

**Big Sandy Power Plant
Fly Ash Pond
Alternate Source Demonstration**

The Big Sandy Fly Ash Pond initiated an assessment monitoring program in accordance with 40 CFR 257.95 on April 13, 2018. Groundwater protection standards (GWPS) were set in accordance with 257.95(d)(2) and a statistical evaluation of the assessment monitoring data was conducted. The statistical evaluation revealed an exceedance of the GWPS for beryllium, cobalt, and lithium at Monitoring Well MW-1603 on January 8, 2019. A successful alternate source demonstration (ASD) was completed per 257.95(g)(3), therefore, the Big Sandy Fly Ash Pond will remain in assessment monitoring. An alternate source demonstration is documentation that shows a source other than the CCR unit was responsible for causing the statistics to exceed the GWPS. The ASD document will explain the alternate cause of the GWPS exceedances. The successful ASD is attached.

Alternative Source
Demonstration Report
for Beryllium, Cobalt
and Lithium

Big Sandy Fly Ash Pond
Louisa, Kentucky

Prepared for:

American Electric
Power

Prepared by:

EHS  **Support**[™]

February 2019



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Acronyms

AEP	American Electric Power, Kentucky Power Company
ASD	alternative source demonstration
BSFAP	Big Sandy Fly Ash Pond
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
EPRI	Electric Power Research Institute
ft bgs	feet below ground surface
KGS	Kentucky Geological Survey
Ma	Million-Year-Old
mg/L	milligrams per liter
MSL	mean sea level
SSI	statistically significant increases
SSL	statistically significant levels
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

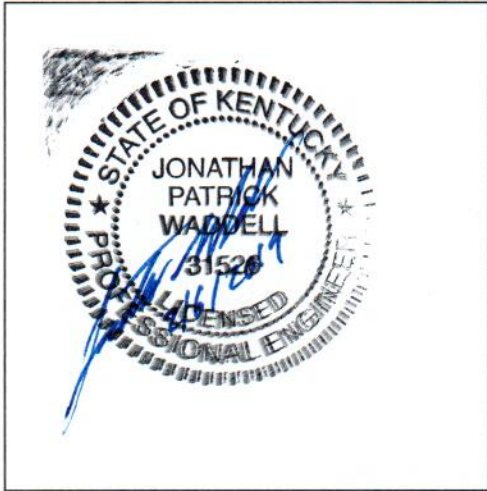
DRAFT Alternative Source Demonstration Report for Beryllium, Cobalt and Lithium
Big Sandy Fly Ash Pond
Certification by Qualified Professional Engineer

Certification by Qualified Professional Engineer

I certify that the alternative source demonstration (ASD) conducted and presented within this report is accurate and appropriate for evaluating the groundwater monitoring data for the Big Sandy Fly Ash Pond Coal Combustion Residual (CCR) management area associated with the Big Sandy Power Plant located in Louisa, Kentucky. This ASD meets the requirements of the United States Environmental Protection Agency CCR Rule defined at 40 Code of Federal Regulations 257.95(g)(3)(ii).

Jonathan Patrick Waddell
Printed Name of Licensed Professional Engineer


Signature



31526
License Number

KY
Licensing State

02/06/2019
Date



1 Introduction

EHS Support LLC (“EHS Support”) was retained by American Electric Power, Kentucky Power Company (“AEP”) to conduct an alternative source demonstration (ASD) investigation at the Big Sandy Fly Ash Pond (BSFAP) associated with the Big Sandy Power Plant located in Louisa, Kentucky (**Figure 1**). This ASD has been prepared per the requirements of the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule (40 Code of Federal Regulations [CFR] 257.95).

1.1 Objectives

AEP’s objective for this ASD investigation is to assess groundwater monitoring data collected in compliance with the CCR Rule as allowed under paragraph 40 CFR 257.95(g)(3)(ii) of the CCR Rule. This part of the rule allows AEP to determine whether the source(s) for statistically significant exceedances of beryllium, cobalt, and lithium reported from groundwater monitoring well MW-1603 are associated with the CCR unit, or if the statistically significant increases (SSIs) resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

1.2 Lines of Evidence

This ASD for the BSFAP has been conducted to evaluate potential alternate sources or reasons for the statistically significant exceedances of beryllium, cobalt, and lithium within monitoring well MW-1603. A potential alternate source is evident, based on the following lines of evidence:

- Lack of exceedances and increasing trends of primary indicators of CCR
- BSFAP water concentrations are lower than those of the corresponding constituent observed in groundwater
- Major ion chemistry does not indicate mixing between BSFAP water and groundwater

For the purposes of this ASD investigation, constituents were identified that would serve as a primary indicator for coal ash leachate. A primary indicator must meet **both** of the following criteria:

- Constituent that typically has high concentration in leachate, relative to background, such that it is expected to have elevated concentration in the event of a release.
- Constituent is not reactive and has high mobility in groundwater such that it is expected to be at the leading edge of the plume, meaning that it will have elevated concentrations relative to background across the entire area of the plume.

As boron and sulfate are primary indicators for coal ash leachate (Electric Power Research Institute [EPRI], 2012) they were evaluated in this ASD investigation. Other potential indicators that were evaluated in this ASD investigation include chloride, potassium, sodium, fluoride, molybdenum, and bromide.



2 Project Background

AEP has complied with the CCR Rule requirements relative to investigation, assessment, and monitoring of the BSFAP, as discussed in the following sections.

2.1 Site Location and History

The Big Sandy Power Plant is located along the Kentucky side of the Big Sandy River that forms the border with West Virginia (**Appendix A, Figure A1**). The CCRs formerly generated by the Big Sandy Plant were disposed in a nearby existing surface impoundment or BSFAP (**Figure A1** and **Figure 1**). The BSFAP is located approximately 1.3 miles northwest of the Big Sandy Power Plant. The BSFAP formerly received wet-sluiced fly ash from the coal burning process as well as bottom ash that was periodically transferred from the Bottom Ash Ponds next to the main plant area. AEP permanently ceased burning coal at the Big Sandy Power Plant in November 2015 and transitioned to a 278-megawatt natural-gas-fired unit. As a result, CCR wastes are no longer being generated and operation of the BSFAP for disposal of CCR waste has ceased. The BSFAP was formed by constructing a dam across the valley of Horseford Creek and is contained by a dam called the Main Dam, located at the north end of the Horseford Creek valley (**Appendix A, Figure A1**).

2.2 Site Geology

The topography of the Louisa (Lawrence County), Kentucky area is dependent on the subsurface geology. Harder bedrock formations of marine limestone and shales of the Conemaugh Formation make up the hills while the creek and river bottoms cut through the weaker bedrock of sandstones, siltstones, and coal seams of the upper portion of the Breathitt Group. The creek and river bottoms consist of clays, silts, sands and gravels of alluvial and lacustrine deposits. As shown on **Figure A1 (Appendix A)**, the BSFAP now fills one of these creek bottoms that contains Horseford Creek, which is a tributary of Blaine Creek.

The bedrock around the site consists of Pennsylvanian-aged (Carboniferous) fluvial deposits that were deposited in the Central Appalachian Basin. Both the Kentucky Geological Survey (KGS) and the United States Geological Survey (USGS) have painstakingly mapped the coal deposits associated with the 300-million-year-old (Ma) stream deposits to understand the extent and thicknesses for mining in both Kentucky and West Virginia. This section provides a summary of the more extensive literature of the bedrock found in the referenced sources.

The Central Appalachian Basin is a part of an extensive foreland basin formed behind the Appalachian Orogenic Belt that received eroded sediments from those mountains within the larger fluvial systems. The regional stratigraphic framework is provided on **Figure A2 (Appendix A)**. The sediments in this portion of the basin received sediments in the Devonian period (~400 Ma) to the Permian period (~275 Ma). Over geologic time, the Permian-aged sediments and most of the Pennsylvanian-aged sediments that were formed into hard-rock were removed through erosion. The bedrock in the area, currently exposed, is middle to upper Pennsylvanian as shown on the KGS geological map (**Figure A2 of Appendix A**). The oldest formation exposed is the upper portions of the Breathitt Group. The Breathitt Group consists of several different formations as provided on **Figure A2 (Appendix A)**. Only the uppermost formation, the Princess Formation, is exposed at the surface in this area around Louisa.



The upper 200 feet of the Princess Formation consist primarily of yellowish- to dark-gray, ripple-bedded siltstone with some interbedded light-yellowish to yellowish-gray, fine to medium-grained, cross-bedded sandstone and medium to dark-gray, finely-bedded shale (Ward, 1978). This sequence has a series of interbedded coal beds that have been numbered within the Princess Formation by the KGS and USGS, as shown on **Figure A3 (Appendix A)** and summarized by Rice and Hiatt (1994). The KGS has documented and photographed the uppermost of these coal beds (Princess Number 7 and Princess Number 8) along Highway 23 as shown on **Figure A4 (Appendix A)**. Along Highway 23, the Princess Number 8 was documented to be an elevation of 650 feet, 660 feet, 632 feet, and 670 feet mean sea level (MSL). These elevations are shown on **Figure A4 (Appendix A)**. One of the marker beds associated with the Princess Formation at the Princess Number 5 coal seam is the Vanport Limestone (Ward, 1978) or also called the Kilgore Flint Member (Ruppert et al., 2010). This 3-foot brownish-gray, very fossiliferous, limestone is also a source of sideritic ironstone.

