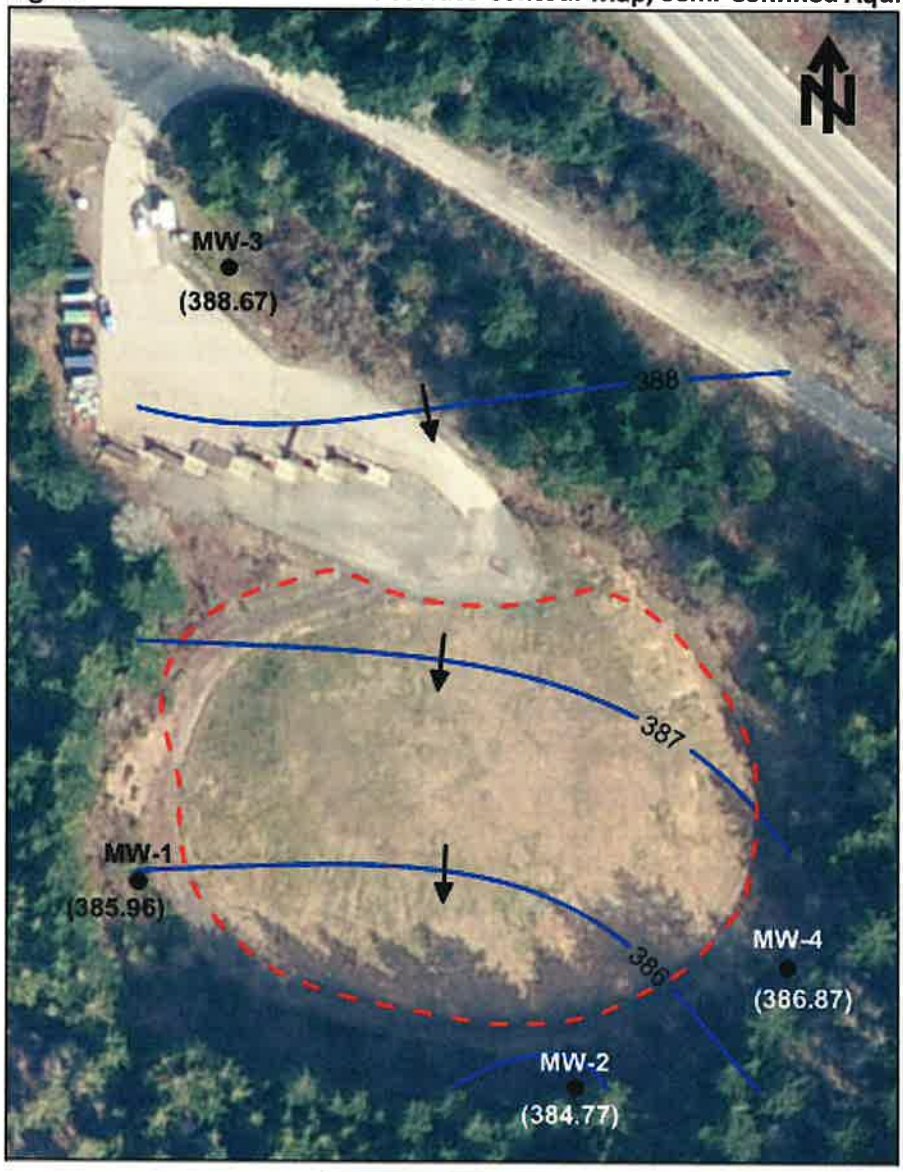


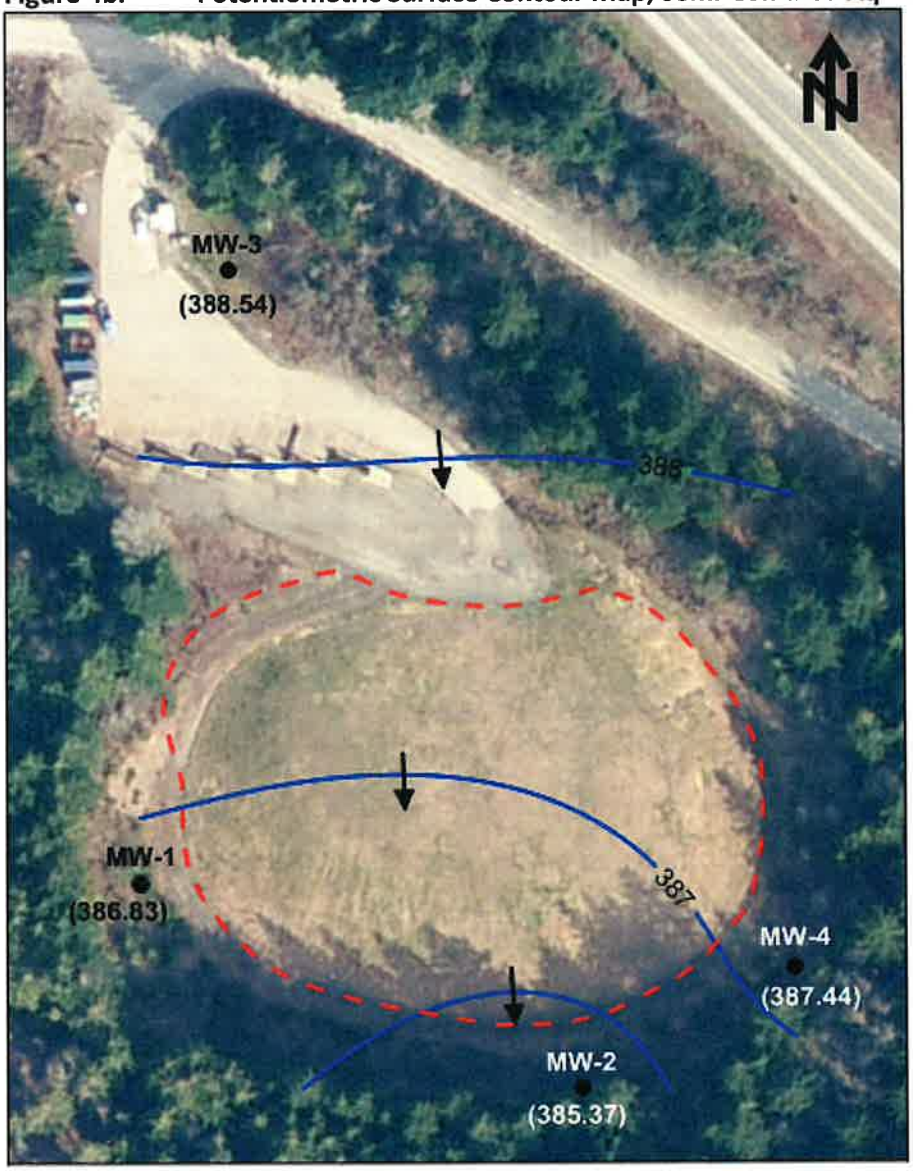
Figure 4a. **Potentiometric Surface Contour Map, Semi-Confined Aquifer, March 2018.**



LEGEND

MW-1 ●	Monitoring Well
—375—	Potentiometric Surface Contour
(375.18)	Static Water-Level Elevation (feet above MSL)
↙	Direction of Groundwater Flow
▭	Approximate Landfill Boundary

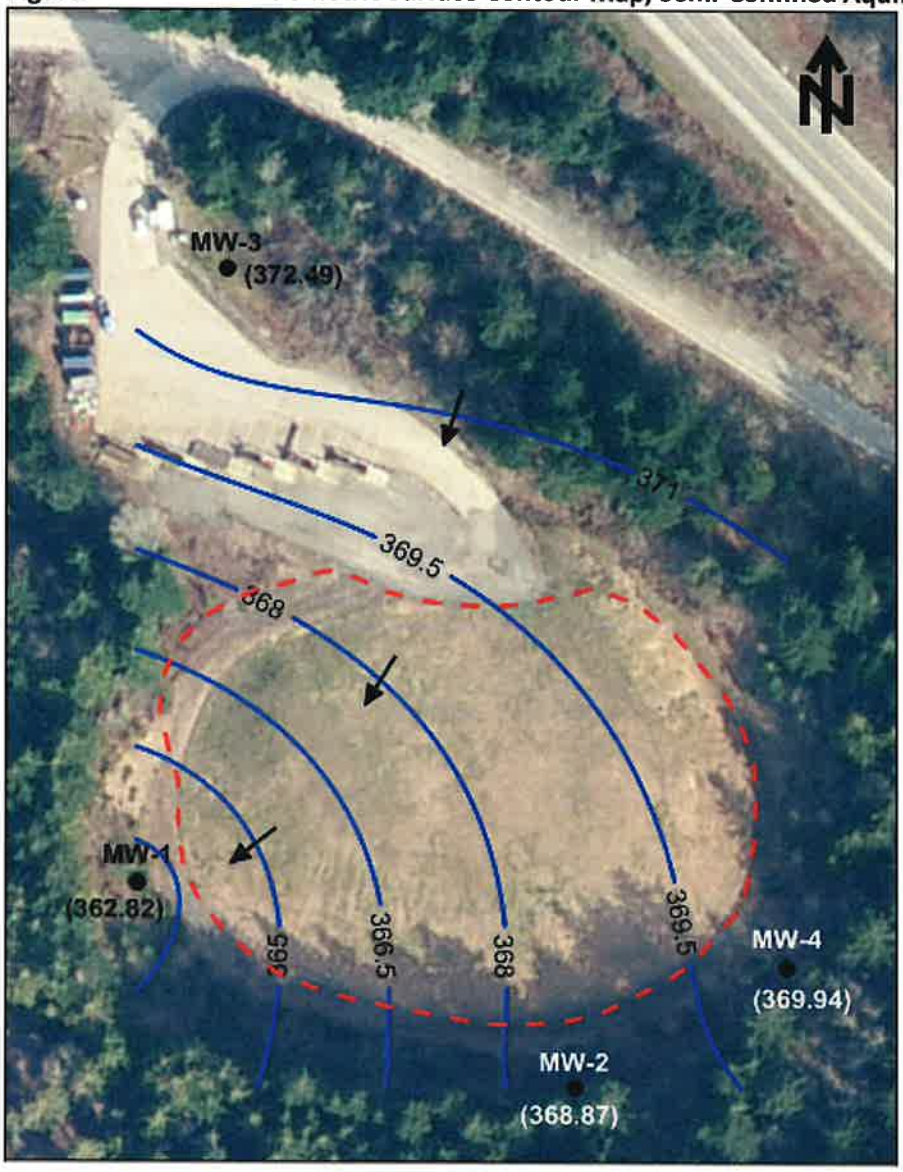
Figure 4b. Potentiometric Surface Contour Map, Semi-Confined Aquifer, June 2018.



LEGEND

MW-1 ●	Monitoring Well
—375—	Potentiometric Surface Contour
(375.18)	Static Water-Level Elevation (feet above MSL)
↙	Direction of Groundwater Flow
▭	Approximate Landfill Boundary

Figure 4c. Potentiometric Surface Contour Map, Semi-Confined Aquifer, September 2018.



LEGEND

MW-1 ●	Monitoring Well
—375—	Potentiometric Surface Contour
(375.18)	Static Water-Level Elevation (feet above MSL)
↙	Direction of Groundwater Flow
▭	Approximate Landfill Boundary

Figure 4d. Potentiometric Surface Contour Map, Semi-Confined Aquifer, December 2018.

LEGEND

MW-1 ●	Monitoring Well
—375—	Potentiometric Surface Contour
(375.18)	Static Water-Level Elevation (feet above MSL)
↙	Direction of Groundwater Flow
	Approximate Landfill Boundary

APPENDIX A

2018 GROUNDWATER ANALYTICAL DATA

2018 Inorganic Monitoring Results
Sauk Landfill

MONITORING WELL / Sampling Date			MW-1 3/16/2018	MW-1 6/28/2018	MW-1 9/13/2018	MW-1 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
CONVENTIONALS						
Chemical Oxygen Demand	mg/L		8 U	20 U	20 U	20 U
Total Organic Carbon	mg/L		1.52	0.15 U	0.15 U	0.15 U
Total Dissolved Solids †	mg/L	**500	58	63	72 N	54
Alkalinity †	mg/L		39.8	34.5	37.2	36.6
Bicarbonate †	mg CaCO3/L		36.9	34.5	37.2	35.4
Ammonia as nitrogen	mg/L		0.01 U	0.01 U	0.01	0.01 U
Nitrate as nitrogen	mg/L	*10	0.42	0.42	0.42	0.41
Nitrite as nitrogen	mg/L		0.1 U	0.1 U	0.1 U	0.1 U
Chloride	mg/L	**250	4.1	5.6	4.5	3.7
Sulfate	mg/L	**250	2.1	1.8	1.9	2.9
pH	SU	**6.5-8.5	6.76	6.71	**6.4**	6.76
Specific Conductance	µS/cm		87	90	94	0.094
Temperature	°C		8.92	9.09	9.52	8.71
METALS						
Dissolved Barium †	mg/L	*1.0	0.0047	0.005	0.006	0.0051
Dissolved Iron	mg/L	**0.3	0.05 U	0.05 U	0.05 U	0.05 U
Dissolved Manganese	mg/L	**0.05	0.001 U	0.001 U	0.001 U	0.001 U
Dissolved Vanadium †	mg/L		0.01 U	0.01 U	0.01 U	0.01 U
Dissolved Zinc	mg/L	**5.0	0.05 U	0.05 U	0.05 U	0.05 U
Total Calcium †	mg/L		13	11.2	12.1	11.5
Total Magnesium †	mg/L		2.84	2.42	2.61	2.43
Total Potassium †	mg/L		0.69	0.5 U	0.58	0.5
Total Sodium †	mg/L		2.56	1.3	2.24	2.15

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen

Units:

mg/L = milligrams per liter
µg/L = micrograms per liter
SU = standard units
µS/cm = microsiemens per centimeter
C = degrees centigrade
mg CaCO3/L = milligrams of calcium carbonate per liter

Qualifiers:

U Indicates the analyte of interest was not detected, to the limit of detection indicated.

J Indicates the analyte of interest was detected below the routine reporting limit and should be regarded as an estimate.

NT Not tested.

N The result could be biased high by 10 mg/L

Results shown in bold exceed Ground Water Quality Criteria.

† Indicates supplement analytes measured due to Ecology request

2018 Inorganic Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-2 3/16/2018	MW-2 6/28/2018	MW-2 9/13/2018	MW-2 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
CONVENTIONALS						
Chemical Oxygen Demand	mg/L		8 U	20 U	20 U	20 U
Total Organic Carbon	mg/L		3.43	0.15 U	0.15 U	0.15 U
Total Dissolved Solids †	mg/L	**500	58	106	112	103
Alkalinity †	mg/L		65.4	59.7	59.8	59.7
Bicarbonate †	mg CaCO3/L		61.3	59.7	59.8	59.9
Ammonia as nitrogen	mg/L		0.01 U	0.01 U	0.01 U	0.01 U
Nitrate as nitrogen	mg/L	*10	1.88	1.37	1.7	1.99
Nitrite as nitrogen	mg/L		0.1 U	0.1 U	0.1 U	0.1 U
Chloride	mg/L	**250	5.7	5.6	6.1	7.3
Sulfate	mg/L	**250	3	3.1	2.7	2.8
pH	SU	**6.5-8.5	6.67	6.71	**6.24**	6.75
Specific Conductance	µS/cm		165	143	152	0.171
Temperature	°C		8.67	9.59	9.29	8.63
METALS						
Dissolved Barium †	mg/L	*1.0	0.021	0.022	0.021	0.022
Dissolved Iron	mg/L	**0.3	0.05 U	0.05 U	0.05 U	0.05 U
Dissolved Manganese	mg/L	**0.05	0.001 U	0.001 U	0.001 U	0.001 U
Dissolved Vanadium †	mg/L		0.01 U	0.01 U	0.01 U	0.01 U
Dissolved Zinc	mg/L	**5.0	0.05 U	0.05 U	0.05 U	0.05 U
Total Calcium †	mg/L		22.9	18.2	18.9	20.4
Total Magnesium †	mg/L		5.67	4.42	4.74	5.05
Total Potassium †	mg/L		1.12	0.7	0.77	0.73
Total Sodium †	mg/L		4.85	3.22	3.97	4.12

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen

Units:

mg/L = milligrams per liter
µg/L = micrograms per liter
SU = standard units
µS/cm = microsiemens per centimeter
C = degrees centigrade
mg CaCO3/L = milligrams of calcium carbonate per liter

Qualifiers:

U Indicates the analyte of interest was not detected, to the limit of detection indicated.
J Indicates the analyte of interest was detected below the routine reporting limit and should be regarded as an estimate.
NT Not tested.

Results shown in bold exceed Ground Water Quality Criteria.
† Indicates supplement analytes measured due to Ecology request

2018 Inorganic Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-3 3/16/2018	MW-3 6/28/2018	MW-3 9/13/2018	MW-3 12/7/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
CONVENTIONALS						
Chemical Oxygen Demand	mg/L		8 U	20 U	20 U	20 U
Total Organic Carbon	mg/L		1.64	0.15 U	0.15 U	0.15 U
Total Dissolved Solids †	mg/L	**500	55	54	62 N	57
Alkalinity †	mg/L		37.2	34.6	36.7	36.4
Bicarbonate †	mg CaCO3/L		36.1	34.6	36.7	37.6
Ammonia as nitrogen	mg/L		0.01 U	0.01 U	0.01 U	0.05 U
Nitrate as nitrogen	mg/L	*10	0.48	0.36	0.32	0.34
Nitrite as nitrogen	mg/L		0.1 U	0.1 U	0.1 U	0.1 U
Chloride	mg/L	**250	2.8	1.9	2.7	3.2
Sulfate	mg/L	**250	2	2.2	2.2	2.1
pH	SU	**6.5-8.5	**6.37**	6.56	**6.44**	7.89
Specific Conductance	µS/cm		97	91	86	0.096
Temperature	°C		9.14	10.31	9.25	8.9
METALS						
Dissolved Barium †	mg/L	*1.0	0.0054	0.005	0.005	0.006
Dissolved Iron	mg/L	**0.3	0.05 U	0.05 U	0.05 U	0.05 U
Dissolved Manganese	mg/L	**0.05	0.001 U	0.001 U	0.001 U	0.001 U
Dissolved Vanadium †	mg/L		0.01 U	0.01 U	0.01 U	0.01 U
Dissolved Zinc	mg/L	**5.0	0.05 U	0.05 U	0.05 U	0.05 U
Total Calcium †	mg/L		13.8	10.4	12.1	14
Total Magnesium †	mg/L		2.06	1.55	1.84	2.08
Total Potassium †	mg/L		0.68	0.5 U	0.42	0.62
Total Sodium †	mg/L		2.75	1.06	2.02	2.22

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen

Units:

mg/L = milligrams per liter
µg/L = micrograms per liter
SU = standard units
µS/cm = microsiemens per centimeter
C = degrees centigrade
mg CaCO3/L = milligrams of calcium carbonate per liter

Qualifiers:

U Indicates the analyte of interest was not detected, to the limit of detection indicated.

J Indicates the analyte of interest was detected below the routine reporting limit and should be regarded as an estimate.

NT Not tested.

Results shown in bold exceed Ground Water Quality Criteria.

† Indicates supplement analytes measured due to Ecology request

2018 Inorganic Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-4 3/16/2018	MW-4 6/28/2018	MW-4 9/13/2018	MW-4 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
CONVENTIONALS						
Chemical Oxygen Demand	mg/L		8 U	20 U	20 U	20 U
Total Organic Carbon	mg/L		1.28	0.15 U	0.15 U	0.15 U
Total Dissolved Solids †	mg/L	**500	31	101	124	82
Alkalinity †	mg/L		22.8	19.1	21	20.4
Bicarbonate †	mg CaCO3/L		23.8	19.1	21	22.2
Ammonia as nitrogen	mg/L		0.01 U	0.01 U	0.01 U	0.01 U
Nitrate as nitrogen	mg/L	*10	0.41	0.68	0.75	0.51
Nitrite as nitrogen	mg/L		0.1 U	0.1 U	0.1 U	0.1 U
Chloride	mg/L	**250	15.2	22.8	29.1	18.5
Sulfate	mg/L	**250	1.4	1.2	1.2	1.8
pH	SU	**6.5-8.5	**6.17**	6.76	**6.12**	6.7
Specific Conductance	µS/cm		91	90	139	0.118
Temperature	°C		8.31	8.76	9.66	7.6
METALS						
Dissolved Barium †	mg/L	*1.0	0.0066	0.009	0.01	0.0072
Dissolved Iron	mg/L	**0.3	0.05 U	0.05 U	0.05 U	0.05 U
Dissolved Manganese	mg/L	**0.05	0.001 U	0.001 U	0.001 U	0.001 U
Dissolved Vanadium †	mg/L		0.01 U	0.01 U	0.01 U	0.01 U
Dissolved Zinc	mg/L	**5.0	0.05 U	0.05 U	0.05 U	0.05 U
Total Calcium †	mg/L		11.3	11.8	14.1	11.5
Total Magnesium †	mg/L		2.06	2.08	2.59	2.05
Total Potassium †	mg/L		0.73	0.53	0.71	0.59
Total Sodium †	mg/L		6.68	5.38	7.33	6.16

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen

Units:

mg/L = milligrams per liter
µg/L = micrograms per liter
SU = standard units
µS/cm = microsiemens per centimeter
C = degrees centigrade
mg CaCO3/L = milligrams of calcium carbonate per liter

Qualifiers:

U Indicates the analyte of interest was not detected, to the limit of detection indicated.

J Indicates the analyte of interest was detected below the routine reporting limit and should be regarded as an estimate.

NT Not tested.

Results shown in bold exceed Ground Water Quality Criteria.

