NEVADA DIVISION OF
ENVIRONMENTAL PROTECTION

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January 21, 2016

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Re: **BMI Plant Sites, Common Areas Projects and Other Industrial Sites, Henderson, Nevada**
Draft Up-Gradient Groundwater Quality Technical Memorandum for TDS, Arsenic and Perchlorate

Dear Messrs.:

All of the parties listed above shall be referred to as "the Companies" for the purposes of this letter. The NDEP has prepared an Up-Gradient Groundwater Quality Technical Memorandum for TDS, Arsenic and Perchlorate (attachment A). This work was performed as a part of the NDEP's January 21, 2014 Regional Groundwater Goals and Directives letter (attachment B). The NDEP has incorporated the Companies comments received after the April 15, 2015 draft submittal.

Please contact the undersigned with any questions at jdotchin@ndep.nv.gov or 702-486-2850 Ext. 235.

Sincerely,

James (JD) Dotchin
Chief
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NDEP-Las Vegas

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Attachments (2)

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HACKENBERRY ASSOCIATES, LLC

Technical Memorandum

To:	Kurt Fehling, Kirk Stowers, and JD Dotchin
From:	Paul S. Hackenberry, Jr., C.E.M. #1823 (Exp. 4/15/2017) Paul K. Black, Ph.D., Neptune & Company, Inc. Anna L. Springsteen, M.S., Neptune & Company, Inc.
Deliverable reviewed:	Up-Gradient Groundwater Review
Deliverable date:	November 6, 2015

Introduction

This up-gradient groundwater review for TDS, arsenic, and perchlorate was initiated in response to the Nevada Division of Environmental Protection's (NDEP's) BMI Regional Goals and Directives letter sent to Basic Remediation Company, Olin Corporation, NV Environmental Response Trust, Montrose Chemical Corporation of CA, Stauffer Management Company, LLC, and Titanium Metals Corporation (TIMET), herein referred to as the BMI Companies. In the communication to the BMI Companies the NDEP stated that it would "...develop and defend the definition of up-gradient groundwater quality" in terms of total dissolved solids (TDS), perchlorate, and arsenic (NDEP, 2013 and 2014). The NDEP also noted that groundwater quality might be different at each site and that if up-gradient groundwater conentrations exceeded remediation standards this would be considered with regards to sitewide and down-gradient Remedial Action Objectives (RAOs) (NDEP, 2013 and 2014).

The primary objective of this groundwater evaluation is to calculate and present estimates of the reasonable upper end of up-gradient groundwater quality for TDS, perchlorate, and arsenic.This memorandum outlines the methods used, which include identifying suitable groundwater data, exploratory data analysis, and calculation of the 90th percentile of the data for each analyte. The 90th percentile is used to represent the upper end of up-gradient groundwater quality.

For some analytes, up-gradient groundwater might be unimpacted and, hence, represents background conditions. For others, up-gradient groundwater might be impacted by other sources or by migration from the sites to offsite locations. There are few long-term wells located on the edge of the sites that can be used to characterize up-gradient conditions. Criteria were established to select appropriate up-gradient wells and groundwater sample concentrations from the NDEP Regional Database. Sixteen wells met the critera, and the data from these wells were used to calculate the 90th percentiles of the TDS, arsenic, and perchlorate data:

- TDS: 2,900 mg/L
- Arsenic: 59 µg/L
- Perchlorate: 400 µg/L

These concentrations represent upper threshold values of up-gradient groundwater quality levels for these three analytes. A more detailed explanation of the process follows.

Groundwater and Well Data Sources

The NDEP online groundwater database was used to develop the list of wells and compile data for TDS, arsenic, and perchlorate. The NDEP online database, which is maintained by Neptune and Company, Inc. (Neptune) includes:

1. All groundwater data submitted to Neptune through DVSRs; and
2. Data from the "All Wells database," which is maintained by the BMI Companies for construction details and other well-specific information.

The NDEP online groundwater database can be accessed at: http://ndep2.neptuneinc.org.

Selection Criteria for Up-Gradient Wells

In reviewing the NDEP online database it was clear that selection criteria were needed to identify suitable up-gradient wells. Five criteria were established to select wells from the database:

1. Wells must have samples collected in 2004 or later, because this was when the NDEP implemented consistent site wide sampling and analysis plans;
2. Wells must have more than one sample for each of the three analytes (TDS, perchlorate, and arsenic);
3. Wells must be located along the south (up gradient) and/or east or west perimeter (cross gradient) of company properties;
4. Wells located in alluvium, transitional Muddy Creek formation (xMCf), and Upper Muddy Creek formation (UMCf), must be screened in a shallow or middle water bearing zone; and
5. Wells must be no deeper than 100 ft.

The NDEP has developed and maintained an electronic file with copies of Quality Assurance Project Plans (QAPP), Sampling and Analysis Plans (SAP), and Field Sampling and Standard Operating Procedure (FS SOP) as submitted by the BMI Companies. The earliest plans that followed standard procedures appear to have occurred in 2004 and continued forward with BRC's Eastside Hyrdogeologic Characterization and later BMI Companies' site related reports. Using 2004 as a starting point, the date range of available data in the NDEP online database was 2004-2014. After applying the other four criteria above, the resulting date range of available relevant groundwater data was 2004-2013. In total 16 up-gradient and cross-gradient wells were selected for review as listed below (Table 1) and shown in Figure 1.

Table 1: Wells included in calculations of background threshold concentrations

1. AA-MW-05	5. AA-UW4	9. H-11	13. TMMW-101
2. AA-MW-24	6. AA-UW5	10. HMWWT-6	14. TMMW-102
3. AA-UW2	7. DBMW-16	11. MCF-03B	15. TMMW-103
4. AA-UW3	8. DBMW-17	12. MW-01	16. TMMW-104

The wells selected were the furthest south, east, and west of the BMI Industrial Facilities, the BMI Upper Ponds, and Former AMPAC Facilities. Groundwater elevation maps provided by the Companies were evaluated and consistently showed the groundwater gradient to be north to northeast across the site. There are no Shallow Zone wells meeting the five criteria further south of the wells selected for calculation of background threshold values. on which to base an up-gradient contour map.

Data Validation Status

The validation status of data selected for the up-gradient groundwater analysis was reviewed using three database validation fields (validation flag, validation level, and final validation qualifier) to confirm that the selected data are considered useable. On this basis, TDS data validation was 90%; arsenic was 100%; and perchlorate was 89% of the data used. The validation fields were blank in the NDEP online database for the non-validated portion of the TDS and perchlorate data. For data flagged as non-detect (0% of TDS, 19% of arsenic, and 10% of perchlorate data), the detection limit was used. Because up-gradient values were determined based on the 90th percentile and the data had high detect frequencies, non-detects have minimal influence on estimation of the up-gradient threshold values.

TDS, Arsenic, and Perchlorate Review

Exploratory data analysis of the up-gradient groundwater data for TDS, arsenic, and perchlorate was conducted using spatial plots, box plots, and quantile plots. Although the groundwater quality might be different at each of the BMI Companies' sites, there are an insufficient number of wells up-gradient of any single site to perform a statistical analysis on a site-by-site basis.

The spatial plots for each analyte provide context for each of the three analytes across the BMI Companies' facilities and downgradient areas, as well as the location of the 16 up-gradient wells. These plots display the data on a map as a circle with the radii and color intensity scaled based on the concentration at that well relative to the range of all the plotted data. The color and size of the plotted points reflects the mean concentration recorded for each well. The BMI Companies industrial area and former Upper and Lower Ponds are also plotted for reference. The legend on the spatial plots shows the minimum, the 25th, 50th, 75th, and 90th percentiles and the maximum concentrations.

The box plots display a summary of the data distribution for each well (ordered from west to east) showing the minimum and maximum; 25th, 50th, and 75th percentiles; and whiskers. The whiskers represent data points greater than 1.5 times the interquartile range. Data points beyond the whiskers could be representative of data with skew or a wide spread. Plots where no whiskers are apparent could represent data with a relatively small spread.

The quantile plots display the ranked data against the fraction of data points each ranked data point exceeds (U.S. EPA, 2006). The quantile plots also show the minimum; 25th, 75th, and 90th percentiles; median, average, geometric mean, and maximum.