The USGS has analyzed the Princess Number 9 coal in other states for geochemistry at over 3,700 locations (Ruppert et al., 2000). In Pennsylvania and West Virginia, the Princess Number 9 coal is identified as the Upper Freeport Coal Bed. The thickness of this coal bed is not usually mineable in Northeastern Kentucky. The coal is medium-sulfur bituminous coal that has relatively high sulfur concentrations in relation to the surrounding rock. USGS reports in Ruppert et al., (2000) that the coal itself has metal concentrations including beryllium, cadmium, cobalt, lead, nickel, arsenic, and selenium. Maps of the beryllium, cobalt and lead concentrations from the coal are provided on **Figure A5-A** and **A5-B (Appendix A)**.

The uppermost coal bed, Princess Number 9, has been designated as the top of the Breathitt Group's Princess formation and the bottom of the overlying Conemaugh Formation. The bottom 100 feet of the formation that is exposed in the hills in the area is a yellowish- to yellowish-gray, calcareous, lenticular, siltstone with some light yellowish-gray, fine-grained to coarse grained, massive, cross-bedded sandstone (Ward, 1978).

The Brush Creek Limestone Member, another marker bed used by the KGS and USGS, is at the top of this 100-foot thick sequence of the Conemaugh Formation. This 2-foot-thick olive- to yellowish-gray, not very fossiliferous, marine limestone is used to determine the "structure" of these Upper Pennsylvanian-aged sediments. The KGS has mapped this marker bed due to the presence of coal at the top of the limestone in the region (**Figure A4, Appendix A**). Using the elevation of the Brush Creek Limestone Member (structural contours) as shown on **Figure A6 (Appendix A)**, the limestone is dipping towards the north as are the rest of the strata of the Conemaugh Formation and Breathitt Group into a very large regional syncline system called the Allegheny Synclinorium (or the Parkersburg Syncline in West Virginia) as shown on **Figure A6 (Appendix A)** from Chesnut (1992). The Conemaugh Formation above the Brush Creek Limestone Member, that makes up the top of the hills in the area, is primarily a yellowish-gray to dusky-yellow and maroon shale with some interbedded yellowish-gray to dusky-yellow, slightly calcareous, siltstones and sandstones (Ward, 1978).

The stream and river valleys of Blaine Creek, Big Sandy River, and the smaller tributary valleys contain Quaternary-aged alluvium that are largely floodplain deposits consisting of silts, sands, gravels, and clays (Ward, 1978). Per the recent work of Erjavec (2018), the hillsides of the valleys were inundated by lake water from pro-glacial Lake Tight when the pre-glacial Teays River was blocked by advancing early Wisconsinian-aged glaciers (**Figure A7, Appendix A**). This lake lasted approximately 10,000 years and reached an elevation of 900 feet MSL (Bailey et al., 2014). As shown on **Figure A7 (Appendix A)**, only the



very top of the hills in the area are over 900 feet so they were islands in this lake the size of present-day Lake Erie. Lake Tight deposited varved (rhythmites) lacustrine gray and black silts and clays called the Minford Clay Member of the Teays Formation. The Minford Clay has been studied extensively in Ohio and nearby in West Virginia by Bonnett et al. (1991). Bonnett et al. (1991) discussed in length the amount of iron oxides like hematite and chlorite and weathered products like kaolinite, limonite, and goethite in these varved sediments.

2.3 Groundwater Monitoring Network Evaluation

On behalf of AEP, Geosyntec Consultants, Inc. (“Geosyntec”) conducted an assessment of the groundwater monitoring network in the uppermost aquifer associated with the BSFAP (Geosyntec, 2016). Geosyntec determined that the hydrostratigraphy in the vicinity of the BSFAP is characterized by an interconnected water-bearing system comprised of Pennsylvanian-aged bedrocks of the Breathitt Group and the Quaternary alluvium. The Conemaugh Formation and Breathitt Group consists of sandstones, siltstones, shale, and coal that may grade laterally and vertically into one another. The Quaternary alluvium deposits include sandy lean clay to silty sand and gravel at the bottom of the Horseford Creek valley and the floodplain of the Blaine Creek. Based on these hydrogeologic conditions, Geosyntec defined the interconnected water-bearing system of the fractured bedrock and alluvium as the uppermost aquifer for the BSFAP CCR unit. This determination was based on the presence of groundwater in numerous monitoring wells screened in the water-bearing units, the recovery of these wells during pumping and development, and a potentiometric surface generally consistent with site topography and surface water elevations.

To assess the upper water-bearing aquifer, Geosyntec identified the groundwater monitoring network as consisting of 10 groundwater monitoring wells to provide detection monitoring in the uppermost aquifer (fractured bedrock and alluvium) (Geosyntec, 2016). Of these 10 wells, six (MW-1011, MW-1012, MW-1203, MW-1601, MW-1602, and MW-1603) are screened in fractured sandstone and shale layers of the Breathitt formation. The remaining four monitoring wells (MW-1604 through MW-1607) are screened in the alluvium. The location of each groundwater monitoring well within the uppermost aquifer is shown in **Figure 2**.

Three of the monitoring wells (MW-1011, MW-1012, and MW-1203) screened in bedrock were installed on the hillside slopes upgradient of the BSFAP to support background monitoring. Three monitoring wells (MW-1601, MW-1602, and MW-1603) installed in bedrock are located downgradient of the BSFAP and used for compliance monitoring. Two monitoring wells (MW-1604 and MW-1605) screened in alluvium are used for background monitoring; while two other monitoring wells (MW-1606 and MW-1607), screened in alluvium and located below the Main Dam are used for compliance monitoring.

The monitoring well network is monitoring different portions of the Pennsylvanian-aged sequence of sandstones, siltstones, and coals as shown in **Table 2-1**.

As bedrock monitoring well MW-1603 is the focus of this ASD, the boring log provided in **Appendix B** shows the boring containing alternating sequences of yellowish-brown sandstones and bluish-gray to black shales (beginning at 13 feet below ground surface [ft bgs] and extending to the bottom of the boring at 39.5 ft bgs) that are indicative of the upper portion of the Princess Formation discussed in the previous section. Within the screened interval (22 to 32 ft bgs), a description of the shale at a depth of



24 to 25 ft bgs was “intensely fractured, black, wet, nearly all organic matter; slight coaly texture.” This elevation corresponds with the measurements by the KGS of the elevation of the Princess Number 8 coal discussed in **Section 2.2**. A coal or “organic material” also was logged in three other monitoring wells (MW-1608, MW-1609, MW-1610) in the network (shown on **Table 2-1**) at the same approximate elevation between 630 and 650 feet that matches the KGS measurements. Three monitoring wells did not document any coal in this section (MW-1601, MW-1602, MW-1611) and four wells were installed below this coal layer in the sedimentary sequence (MW-1604, MW-1605, MW-1606, MW-1607).

Table 2-1 Screened Interval of Monitoring Wells

Well/Boring	Surface Elevation (feet MSL)	Screened Interval (feet MSL)	Coal or “Organics” Description at 632-650 feet?
MW-1601	713.8	646.8-636.8	No coal logged
MW-1602	711.6	632.1-622.1	No coal logged
MW-1603	673.2	651.2-641.2	Yes at a depth of ~25 feet (Elevation of 648 feet)
MW-1604	553.1	513.1-503.1	---
MW-1605	554.4	538.9-528.9	---
MW-1606	551	513.1-503.1	---
MW-1607	542.2	518.7-508.7	---
MW-1608	716.2	606.6-596.6	Yes at depths of ~74 feet (Elevation of 642 feet), ~ 75.3 to 76.6 feet (Elevation of 641 to 640 feet) and ~ 83.5 to 84 feet (Elevation of 633 to 632 feet)
MW-1609	~728	---	Yes at a depth of ~79 feet (Elevation of 649 feet)
MW-1610	~716	---	Yes at a depth of ~81 feet (Elevation of 635 feet)
MW-1611	~711	606-596	No coal logged

--- = Boring advanced below the coal interval

Not logged = Boring log has no description of coal or “organics” in the interval between 632 to 650 MSL

~ = Approximate

MSL = mean sea level

Geosyntec determined that the groundwater monitoring well network described above meets the requirements of 40 CFR §257.91, as it consists of a sufficient number of wells installed at the appropriate locations and depths to yield groundwater samples from the uppermost aquifer that accurately represent the quality of background groundwater and groundwater passing the waste boundary of the BSFAP.