† Indicates supplement analytes measured due to Ecology request

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-1 3/16/2018	MW-1 6/28/2018	MW-1 9/13/2018	MW-1 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
1,1,1,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,1-trichloroethane	µg/L	200*	0.4 U	0.4 U	0.4 U	0.4 U
1,1,2,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichlorofluorotoluene (Freon-113)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethane	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethene	µg/L	7****	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dibromo-3-chloropropane (DBCP)	µg/L	0.2****	1 U	1 U	1 U	1 U
1,2-dibromoethane (EDB)	µg/L	0.001***	0.01 U	0.01 U	0.01 U	0.01 U
1,2-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloroethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloropropane	µg/L	0.6***	0.4 U	0.4 U	0.4 U	0.4 U
1,3,5-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,3-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,4-dichlorobenzene	µg/L	4***	0.4 U	0.4 U	0.4 U	0.4 U
1,4-dioxane	µg/L	7***	5 U	5 U	5 U	5 U
2,2-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-butanone	µg/L		3 U	3 U	3 U	3 U
2-chloroethyl vinyl ether	µg/L		2 U	2 U	2 U	2 U
2-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-nitropropane	µg/L		10 U	10 U	10 U	10 U
2-phenylbutane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-methyl-2-pentanone	µg/L		4 U	4 U	4 U	4 U
Acetone	µg/L		3 U	3 U	3 U	3 U
Acrolein	µg/L		4 U	4 U	4 U	4 U
Acrylonitrile	µg/L	0.07***	0.05 U	0.05 U	0.05 U	0.05 U
Allyl chloride	µg/L		2 U	2 U	2 U	2 U
Benzene	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
Bromobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Bromodichloromethane	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Bromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon disulfide	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon tetrachloride	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobenzene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chlorodibromomethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorodifluoromethane (Freon-22)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroform	µg/L	7.0***	0.4 U	0.4 U	0.4 U	0.4 U
Chloromethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
cis-1,2-dichloroethene	µg/L	70****	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Cymene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dibromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL / Sampling Date			MW-1 3/16/2018	MW-1 6/28/2018	MW-1 9/13/2018	MW-1 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
Dichlorodifluoromethane (CFC-12)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dichloromethane	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Dichloromonofluoromethane (Freon-21)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Diethyl ether	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Ethyl methacrylate	µg/L		3 U	3 U	3 U	3 U
Ethylbenzene	µg/L	700****	0.4 U	0.4 U	0.4 U	0.4 U
Hexachloro-1,3-butadiene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Hexachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Isopropylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m+p-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Methyl acrylate	µg/L		2 U	2 U	2 U	2 U
Methyl iodide	µg/L		5 U	5 U	5 U	5 U
Methyl methacrylate	µg/L		2 U	2 U	2 U	2 U
Methyl n-butyl ketone	µg/L		5 U	5 U	5 U	5 U
Methyl tert-butyl ether	µg/L		1 U	1 U	1 U	1 U
Methylacrylonitrile	µg/L		4 U	4 U	4 U	4 U
Naphthalene	µg/L		1 U	1 U	1 U	1 U
n-butyl chloride	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-propylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
o-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Pentachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Styrene (monomer)	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Tert-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Tetrachloroethene	µg/L	0.8***	0.4 U	0.4 U	0.4 U	0.4 U
Tetrahydrofuran	µg/L		3 U	3 U	3 U	3 U
Toluene	µg/L	1****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,2-dichloroethene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,4-dichlorobutene	µg/L		5 U	5 U	5 U	5 U
Tribromomethane (Bromoform)	µg/L	5***	5 U	0.4 U	0.4 U	0.4 U
Trichloroethene	µg/L	3***	0.4 U	0.4 U	0.4 U	0.4 U
Trichlorofluoromethane (CFC-11)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Vinyl chloride	µg/L	0.02***	0.01 U	0.01 U	0.01 U	0.01 U

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen
**** = 246-290 WAC criteria

Units:

µg/L= micrograms per liter

Qualifiers:

U — Indicates the analyte of interest was not detected, to the limit of detection indicated.

J — Indicates the analyte of interest was detected below the routine reporting limit. This value should be regarded as an estimate.

Results shown in bold exceed Ground Water Quality Criteria.

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-2 3/16/2018	MW-2 6/28/2018	MW-2 9/13/2018	MW-2 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
1,1,1,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,1-trichloroethane	µg/L	200*	0.4 U	0.4 U	0.4 U	0.4 U
1,1,2,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichlorofluorotoluene (Freon-113)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethane	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethene	µg/L	7****	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dibromo-3-chloropropane (DBCP)	µg/L	0.2****	1 U	1 U	1 U	1 U
1,2-dibromoethane (EDB)	µg/L	0.001***	0.01 U	0.01 U	0.01 U	0.01 U
1,2-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloroethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloropropane	µg/L	0.6***	0.4 U	0.4 U	0.4 U	0.4 U
1,3,5-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,3-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,4-dichlorobenzene	µg/L	4***	0.4 U	0.4 U	0.4 U	0.4 U
1,4-dioxane	µg/L	7***	5 U	5 U	5 U	5 U
2,2-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-butanone	µg/L		3 U	3 U	3 U	3 U
2-chloroethyl vinyl ether	µg/L		2 U	2 U	2 U	2 U
2-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-nitropropane	µg/L		10 U	10 U	10 U	10 U
2-phenylbutane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-methyl-2-pentanone	µg/L		4 U	4 U	4 U	4 U
Acetone	µg/L		3 U	3 U	3 U	3 U
Acrolein	µg/L		4 U	4 U	4 U	4 U
Acrylonitrile	µg/L	0.07***	0.05 U	0.05 U	0.05 U	0.05 U
Allyl chloride	µg/L		2 U	2 U	2 U	2 U
Benzene	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
Bromobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Bromodichloromethane	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Bromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon disulfide	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon tetrachloride	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobenzene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chlorodibromomethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorodifluoromethane (Freon-22)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroform	µg/L	7.0***	0.4 U	0.4 U	0.4 U	0.4 U
Chloromethane	µg/L		0.4 U	0.4 U	0.4 U	0.5
cis-1,2-dichloroethene	µg/L	70****	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Cymene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dibromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-2 3/16/2018	MW-2 6/28/2018	MW-2 9/13/2018	MW-2 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
Dichlorodifluoromethane (CFC-12)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dichloromethane	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Dichloromonofluoromethane (Freon-21)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Diethyl ether	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Ethyl methacrylate	µg/L		3 U	3 U	3 U	3 U
Ethylbenzene	µg/L	700****	0.4 U	0.4 U	0.4 U	0.4 U
Hexachloro-1,3-butadiene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Hexachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Isopropylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m+p-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Methyl acrylate	µg/L		2 U	2 U	2 U	2 U
Methyl iodide	µg/L		5 U	5 U	5 U	5 U
Methyl methacrylate	µg/L		2 U	2 U	2 U	2 U
Methyl n-butyl ketone	µg/L		5 U	5 U	5 U	5 U
Methyl tert-butyl ether	µg/L		1 U	1 U	1 U	1 U
Methylacrylonitrile	µg/L		4 U	4 U	4 U	4 U
Naphthalene	µg/L		1 U	1 U	1 U	1 U
n-butyl chloride	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-propylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
o-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Pentachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Styrene (monomer)	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Tert-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Tetrachloroethene	µg/L	0.8***	0.4 U	0.4 U	0.4 U	0.4 U
Tetrahydrofuran	µg/L		3 U	3 U	3 U	3 U
Toluene	µg/L	1****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,2-dichloroethene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,4-dichlorobutene	µg/L		5 U	5 U	5 U	5 U
Tribromomethane (Bromoform)	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Trichloroethene	µg/L	3***	0.4 U	0.4 U	0.4 U	0.4 U
Trichlorofluoromethane (CFC-11)	µg/L		0.3 J	0.4 U	0.3 J	0.3 J
Vinyl chloride	µg/L	0.02***	0.01 U	0.01 U	0.01 U	0.01 U

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen
**** = 246-290 WAC criteria

Units:

µg/L= micrograms per liter

Qualifiers:

U — Indicates the analyte of interest was not detected, to the limit of detection indicated.

J — Indicates the analyte of interest was detected below the routine reporting limit. This value should be regarded as an estimate.

Results shown in bold exceed Ground Water Quality Criteria.

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-3 3/16/2018	MW-3 6/28/2018	MW-3 9/13/2018	MW-3 12/7/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
1,1,1,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,1-trichloroethane	µg/L	200*	0.4 U	0.4 U	0.4 U	0.4 U
1,1,2,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichlorofluorotoluene (Freon-113)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethane	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethene	µg/L	7****	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichlorobenzene	µg/L		0	0.4 U	0.4 U	0.4 U
1,2,3-trichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dibromo-3-chloropropane (DBCP)	µg/L	0.2****	1 U	1 U	1 U	1 U
1,2-dibromoethane (EDB)	µg/L	0.001***	0.01 U	0.01 U	0.01 U	0.01 U
1,2-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloroethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloropropane	µg/L	0.6***	0.4 U	0.4 U	0.4 U	0.4 U
1,3,5-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,3-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,4-dichlorobenzene	µg/L	4***	0.4 U	0.4 U	0.4 U	0.4 U
1,4-dioxane	µg/L	7***	5 U	5 U	5 U	5 U
2,2-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-butanone	µg/L		3 U	3 U	3 U	3 U
2-chloroethyl vinyl ether	µg/L		2 U	2 U	2 U	2 U
2-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-nitropropane	µg/L		10 U	10 U	10 U	10 U
2-phenylbutane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-methyl-2-pentanone	µg/L		4 U	4 U	4 U	4 U
Acetone	µg/L		3 U	3 U	3 U	3 U
Acrolein	µg/L		4 U	4 U	4 U	4 U
Acrylonitrile	µg/L	0.07***	0.05 U	0.05 U	0.05 U	0.05 U
Allyl chloride	µg/L		2 U	2 U	2 U	2 U
Benzene	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
Bromobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Bromodichloromethane	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Bromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon disulfide	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon tetrachloride	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobenzene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chlorodibromomethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorodifluoromethane (Freon-22)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroform	µg/L	7.0***	0.4 U	0.4 U	0.4 U	0.4 U
Chloromethane	µg/L		0.4 U	0.4 U	0.4 U	0.4
cis-1,2-dichloroethene	µg/L	70****	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Cymene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dibromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-3 3/16/2018	MW-3 6/28/2018	MW-3 9/13/2018	MW-3 12/7/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
Dichlorodifluoromethane (CFC-12)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dichloromethane	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Dichloromonofluoromethane (Freon-21)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Diethyl ether	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Ethyl methacrylate	µg/L		3 U	3 U	3 U	3 U
Ethylbenzene	µg/L	700****	0.4 U	0.4 U	0.4 U	0.4 U
Hexachloro-1,3-butadiene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Hexachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Isopropylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m+p-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Methyl acrylate	µg/L		2 U	2 U	2 U	2 U
Methyl iodide	µg/L		5 U	5 U	5 U	5 U
Methyl methacrylate	µg/L		2 U	2 U	2 U	2 U
Methyl n-butyl ketone	µg/L		5 U	5 U	5 U	5 U
Methyl tert-butyl ether	µg/L		1 U	1 U	1 U	1 U
Methylacrylonitrile	µg/L		4 U	4 U	4 U	4 U
Naphthalene	µg/L		1 U	1 U	1 U	1 U
n-butyl chloride	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-propylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
o-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Pentachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Styrene (monomer)	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Tert-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Tetrachloroethene	µg/L	0.8***	0.4 U	0.4 U	0.4 U	0.4 U
Tetrahydrofuran	µg/L		3 U	3 U	3 U	3 U
Toluene	µg/L	1****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,2-dichloroethene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,4-dichlorobutene	µg/L		5 U	5 U	5 U	5 U
Tribromomethane (Bromoform)	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Trichloroethene	µg/L	3***	0.4 U	0.4 U	0.4 U	0.4 U
Trichlorofluoromethane (CFC-11)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Vinyl chloride	µg/L	0.02***	0.01 U	0.01 U	0.01 U	0.01 U

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen
**** = 246-290 WAC criteria

Units:

µg/L= micrograms per liter

Qualifiers:

U — Indicates the analyte of interest was not detected, to the limit of detection indicated.

J — Indicates the analyte of interest was detected below the routine reporting limit. This value should be regarded as an estimate.

Results shown in bold exceed Ground Water Quality Criteria.

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL			MW-4	MW-4	MW-4	MW-4
Sampling Date			3/16/2018	6/28/2018	9/13/2018	12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
1,1,1,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,1-trichloroethane	µg/L	200*	0.4 U	0.4 U	0.4 U	0.4 U
1,1,2,2-tetrachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1,2-trichlorofluorotoluene (Freon-113)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethane	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloroethene	µg/L	7****	0.4 U	0.4 U	0.4 U	0.4 U
1,1-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,3-trichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2,4-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dibromo-3-chloropropane (DBCP)	µg/L	0.2****	1 U	1 U	1 U	1 U
1,2-dibromoethane (EDB)	µg/L	0.001***	0.01 U	0.01 U	0.01 U	0.01 U
1,2-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloroethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
1,2-dichloropropane	µg/L	0.6***	0.4 U	0.4 U	0.4 U	0.4 U
1,3,5-trimethylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,3-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
1,4-dichlorobenzene	µg/L	4***	0.4 U	0.4 U	0.4 U	0.4 U
1,4-dioxane	µg/L	7***	5 U	5 U	5 U	5 U
2,2-dichloropropane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-butanone	µg/L		3 U	3 U	3 U	3 U
2-chloroethyl vinyl ether	µg/L		2 U	2 U	2 U	2 U
2-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
2-nitropropane	µg/L		10 U	10 U	10 U	10 U
2-phenylbutane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-chlorotoluene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
4-methyl-2-pentanone	µg/L		4 U	4 U	4 U	4 U
Acetone	µg/L		3 U	3 U	3 U	3 U
Acrolein	µg/L		4 U	4 U	4 U	4 U
Acrylonitrile	µg/L	0.07***	0.05 U	0.05 U	0.05 U	0.05 U
Allyl chloride	µg/L		2 U	2 U	2 U	2 U
Benzene	µg/L	1.0***	0.4 U	0.4 U	0.4 U	0.4 U
Bromobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Bromodichloromethane	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Bromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon disulfide	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Carbon tetrachloride	µg/L	0.3***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobenzene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Chlorobromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chlorodibromomethane	µg/L	0.5***	0.4 U	0.4 U	0.4 U	0.4 U
Chlorodifluoromethane (Freon-22)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Chloroform	µg/L	7.0***	0.4 U	0.4 U	0.4 U	0.4 U
Chloromethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
cis-1,2-dichloroethene	µg/L	70****	0.4 U	0.4 U	0.4 U	0.4 U
cis-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Cymene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dibromomethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U

2018 Volatile Organic Compound Monitoring Results
Sauk Landfill

MONITORING WELL Sampling Date			MW-4 3/16/2018	MW-4 6/28/2018	MW-4 9/13/2018	MW-4 12/6/2018
Analyte	Units	GW Quality Standards (173-200 WAC)				
Dichlorodifluoromethane (CFC-12)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Dichloromethane	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Dichloromonofluoromethane (Freon-21)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Diethyl ether	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Ethyl methacrylate	µg/L		3 U	3 U	3 U	3 U
Ethylbenzene	µg/L	700****	0.4 U	0.4 U	0.4 U	0.4 U
Hexachloro-1,3-butadiene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Hexachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Isopropylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m+p-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
m-dichlorobenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Methyl acrylate	µg/L		2 U	2 U	2 U	2 U
Methyl iodide	µg/L		5 U	5 U	5 U	5 U
Methyl methacrylate	µg/L		2 U	2 U	2 U	2 U
Methyl n-butyl ketone	µg/L		5 U	5 U	5 U	5 U
Methyl tert-butyl ether	µg/L		1 U	1 U	1 U	1 U
Methylacrylonitrile	µg/L		4 U	4 U	4 U	4 U
Naphthalene	µg/L		1 U	1 U	1 U	1 U
n-butyl chloride	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
n-propylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
o-xylene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Pentachloroethane	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Styrene (monomer)	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Tert-butylbenzene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Tetrachloroethene	µg/L	0.8***	0.4 U	0.4 U	0.4 U	0.4 U
Tetrahydrofuran	µg/L		3 U	3 U	3 U	3 U
Toluene	µg/L	1****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,2-dichloroethene	µg/L	100****	0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,3-dichloropropene	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Trans-1,4-dichlorobutene	µg/L		5 U	5 U	5 U	5 U
Tribromomethane (Bromoform)	µg/L	5***	0.4 U	0.4 U	0.4 U	0.4 U
Trichloroethene	µg/L	3***	0.4 U	0.4 U	0.4 U	0.4 U
Trichlorofluoromethane (CFC-11)	µg/L		0.4 U	0.4 U	0.4 U	0.4 U
Vinyl chloride	µg/L	0.02***	0.01 U	0.01 U	0.01 U	0.01 U

Groundwater Quality Criteria:

* = Primary Contaminant
** = Secondary Contaminant
*** = Carcinogen
**** = 246-290 WAC criteria

Units:

µg/L= micrograms per liter

Qualifiers:

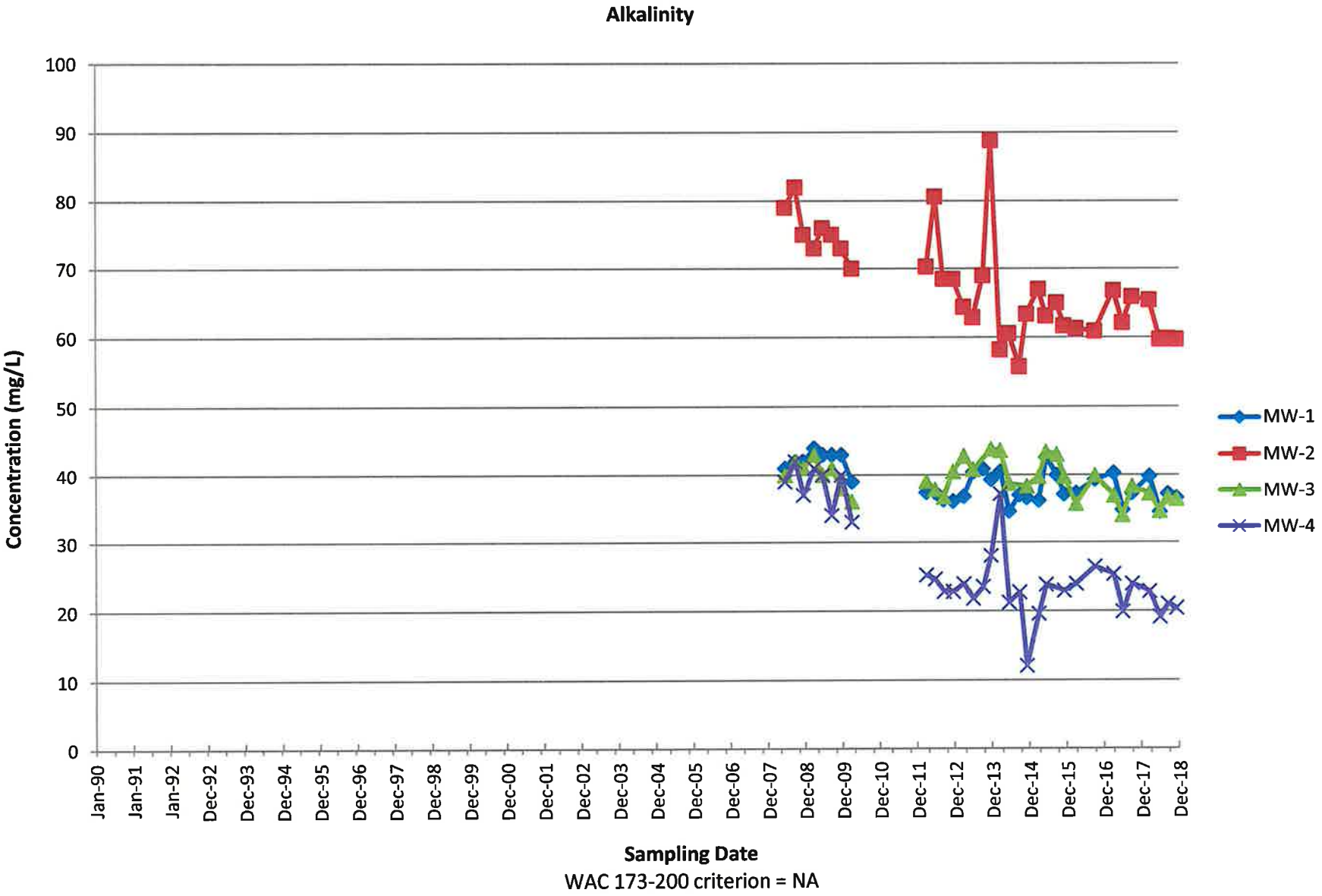
U — Indicates the analyte of interest was not detected, to the limit of detection indicated.

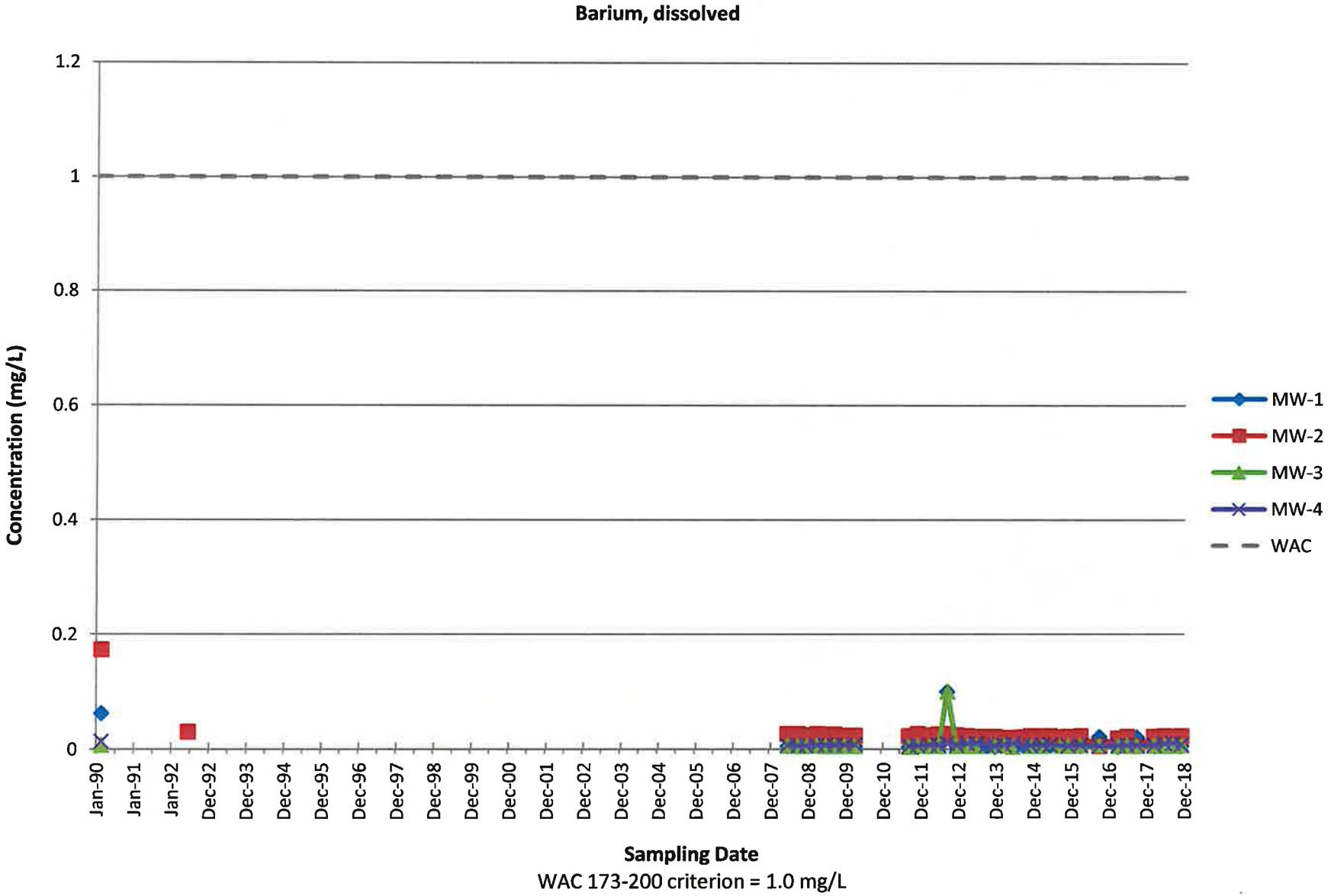
J — Indicates the analyte of interest was detected below the routine reporting limit. This value should be regarded as an estimate.