The plots are attached organized first by analyte (TDS, arsenic, and perchlorate) and then by plot type (spatial plot (regional and then just up-gradient), box plot, and quantile plot).

TDS Summary

The regional concentration distribution for TDS is shown in the first attached spatial plot for TDS (Figure 2), with the up-gradient wells shown again, but separately, on the second spatial plot (Figure 3). The spatial plot shows relatively high TDS concentrations on the BMI Companies' sites (often greater than 3,000 mg/L), and a few very high TDS concentrations to the north of the Upper and Lower Ponds. The up-gradient wells exhibit lower TDS concentrations in general, confirming their representation of up-gradient conditions. The box plots (Figure 4) show large TDS concentration differences between some of the wells, suggesting, perhaps that wells AA-UW2, AA-UW3 and AA-UW4 might not represent up-gradient TDS conditions (concentrations near or greater than 4,000 mg/L). These three wells are located east of the BMI Companies' sites and on the southwest corner of the Upper Ponds. The TDS concentration data for the remaining wells are all less than 3,000 mg/L. The quantile plot (Figure 5) shows that the minimum TDS concentration from this up-gradient data set is 550 mg/L; the maximum is 7,000 mg/L; and the 90th percentile is 2,900 mg/L. A distinct break on the box and quantile plots occurs at 3,000 mg/L (93rd percentile). The EPA TDS secondary water quality standard is 500 mg/L. The estimated 90th percentile, or up-gradient threshold concentration, for TDS is 2,900 mg/L.

Arsenic Summary

The regional concentration distribution for arsenic is shown in the first spatial plot for arsenic (Figure 6). The second spatial plot (Figure 7) shows the up-gradient wells. These wells appear to represent arsenic concentrations at the lower end of the arsenic concentration range for the BMI Companies' sites. However, wells to the west of the sites appear to exhibit the lowest arsenic concentrations, suggesting, perhaps, that the selected up-gradient wells are impacted with an arsenic contamination source. The box plots show that wells AAUW-4 and MCF-03B have the highest arsenic concentrations for the up-gradient wells (Figure 8), with maximum values greater than 90 µg/L. The quantile plot shows that the minimum arsenic concentration from these wells is less than 1 µg/L; the maximum is 97 µg/L; and the 90th percentile is 59 µg/L (Figure 9). A break on the quantile plot occurs at an arsenic concentration of about 51 µg/L (82nd percentile) and a distinct break on the box and quantile plots occurs at 62 µg/L (93rd percentile). The EPA current MCL for arsenic is 10 µg/L and the former MCL was 50 µg/L. The estimated 90th percentile, or up-gradient threshold concentration, for arsenic is estimated as 59 mg/L.

Perchlorate Summary

The regional and up-gradient concentration distribution for perchlorate is shown in the two attached spatial plots for perchlorate (Figures 10 and 11). On the regional spatial plot there are high perchlorate concentrations on the NERT property, and comparatively low concentrations in the selected up-gradient wells. The quantile plot shows that the reported minimum perchlorate concentration is less than 1 µg/L; the maximum is 7,600 µg/L; and the 90th percentile is 397 µg/L. The box and quantile plots suggest the up-gradient levels are considerably less, as 85 percent of the data do not exceed 175 µg/L (Figures 12 and 13). Wells TMMW-102, TMMW-103, H-11, and MW-01 that have the highest perchlorate concentrations for the up-gradient wells are located south of the BMI Companies' sites, suggesting that these wells may too be impacted with some perchlorate contamination source. The Nevada provisional standard for perchlorate is 18 µg/L. The estimated 90th percentile, or up-gradient threshold concentration, for perchlorate is estimated as 400 µg/L.

References

Nevada Division of Environmental Protection, 2013. *Regional Groundwater Response to Comments* & *NDEP Proposed BMI Regional Groundwater Goals and Directives*. BMI Plant Sites, Regional Area and Common Areas Projects, Henderson, Nevada. October 1.

Nevada Division of Environmental Protection, 2014. NDEP BMI Regional Groundwater Goals and Directives. BMI Plant Sites, Regional Area and Common Areas Projects, Henderson, Nevada. January 21.

U.S. EPA, 2006. Data Quality Assessment: Statistical Methods for Practioners, EPA QA/G-9S. Office of Environmental Information, Washington, D.C. EPA/240/B-06/003. February.