2.4 Groundwater Monitoring

AEP has conducted groundwater monitoring of the uppermost aquifer to meet the requirements of the CCR Rules. These monitoring activities generally included the following activities:

- Collection of groundwater samples and analysis for Appendix III and Appendix IV constituents, as specified in 40 CFR 257.94 *et seq.* and AEP's *Groundwater Sampling and Analysis Plan* (AEP and EHS Support, October 2016)
- Completion of validation tests for groundwater data, including tests for completeness, valid values, transcription errors, and consistent units
- Establishment of background data for each Appendix III and Appendix IV constituent
- Initiation of detection monitoring sampling and analysis
- Evaluation of the groundwater data using a statistical process in accordance with 40 CFR 257.93, which was prepared, certified, and posted to AEP's CCR website in April 2017 in AEP's *Statistical Analysis Plan* (Geosyntec, January 2017). The statistical process was guided by USEPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* ("Unified Guidance", USEPA, 2009).
- Initiation of assessment monitoring sampling and analysis
- Completion of statistical data evaluation and determination of groundwater protection standards



3 Alternative Source Demonstration Requirements

3.1 CCR Rule Applicability

Per the CCR Rule at 40 CFR 257.94(e)(2), “The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report.”

3.2 Alternative Source Demonstration

Potential causes that may support the ASD may include, but are not limited to, sampling causes (ASD Type I), laboratory causes (ASD Type II), statistical evaluation causes (TYPE III) and/or natural variation causes (Type IV). This ASD for the BSFAP will be focused on assessing whether Type IV natural variations in groundwater could be the cause of statistically significant exceedances of beryllium, cobalt, and lithium reported from groundwater monitoring well MW-1603.

3.3 Water Monitoring Results

The constituents discussed below will typically provide the information required:

- The constituents listed in **Table 1** are analyzed in groundwater to identify primary indicators for potential leachate and to assess potential effects from the BSFAP leachate.
- Major ion concentrations (alkalinity, chloride, sulfate, calcium, magnesium, potassium, and sodium) in leachate and groundwater are used to evaluate whether downgradient groundwater chemistry remains representative of background groundwater chemistry. Major ion chemistry can also be used to evaluate natural variability due to seasonal changes or other causes.
- Field turbidity in groundwater is an indicator of the presence of suspended solids that may contribute to elevated concentrations of constituents monitored in unfiltered samples under the CCR Rule.
- pH in leachate and groundwater provides information on chemical reactions and mobility in groundwater.
- Dissolved oxygen, oxidation reduction potential (ORP), and iron and manganese in groundwater are all indicators of redox conditions. Changes in redox can affect the chemical state and solubility of sulfate in addition to trace elements including arsenic and selenium. For example, under strongly reduced conditions (ORP less than -200 mV at pH 7), sulfate can be reduced to form hydrogen sulfide or it can precipitate as iron sulfide, arsenic reduces to the more mobile arsenite species, and selenium reduces to the low-mobility selenite species.

Groundwater monitored at a CCR unit for compliance with the CCR Rule is a compilation of the history of all sources of water comingling at that particular monitoring well. Different sources may contribute some of the same constituents, making source identification challenging. The identification and use of



water quality “signatures” can be used as a tool for deciphering the similarity between potential sources and the water quality at a specific monitoring point.



4 Alternative Source Demonstration Assessment

As stated within **Section 1.2**, the primary indicators for CCR (coal ash leachate) impacts in groundwater are boron and sulfate. In addition to these two constituents, chloride will also be a primary indicator for this ASD. Other potential indicators that may be evaluated include potassium, sodium, fluoride, molybdenum, and bromide.

As identified in **Section 1.1**, elevated concentrations of beryllium, cobalt, and lithium have been reported in groundwater samples from monitoring well MW-1603. The water quality signatures for MW-1603 will be discussed within **Section 4.3** and compared to the water quality of the BSFAP.

EPRI (2012) describes three tiers of investigation for evaluation of water quality signatures to determine if elevated concentrations represent a release from a CCR facility. Conversely, these tools can also be used to evaluate whether or not sources other than CCR are contributing to groundwater quality degradation. The three tiers defined by EPRI (2012) are:

- Tier I: Trend Analysis and Statistics
- Tier II: Advanced Geochemical Evaluation Methods
- Tier III: Isotopic Analyses

The CCR Rule requires statistical analysis under detection monitoring and under assessment monitoring for the determination of SSIs or statistically significant levels (SSLs). Many of the primary and potential indicator constituents listed for coal ash (EPRI, 2017) are included in AEP's constituent list for the BSFAP groundwater monitoring programs, including the primary constituents boron and sulfate. If there is an SSI/SSL without a corresponding increase in a primary indicator constituent (boron and usually sulfate for coal ash), then this is a key line of evidence for an ASD.

4.1 Groundwater Data Analysis

4.1.1 Primary Indicators

Temporal plots for primary indicators boron, sulfate, and chloride reported in groundwater monitoring well MW-1603 are provided in **Figure 4-1** to **Figure 4-3**, respectively, with data for the BSFAP water presented for comparison.

The BSFAP water signature is plotted as a constant concentration in **Figure 4-1** to **Figure 4-12**. This sample was collected on October 19, 2017. As the BSFAP accepted fly ash prior to 1970, it is probable that BSFAP water quality has historically varied over time. However, since the BSFAP ceased accepting fly ash by 2016, the water quality is anticipated to be more stable; therefore, this October 2017 data provides a reasonable representation of current BSFAP conditions.