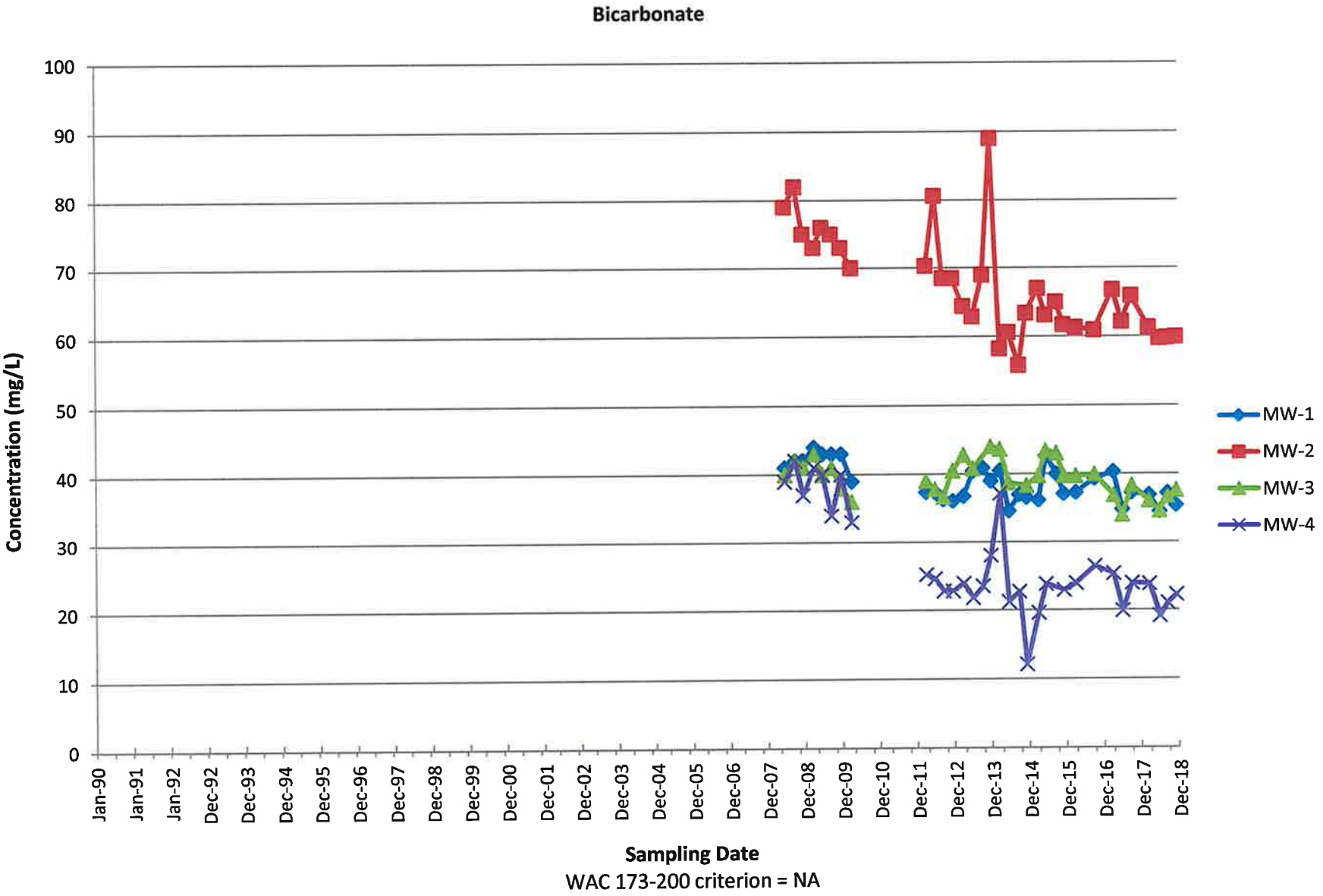
Results shown in bold exceed Ground Water Quality Criteria.

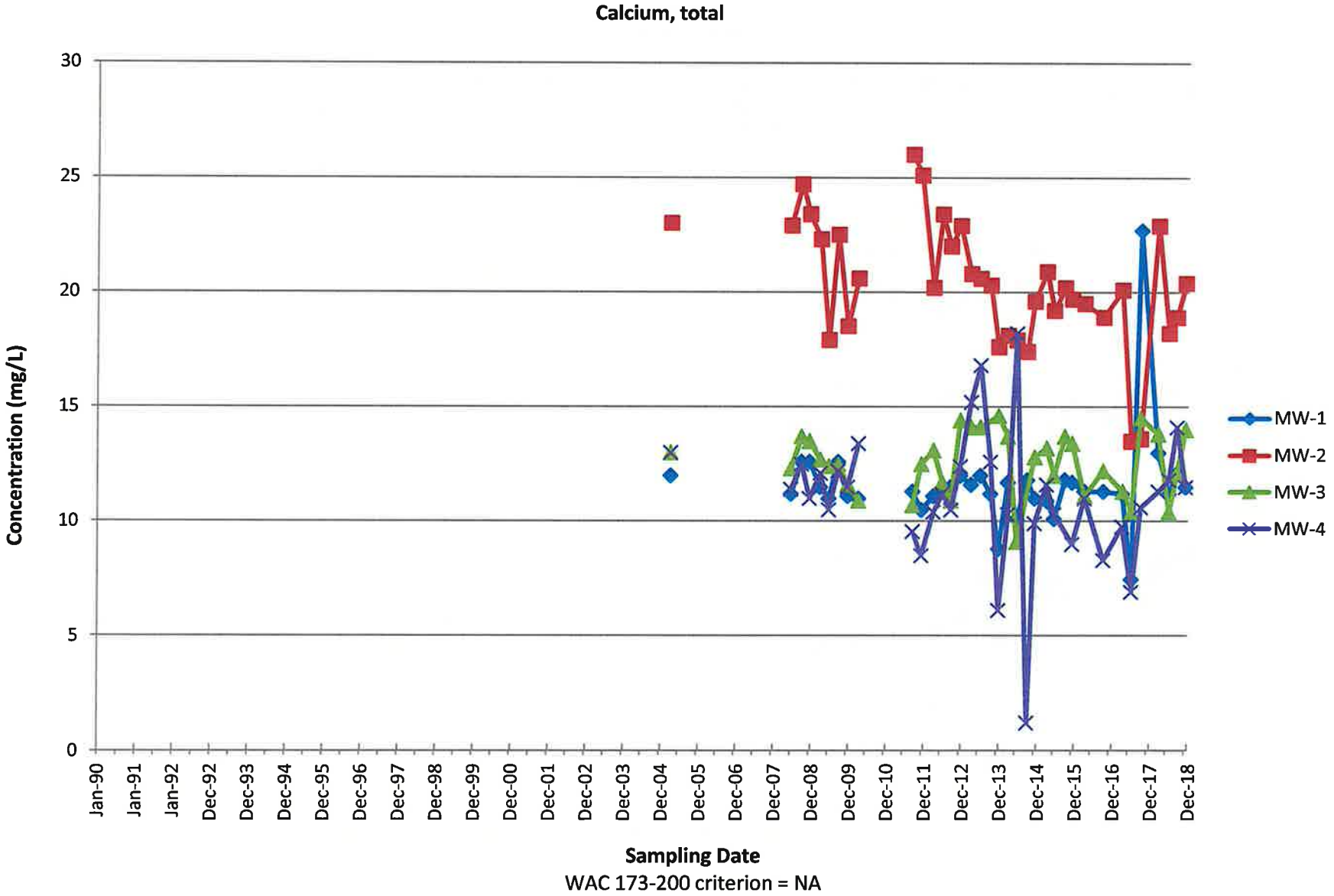
APPENDIX B

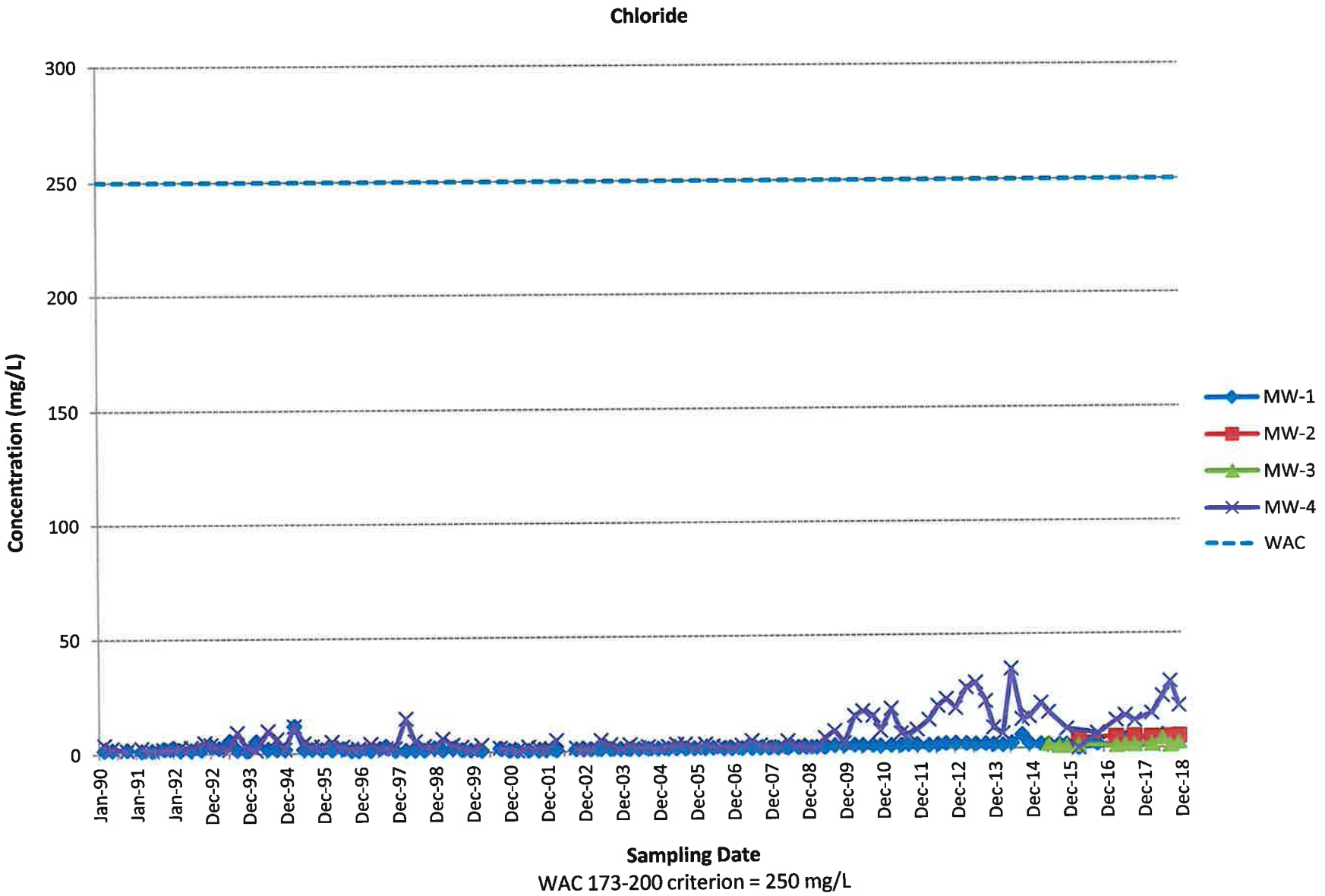
TIME-SERIES PLOTS 1990 – 2018

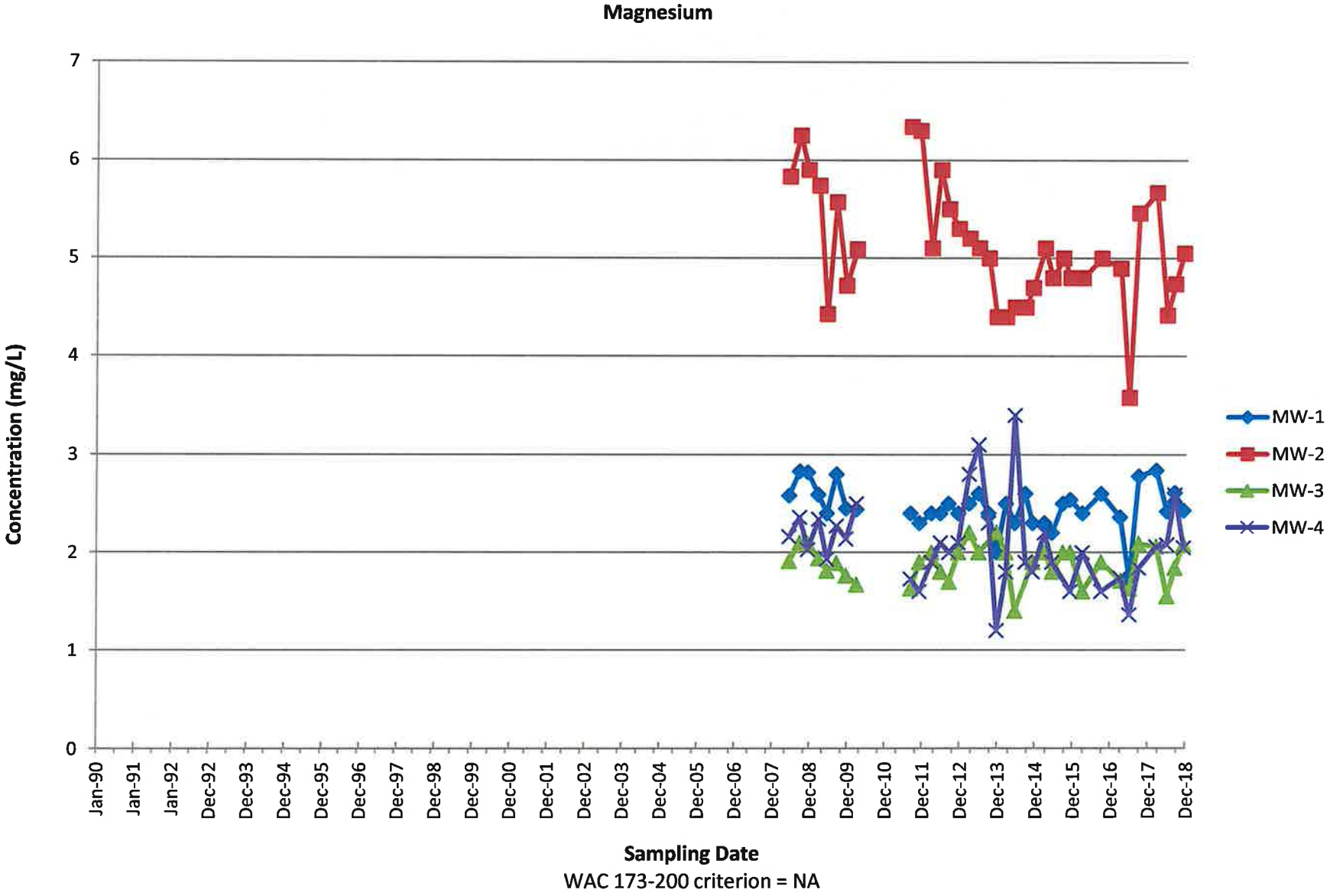

Alkalinity
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
Sampling Date
WAC 173-200 criterion = NA


Barium, dissolved
1.2
1
0.8
0.6
0.4
0.2
0
Concentration (mg/L)
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
Sampling Date
MW-1
MW-2
MW-3
MW-4
WAC
WAC 173-200 criterion = 1.0 mg/L

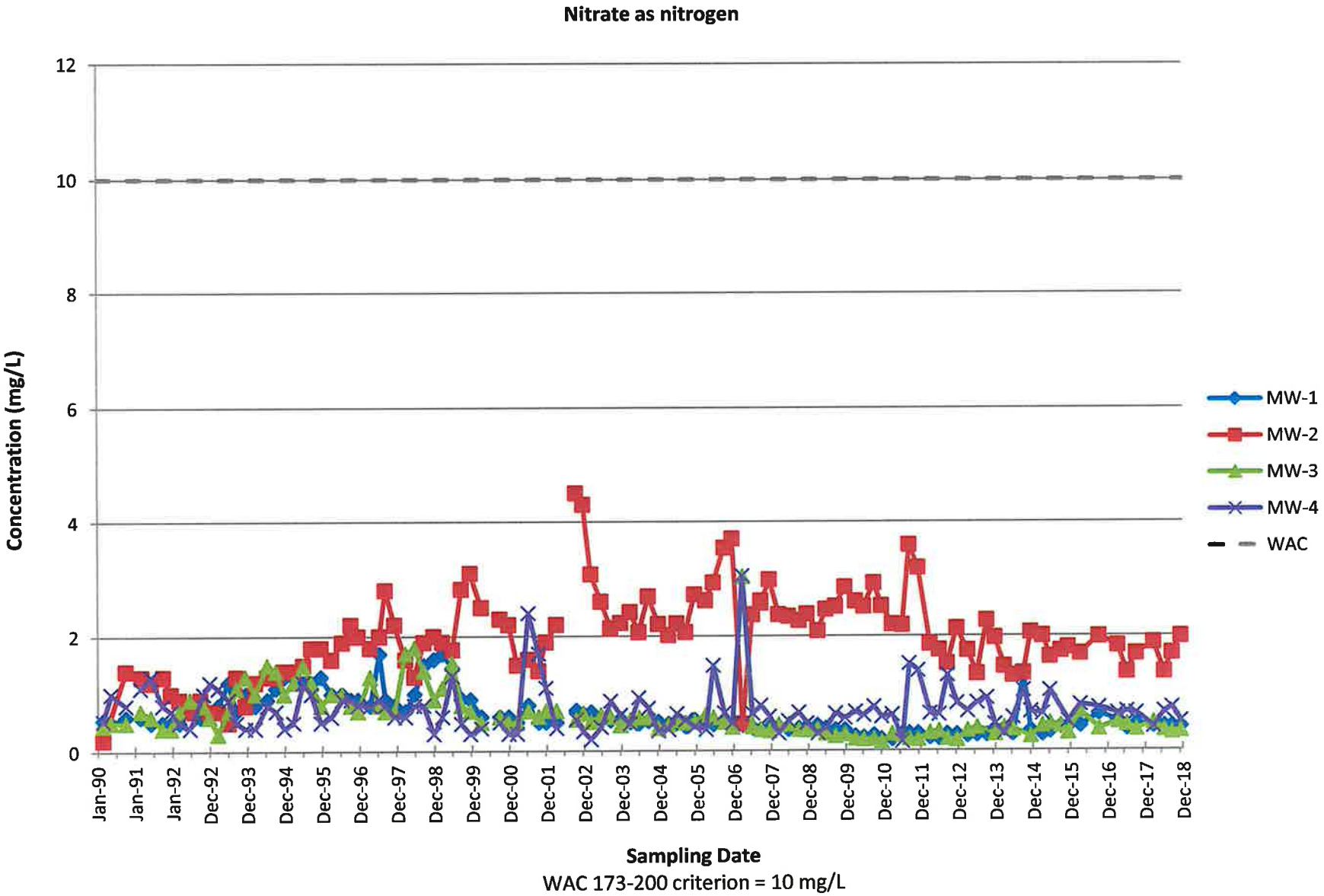

Bicarbonate
Concentration (mg/L)
100
90
80
70
60
50
40
30
20
10
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
Sampling Date
WAC 173-200 criterion = NA

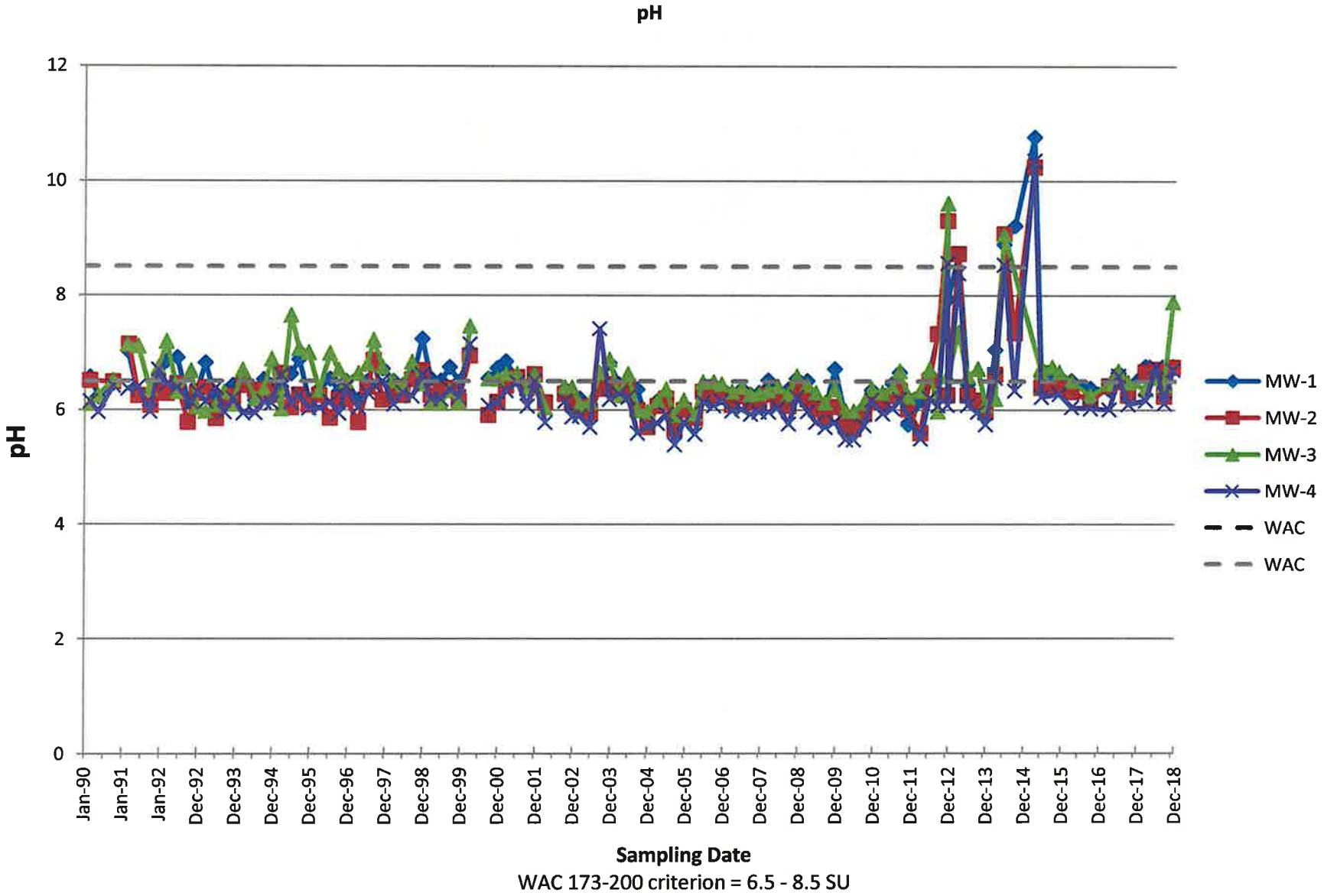

Calcium, total
Concentration (mg/L)
30
25
20
15
10
5
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
Sampling Date
WAC 173-200 criterion = NA