Figure 1 Site map showing up-gradient well locations

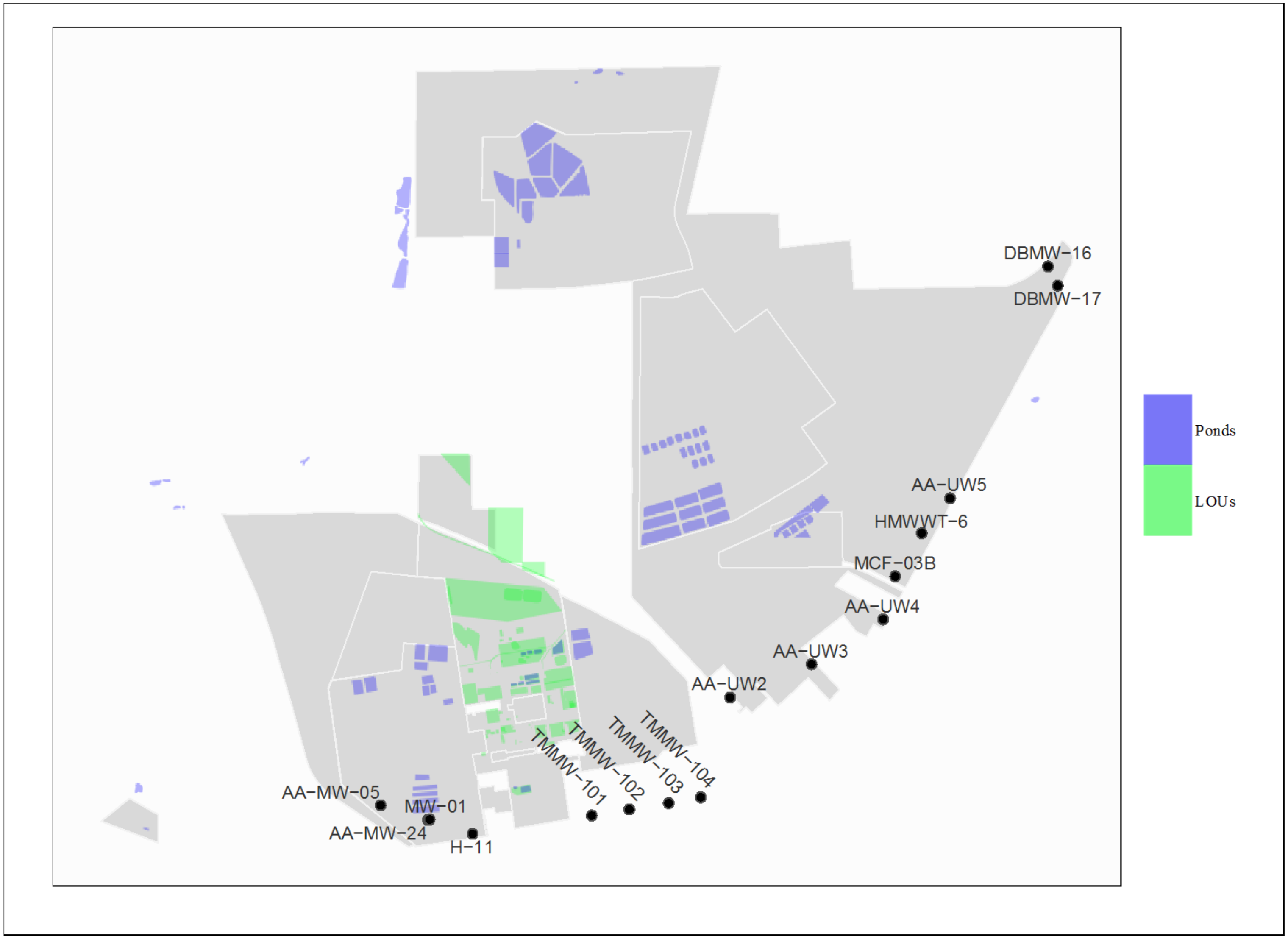


Figure 2 All wells scaled to TDS values

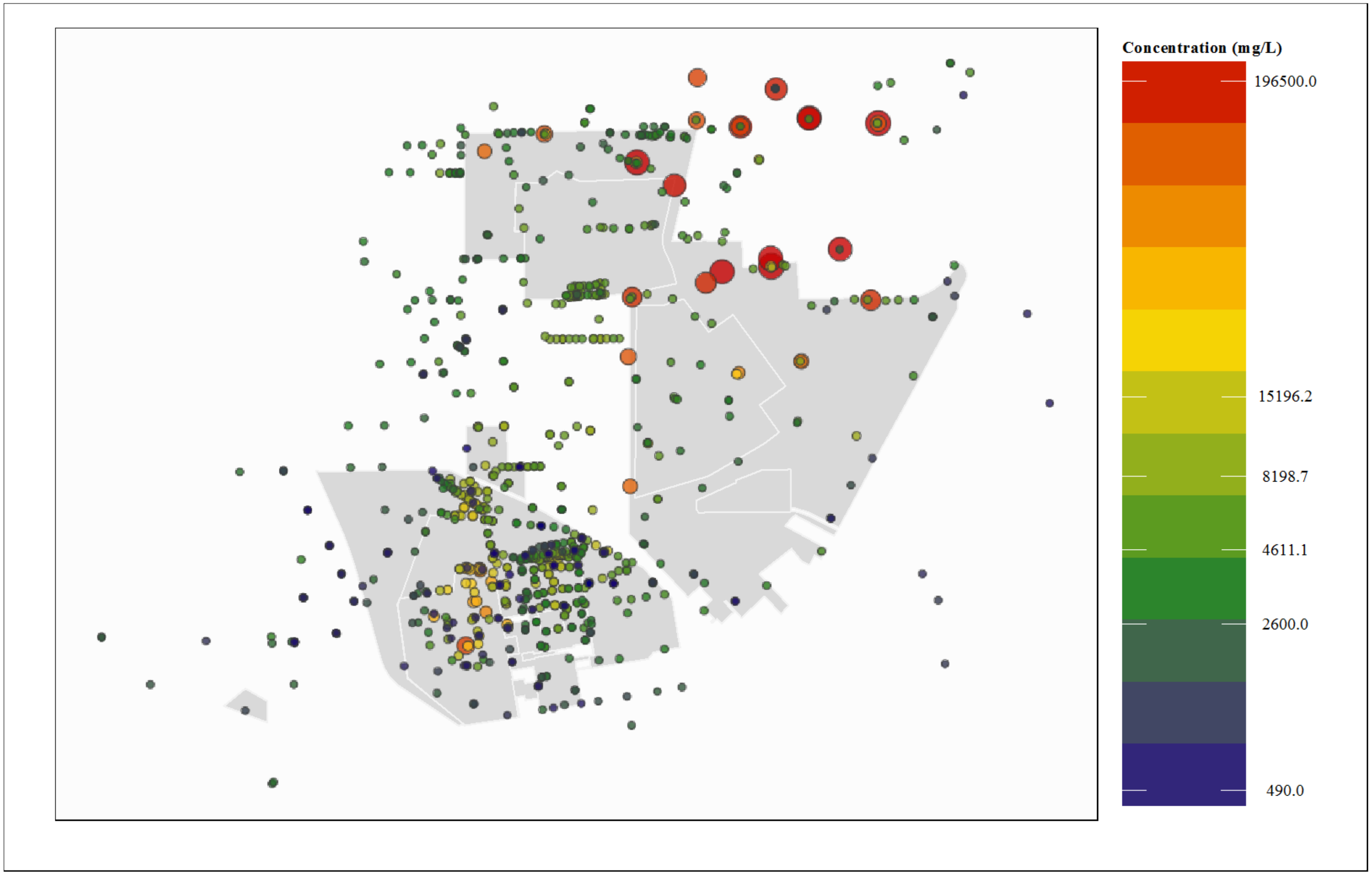


Figure 3 Up-gradient wells scaled to TDS values

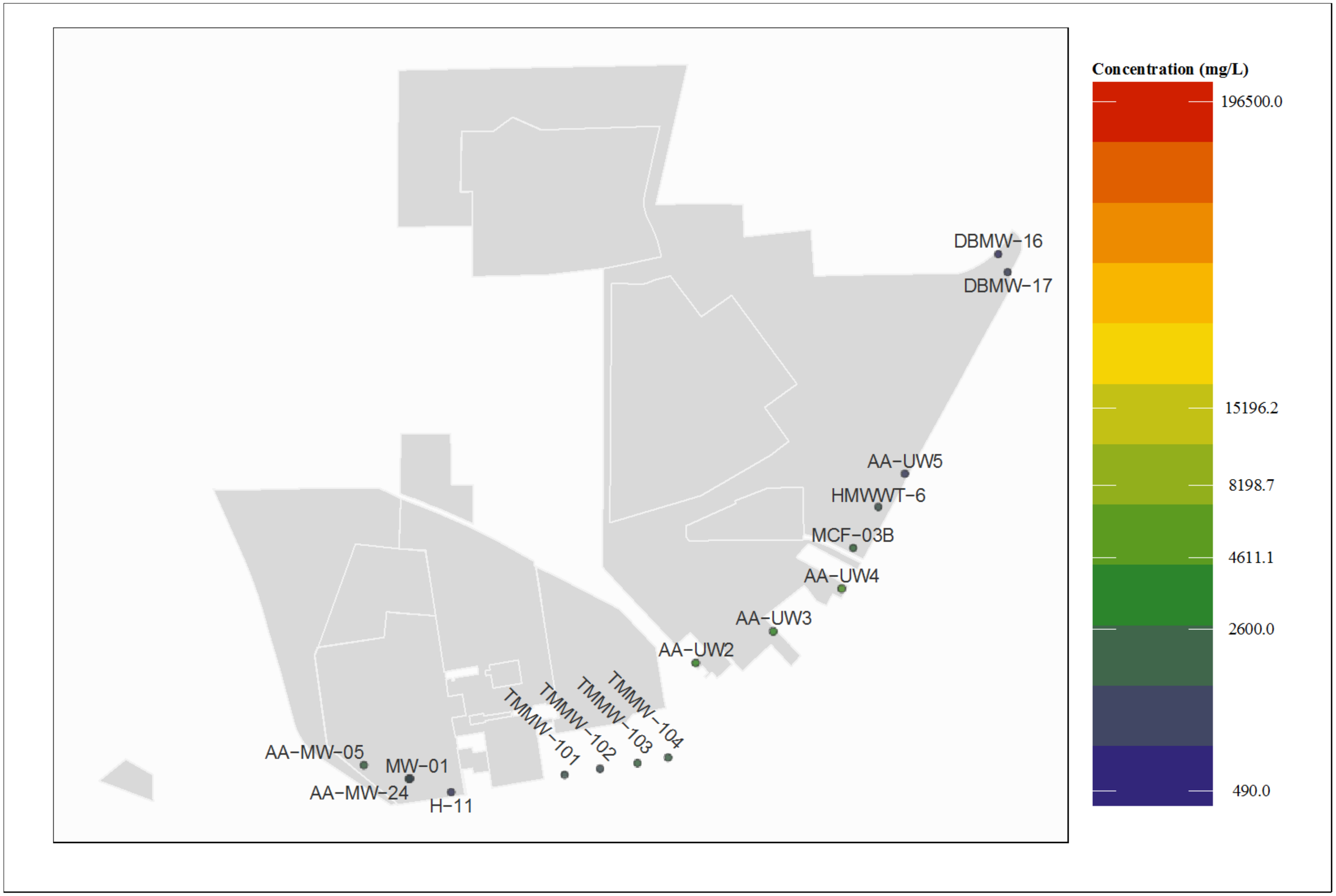


Figure 4 Boxplots for TDS

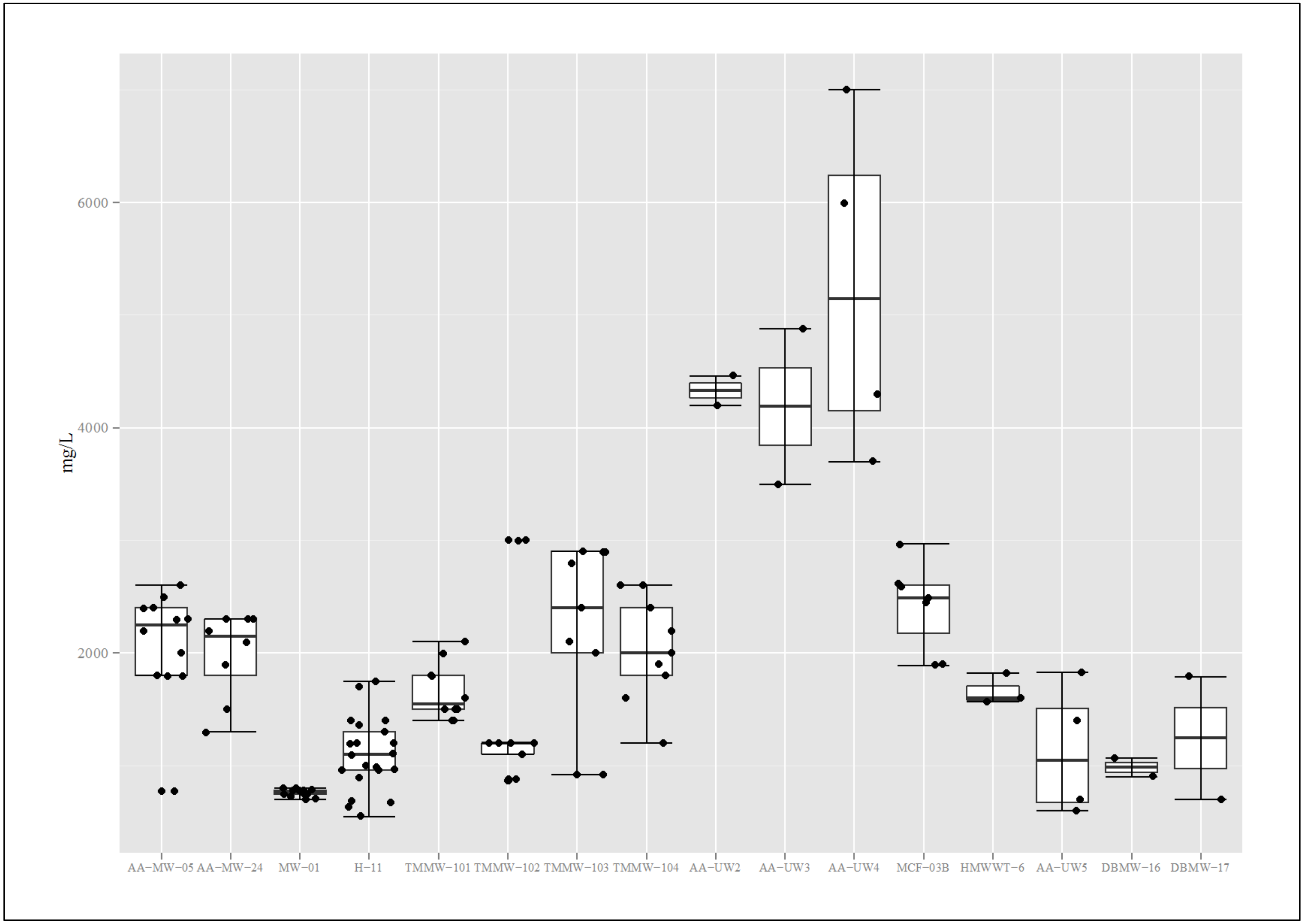


Figure 5 Quantile plot for TDS

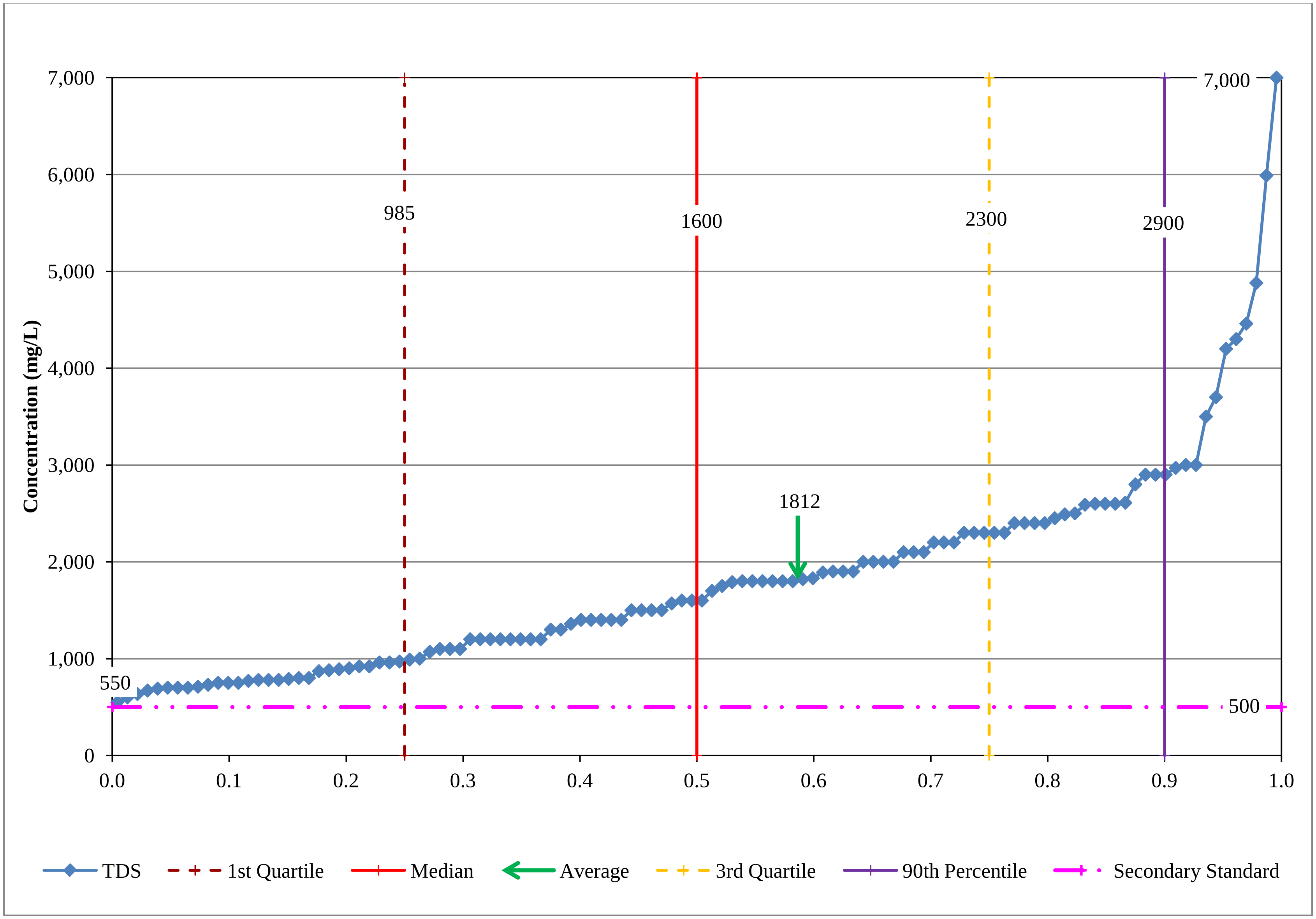


Figure 6 All wells scaled to arsenic values

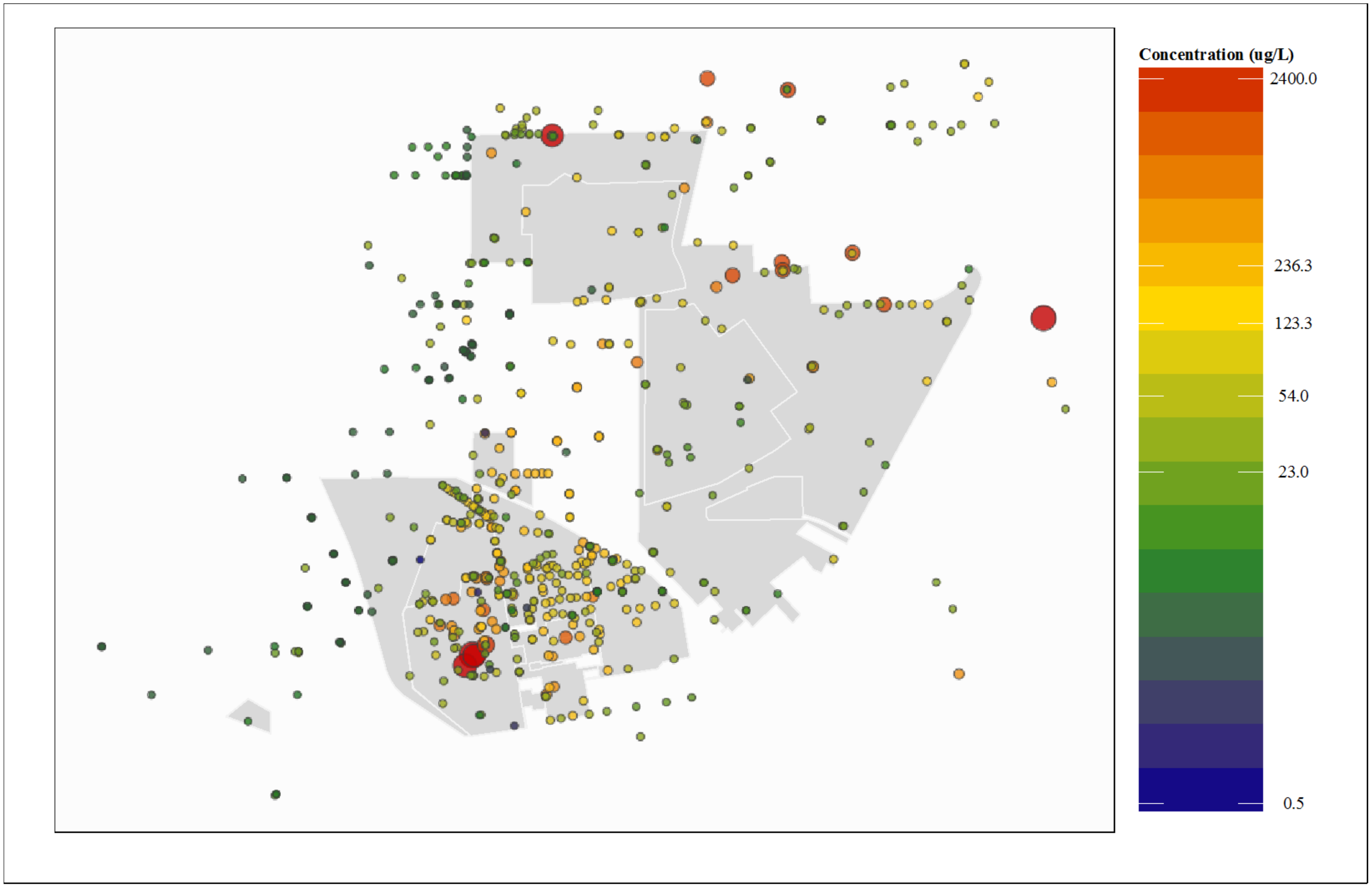


Figure 7 Up-gradient wells scaled to arsenic values

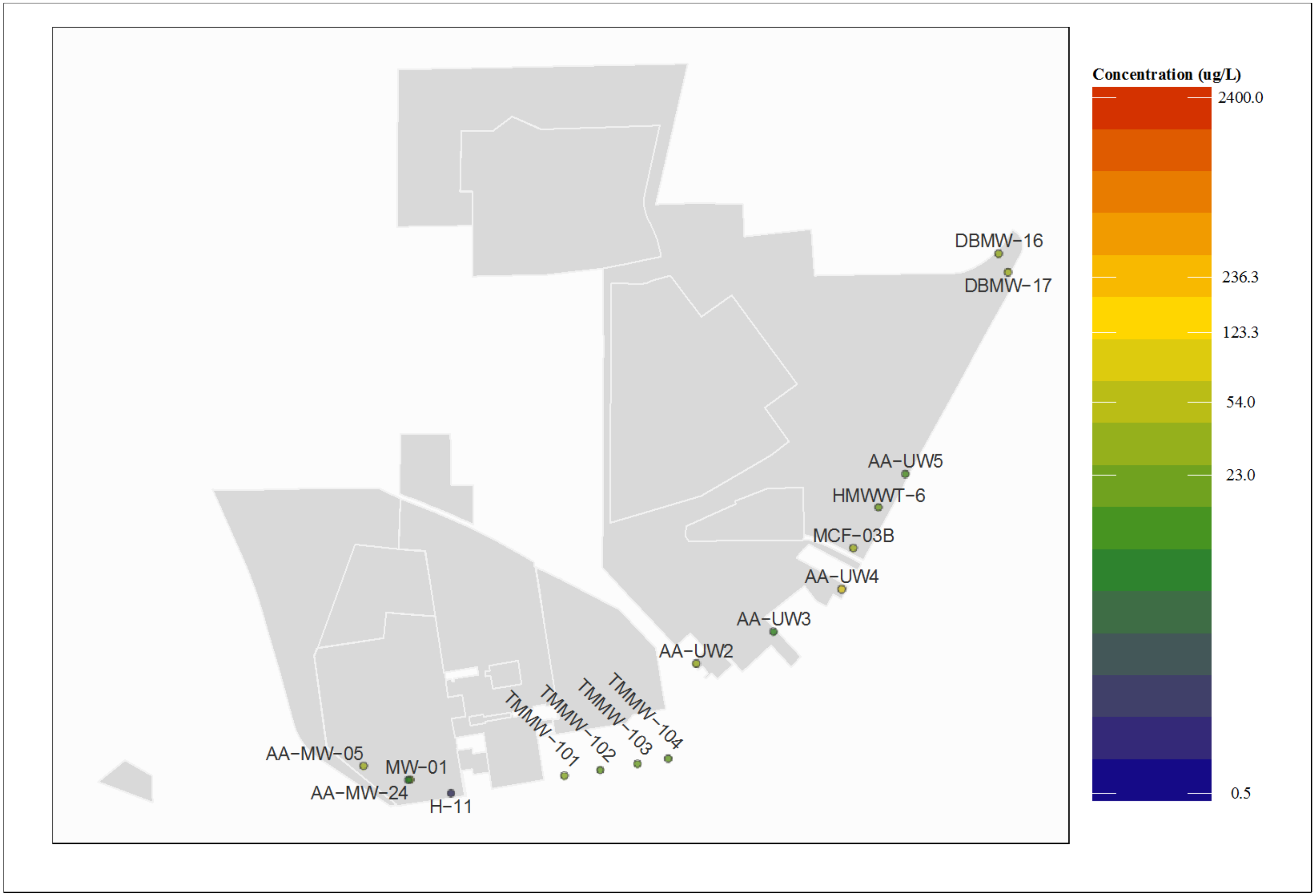


Figure 8 Boxplots for arsenic

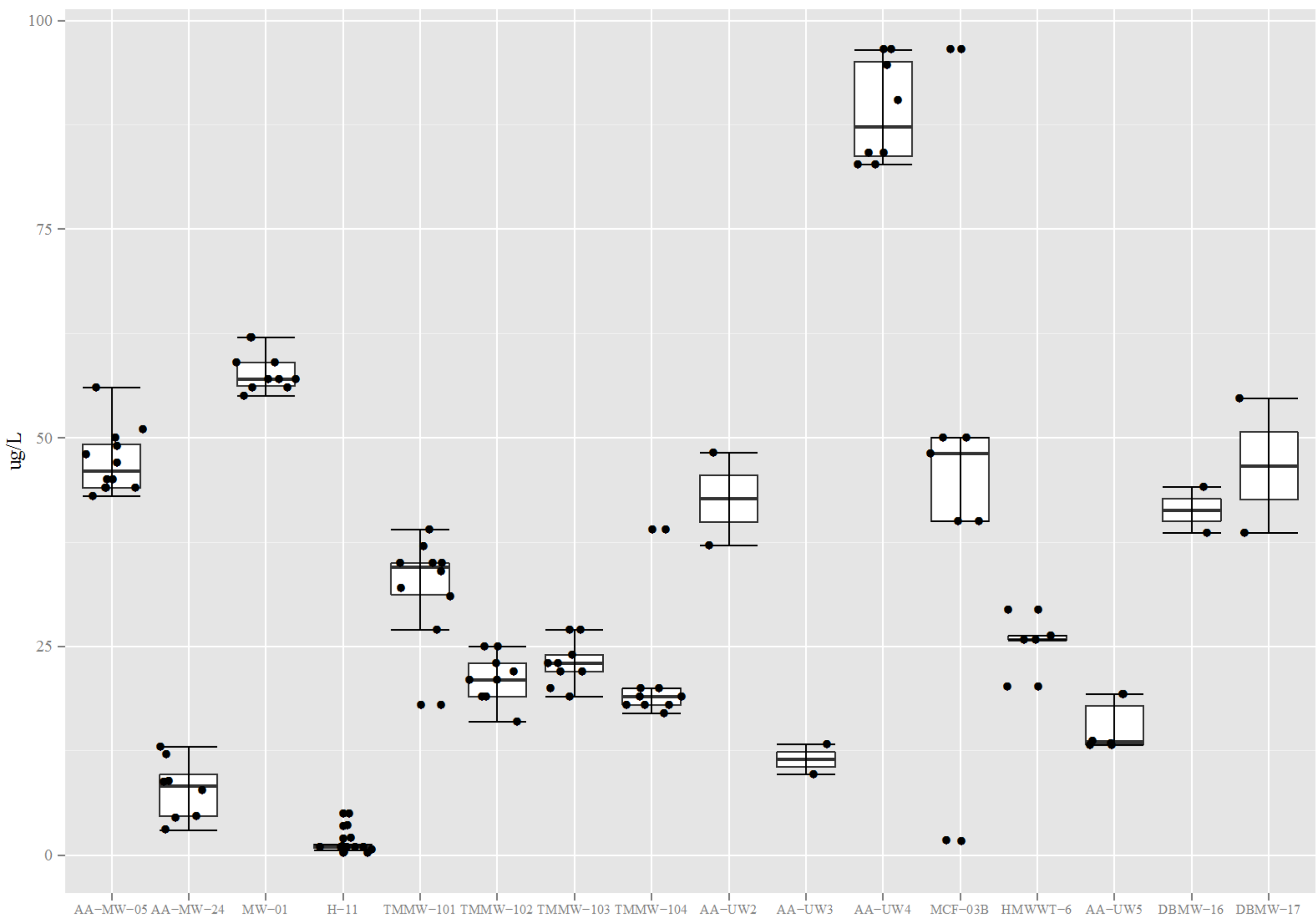


Figure 9 Quantile plot for arsenic

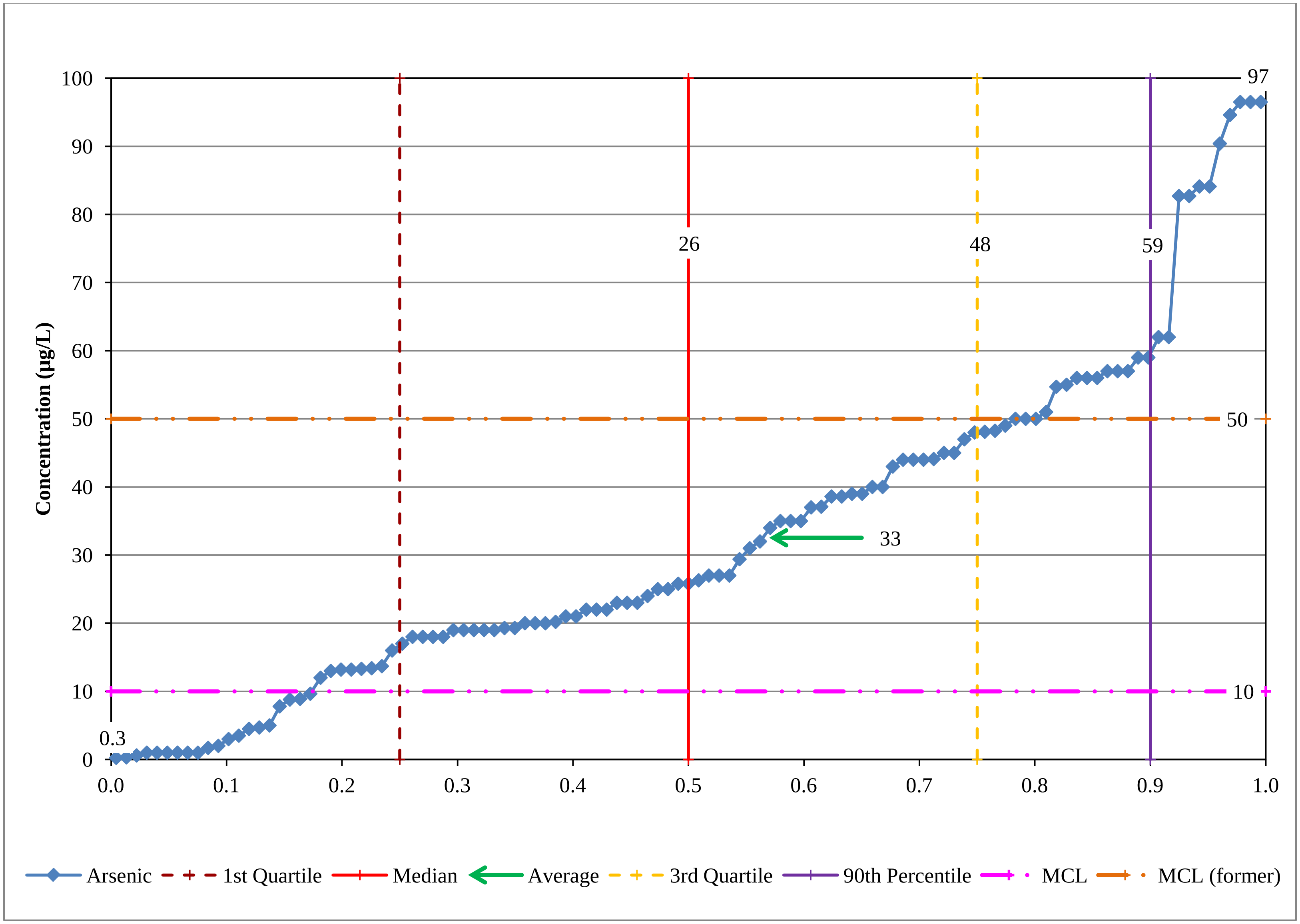


Figure 10 All wells scaled to perchlorate values