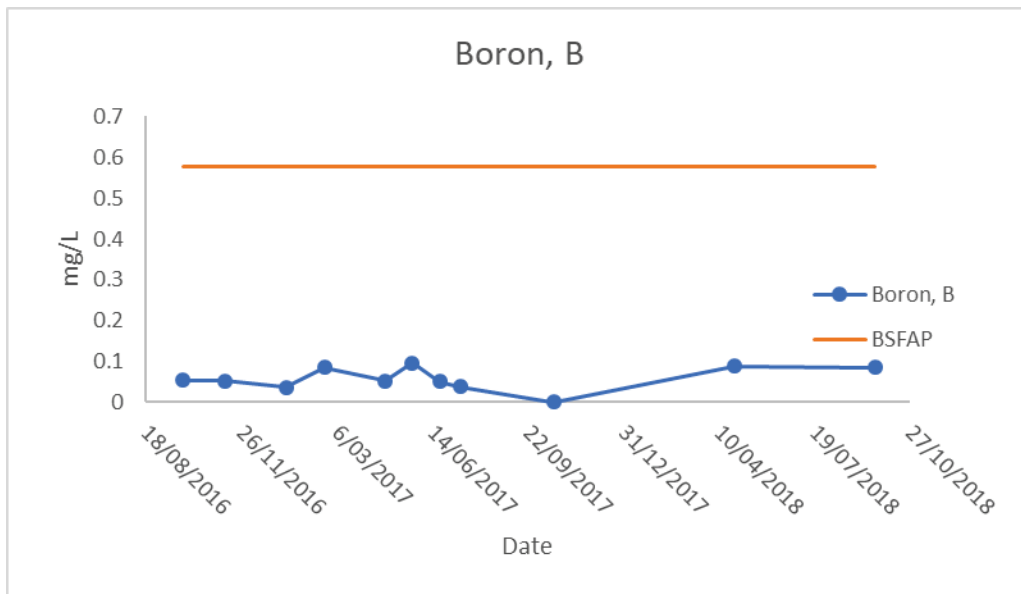


Figure 4-1 MW-1603 Boron concentrations

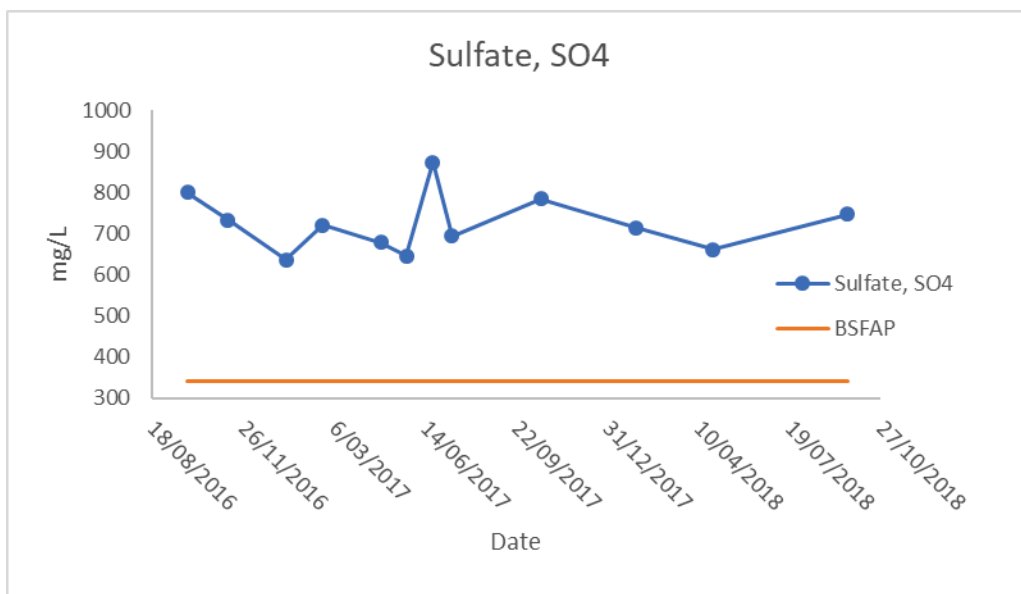


Figure 4-2 MW-1603 Sulfate

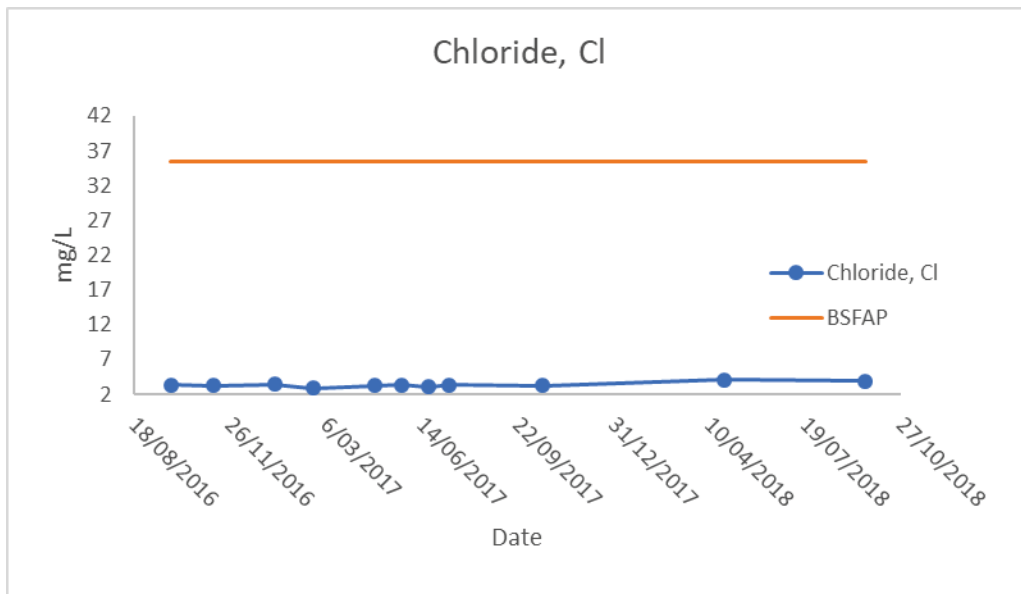


Figure 4-3 MW-1603 Chloride

Boron concentrations in MW-1603 have remained relatively constant, with some variability and only a slight increase from 0.054 milligrams per liter (mg/L) to 0.085 mg/L over the monitoring period (August 2016 through September 2018). Sulfate was initially reported as 801 mg/L and 747 mg/L in September 2016 and has shown a very slight decreasing trend during the monitoring period. Chloride concentrations in MW-1603 have also remained relatively constant, with some variability and only a slight increase over the monitoring period from an initial concentration of 3.37 mg/L (September 2016) to 3.92 mg/L (January 2018). Comparing the concentrations in groundwater to the BSFAP, boron and chloride are present at higher concentrations in the BSFAP than in groundwater, while sulfate is present at higher concentrations in groundwater than in the BSFAP.

4.1.2 Potential Indicators

Temporal plots for potential indicators bromide, fluoride, molybdenum, potassium and sodium reported in groundwater monitoring well MW-1603 are provided in **Figure 4-4** to **Figure 4-8**, respectively, with data for the BSFAP water presented for comparison.

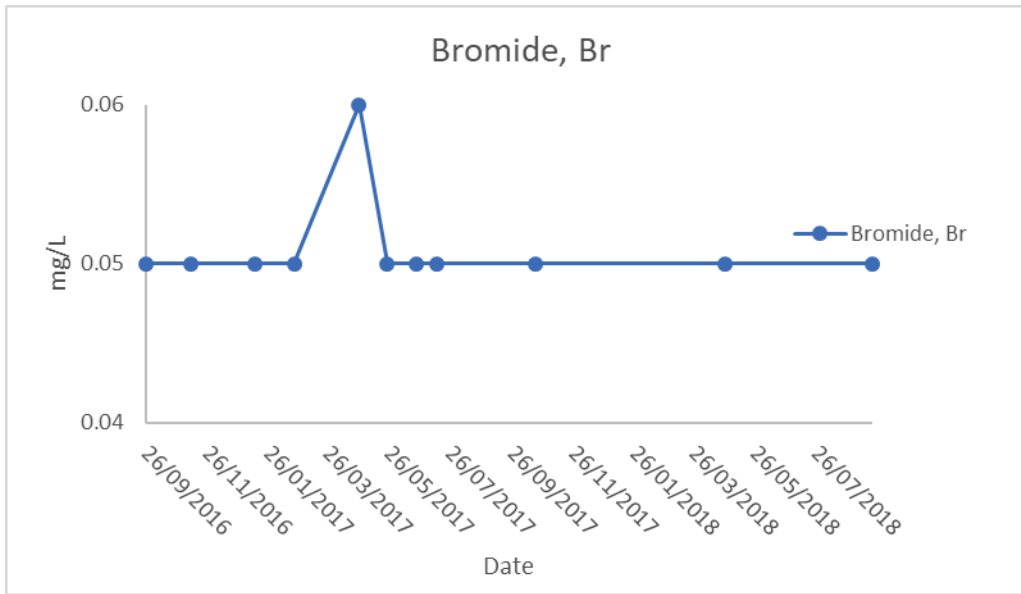


Figure 4-4 MW-1603 Bromide Concentrations¹

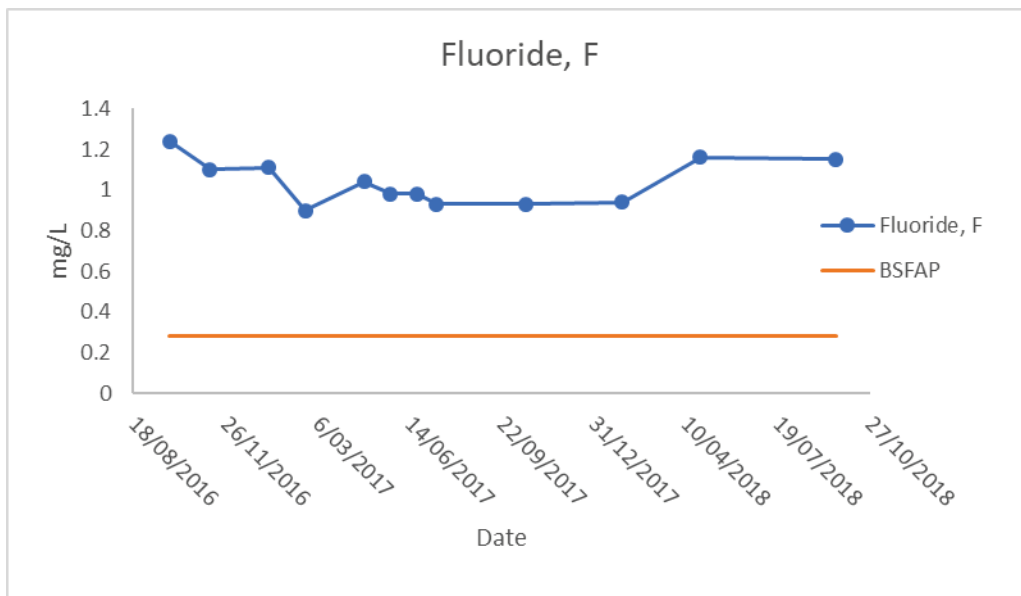


Figure 4-5 MW-1603 Fluoride Concentrations

¹ Bromide is below the level of reporting for the BSFAP water, with a detection level of <0.05 milligrams per liter.