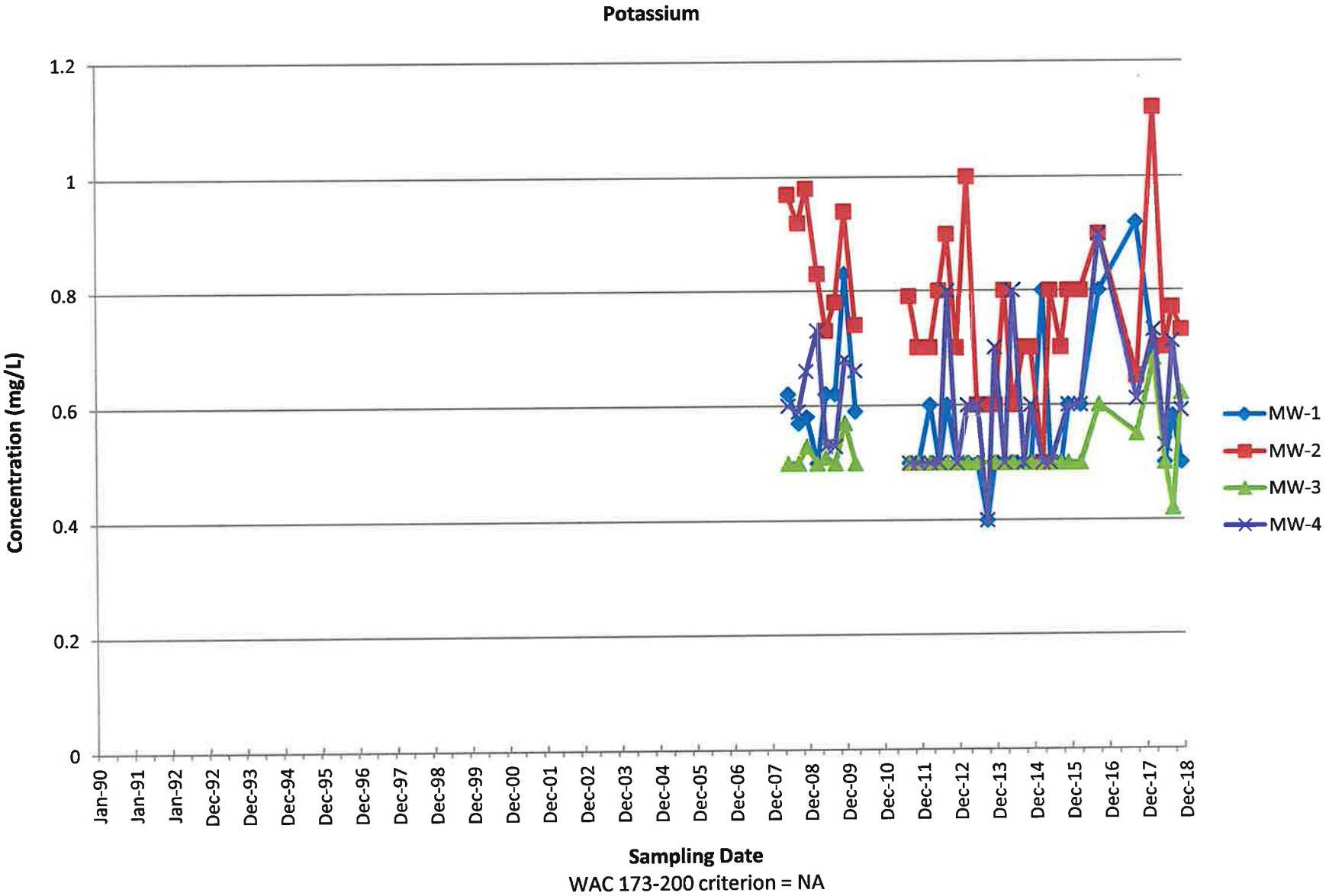

Chloride
300
250
200
150
100
50
0
Concentration (mg/L)
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
Sampling Date
MW-1
MW-2
MW-3
MW-4
WAC
WAC 173-200 criterion = 250 mg/L

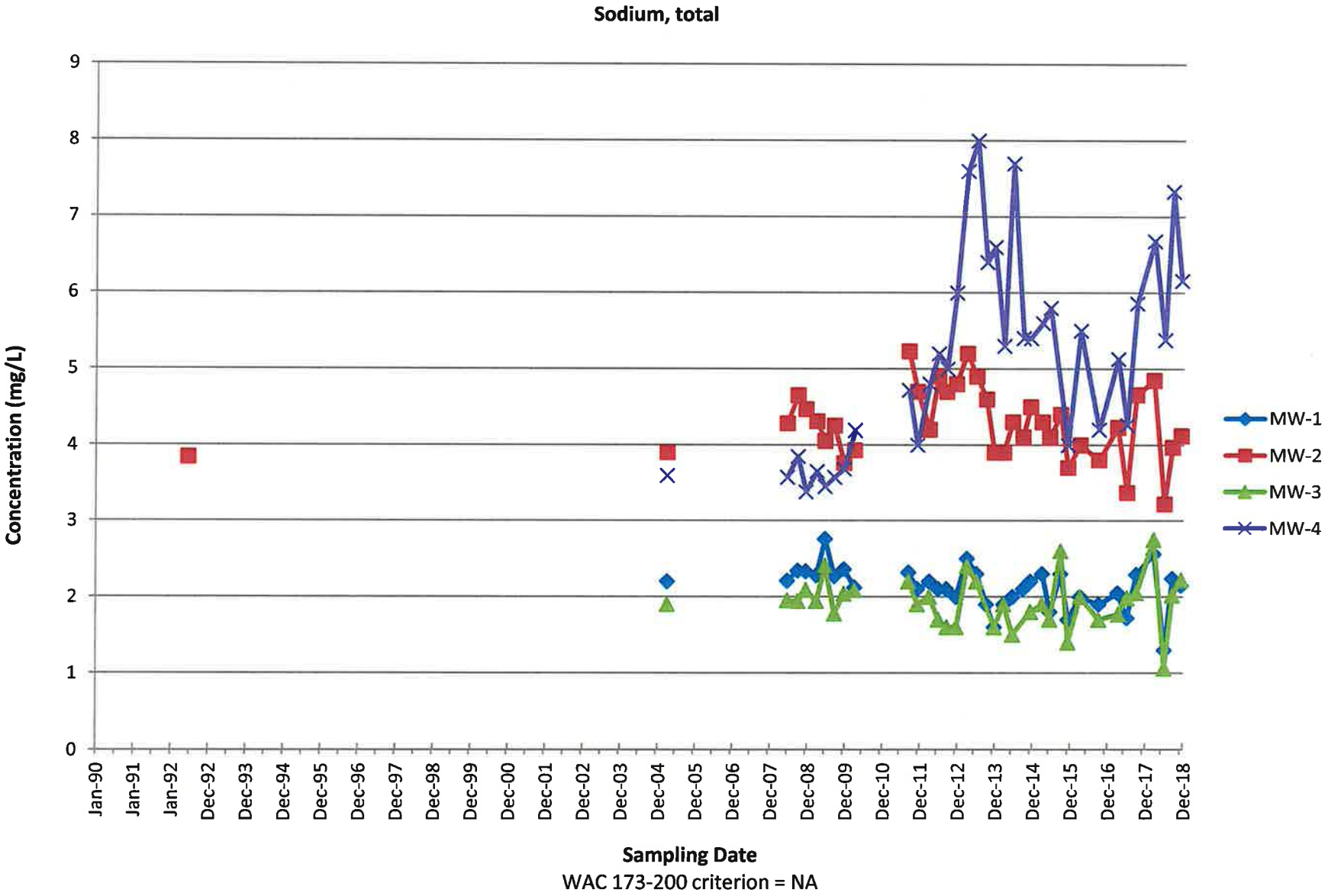


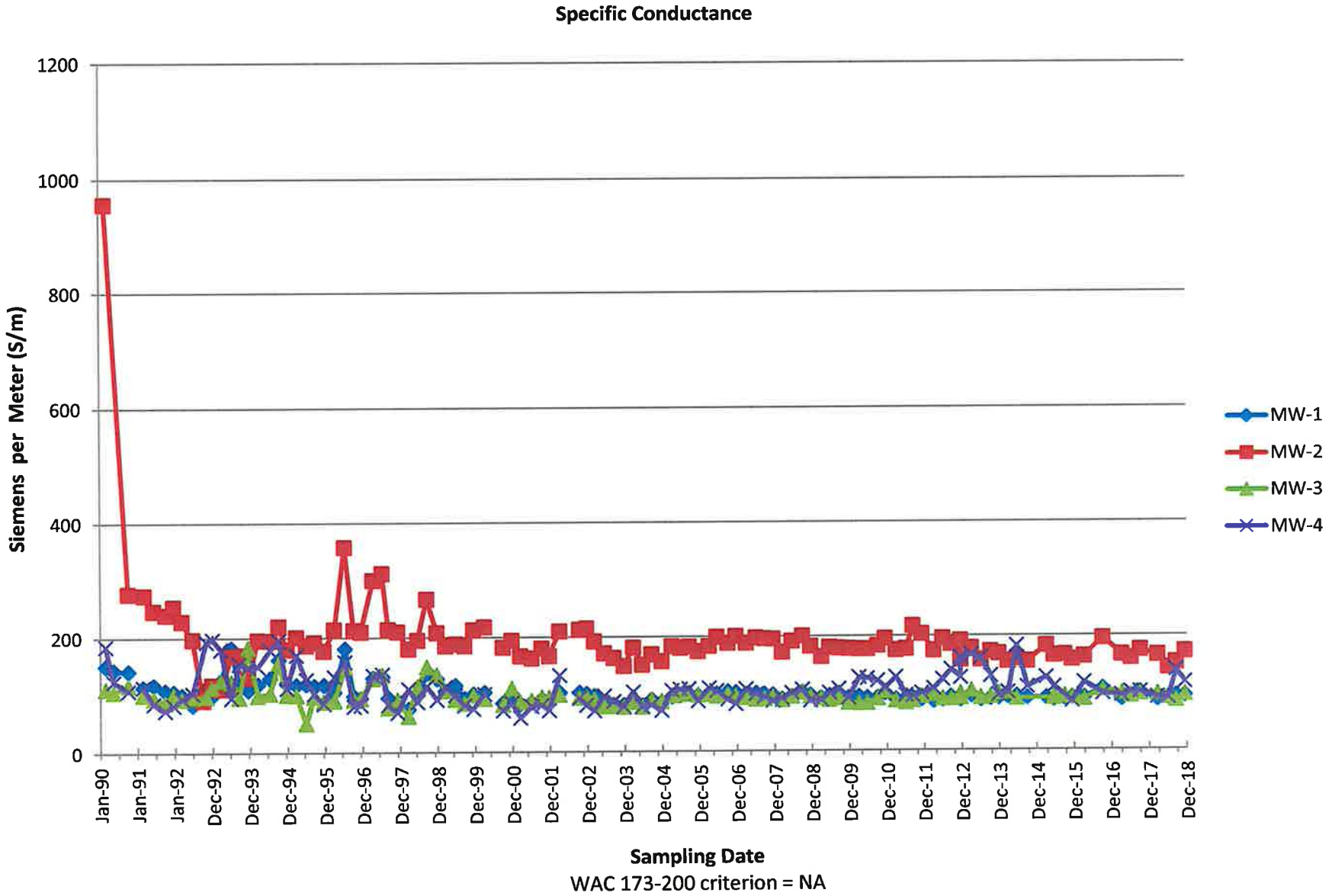
WAC 173-200 criterion = NA

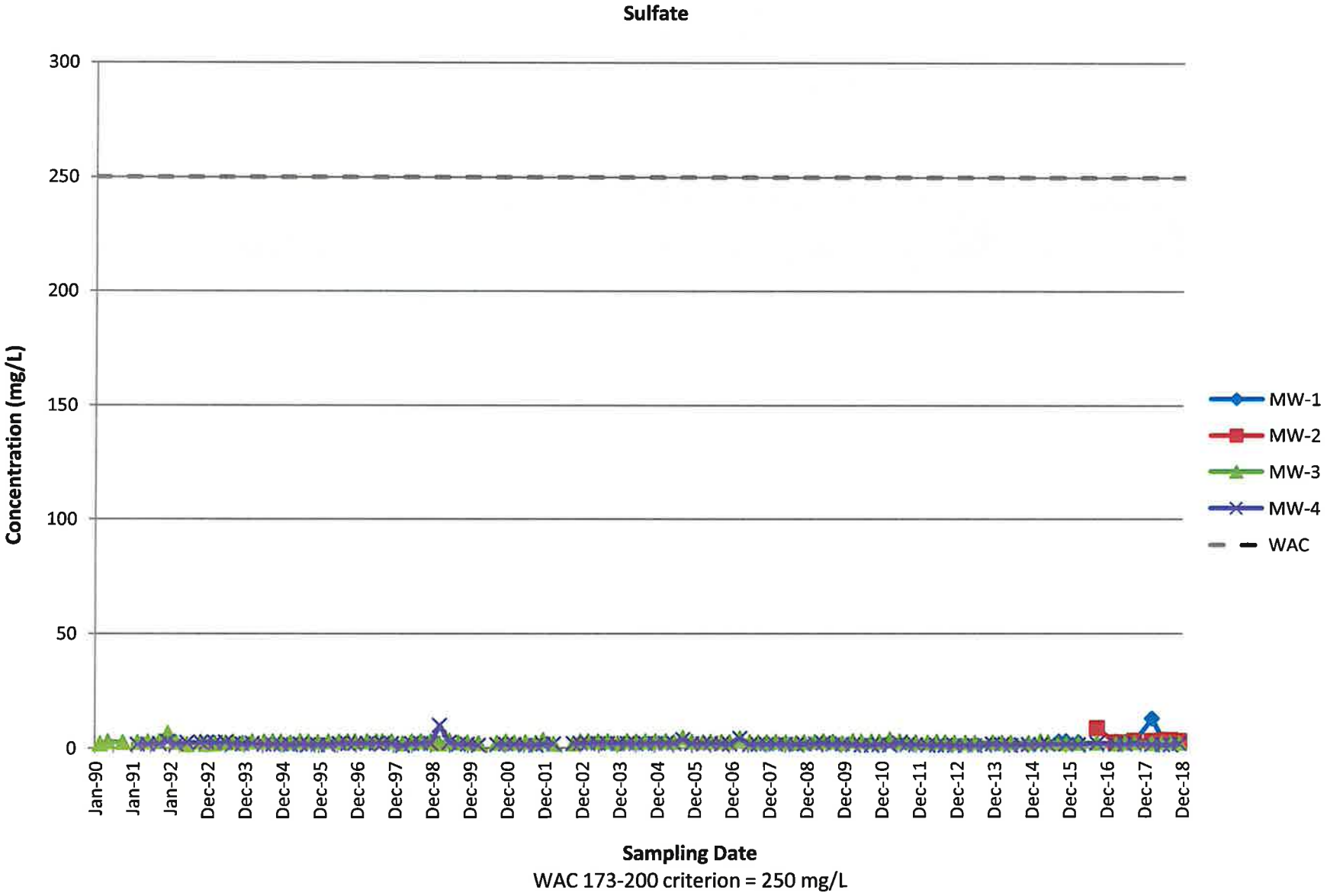

Nitrate as nitrogen
Concentration (mg/L)
12
10
8
6
4
2
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
WAC
Sampling Date
WAC 173-200 criterion = 10 mg/L

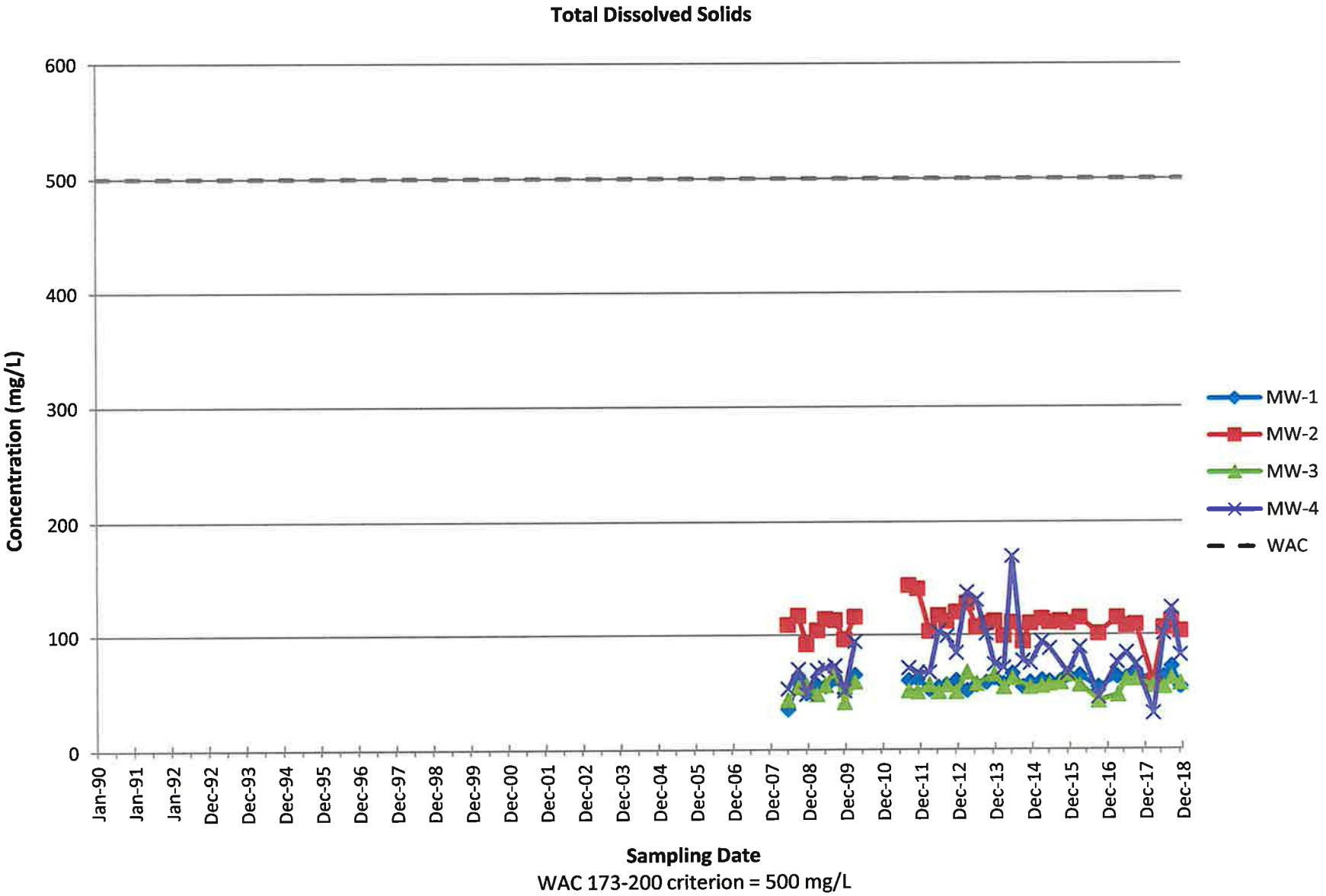

pH
12
10
8
6
4
2
0
pH
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
Sampling Date
MW-1
MW-2
MW-3
MW-4
WAC
WAC
WAC 173-200 criterion = 6.5 - 8.5 SU

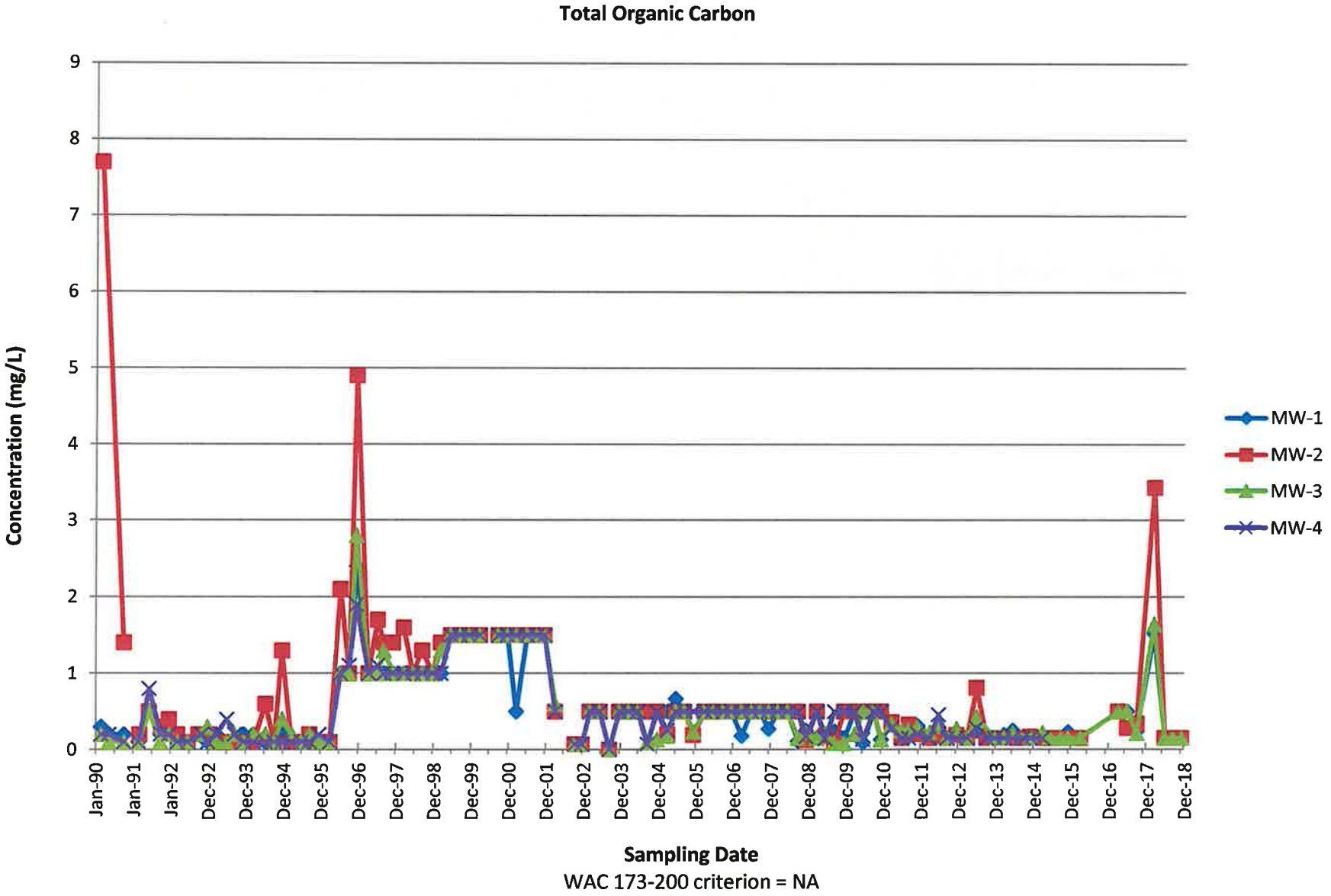

Potassium
Concentration (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
Sampling Date
WAC 173-200 criterion = NA


Sodium, total
Concentration (mg/L)
0
1
2
3
4
5
6
7
8
9
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
Sampling Date
WAC 173-200 criterion = NA


Specific Conductance
Siemens per Meter (S/m)
1200
1000
800
600
400
200
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
Sampling Date
WAC 173-200 criterion = NA
MW-1
MW-2
MW-3
MW-4


Sulfate
300
250
200
150
100
50
0
Concentration (mg/L)
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
WAC
Sampling Date
WAC 173-200 criterion = 250 mg/L


Total Dissolved Solids
600
500
400
300
200
100
0
Concentration (mg/L)
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
WAC
Sampling Date
WAC 173-200 criterion = 500 mg/L


Total Organic Carbon
Concentration (mg/L)
9
8
7
6
5
4
3
2
1
0
Jan-90
Jan-91
Jan-92
Dec-92
Dec-93
Dec-94
Dec-95
Dec-96
Dec-97
Dec-98
Dec-99
Dec-00
Dec-01
Dec-02
Dec-03
Dec-04
Dec-05
Dec-06
Dec-07
Dec-08
Dec-09
Dec-10
Dec-11
Dec-12
Dec-13
Dec-14
Dec-15
Dec-16
Dec-17
Dec-18
MW-1
MW-2
MW-3
MW-4
Sampling Date
WAC 173-200 criterion = NA

APPENDIX C

2018 FOURTH QUARTER DATA VALIDATION REPORT

SAUK LANDFILL FOURTH QUARTER 2018 DATA VALIDATION REPORT

1. INTRODUCTION

This report presents the results of data validation on reports 18-45458 and 18-45577 by Edge Analytical, Burlington, Washington. Sample identifications and the analyses requested are provided in the following table.