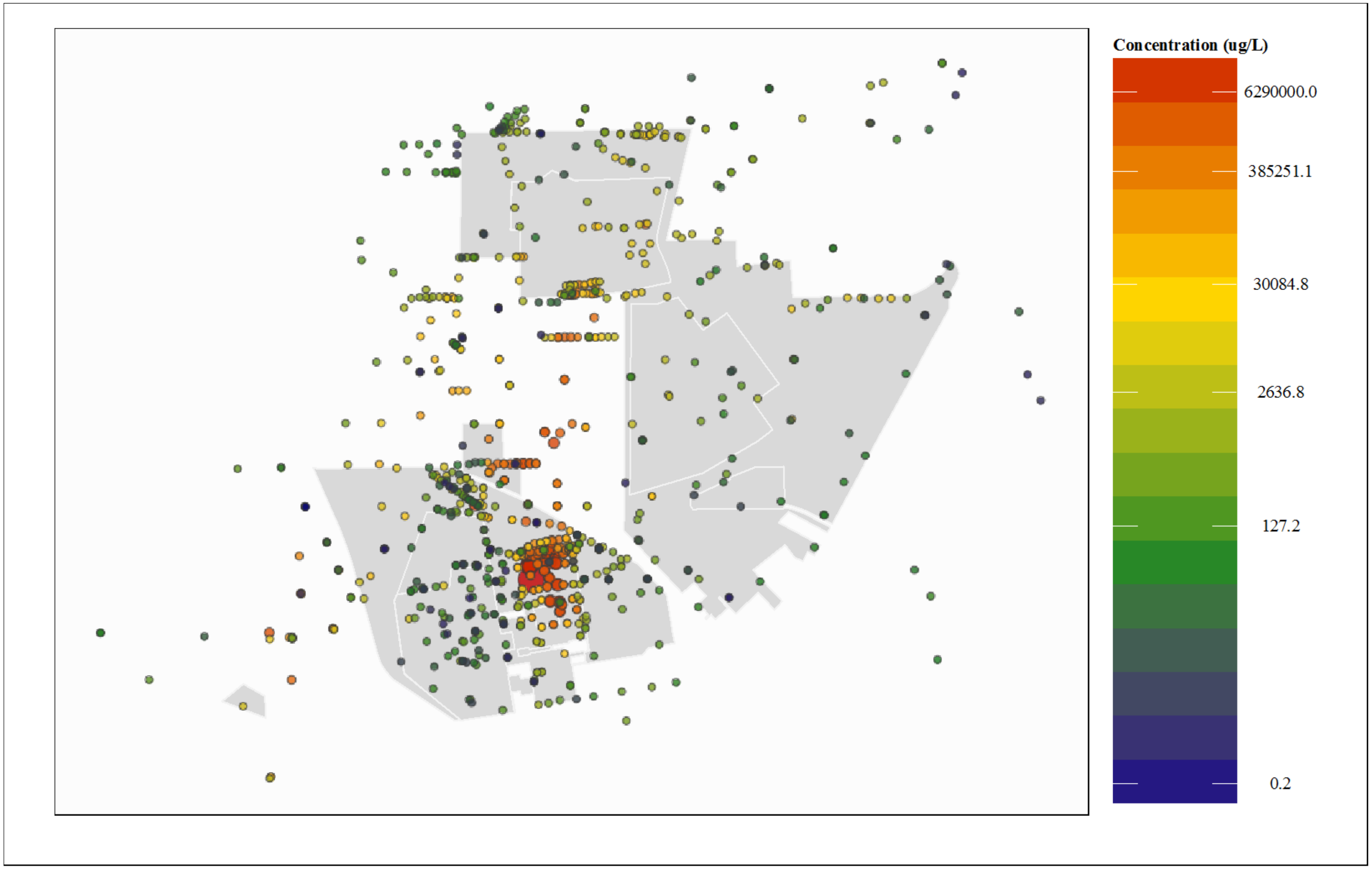


Figure 11 Up-gradient wells scaled to perchlorate values

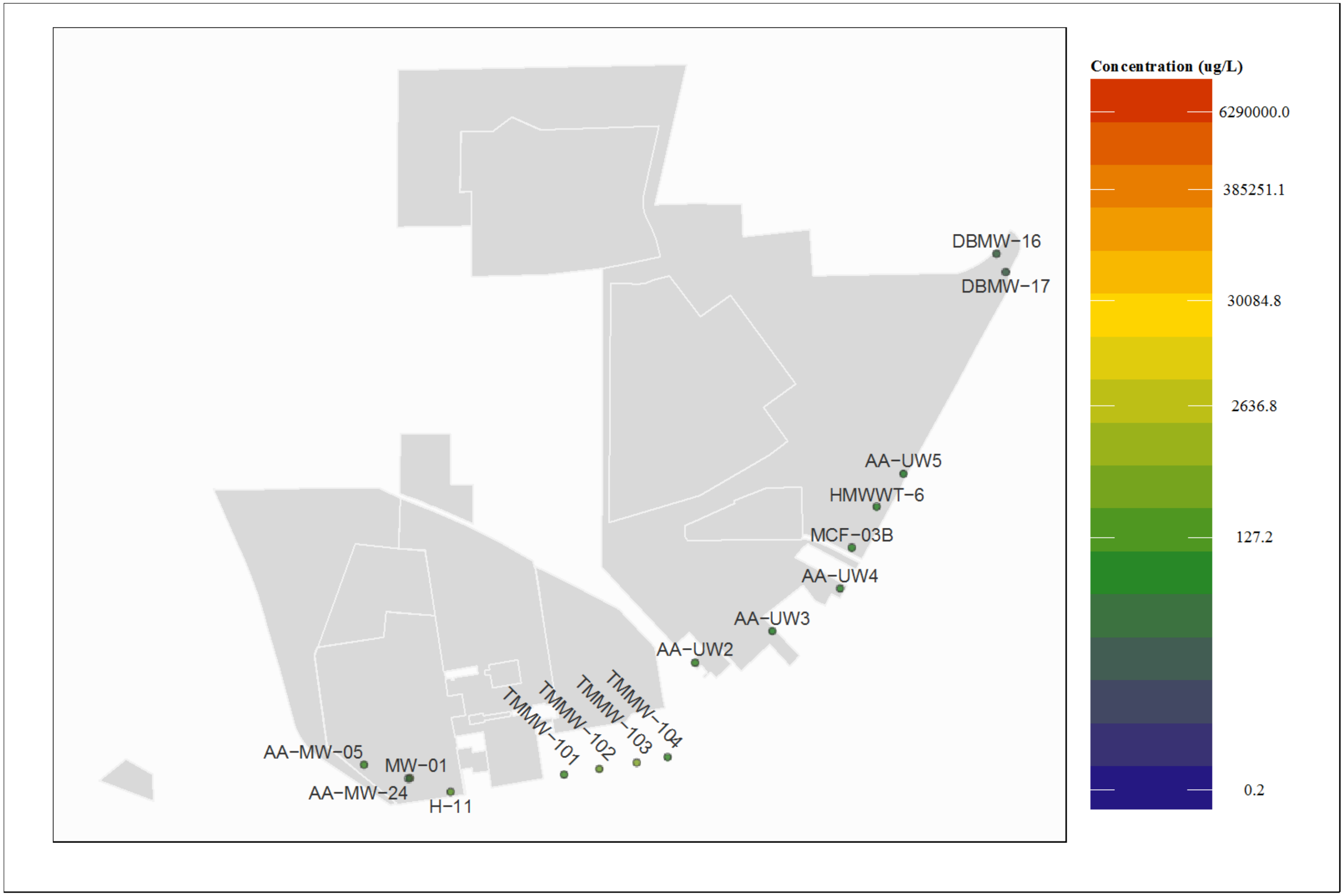


Figure 12 Boxplots for perchlorate

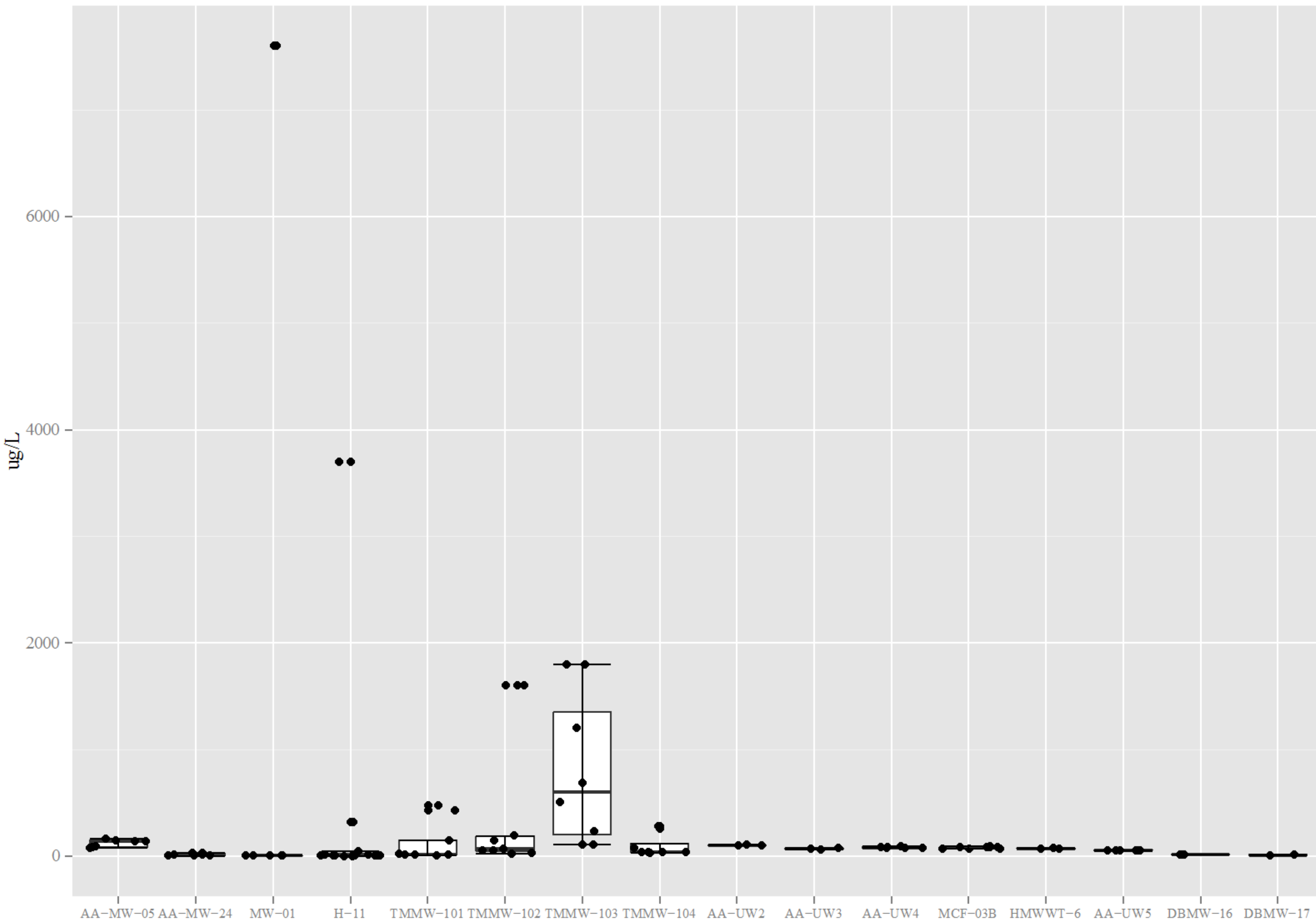
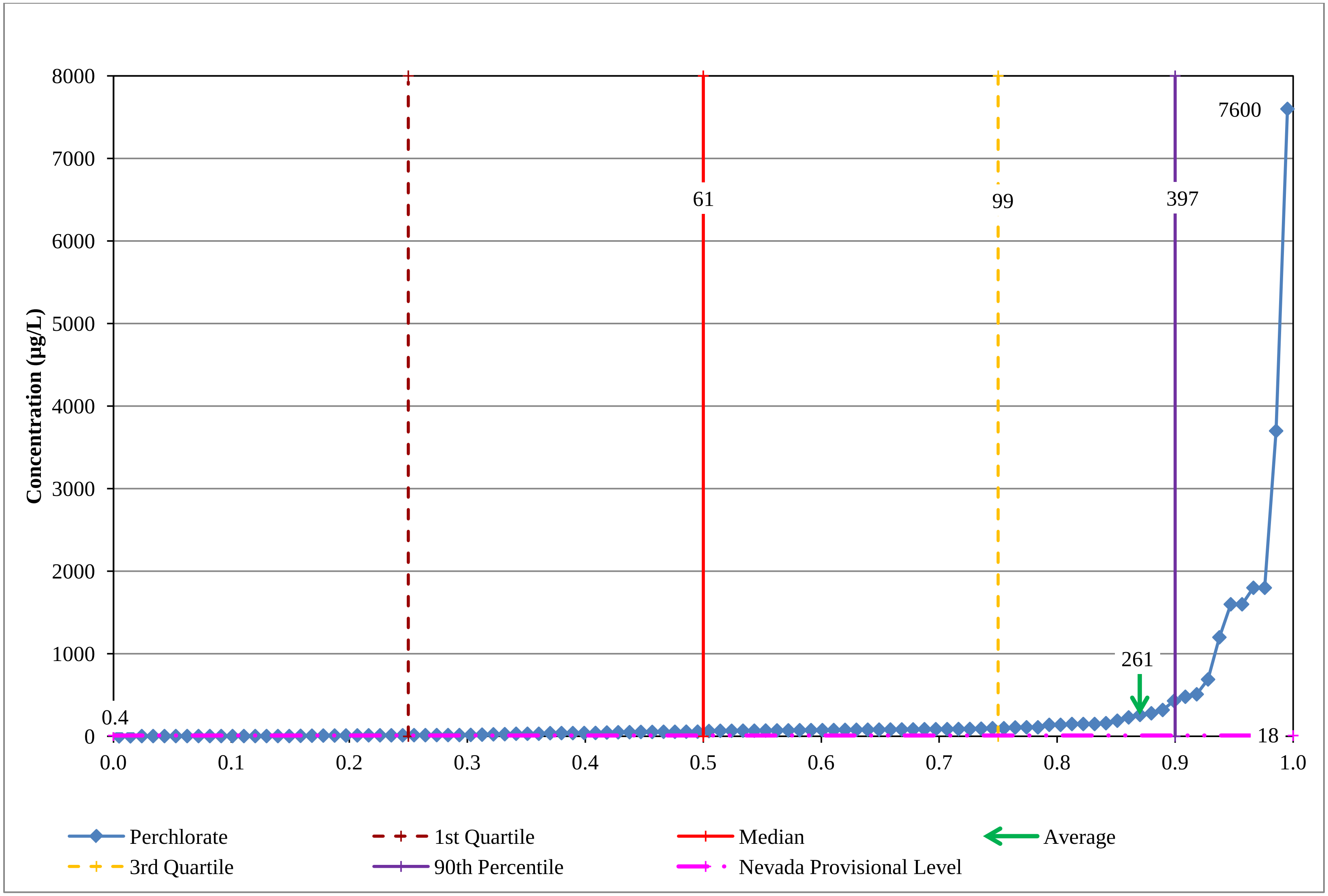


Figure 13 Quantile plot for perchlorate



BMI Regional Goals and Directives

1. Containment of identified contaminants of potential concern (COPCs) at site property boundaries for groundwater above remediation standards will be a required performance measure for any selected long term groundwater remedy.
    a. Property boundary is the legal property boundary
    b. Remediation Standards will be defined as either BCL's or Background

2. Ultimate Remedial Action Objective (RAO) is to permanently restore the down gradient aquifer from site property boundaries to the Las Vegas Wash (the Wash) to below remediation standards.