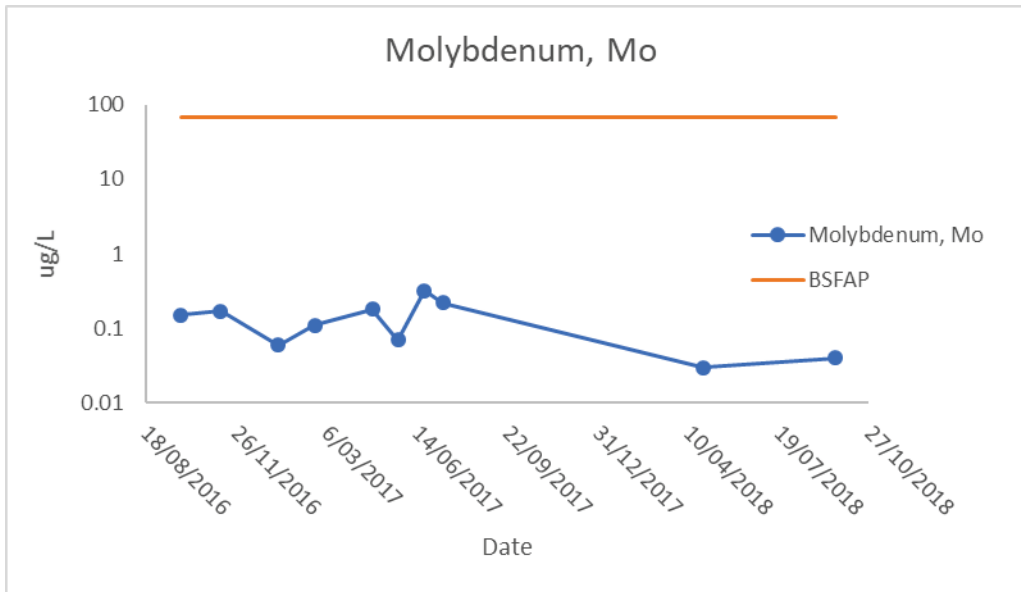


Figure 4-6 MW-1603 Molybdenum Concentrations

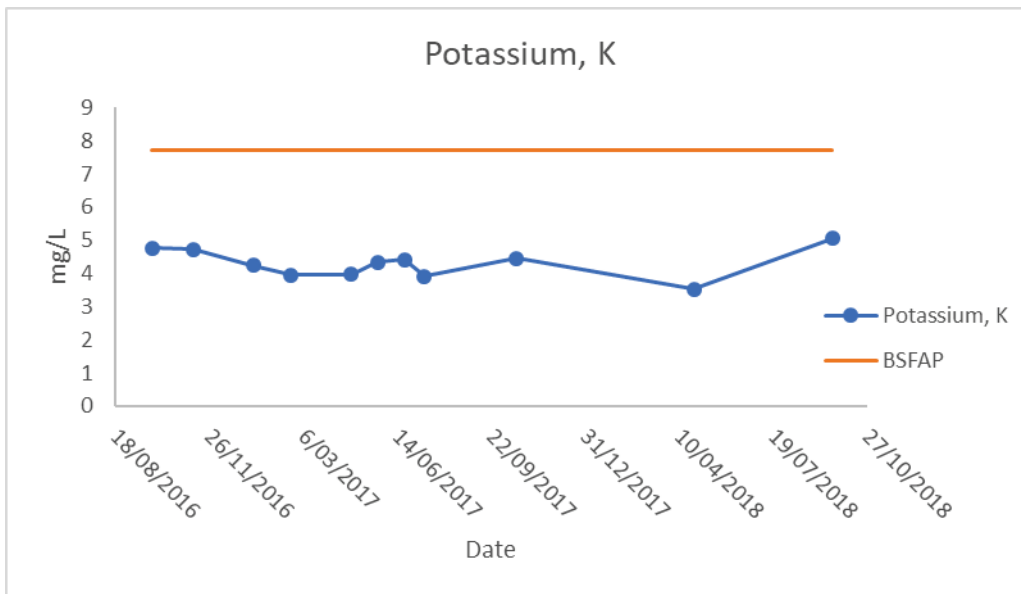


Figure 4-7 MW-1603 Potassium Concentrations

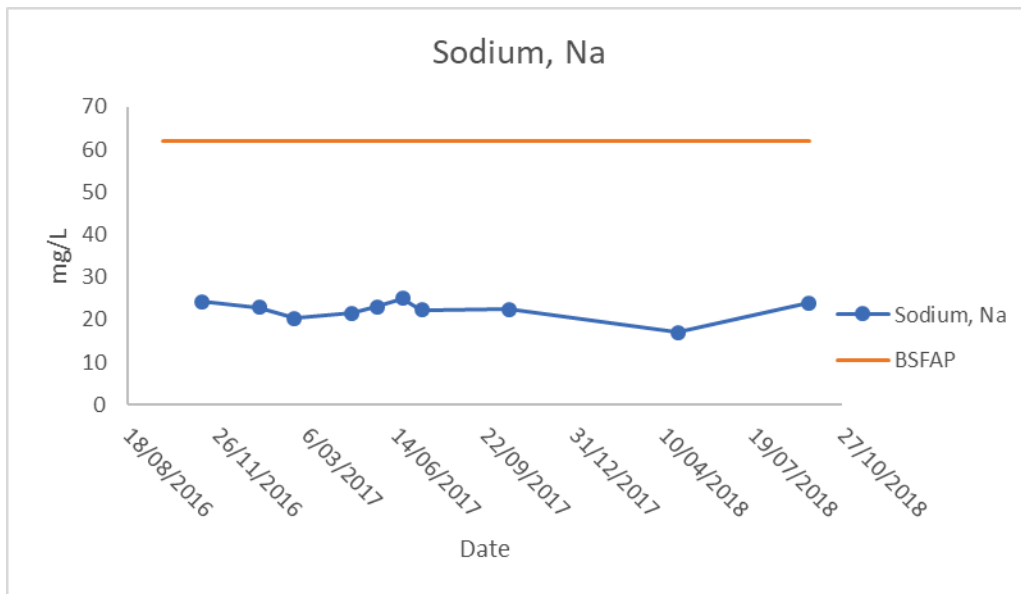


Figure 4-8 MW-1603 Sodium Concentrations

Molybdenum, potassium and sodium are present in groundwater at concentrations below the concentration within the BSFAP. Fluoride and bromide groundwater concentrations are more elevated than those within the BSFAP.

The comparison of pH between the BSFAP and MW-1603 is provided in **Figure 4-9** below. This illustrates the significant difference in pH between the pond water and groundwater, between approximately 3 to 5 standard units.

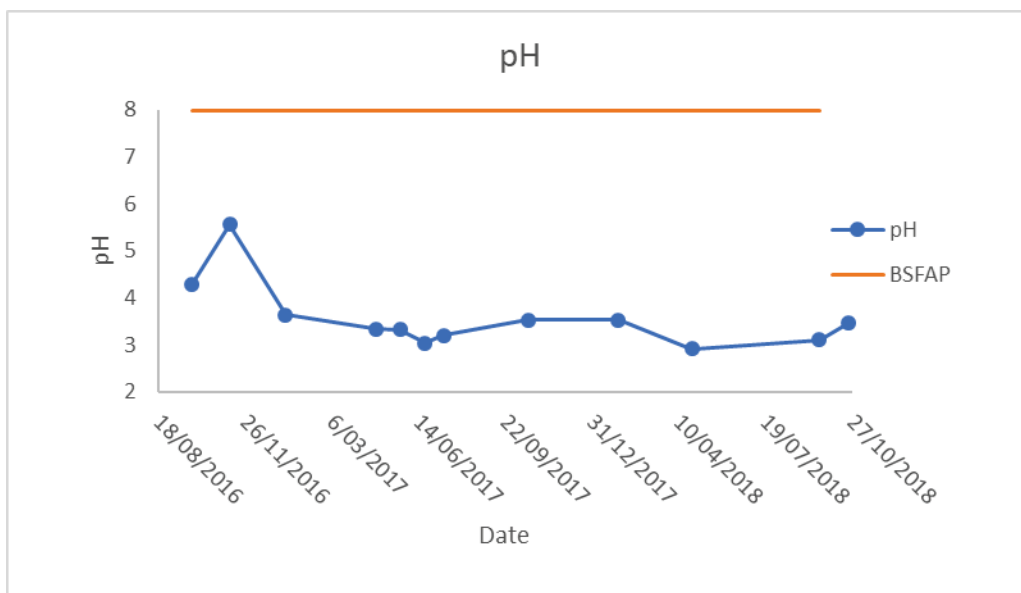


Figure 4-9 MW-1603 pH values



4.1.3 ASD Constituent Trends

Temporal plots for the elevated ASD constituents, beryllium, cobalt and lithium reported in groundwater monitoring well MW-1603, are provided in **Figure 4-10** to **Figure 4-12** below, with data for the BSFAP water presented for comparison.