Sample Location	Skagit County Sample ID	Lab Sample ID	Analysis (All Samples)
MW-1	2944	92722	Dissolved Metals (Ag, An, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, Tl, V, Zn): 200.7/Filter, 200.8/Filter, 245.1/Filter
MW-2	2645	92723	Total Metals (Ca, K, Mg, Na): 200.7
MW-2 Duplicate	2946	92724	Inorganic Anions (NO_3, NO_2, Cl, SO_4): 300.0
MW-3	2947	92934	Nutrients (NH_3): SM 4500
MW-4	2648	92725	Demand (TOC, COD): SM 5310B, SM 5220D
			Organics (VOCs): 8260B, 8260SIM
			Properties (Alkalinity, TDS, Bicarbonate): SM 2320B, SM 2540C

Fourth quarter samples were collected on December 6 and 7, 2018.

2. SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Samples were taken off site for analysis. Custody of the samples was controlled and documented on a chain of custody form. Unique sample identification numbers were recorded on the chain of custody forms along with date, time, matrix type, analysis required, and other required information.

2.1 Dissolved Metals

Sample custody was maintained throughout collection, transport, and lab receipt.

2.2 Total Metals

Sample custody was maintained throughout collection, transport, and lab receipt.

2.3 Inorganic Anions

Sample custody was maintained throughout collection, transport, and lab receipt.

2.4 Nutrients

Sample custody was maintained throughout collection, transport, and lab receipt.

2.5 Demand

Sample custody was maintained throughout collection, transport, and lab receipt.

2.6 Organics

Sample custody was maintained throughout collection, transport, and lab receipt.

2.7 Properties

Sample custody was maintained throughout collection, transport, and lab receipt.

3. HOLDING TIME

3.1 Dissolved Metals

All analyses were performed within the recommended maximum holding time.

3.2 Total Metals

All analyses were performed within the recommended maximum holding time.

3.3 Inorganic Anions

All analyses were performed within the recommended maximum holding time.

3.4 Nutrients

All analyses were performed within the recommended maximum holding time.

3.5 Demand

All analyses were performed within the recommended maximum holding time.

3.6 Organics

All analyses were performed within the recommended maximum holding time.

3.7 Properties

All analyses were performed within the recommended maximum holding time.

4. METHOD BLANKS

The purpose of blank analysis assessment is to determine the existence and magnitude of contamination resulting from laboratory activities.

4.1 Dissolved Metals

Goals for blank analyses were met. Method blanks were analyzed using the 245.1/Filter method and were target analyte free.

4.2 Total Metals

Goals for blank analyses were met. Method blanks were analyzed and were target analyte free.

4.3 Inorganic Anions

No method blank analyses were performed for inorganic anions.

4.4 Nutrients

Goals for blank analyses were met. Method blanks were analyzed and were target analyte free.

4.5 Demand

Goals for blank analyses were met. Method blanks were analyzed and were target analyte free.

4.6 Organics

Goals for blank analyses were met. Method blanks were analyzed and were target analyte free.

4.7 Properties

Goals for blank analyses were met. Method blanks were analyzed and were target analyte free.

5. LABORATORY FORTIFIED BLANK

5.1 Dissolved Metals

Goals for LCS recovery were met.

5.2 Total Metals

Goals for LCS recovery were met.

5.3 Inorganic Anions

Goals for LCS recovery were met.

5.4 Nutrients

Goals for LCS recovery were met.

5.5 Demand

Goals for LCS recovery were met.

5.6 Organics

Goals for LCS recovery were met.

5.7 Properties

Goals for LCS recovery were met.

6. LABORATORY DUPLICATE PRECISION

6.1 Dissolved Metals

The relative perfect difference (RPD) values for dissolved metal sample duplicates were in control.

6.2 Total Metals

All RPD values for total metal sample duplicates were in control.

6.3 Inorganic Anions

The RPD values for the inorganic anion sample duplicates performed by method 300.0 were in control.

6.4 Nutrients

The RPD for nutrients were in control.

6.5 Demand

The RPD values for the demand sample duplicates analyzed in the same batch were in control.

6.6 Organics

The RPD values for the organics sample duplicates analyzed in the same batch were in control.

6.7 Properties

The RPD values for the property sample duplicates analyzed in the same batch were in control.

7. MATRIX SPIKE AND MATRIX SPIKE DUPLICATE ANALYSES

7.1 Dissolved Metals

The MS/MSDs were in control for all recoveries and RPDs.

7.2 Total Metals

The MS/MSDs were in control for all recoveries and RPDs.

7.3 Inorganic Anions

The MS/MSDs were in control for all recoveries and RPDs.

7.4 Nutrients

The MS/MSDs were in control for all recoveries and RPDs.

7.5 Demand

The MS/MSDs were in control for all recoveries and RPDs.

7.6 Organics

The MS/MSDs were in control for all recoveries and RPDs.

7.7 Properties

The MS/MSDs were in control for all recoveries and RPDs.

8. FIELD DUPLICATE

Analyte Name	Field Duplicate at Location MW-2		
	Primary (2945)	Duplicate (2946)	RPD (%)
Total Metals (mg/L)			
Calcium	20.4	19.1	6.6
Magnesium	5.05	4.72	6.8
Potassium	0.73	0.53	31.7
Sodium	4.12	3.75	9.4
Dissolved Metals (mg/L)			
Barium	0.022	0.021	4.7
Inorganic Anions (mg/L)			
Chloride	7.3	7.3	0.0
Nitrate-N	1.99	2.01	1.0
Sulfate	2.8	2.8	0.0
Properties (mg/L)			
Alkalinity	59.7	60.7	1.7
Bicarbonate	59.9	59.8	0.2
Total Dissolved Solids	103	108	4.7

Bold = Relative Percent Difference (RPD) exceeds 20% acceptance criteria NDs not shown

8.1 Dissolved Metals

All RPDs between the duplicate samples were within ≤ 20%.

8.2 Total Metals

The RPD for potassium was 31.7% above the RPD of 20%. Since the results were just above the PQL no further action was taken on the data set. All RPDs between the duplicate samples were within ≤ 20%.

8.3 Inorganic Anions

All RPDs between the duplicate samples were within ≤ 20%.

8.4 Nutrients

All RPDs between the duplicate samples were within ≤ 20%.

8.5 Demand

All RPDs between the duplicate samples were within < 20%.

8.6 Organics

All RPDs between the duplicate samples were within ≤ 20%.

8.7 Properties

All RPDs between the duplicate samples were within ≤ 20%.

9. DETECTION LIMITS

9.1 Dissolved Metals – 200.7/Filter

Detection limit goals were met for all results.

9.2 Total Metals

Detection limit goals were met for all results.

9.3 Inorganic Anions – 300.0

Detection limit goals were met for all results.

9.4 Nutrients – SM 4500

Detection limit goals were met for all results.

9.5 Demand – SM 5310B, SM 5220D

Detection limit goals were met for all results.

9.6 Organics – 8260B, 8260SIM

Detection limit goals were met for all results.

9.7 Properties

Detection limit goals were met for all results.

10. DATA VALIDATION AND USABILITY

With the exception of the above noted anomalies, standard analytical protocols were followed in the analysis of the samples and all laboratory quality control samples analyzed in conjunction with the samples in this project were within established control limits. Limitations were stated and clearly identified where applicable. As a result of this review, the data are found to be acceptable as reported by the laboratory for the intended use in this project.

APPENDIX D

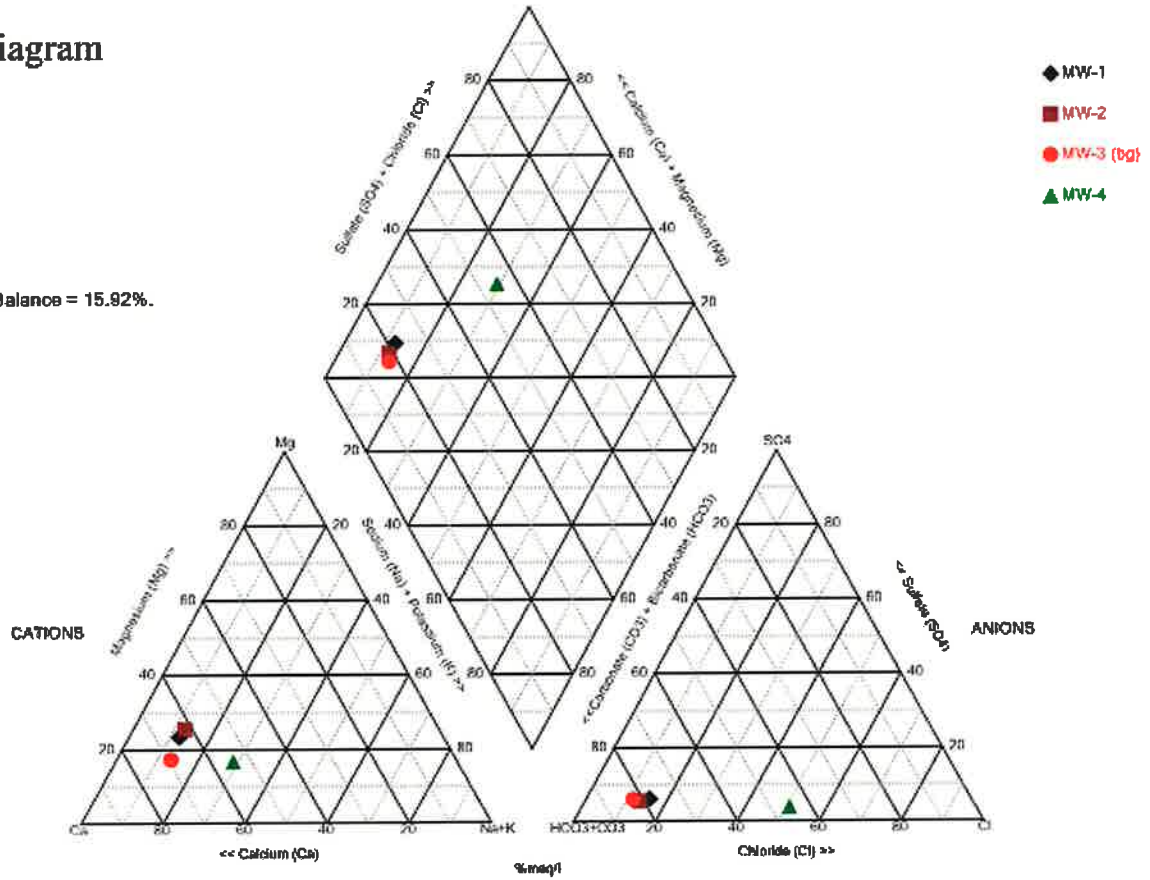
PIPER DIAGRAMS 2018

WQStat Plus™ v.9.4.41

Piper Diagram

3/16/2018

Cation-Anion Balance = 15.92%.



Analysis Run 4/23/2019 11:56 AM

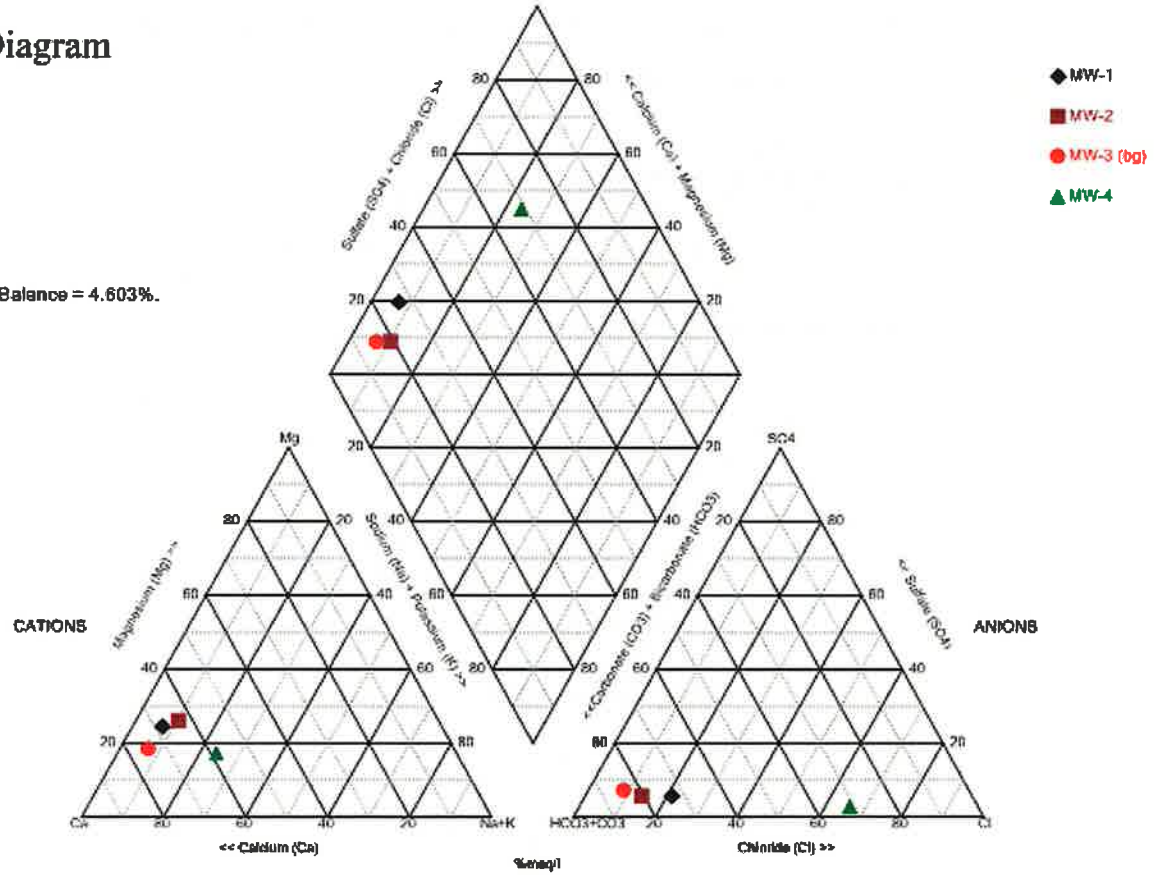
Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Piper Diagram

6/28/2018

Cation-Anion Balance = 4.603%.



Analysis Run 4/23/2019 1:26 PM

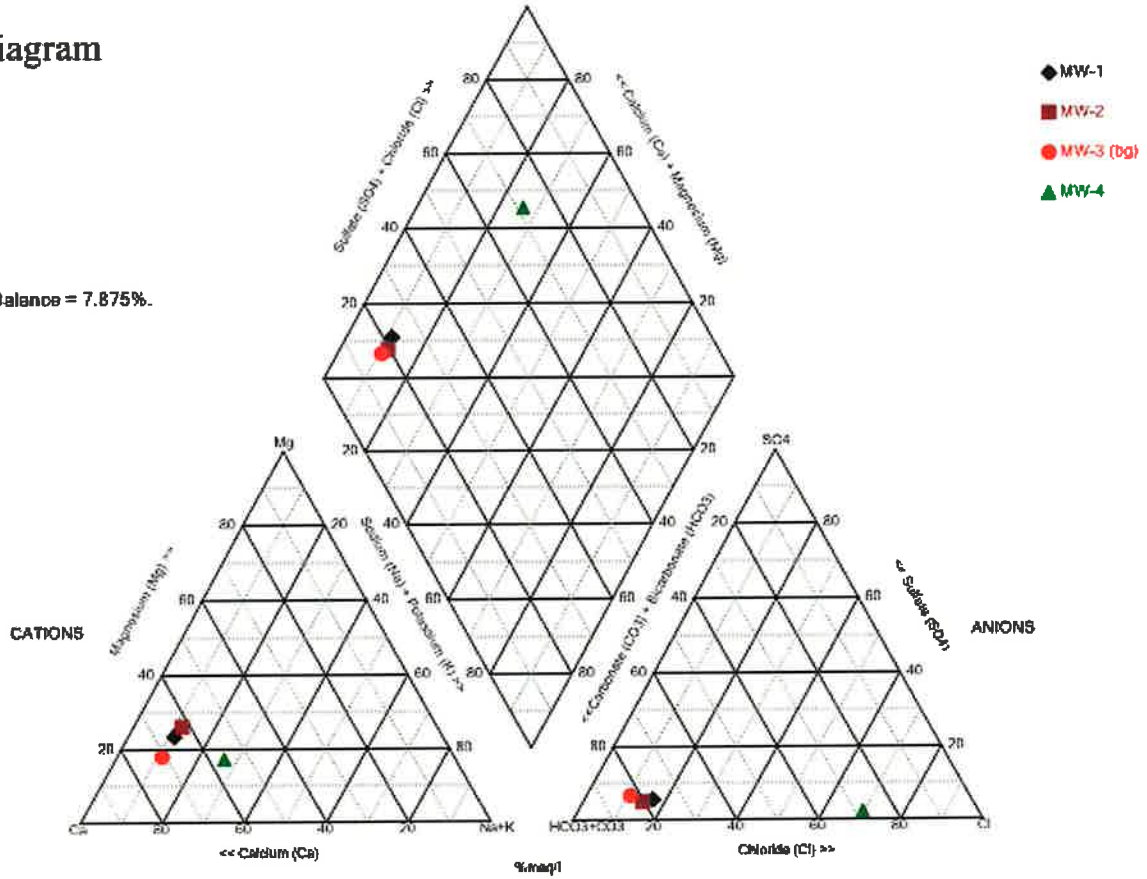
Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Piper Diagram

9/13/2018

Cation-Anion Balance = 7.875%.

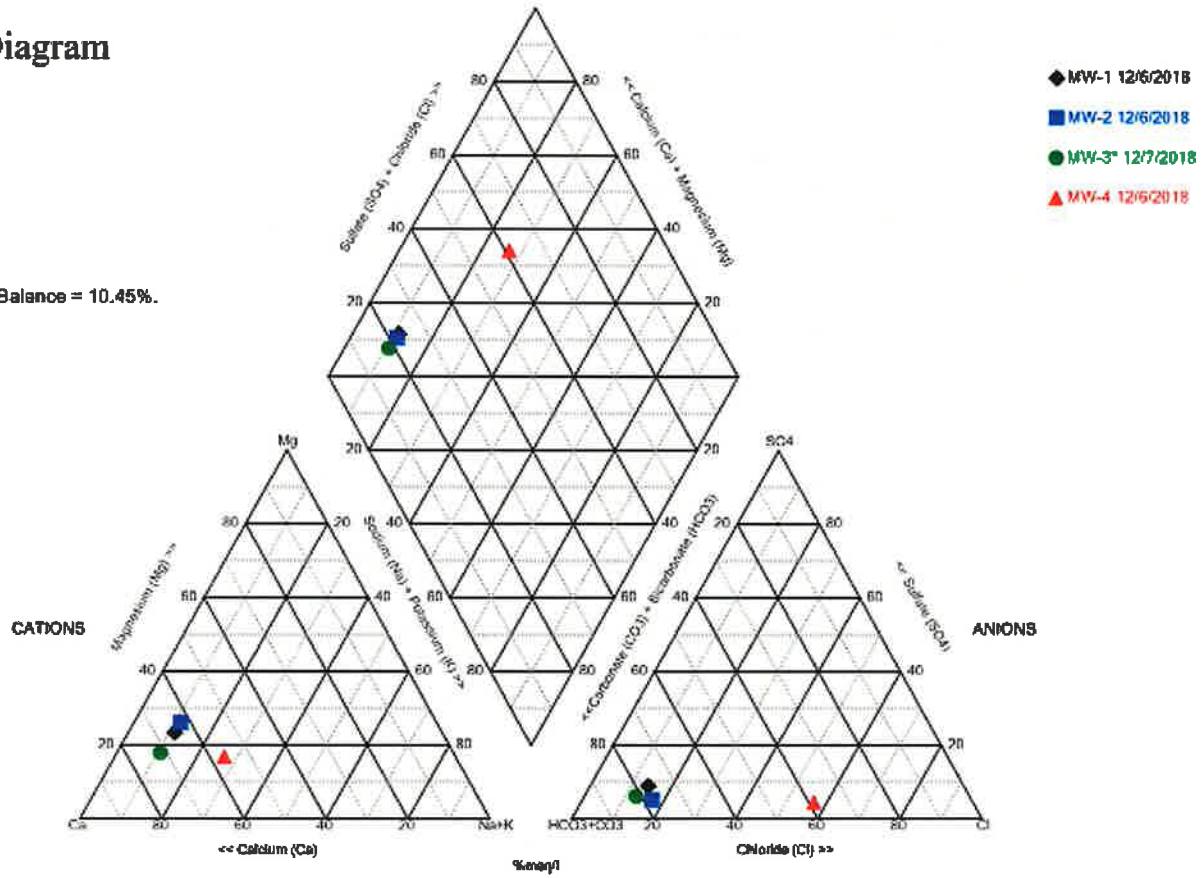


Analysis Run 4/23/2019 1:26 PM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Piper Diagram



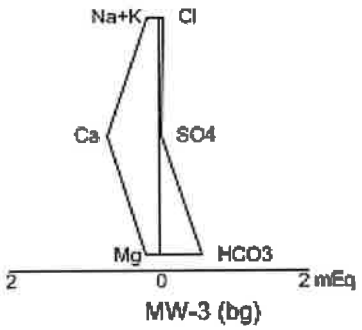
Analysis Run 4/23/2019 1:27 PM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