3. All remedy evaluations must address all contaminants of potential concern (COPCs) discovered on the individual properties regardless of origin of these chemicals, including alleged trespass contaminants.
    a. All COPC's on site including regional indicator chemicals must be considered when evaluating and selecting a groundwater remedy
    b. Shallow water bearing zone should be the focus of the groundwater remedy, Middle and Deeper water bearing zones will be evaluated for potential vertical migration and impact to the Shallow water bearing zone. If these deeper water bearing zones are shown to significantly impact the Shallow Zone a groundwater remedy may be required for these deeper zones or locations where they interface with the Shallow Zone.
    c. Responsibility for implementation and/or cost of ultimate long term groundwater remedy implementation operation and maintenance for alleged trespass contaminants will be addressed on a site by site basis, after remedy evaluation is completed.

4. Long term remedy evaluations can assume containment of COPC's at the up-gradient property boundaries for additional trespass contaminants. Alternatively the NDEP would consider a joint remedial option.

5. Up-gradient groundwater quality (i.e. CLO4, As, TDS)
    a. NDEP will develop and defend the definition of up-gradient groundwater quality.
    b. Costs for this activity may be apportioned as an All Company Task.
    c. Up-gradient groundwater quality may be different at each facility/property and may influence complex wide RAOs.
    d. If up-gradient GW exceeds remediation standards this will be considered with regards to site wide and downgradient RAOs.

6. In off-property areas where plumes are likely co-mingled, NDEP is developing a list of regional indicator chemicals, to serve as surrogates and drivers for determining whether individual plant site remedies are cumulatively protective and will achieve the off-site remedial action objective of aquifer restoration

7. In downgradient areas, NDEP will be evaluating the performance of achieving the remedial action objective along certain transect points of compliance. Performance metrics will likely include statistical evaluation of groundwater concentration trends, annual estimates of contaminant flux, hydraulic containment evaluations, mass discharge, and mass removal rates. Current transects being considered are:
    1. Property boundaries,
    2. Warm Springs Road,
    3. Galleria Drive/Athens Road (likely), and
    4. Immediately up-gradient of the Las Vegas Wash.

8. Downgradient areas of the facilities site boundaries will be evaluated to determine the need for additional assessment or corrective actions after groundwater remedies are in place. If allocations are not developed by the companies; NDEP may perform work and seek reimbursement from the companies.
    a. Ecological risk would be considered after restoration of downgradient aquifer has been demonstrated or as a portion of the feasibility study (FS) under protectiveness and effectiveness.
    b. The groundwater (GW) remedy evaluation must also consider the vapor intrusion pathway in off-site areas.