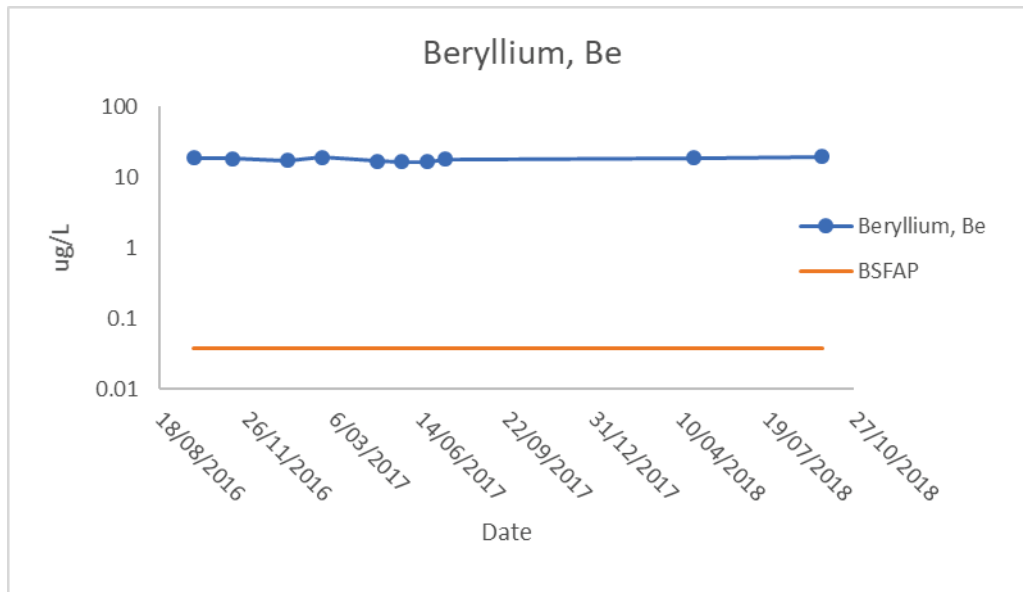


Figure 4-10 MW-1603 Beryllium Concentrations

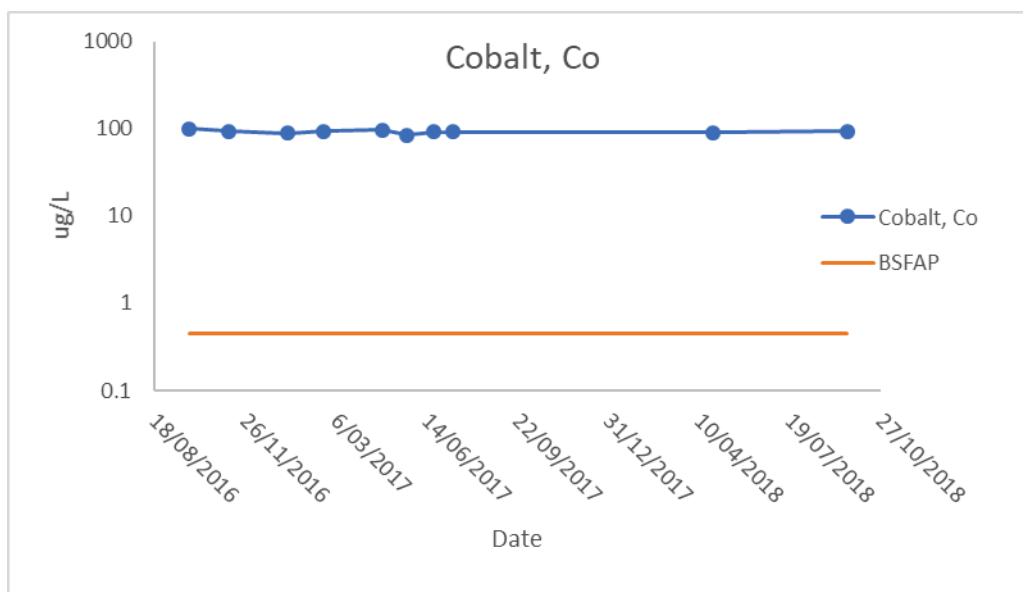


Figure 4-11 MW-1603 Cobalt Concentrations

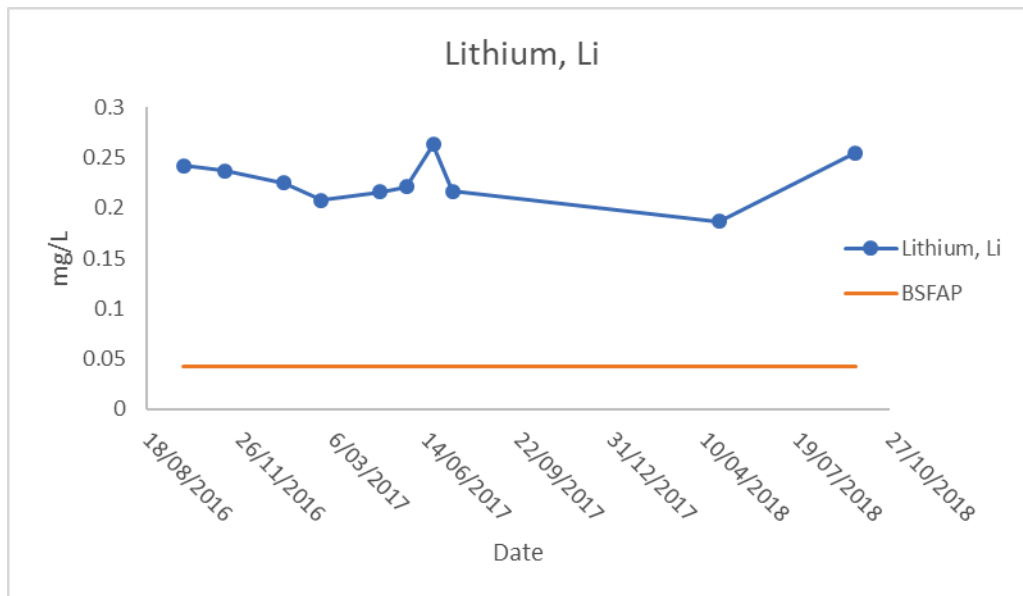


Figure 4-12 MW-1603 Lithium Concentrations

Beryllium, cobalt and lithium are more elevated in groundwater in comparison to BSFAP water indicating the source is not likely associated with the BSFAP.

4.1.4 Indicator Analysis Findings

Based on the temporal plots for primary indicators, potential indicators, and ASD constituents, it is considered unlikely that CCR constituents from the BSFAP are influencing water chemistry in surrounding groundwater. This is based on the primary indicator sulfate, potential indicators fluoride and bromide, and the ASD constituents beryllium, cobalt and lithium all being present at higher concentrations in groundwater compared to the BSFAP water. As the concentrations of these constituents in groundwater are higher, it is unlikely that there is a concentration gradient extending from the BSFAP into groundwater. It is more likely that an alternate source in groundwater is contributing to the higher concentrations observed in groundwater.

There are no consistently increasing trends within MW-1603 that suggest CCR constituents are migrating from the BSFAP into groundwater based on the analyses presented above.

4.2 Statistical Evaluation

A statistical evaluation of analytes was conducted graphically using box plots of the data (**Appendix C**). The box plots show that MW-1603 is statistically the same as the USGS reported regional background (Ruppert et al., 2000) in regards to arsenic, boron, calcium, chloride, chromium, fluoride, molybdenum, potassium, sodium, and strontium. The box plots also show a difference between MW-1603, BSFAP water and/or the regional background for pH, alkalinity, barium, cobalt, lead, lithium, magnesium, selenium, and sulfate. For beryllium, chromium, lead, lithium, molybdenum, and selenium no background values were provided by the USGS. It is likely that the acidic pH conditions, low alkalinity and high sulfate conditions at MW-1603 relative to regional background are driving dissolution of



metals. These geochemical conditions within MW-1603, which are similar to acid mine drainage, are due to the presence of the Princess Coal Seams discussed in **Section 2.2** being intersected by the screened interval of this monitoring well. The combination of the well installation and sampling is allowing the saturated conditions within the coal seams to become aerobic which results in a lowering of pH and increase in metal solubility.

4.3 Tier II Evaluation - Geochemical Evaluation

A simple analysis of primary and potential indicator constituents (as performed in **Section 4.1**) may not provide the lines of evidence required for a robust ASD. It is recognized that naturally occurring indicator constituents and upgradient sources may have an additional influence on groundwater quality. Spatially across a site, groundwater quality may be observed to change due to chemical interactions with the aquifer matrix. EPRI (2012) recommended more sophisticated methods that can be used for multiple parameters over multiple locations. These include ion ratios and Piper plots.

Development of ion ratios involves first selecting two non-competing, non-sorbing constituents. The ratios of these constituents are then compared spatially across the site and a judgment is made as to whether the hydraulically downgradient groundwater is similar to the background groundwater quality.

The median concentrations of boron, chloride, and sulfate are provided in **Table 4-1**. These three constituents were selected based on the recommended indicator species in EPRI (2017). Bromide was not included within the assessment, as bromide was non-detect in the BSFAP water indicating its presence in groundwater was either naturally derived or from an off-site source.

One of the downgradient groundwater monitoring wells (MW-1606) reports similar chloride concentrations to the BSFAP and higher boron concentrations. As the boron concentrations are significantly higher (by a factor of 3) it is considered unlikely that boron in groundwater in the vicinity of this well is related to the BSFAP. Concentrations of boron, chloride, and sulfate reported from MW-1601 are elevated in comparison to other downgradient groundwater monitoring wells. In addition, as discussed above the groundwater quality reported from MW-1603 is unlikely to be influenced by the BSFAP.

Table 4-1 Median Concentrations of Boron, Chloride, and Sulfate

		Median Concentrations 2016 to 2018		
	Location ID	Boron	Chloride	Sulfate
Location	Units	mg/L	mg/L	mg/L
Source	Fly Ash Pond	0.58	35.4	342
Background	MW-1011	0.13 ±0.03	3 ±1	75 ±10
Background	MW-1012	0.18 ±0.03	1 ±0.1	37 ±1
Background	MW-1203	0.12 ±0.02	5 ±0.3	30 ±3
Downgradient	MW-1601	0.22 ±0.05	22 ±5	97 ±27
Downgradient	MW-1602	0.05 ±0.03	11 ±3	106 ±21
Downgradient	MW-1603	0.05 ±0.03	3 ±0.4	707 ±74



		Median Concentrations 2016 to 2018		
	Location ID	Boron	Chloride	Sulfate
Location	Units	mg/L	mg/L	mg/L
Background	MW-1604	0.04 ±0.02	2 ±2 ²	8 ±2
Background	MW-1605	0.06 ±0.03	1 ±0.4	5 ±1
Downgradient	MW-1606	1.81 ±0.07	31 ±0.2	56 ±2
Downgradient	MW-1607	0.19 ±0.04	4 ±4 ³	122 ±27

mg/L = milligrams per liter

Ion ratios have been calculated using boron, chloride, and sulfate as recommended in EPRI (2017) and are provided in **Table 4-2**.