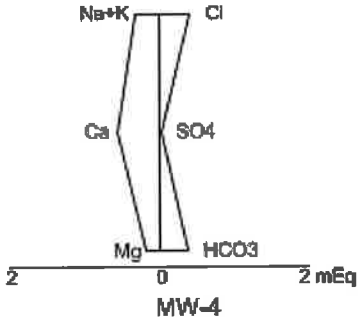
APPENDIX E

STIFF DIAGRAMS 1990-2018

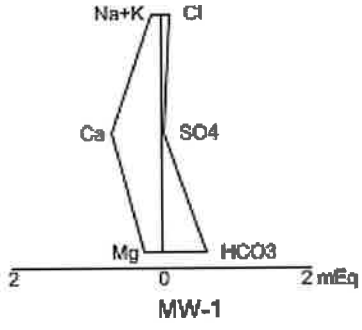
WQStat Plus™ v.9.4.41



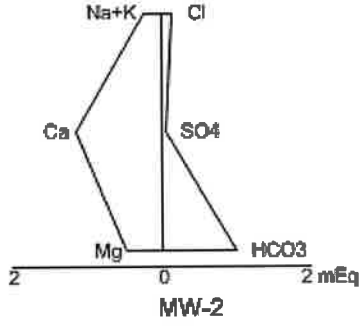
MW-3 (bg)



MW-4



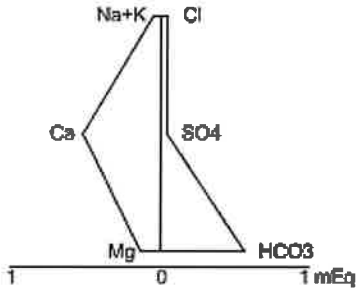
MW-1



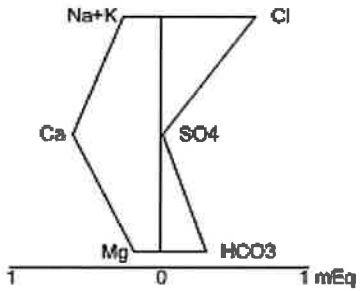
MW-2

Stiff Diagram - 3/16/2018 Analysis Run 4/23/2019 1:31 PM

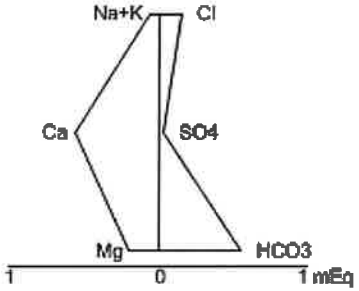
Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)



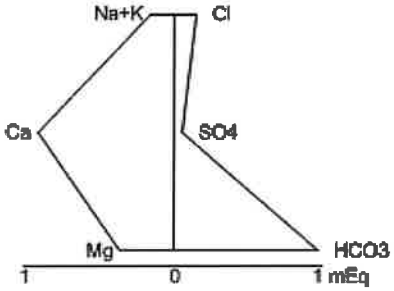
MW-3 (bg)



MW-4



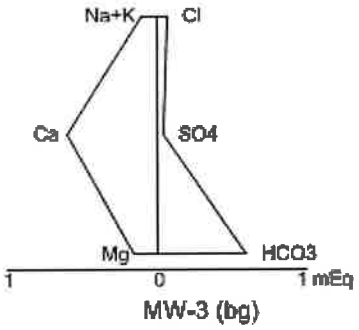
MW-1



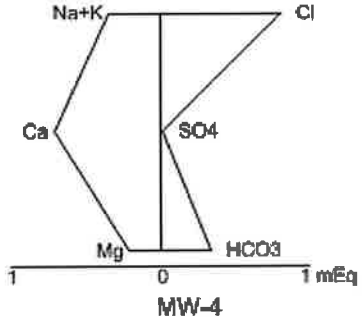
MW-2

Stiff Diagram - 6/28/2018 Analysis Run 4/23/2019 1:31 PM

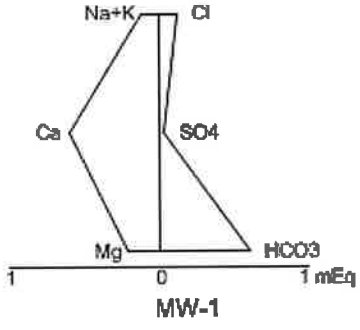
Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)



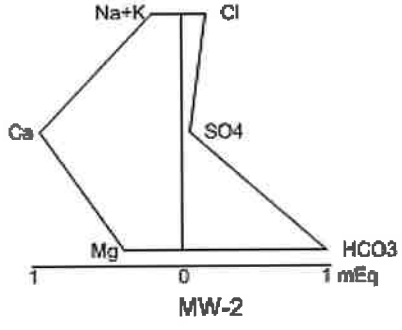
MW-3 (bg)



MW-4



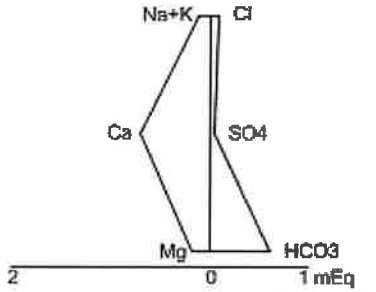
MW-1



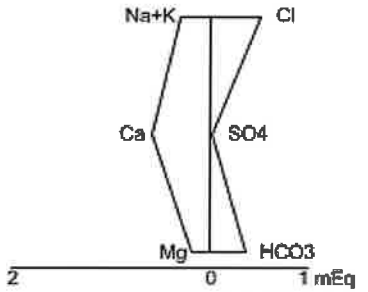
MW-2

Stiff Diagram - 9/13/2018 Analysis Run 4/23/2019 1:32 PM

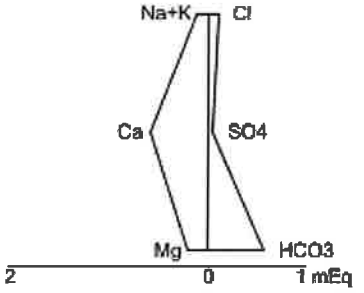
Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)



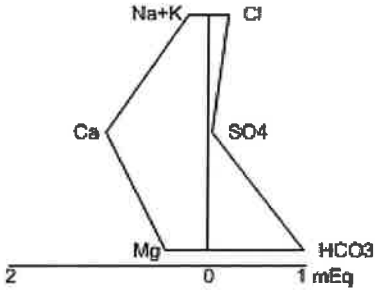
MW-3* 12/7/2018



MW-4 12/6/2018



MW-1 12/6/2018



MW-2 12/6/2018

Stiff Diagram Analysis Run 4/23/2019 1:32 PM

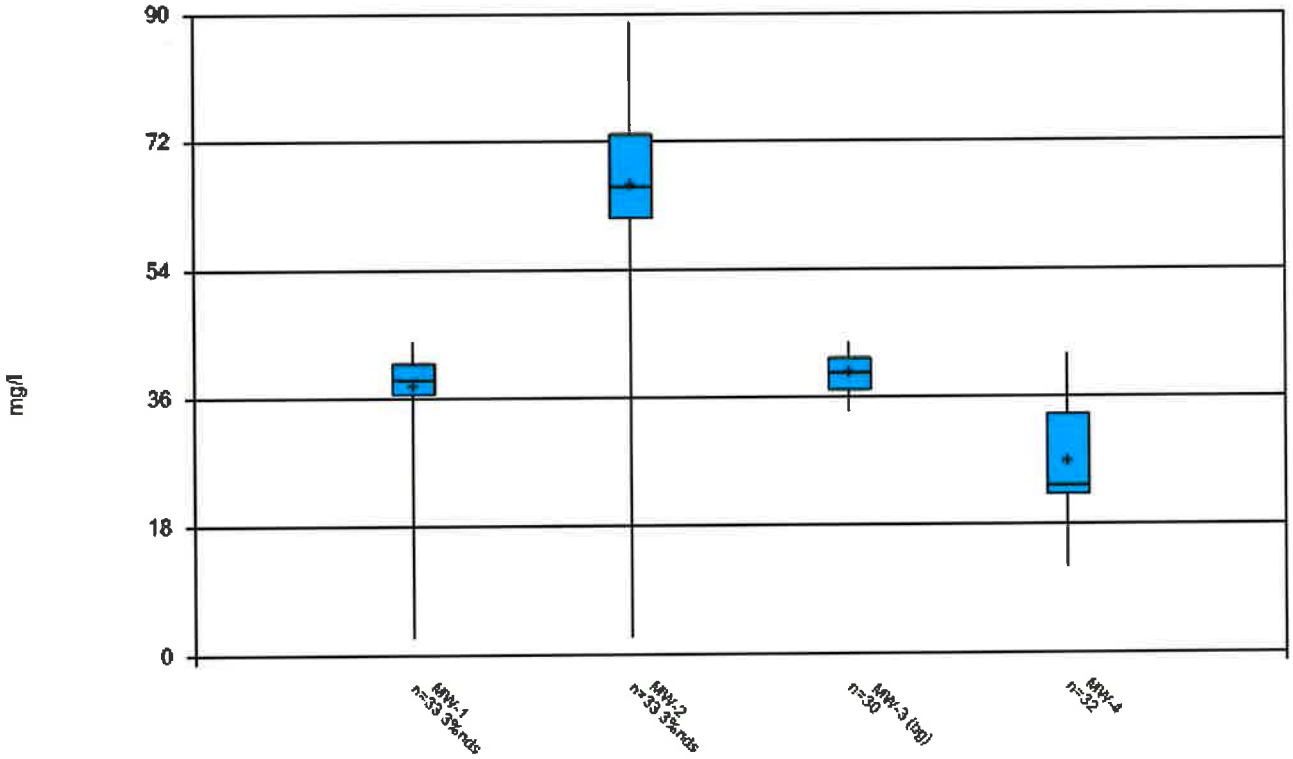
Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

APPENDIX F

BOX PLOTS 1990-2018

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

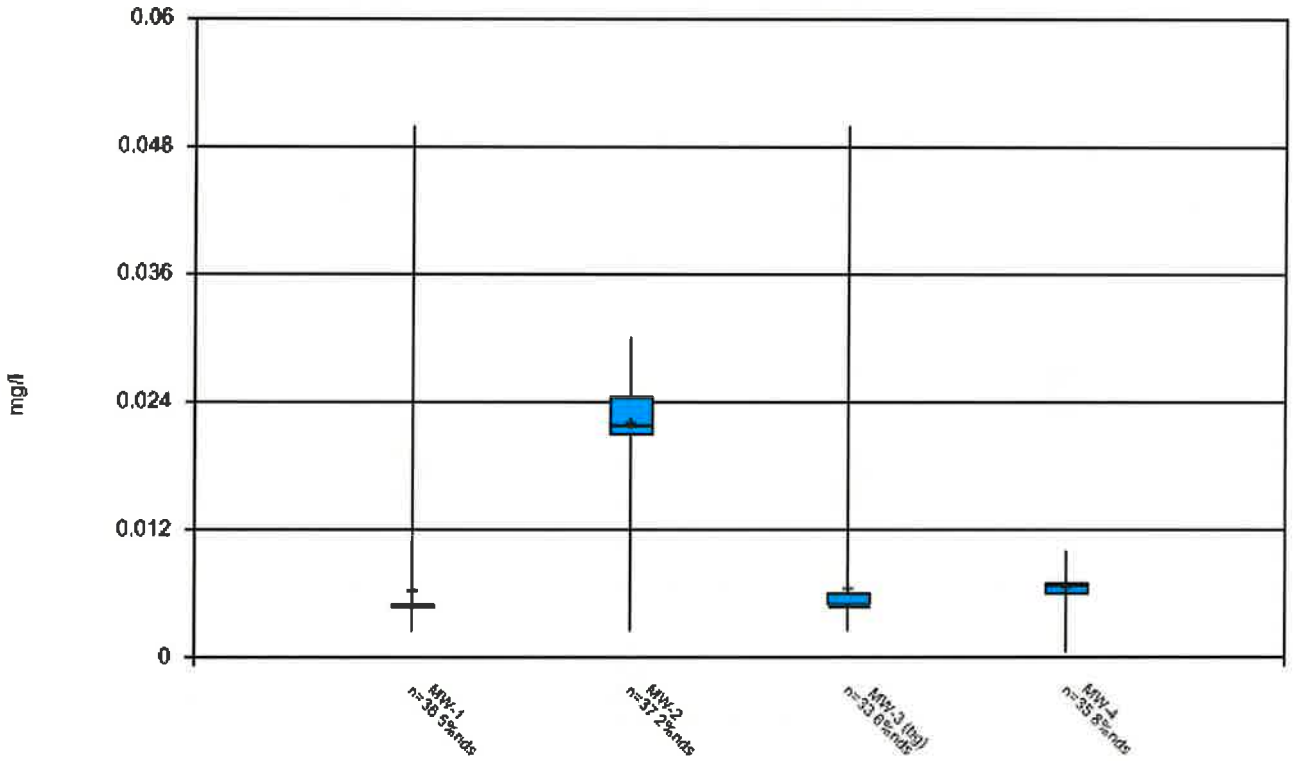


Constituent: Alkalinity Analysis Run 4/23/2019 11:24 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

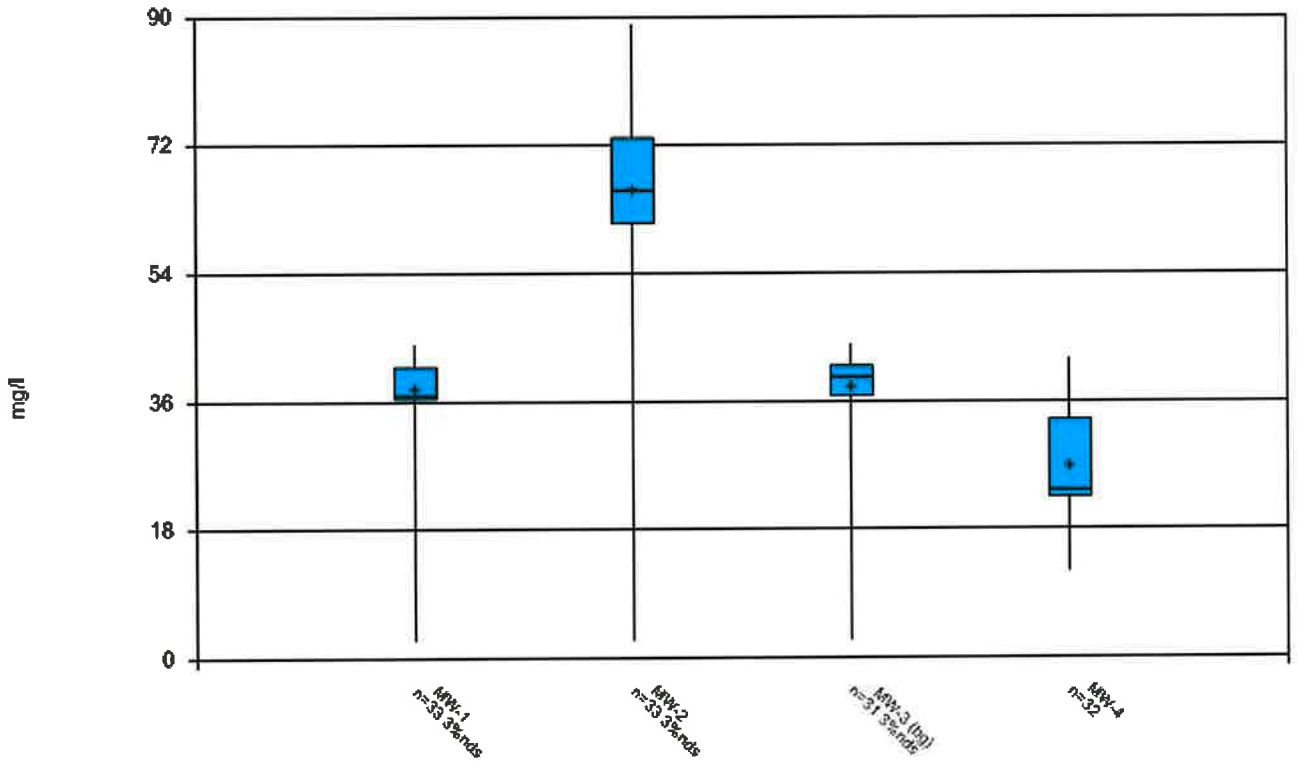


Constituent: BARIUM Analysis Run 4/23/2019 11:25 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

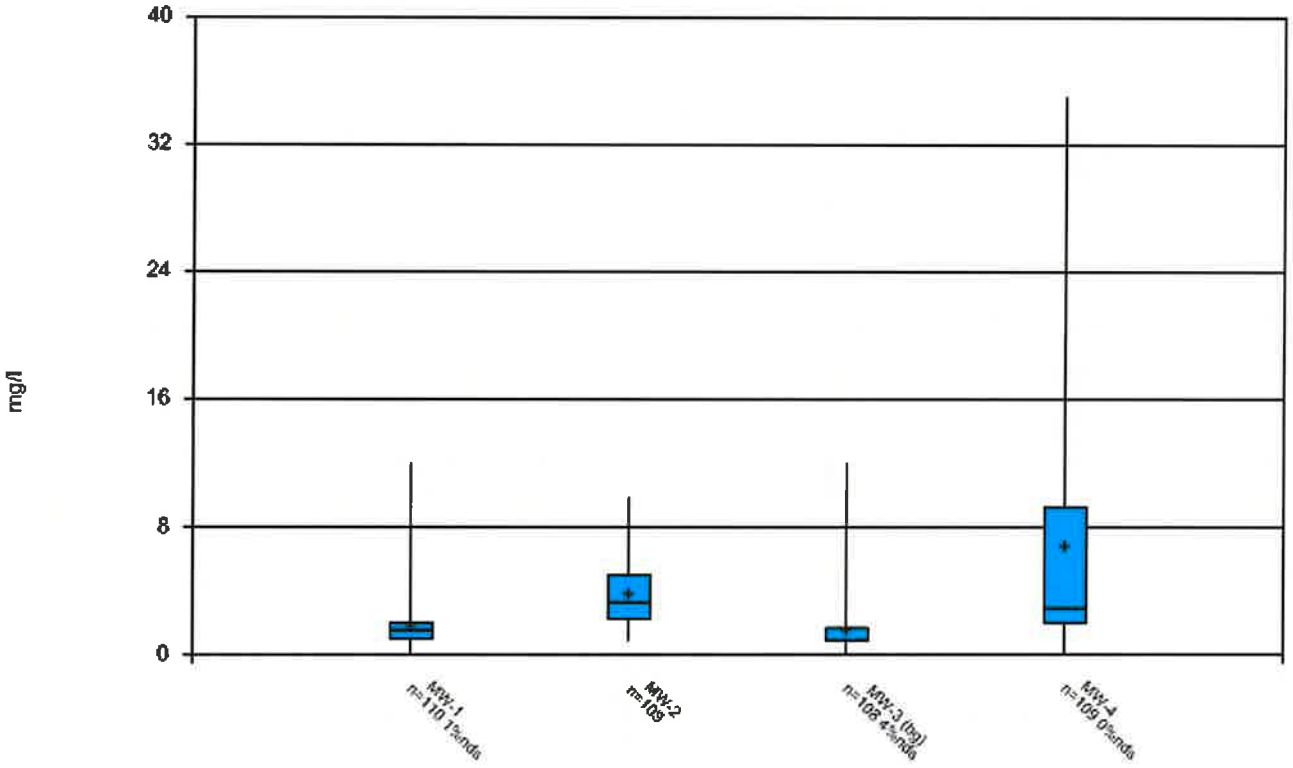


Constituent: Bicarbonate Analysis Run 4/23/2019 11:25 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

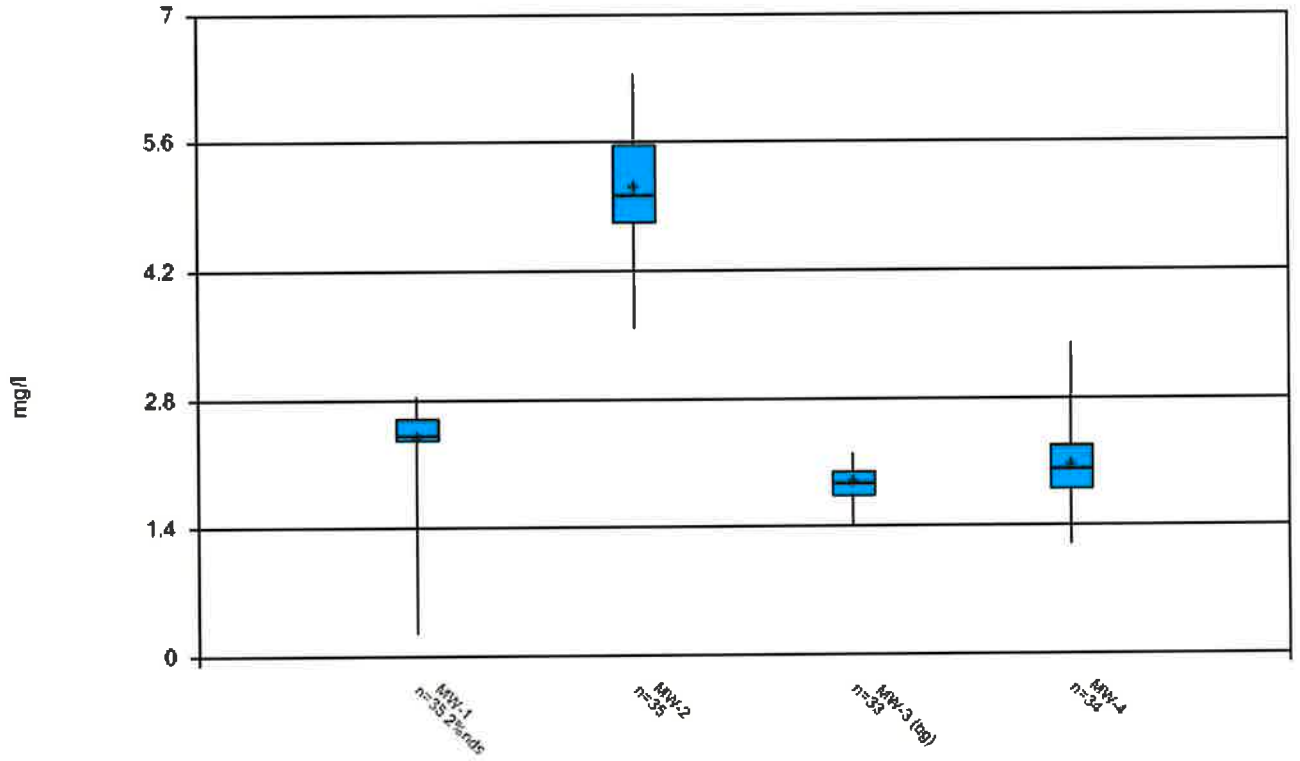


Constituent: Chloride Analysis Run 4/23/2019 11:26 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

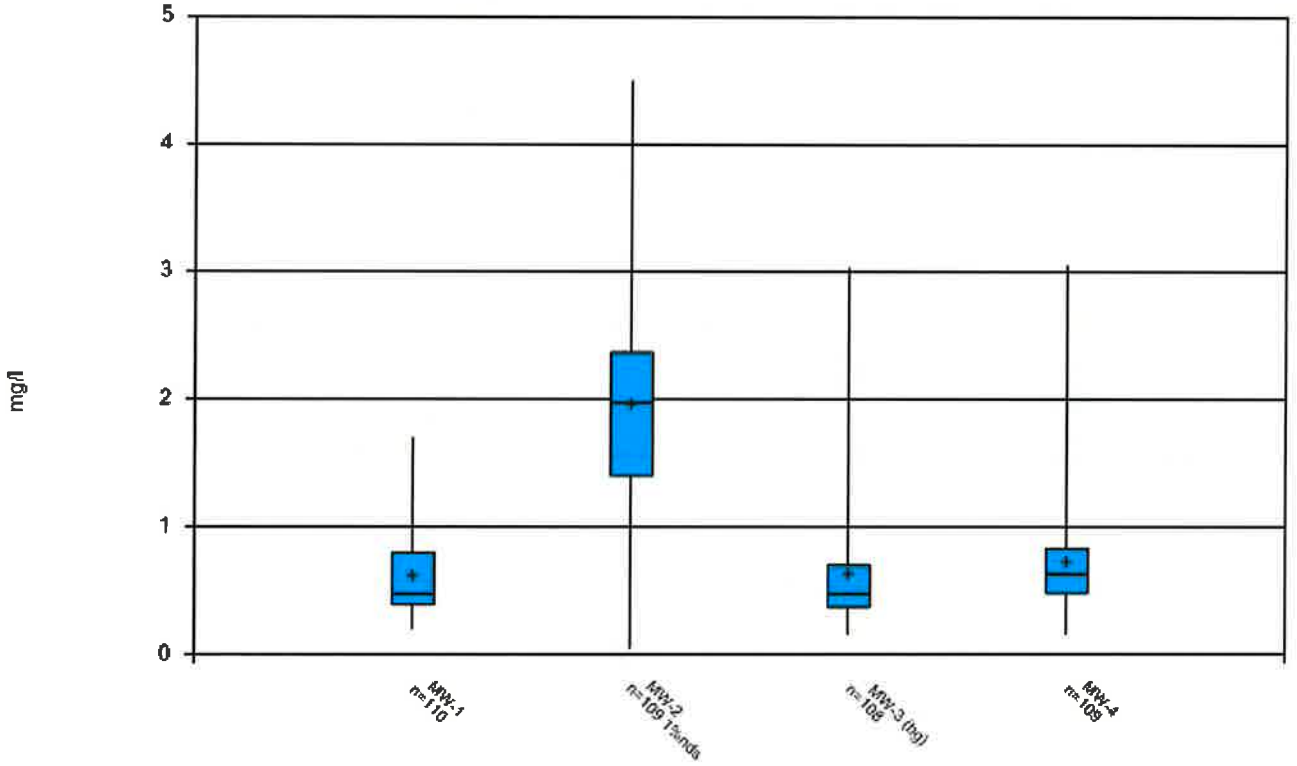


Constituent: MAGNESIUM Analysis Run 4/23/2019 11:27 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

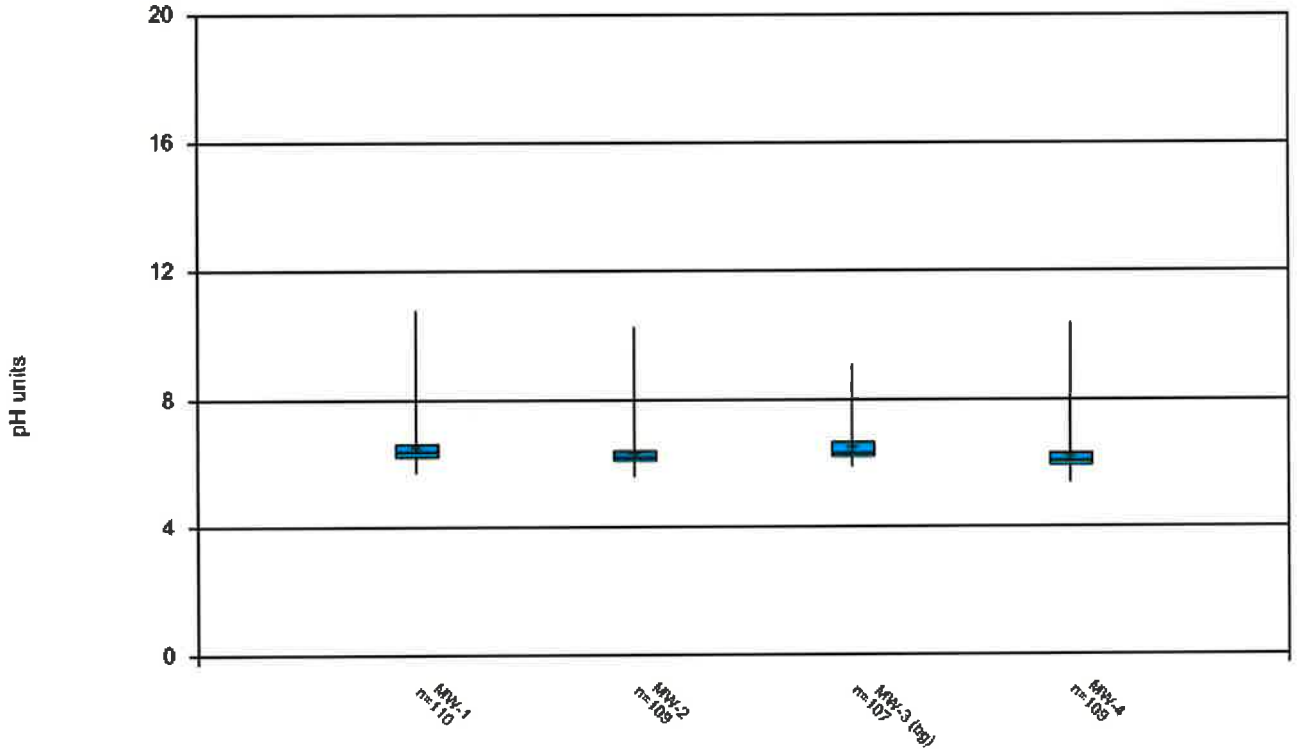


Constituent: Nitrate as nitrogen Analysis Run 4/23/2019 11:28 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

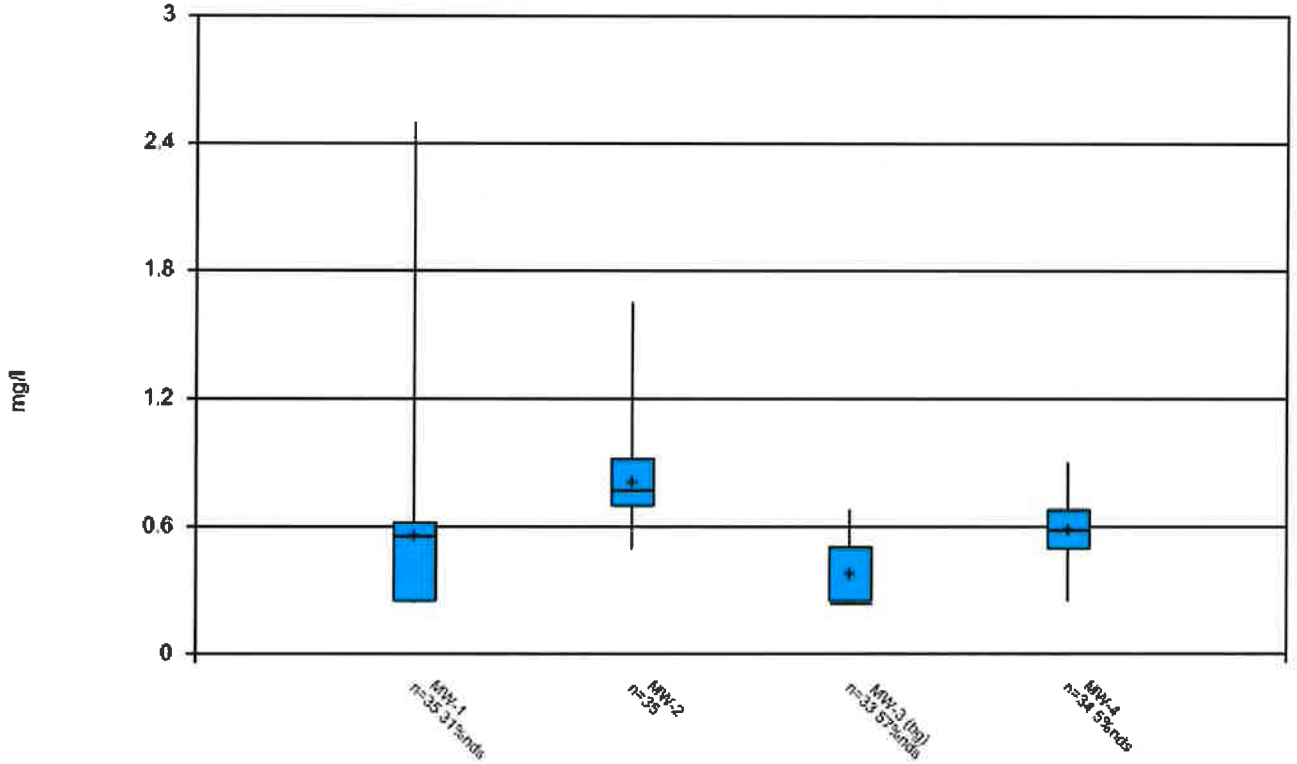


Constituent: pH Analysis Run 4/23/2019 11:28 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

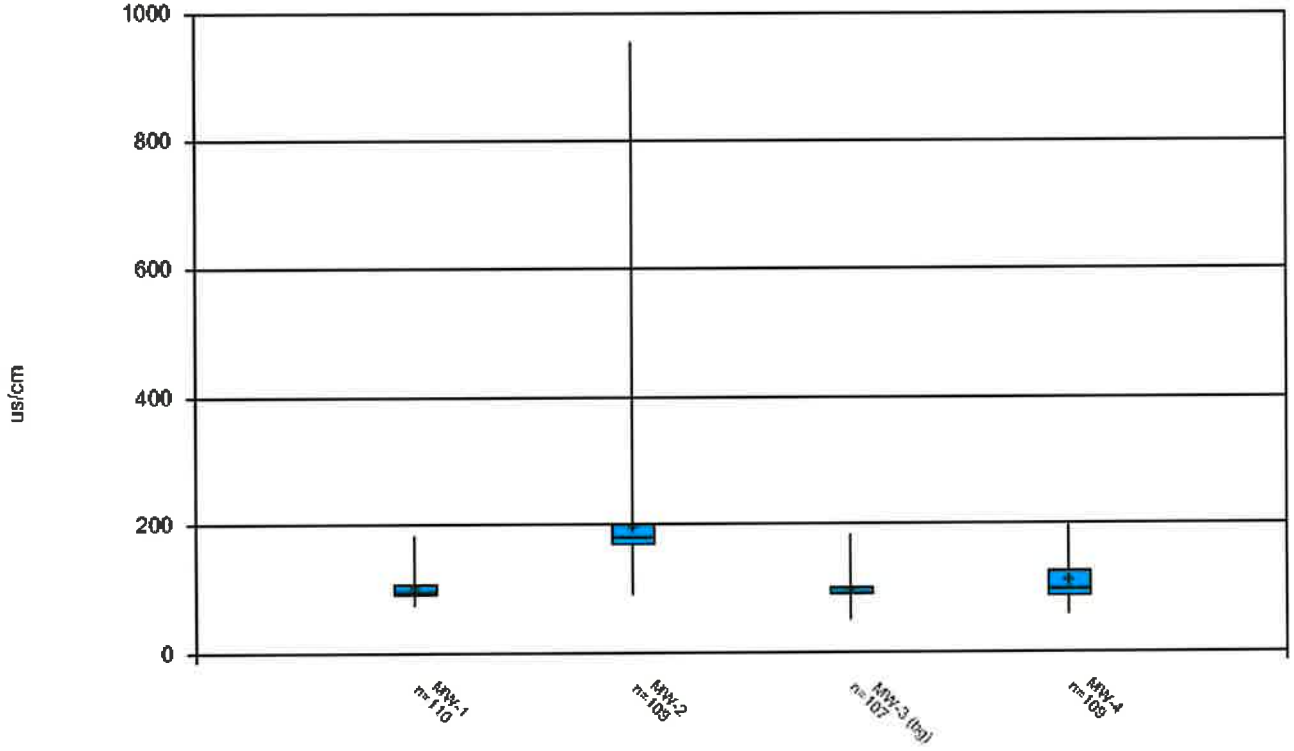


Constituent: Potassium Analysis Run 4/23/2019 11:29 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

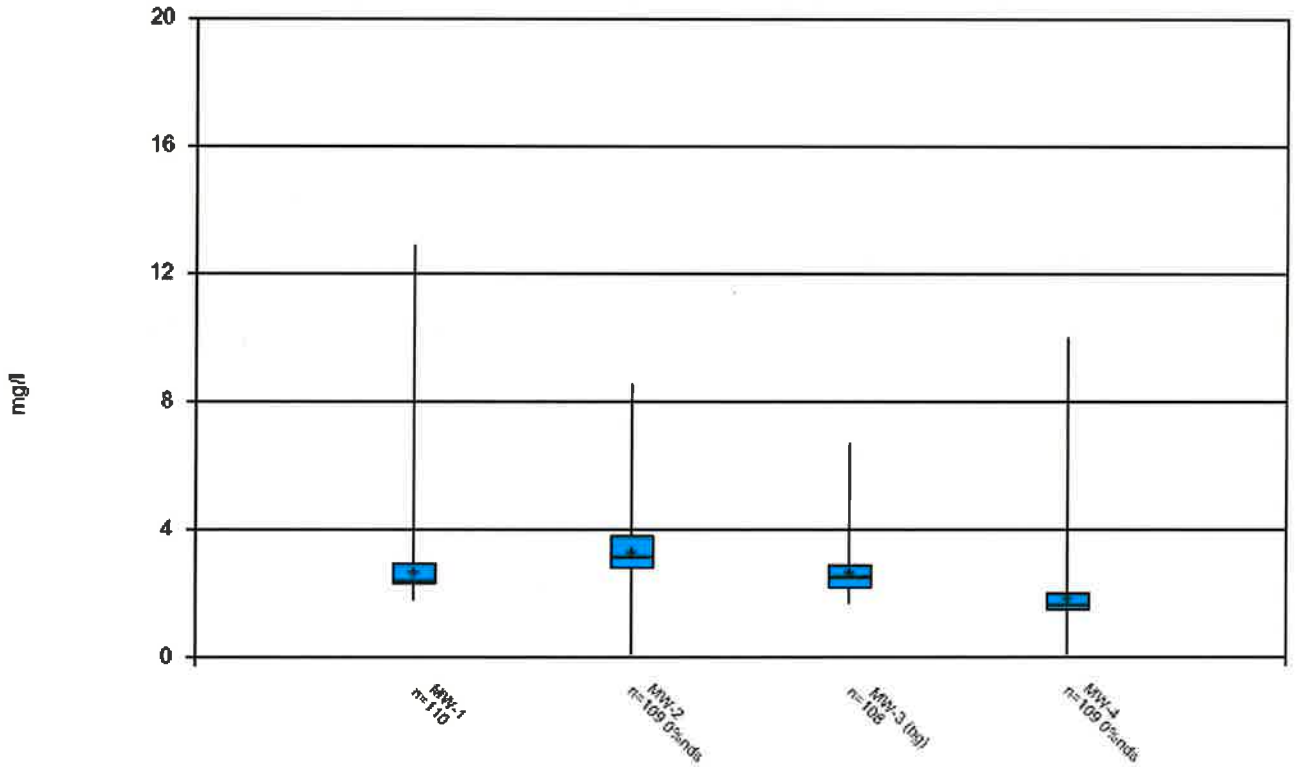


Constituent: Specific Conductance Analysis Run 4/23/2019 11:33 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

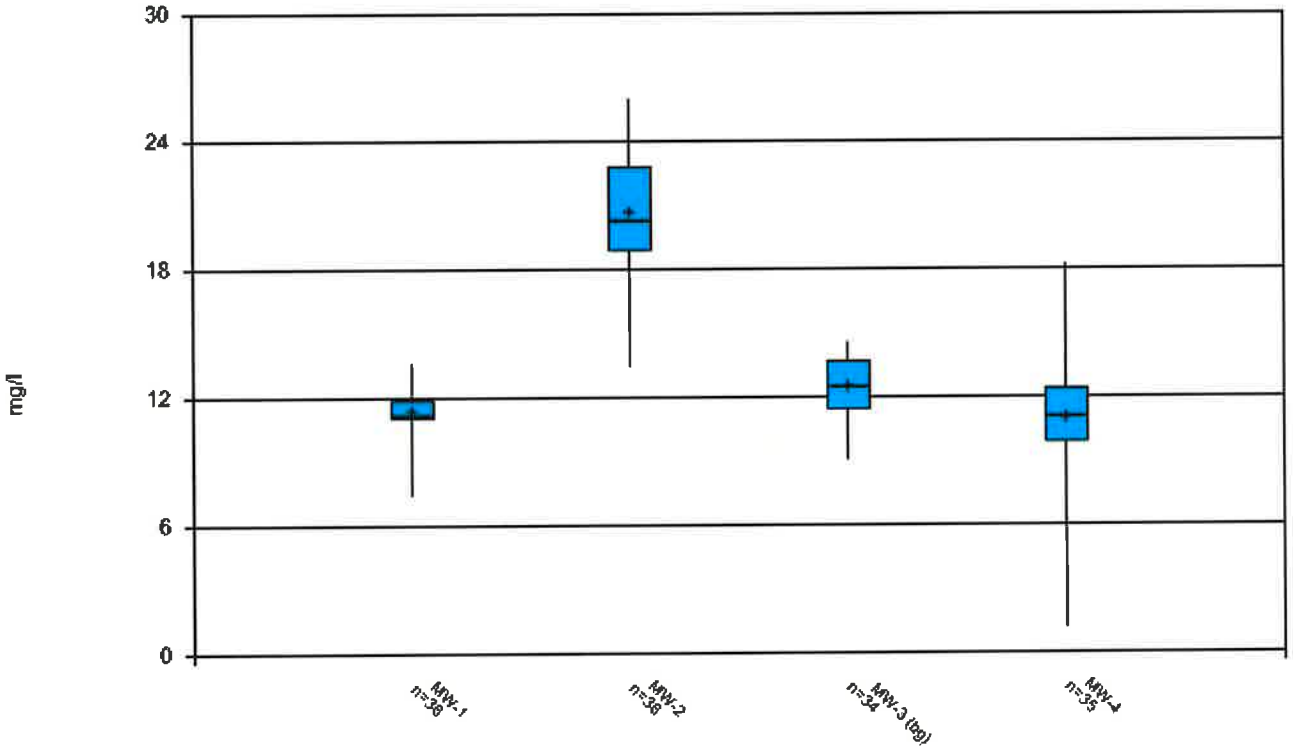


Constituent: Sulfate Analysis Run 4/23/2019 11:33 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

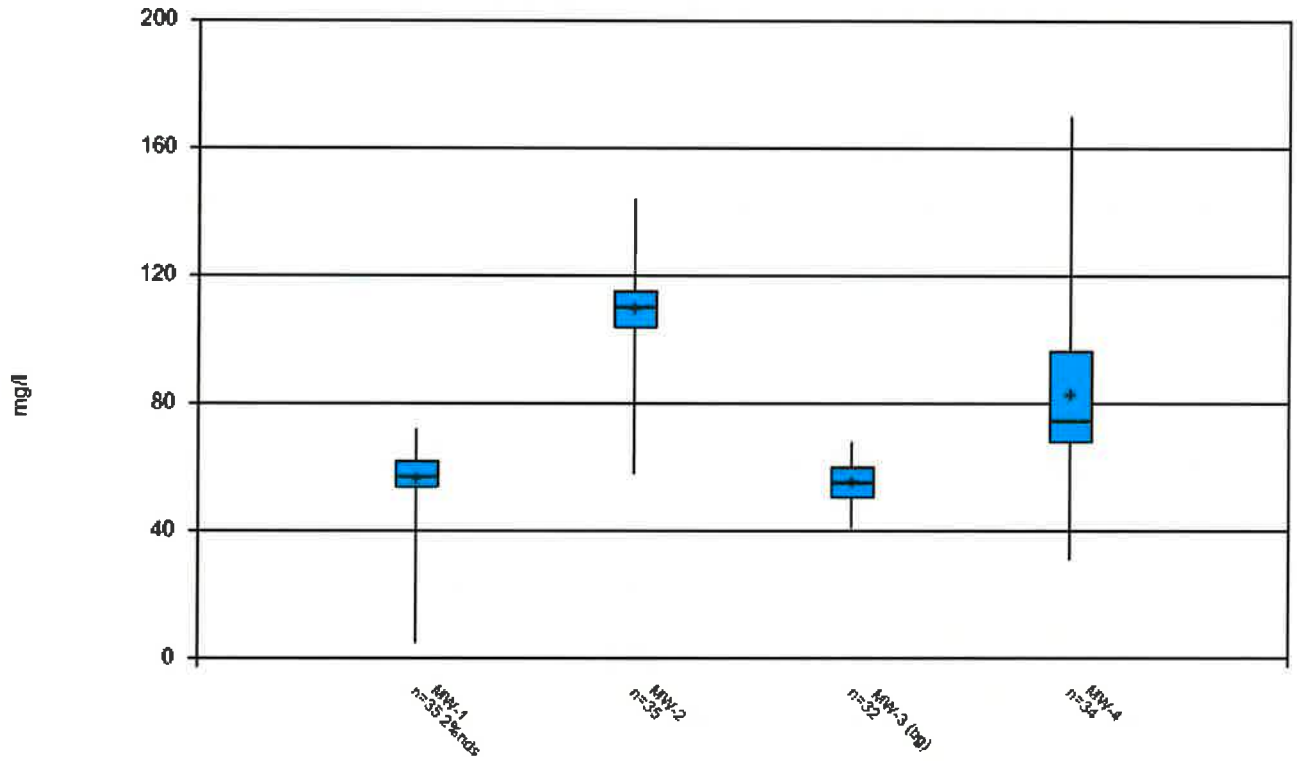


Constituent: Total Calcium Analysis Run 4/23/2019 11:34 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