Table 4-2 Ion Ratios

		Median Concentrations 2016 to 2018		
Location	Location ID	Boron/Sulfate (x1000)	Boron/Chloride	Chloride/Sulfate
Source	Fly Ash Pond	1.68	0.002	0.10
Background	MW-1011	1.42 ±0.43	0.05 ±0.01	0.04 ±0.01
Background	MW-1012	4.89 ±0.83	0.15 ±0.02	0.03 ±0.00
Background	MW-1203	3.87 ±0.8	0.02 ±0.01	0.17 ±0.02
Downgradient	MW-1601	2.21 ±0.38	0.01 ±0.00	0.21 ±0.04
Downgradient	MW-1602	0.51 ±0.27	0.01 ±0.00	0.10 ±0.01
Downgradient	MW-1603	0.07 ±0.03	0.02 ±0.01	0.01 ±0.00
Background	MW-1604	5.07 ±2.51	0.02 ±0.01	0.19 ±0.22
Background	MW-1605	8.37 ±6.41	0.06 ±0.03	0.17 ±0.09
Downgradient	MW-1606	31.86 ±1.29	0.06 ±0.00	0.56 ±0.01
Downgradient	MW-1607	1.61 ±0.63	0.06 ±0.02	0.03 ±0.05

Using the ion ratios of boron/sulfate, boron/chloride, and chloride/sulfate and comparing the values between the BSFAP, downgradient, and background groundwater monitoring wells, does not appear to show a conclusive outcome using all three ratios. Specifically, the ratios of the BSFAP are not consistently different from the groundwater ratios. MW-1603 ratios do show a difference by at least an order of magnitude, with the exception of the boron to chloride ratio. Therefore, based on this ion ratio analysis, it does not appear likely that MW-1603 has been impacted by CCR constituents from the BSFAP.

² Initial analysis concentrations are elevated in September and November 2016 which skews the dataset

³ Initial analysis concentrations are elevated in September and November 2016 which skews the dataset



Piper plots are used to classify groundwater types based on the major ion ratios of calcium, magnesium, sodium (and potassium), alkalinity, chloride, and sulfate. They can be used to visually illustrate ion exchange and mixing between different water chemistries. Piper plots for individual wells are depicted in **Figure 3**.

Figure 4-13 illustrates the relationship between BSFAP and groundwater (background and downgradient). Most groundwaters are a bicarbonate water type (calcium and sodium) and the BSFAP is a calcium sulfate water type. This means: the predominant major ions in groundwater are calcium, sodium and bicarbonate; and calcium and sulfate are dominant in the BSFAP. Background groundwater monitoring well MW-1605 is mostly a sodium sulfate groundwater and downgradient wells MW-1603 and MW-1607 are calcium sulfate water types. It is unlikely that background well MW-1605 water quality is being influenced by CCR constituents as it is not in a downgradient receiving catchment. MW-1603 reports higher concentrations of sulfate than the BSFAP water and MW1607 does have a similar boron/sulfate ion ratio to the BSFAP water but boron/chloride and chloride/sulfate are not comparable. The groundwater water types suggest that mixing and ion exchange are occurring. This suggests that the varying lithologies within the screened sections of the individual monitoring wells are contributing to differing groundwater qualities identified in individual wells. When these coal seams are intersected and mixing of the waters occur, ion exchange occurs between the cations (sodium magnesium and calcium), as does possible dilution and precipitation of anions (alkalinity, chloride and sulfate).

It should be noted that MW-1601, MW-1602, and MW-1603 are bedrock wells which are screened within the Breathitt Group. MW-1604, MW-1605, MW-1606, and MW-1607 are alluvium wells that are screened within either the Horseford Creek or Blaine Creek Quaternary floodplain deposits.



Fly Ash Pond GW ALL

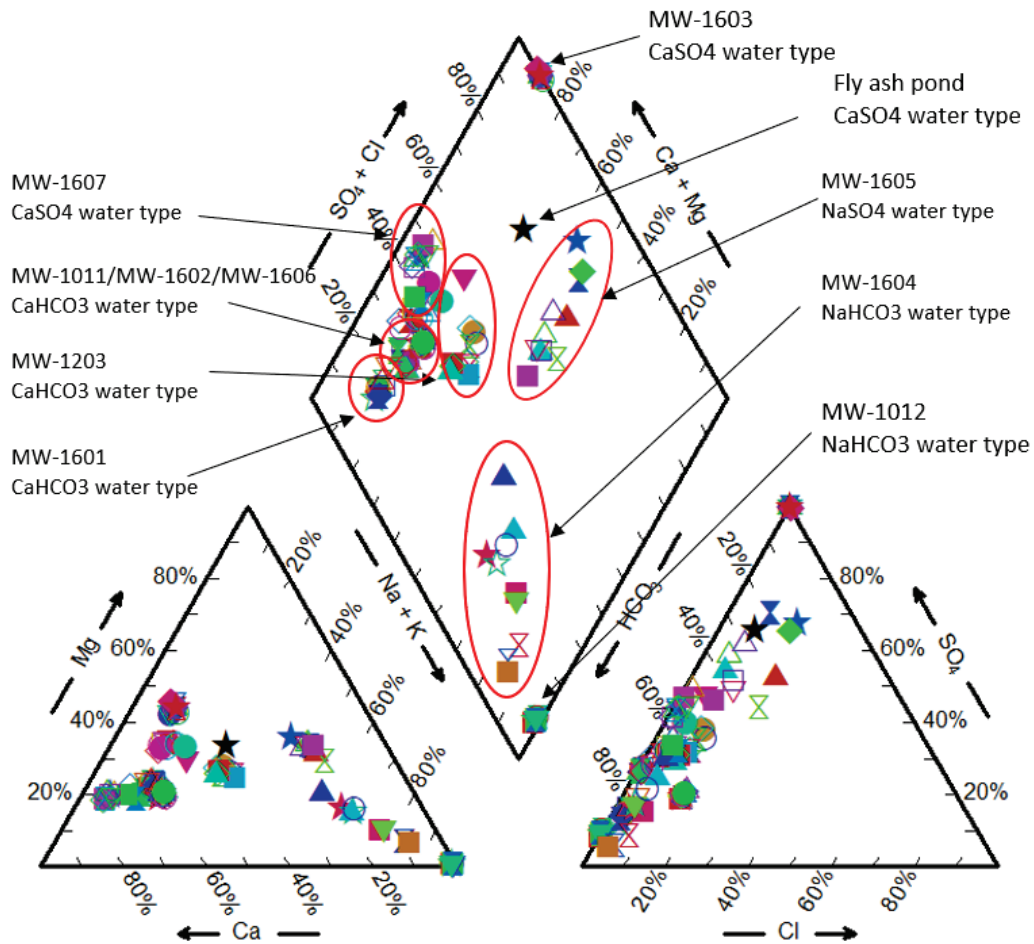


Figure 4-13 BSFAP and Groundwater Piper Plot

Stiff plots can also be used to illustrate major ion relationships. As discussed in EPRI (2017), coal ash leachates display characteristic Stiff plots (Figure 4-14). The Stiff plots for the groundwater samples appear to be representative of natural waters with the exception of MW-1603 (Figure 4-15). The Stiff plot for this location is very similar to the bituminous coal ash leachate in Figure 3-5 of the EPRI (2017) guidance (replicated below as Figure 4-14). This similarity is supported by the boring log for this well location, which reports the presence of, ‘...intensely fractured, black, wet, nearly all organic matter; slight coaly texture’ horizon at the same elevation of the well screen (Geosyntec, 2016). The pH recorded from MW-1603 ranges from pH 2.91 to 5.56, with an average of 3.58, which is also indicative of potential influence from a coal matrix (Bigham and Cravotta, 2006).

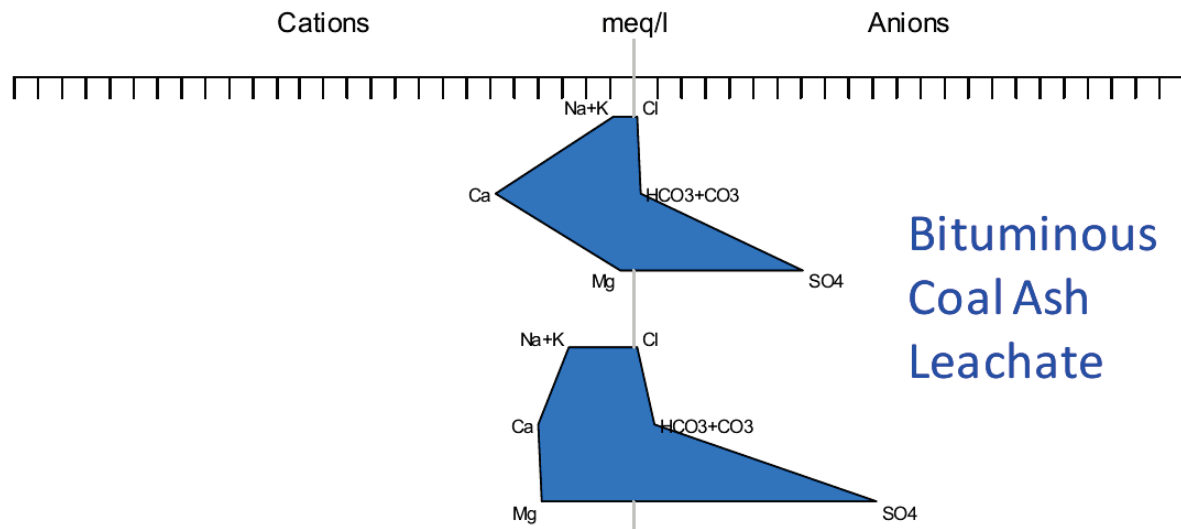


Figure 4-14 Bituminous Coal Ash Leachate Stiff Plot (EPRI, 2017)