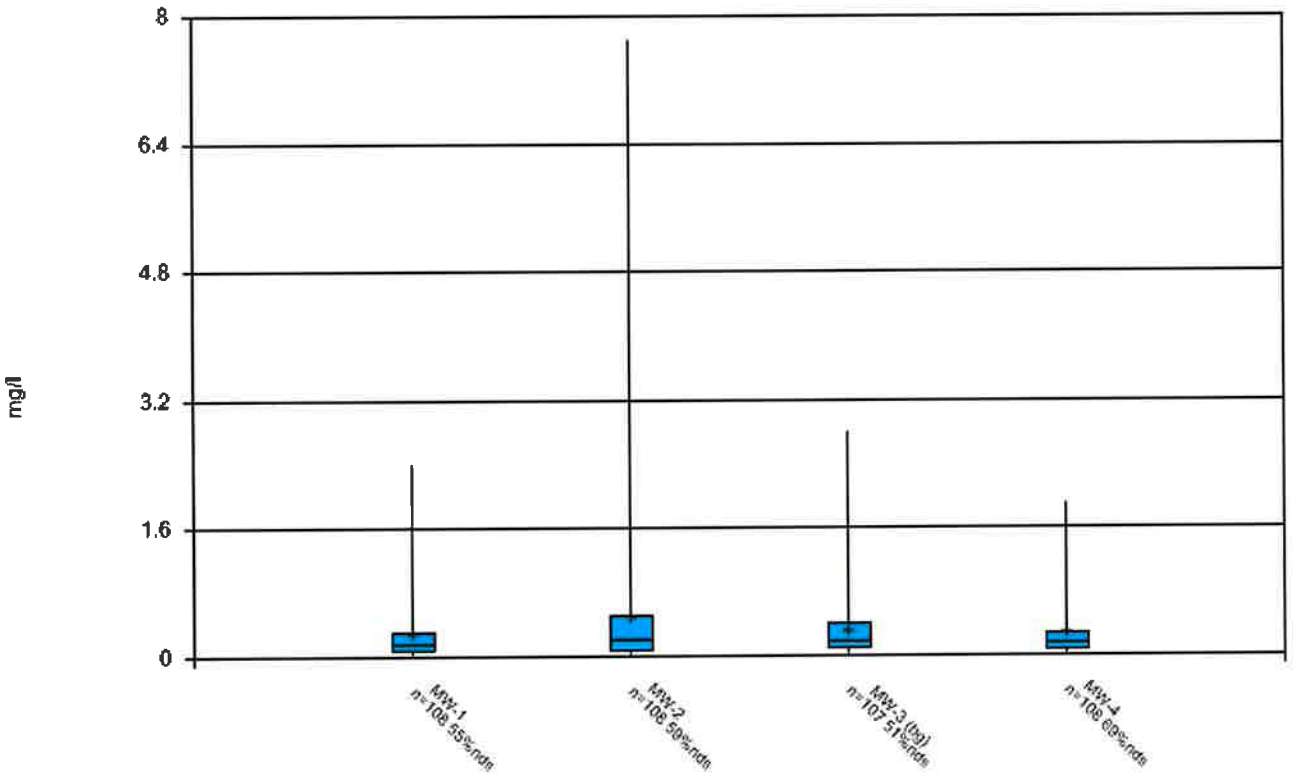


Constituent: Total Dissolved Solids Analysis Run 4/23/2019 11:34 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot

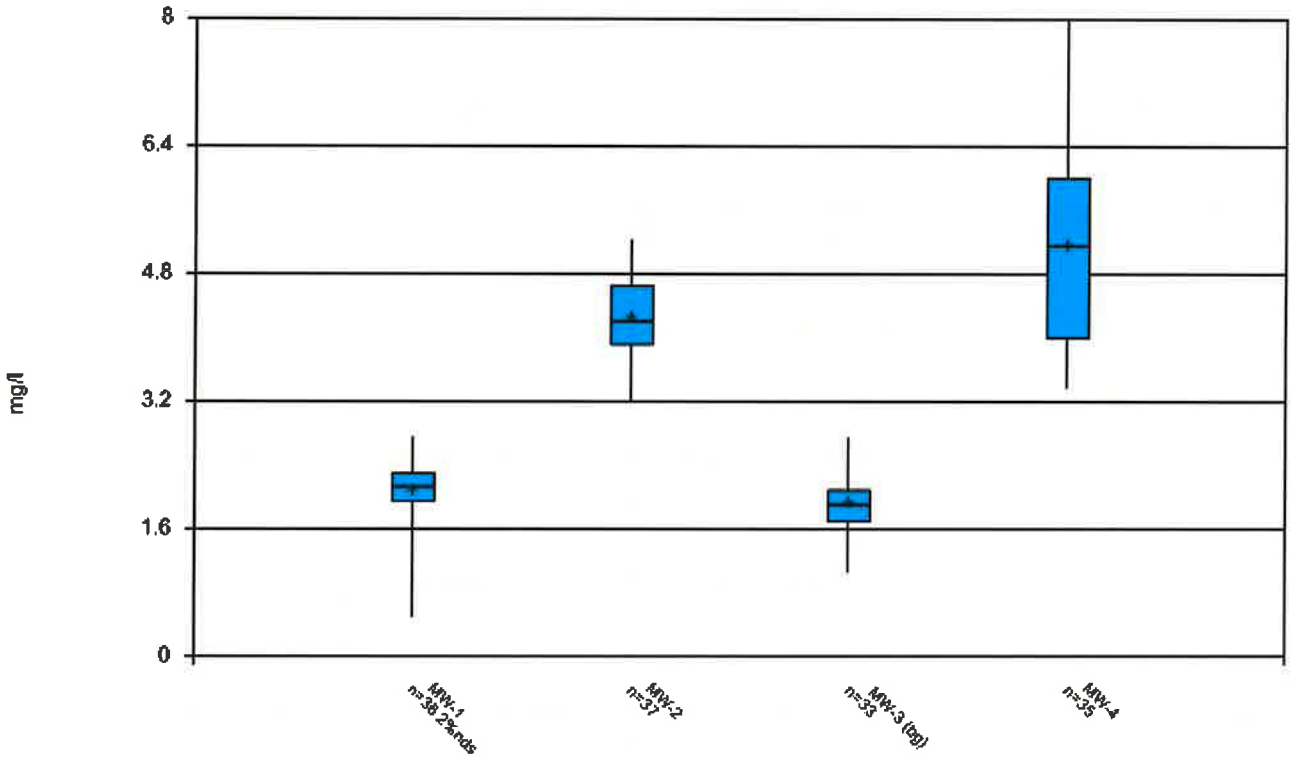


Constituent: Total Organic Carbon Analysis Run 4/23/2019 11:35 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

WQStat Plus™ v.9.4.41

Box & Whiskers Plot



Constituent: Total Sodium Analysis Run 4/23/2019 11:35 AM

Facility: Sauk Landfill Data File: Inorganic_Analytical_Results_(1990-2018)

APPENDIX G

MANN-KENDALL TREND TESTS (1990-2018 AND 2014-2018)

Sauk Landfill Long-Term Mann-Kendall Trend Tests 1990-2018

Analyte	Units	Well	Slope	Z-Score	Critical Value	Significant Trend?	# of Samples	% Non-detects	Alpha
Alkalinity	mg/L	MW-1	-0.5178	-199	-151	Yes	33	3.03	0.02
		MW-2	**-1.687**	**-300**	**-151**	**Yes**	**33**	**3.03**	**0.02**
		MW-3	-0.3567	-133	-132	Yes	30	0	0.02
		MW-4	**-1.771**	**-259**	**-145**	**Yes**	**32**	**0**	**0.02**
Barium, dissolved	mg/L	MW-1	0	-20	-171	No	36	5.556	0.02
		MW-2	**-0.0004171**	**-291**	**-179**	**Yes**	**37**	**2.703**	**0.02**
		MW-3	0	58	151	No	33	6.061	0.02
		MW-4	0	36	166	No	35	8.571	0.02
Bicarbonate	mg/L	**MW-1**	**-0.5479**	**-220**	**-151**	**Yes**	**33**	**3.03**	**0.02**
		MW-2	**-1.699**	**-311**	**-151**	**Yes**	**33**	**3.03**	**0.02**
		MW-3	**-0.3967**	**-141**	**-138**	**Yes**	**31**	**3.226**	**0.02**
		MW-4	**-1.662**	**-246**	**-145**	**Yes**	**32**	**0**	**0.02**
Calcium, total	mg/L	MW-1	0	-16	-171	No	36	0	0.02
		MW-2	**-0.378**	**-214**	**-171**	**Yes**	**36**	**0**	**0.02**
		MW-3	-0.01204	-8	-158	No	34	0	0.02
		MW-4	-0.1138	-79	-166	No	35	0	0.02
Chloride	mg/L	MW-1	0.01585	2.151	2.33	No	110	1.818	0.02
		MW-2	0.00924	0.6273	2.33	No	109	0	0.02
		MW-3	0.006167	1.135	2.33	No	108	4.63	0.02
		MW-4	**0.2945**	**4.725**	**2.33**	**Yes**	**109**	**0.9174**	**0.02**
Magnesium, total	mg/L	MW-1	-0.01229	-69	-166	No	35	2.857	0.02
		MW-2	**-0.1048**	**-199**	**-166**	**Yes**	**35**	**0**	**0.02**
		MW-3	0	-24	-151	No	33	0	0.02
		MW-4	-0.02583	-96	-158	No	34	0	0.02
Nitrate as nitrogen	mg/L	**MW-1**	**-0.0222**	**-8.053**	**-2.33**	**Yes**	**110**	**0**	**0.02**
		MW-2	**0.02895**	**3.256**	**2.33**	**Yes**	**109**	**1.835**	**0.02**
		MW-3	**-0.02338**	**-7.6**	**-2.33**	**Yes**	**108**	**0**	**0.02**
		MW-4	-0.001878	-0.6841	-2.33	No	109	0	0.02
pH	mg/L	MW-1	0.001409	0.3979	2.33	No	110	0	0.02
		MW-2	0.002336	0.6523	2.33	No	109	0	0.02
		MW-3	-0.001949	-0.4496	-2.33	No	107	0	0.02
		MW-4	-0.00514	-1.328	-2.33	No	109	0	0.02
Potassium, total	mg/L	MW-1	0	0	166	No	35	31.43	0.02
		MW-2	-0.003318	-48	-166	No	35	0	0.02
		MW-3	0	45	151	No	33	57.58	0.02
		MW-4	0.001613	52	158	No	34	5.882	0.02
Sodium, total	mg/L	**MW-1**	**-0.03392**	**-188**	**-171**	**Yes**	**36**	**2.778**	**0.02**
		MW-2	-0.02655	-81	-179	No	37	0	0.02
		MW-3	-0.007317	-35	-151	No	33	0	0.02
		MW-4	**0.2362**	**288**	**166**	**Yes**	**35**	**0**	**0.02**
Specific Conductance	us/cm	**MW-1**	**-0.9216**	**-6.362**	**-2.33**	**Yes**	**110**	**0**	**0.02**
		MW-2	**-1.716**	**-5.482**	**-2.33**	**Yes**	**109**	**0**	**0.02**
		MW-3	**-0.3211**	**-2.775**	**-2.33**	**Yes**	**107**	**0**	**0.02**
		MW-4	0.1378	0.3982	2.33	No	109	0	0.02
Sulfate	mg/L	**MW-1**	**-0.02281**	**-5.8**	**-2.33**	**Yes**	**110**	**0**	**0.02**
		MW-2	**0.02306**	**2.765**	**2.33**	**Yes**	**109**	**0.9174**	**0.02**
		MW-3	**-0.01999**	**-4.007**	**-2.33**	**Yes**	**108**	**0**	**0.02**
		MW-4	**-0.02172**	**-4.956**	**-2.33**	**Yes**	**109**	**0.9174**	**0.02**
Total Dissolved Solids	mg/L	MW-1	0.8425	144	166	No	35	2.857	0.02
		MW-2	-0.6003	-98	-166	No	35	0	0.02
		MW-3	0.6138	94	145	No	32	0	0.02
		MW-4	1.736	113	158	No	34	0	0.02
Total Organic Carbon	mg/L	MW-1	-0.0008766	-1.16	-2.33	No	108	55.56	0.02
		MW-2	**-0.006377**	**-2.913**	**-2.33**	**Yes**	**108**	**59.26**	**0.02**
		MW-3	0	-0.6135	-2.33	No	107	51.4	0.02
		MW-4	0	-1.412	-2.33	No	108	69.44	0.02

Sauk Landfill Short-Term Mann-Kendall Trend Tests 2014-2018

Analyte	Units	Well	Slope	Z-Score	Critical Value	Significant Trend?	# of Samples	% Non-detects	Alpha
Alkalinity	mg/L	MW-1	-0.1352	-11	-58	No	17	5.882	0.02
		MW-2	0.06526	1	58	No	17	5.882	0.02
		MW-3	**-1.385**	**-57**	**-48**	**Yes**	**15**	**0**	**0.02**
		MW-4	-0.4275	-13	-53	No	16	0	0.02
Barium, dissolved	mg/L	MW-1	0	-3	-58	No	17	0	0.02
		MW-2	0	27	58	No	17	0	0.02
		MW-3	0	7	48	No	15	0	0.02
		MW-4	0.00002121	14	53	No	16	6.25	0.02
Bicarbonate	mg/L	MW-1	-0.4277	-20	-58	No	17	5.882	0.02
		MW-2	-0.1816	-6	-58	No	17	5.882	0.02
		MW-3	-1.147	-50	-53	No	16	6.25	0.02
		MW-4	-0.08505	-6	-53	No	16	0	0.02
Calcium, total	mg/L	MW-1	0.09662	21	58	No	17	0	0.02
		MW-2	0.3395	29	58	No	17	0	0.02
		MW-3	0.03552	6	53	No	16	0	0.02
		MW-4	0.3537	25	53	No	16	0	0.02
Chloride	mg/L	MW-1	0.47	27	58	No	17	5.882	0.02
		MW-2	-0.02884	-7	-58	No	17	0	0.02
		MW-3	0.2875	24	53	No	16	6.25	0.02
		MW-4	1.886	25	53	No	16	6.25	0.02
Magnesium, total	mg/L	MW-1	0.03118	27	58	No	17	5.882	0.02
		MW-2	0.1113	41	58	No	17	0	0.02
		MW-3	0.01366	9	53	No	16	0	0.02
		MW-4	0.03314	11	53	No	16	0	0.02
Nitrate as nitrogen	mg/L	MW-1	0.01908	34	58	No	17	0	0.02
		MW-2	0.02886	18	58	No	17	5.882	0.02
		MW-3	-0.008209	-8	-53	No	16	0	0.02
		MW-4	0	-3	-53	No	16	0	0.02
pH	mg/L	MW-1	-0.119	-43	-58	No	17	0	0.02
		MW-2	-0.1129	-33	-58	No	17	0	0.02
		MW-3	-0.03935	-11	-44	No	14	0	0.02
		MW-4	-0.09947	-26	-53	No	16	0	0.02
Potassium, total	mg/L	MW-1	0.0272	24	58	No	17	35.29	0.02
		MW-2	0.03206	31	58	No	17	0	0.02
		MW-3	0.04706	50	53	No	16	56.25	0.02
		MW-4	0.02103	28	53	No	16	6.25	0.02
Sodium, total	mg/L	MW-1	0.0153	8	58	No	17	5.882	0.02
		MW-2	-0.03971	-12	-58	No	17	0	0.02
		MW-3	0.08665	27	48	No	15	0	0.02
		MW-4	0.1523	21	53	No	16	0	0.02
Specific Conductance	us/cm	MW-1	0	0	58	No	17	0	0.02
		MW-2	0.1641	3	58	No	17	0	0.02
		MW-3	-0.6565	-6	-44	No	14	0	0.02
		MW-4	-3.676	-31	-53	No	16	0	0.02
Sulfate	mg/L	**MW-1**	**-0.08156**	**-62**	**-58**	**Yes**	**17**	**0**	**0.02**
		MW-2	-0.1337	-32	-58	No	17	5.882	0.02
		MW-3	-0.01596	-19	-53	No	16	0	0.02
		MW-4	0.0116	13	53	No	16	0	0.02
Total Dissolved Solids	mg/L	MW-1	1.317	23	58	No	17	5.882	0.02
		MW-2	-0.5638	-8	-58	No	17	0	0.02
		MW-3	0.5415	12	48	No	15	0	0.02
		MW-4	0.03786	0	53	No	16	0	0.02
Total Organic Carbon	mg/L	MW-1	-0.001517	-13	-53	No	16	43.75	0.02
		MW-2	0	25	53	No	16	75	0.02
		MW-3	-0.003034	-15	-48	No	15	46.67	0.02
		MW-4	0	20	48	No	15	80	0.02

APPENDIX H

WILCOXON RANK SUM TEST 1990-2018

Sauk Landfill Long-Term Mann-Whitney (Wilcoxon) Trend Tests 1990-2018

Analyte	Units	Well	Calculated	Significant @ 0.1	Significant @ 0.05	Significant @ 0.025	Significant @ 0.01	Alpha	Significant
Alkalinity	mg/L	MW-1	-0.9294	No	No	No	No	0.05	No
		MW-2	**6.393**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	-5.221	No	No	No	No	0.05	No
Barium, dissolved	mg/L	MW-1	-1.649	No	No	No	No	0.05	No
		MW-2	**6.428**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**4.233**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
Bicarbonate	mg/L	MW-1	-0.8737	No	No	No	No	0.05	No
		MW-2	**6.456**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	-4.882	No	No	No	No	0.05	No
Calcium, total	mg/L	MW-1	-3.581	No	No	No	No	0.05	No
		MW-2	**7.063**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	-3.181	No	No	No	No	0.05	No
Chloride	mg/L	**MW-1**	**2.869**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-2	**10.51**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**9.205**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
Magnesium, total	mg/L	**MW-1**	**6.237**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-2	**7.086**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**2.035**	**Yes**	**Yes**	**Yes**	**No**	**0.05**	**Yes**
Nitrate as nitrogen	mg/L	MW-1	0.1096	No	No	No	No	0.05	No
		MW-2	**11.11**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**2.866**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
pH	pH	MW-1	0.2379	No	No	No	No	0.1	No
		MW-2	**-3.76**	**Yes**	**Yes**	**Yes**	**Yes**	**0.1**	**Yes**
		MW-4	**-6.234**	**Yes**	**Yes**	**Yes**	**Yes**	**0.1**	**Yes**
Potassium, total	mg/L	**MW-1**	**2.869**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-2	**6.851**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**4.705**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
Sodium, total	mg/L	**MW-1**	**2.7**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-2	**7.179**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**7.082**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
Specific Conductance	us/cm	**MW-1**	**1.677**	**Yes**	**Yes**	**No**	**No**	**0.05**	**Yes**
		MW-2	**12.34**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**2.86**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
Sulfate	mg/L	MW-1	-0.05399	No	No	No	No	0.05	No
		MW-2	**7.444**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	-10.66	No	No	No	No	0.05	No
Total Dissolved Solids	mg/L	MW-1	1.522	Yes	No	No	No	0.05	No
		MW-2	**6.907**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
		MW-4	**5.18**	**Yes**	**Yes**	**Yes**	**Yes**	**0.05**	**Yes**
Total Organic Carbon	mg/L	MW-1	-0.7272	No	No	No	No	0.05	No
		MW-2	0.3293	No	No	No	No	0.05	No
		MW-4	-0.8597	No	No	No	No	0.05	No

Notes:
mg/L = milligrams per liter (parts per million)
µg/L = micrograms per liter (parts per billion)
Results shown in bold text represent a significant difference between the listed down-gradient and up-gradient wells

APPENDIX I

PREDICTION LIMITS 1990-2018

Sauk Landfill Prediction Limits 1990-2018

Analyte	Units	Well	Upper Limit	Observation	Exceeds	Background N	Background Mean	Standard Deviation	% Non-detects	Alpha
Alkalinity	mg/L	MW-1	45.58	36.6	No	30	39.43	2.708	0	0.01667
		MW-2	**45.58**	**59.7**	**Yes**	**30**	**39.43**	**2.708**	**0**	**0.01667**
		MW-4	45.58	20.4	No	30	39.43	2.708	0	0.01667
Barium, dissolved	mg/L	MW-1	0.02424	0.0051	No	33	0.006558	0.007832	6.061	0.01667
		MW-2	0.02424	0.022	No	33	0.006558	0.007832	6.061	0.01667
		MW-4	0.02424	0.0072	No	33	0.006558	0.007832	6.061	0.01667
Bicarbonate	mg/L	MW-1	54.46	35.4	No	31	38.25	7.153	3.226	0.01667
		MW-2	**54.46**	**59.9**	**Yes**	**31**	**38.25**	**7.153**	**3.226**	**0.01667**
		MW-4	54.46	22.2	No	31	38.25	7.153	3.226	0.01667
Calcium, total	mg/L	MW-1	15.64	11.5	No	34	12.54	1.376	0	0.01667
		MW-2	**15.64**	**20.4**	**Yes**	**34**	**12.54**	**1.376**	**0**	**0.01667**
		MW-4	15.64	11.5	No	34	12.54	1.376	0	0.01667
Chloride	mg/L	MW-1	4.488	3.7	No	108	1.521	1.37	4.63	0.01667
		MW-2	**4.488**	**7.3**	**Yes**	**108**	**1.521**	**1.37**	**4.63**	**0.01667**
		MW-4	**4.488**	**18.5**	**Yes**	**108**	**1.521**	**1.37**	**4.63**	**0.01667**
Magnesium, total	mg/L	**MW-1**	**2.321**	**2.43**	**Yes**	**33**	**1.884**	**0.1938**	**0**	**0.01667**
		MW-2	**2.321**	**5.05**	**Yes**	**33**	**1.884**	**0.1938**	**0**	**0.01667**
		MW-4	2.321	2.05	No	33	1.884	0.1938	0	0.01667
Nitrate as nitrogen	mg/L	MW-1	1.55	0.41	No	108	0.6325	0.4235	0	0.01667
		MW-2	**1.55**	**1.99**	**Yes**	**108**	**0.6325**	**0.4235**	**0**	**0.01667**
		MW-4	1.55	0.51	No	108	0.6325	0.4235	0	0.01667
pH	pH	MW-1	7.668	6.76	No	107	6.514	0.4721	0	0.008333
		MW-2	7.668	6.75	No	107	6.514	0.4721	0	0.008333
		MW-4	7.668	6.7	No	107	6.514	0.4721	0	0.008333
Potassium, total	mg/L	MW-1	0.68	0.5	No	33	n/a	n/a	57.58	0.02859
		MW-2	**0.68**	**0.73**	**Yes**	**33**	**n/a**	**n/a**	**57.58**	**0.02859**
		MW-4	0.68	0.59	No	33	n/a	n/a	57.58	0.02859
Sodium, total	mg/L	MW-1	2.695	2.15	No	33	1.93	0.3388	0	0.01667
		MW-2	**2.695**	**4.12**	**Yes**	**33**	**1.93**	**0.3388**	**0**	**0.01667**
		MW-4	**2.695**	**6.16**	**Yes**	**33**	**1.93**	**0.3388**	**0**	**0.01667**
Specific Conductance	us/cm	MW-1	135.1	94	No	107	97.62	17.3	0	0.01667
		MW-2	**135.1**	**171**	**Yes**	**107**	**97.62**	**17.3**	**0**	**0.01667**
		MW-4	135.1	118	No	107	97.62	17.3	0	0.01667
Sulfate	mg/L	MW-1	3.942	2.9	No	108	2.625	0.6081	0	0.01667
		MW-2	3.942	2.8	No	108	2.625	0.6081	0	0.01667
		MW-4	3.942	1.8	No	108	2.625	0.6081	0	0.01667
Total Dissolved Solids	mg/L	MW-1	70.74	54	No	32	55.34	6.809	0	0.01667
		MW-2	**70.74**	**103**	**Yes**	**32**	**55.34**	**6.809**	**0**	**0.01667**
		MW-4	**70.74**	**82**	**Yes**	**32**	**55.34**	**6.809**	**0**	**0.01667**
Total Organic Carbon	mg/L	MW-1	2.8	0.075ND	No	107	n/a	n/a	51.4	0.009175
		MW-2	2.8	0.075ND	No	107	n/a	n/a	51.4	0.009175
		MW-4	2.8	0.075ND	No	107	n/a	n/a	51.4	0.009175

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