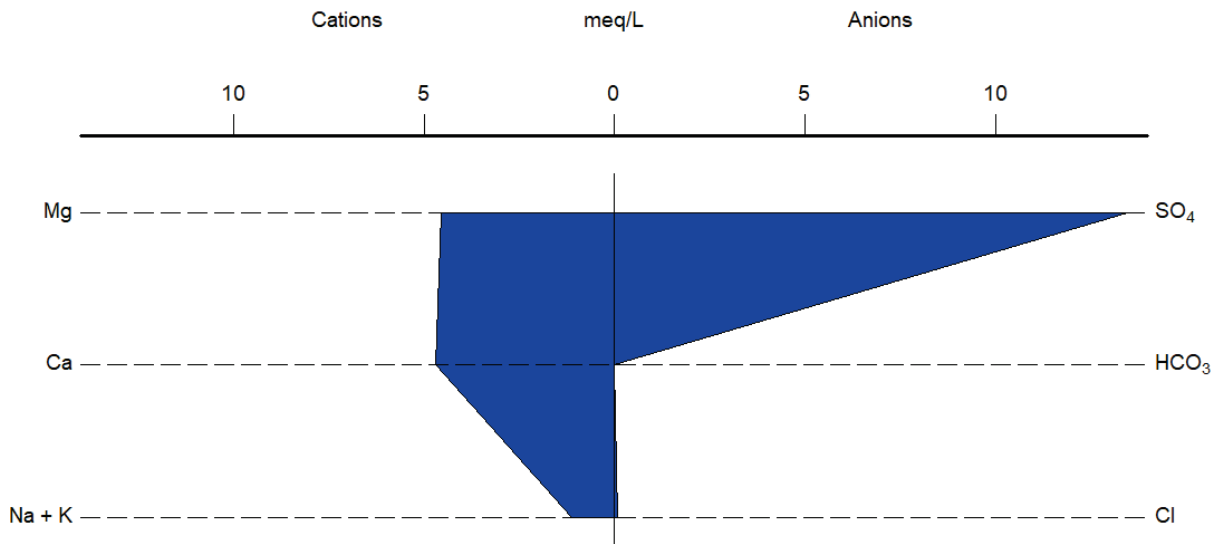


Figure 4-15 Stiff Plot for MW-1603 24th May 2017

In summary, based on the geochemical evaluation there is insufficient evidence to support the presence of CCR constituents, as derived from the BSFAP, in groundwater sampled in the vicinity of MW-1603. The Piper plots do not support mixing between groundwater and BSFAP water at any of the groundwater monitoring locations. The BSFAP water type is calcium sulfate. Only two other groundwater locations report this water type – MW-1603 and MW-1607; however, the magnitude of the calcium and sulfate is considerably different to that expressed in the BSFAP. Cobalt concentrations are approximately 3 times higher in MW-1607 in comparison to the BSFAP water, therefore it is highly unlikely the source of cobalt is from the BSFAP and is more likely to be a characteristic of the lithologies in which these two monitoring locations are screened across.



5 Summary and Conclusions

Using the EPRI (2017) guidance for ASD, the conclusions that are based on the lines of evidence presented and discussed within **Sections 3** and **4** indicate that groundwater in the vicinity of the BSFAP is not being impacted by CCR constituents from the BSFAP. The elevated beryllium, cobalt, and lithium concentrations that triggered the ASD assessment are due to the oxidation of coal seams that have been intersected by well location MW-1603. This is supported by the visual evidence during the logging of core characteristics at this location, the low pH reported in groundwater, and the subsequent likely dissolution and mobility of metalliferous species (beryllium, cobalt, and lithium) by the elevated acidity. The elevated pH in the BSFAP water and the corresponding lower concentrations of minor ions in BSFAP also support the unlikely influence of the BSFAP on groundwater. Therefore, it is concluded that the elevated signatures of beryllium, cobalt, and lithium are related to the dissolution of naturally-occurring coal-seam derived constituents within the shale layers of the Breathitt Group, as supported by the discussion of local and regional geology in **Section 2.2**.



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Tables

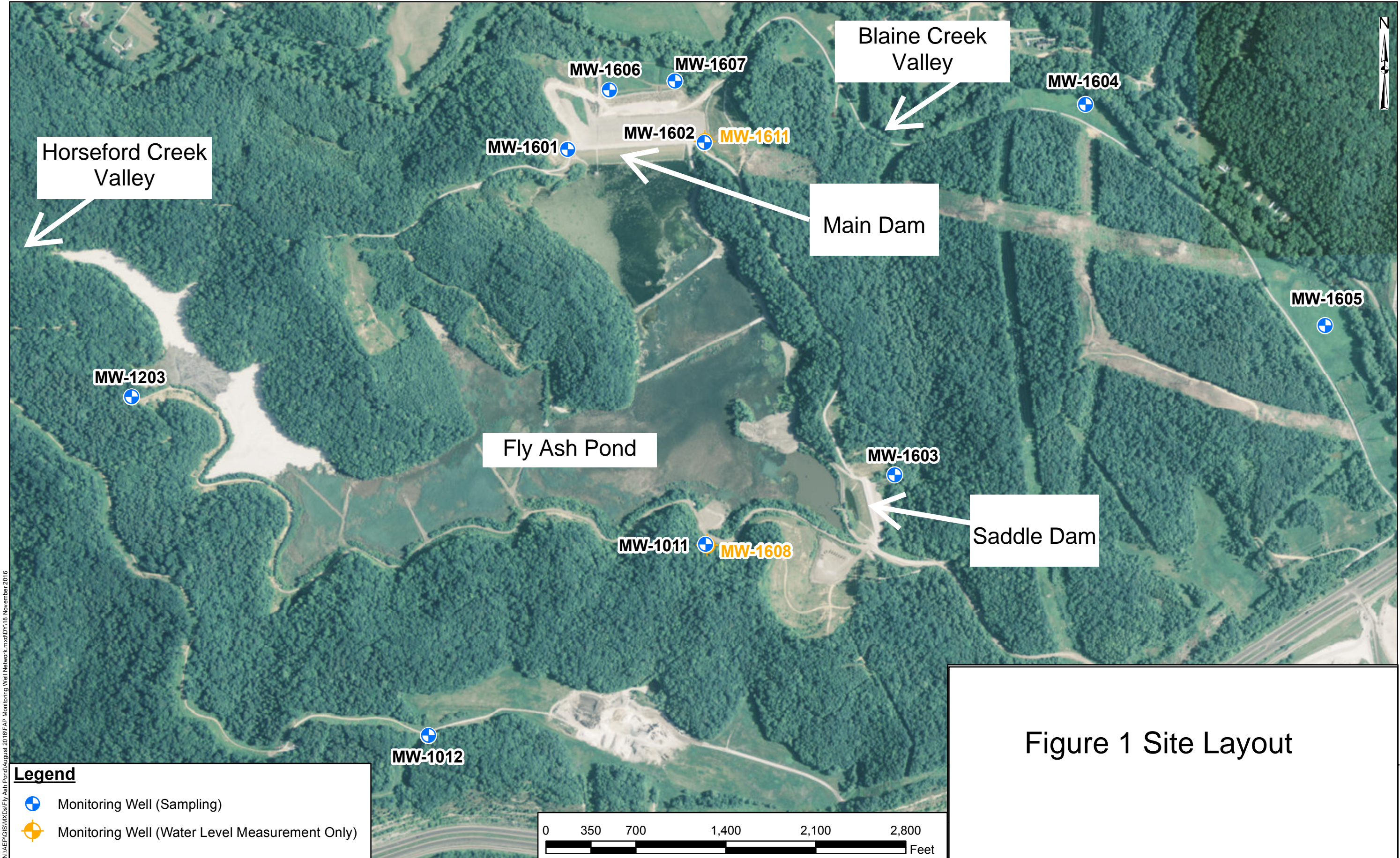


Table 1 Analytical Suite for Water Sampling

	Field Measured	Laboratory Analyzed
Parameter	Turbidity	Alkalinity, as CaCO ₃
	pH	Antimony, Sb
	Electrical Conductivity	Arsenic, As
	Temperature	Barium, Ba
	Oxidation Reducing Potential	Beryllium, Be
	Dissolved Oxygen	Boron, B
		Bromide, Br
		Cadmium, Cd
		Calcium, Ca
		Chloride, Cl
		Chromium, Cr
		Cobalt, Co
		Fluoride, F
		Lead, Pb
		Lithium, Li
		Magnesium, Mg
		Mercury, Hg
		Molybdenum, Mo
		Potassium, K
		Selenium, Se
		Sodium, Na
		Strontium, Sr
		Sulfate, SO ₄
	Thallium, Tl	
	TDS, Residue, Filterable	

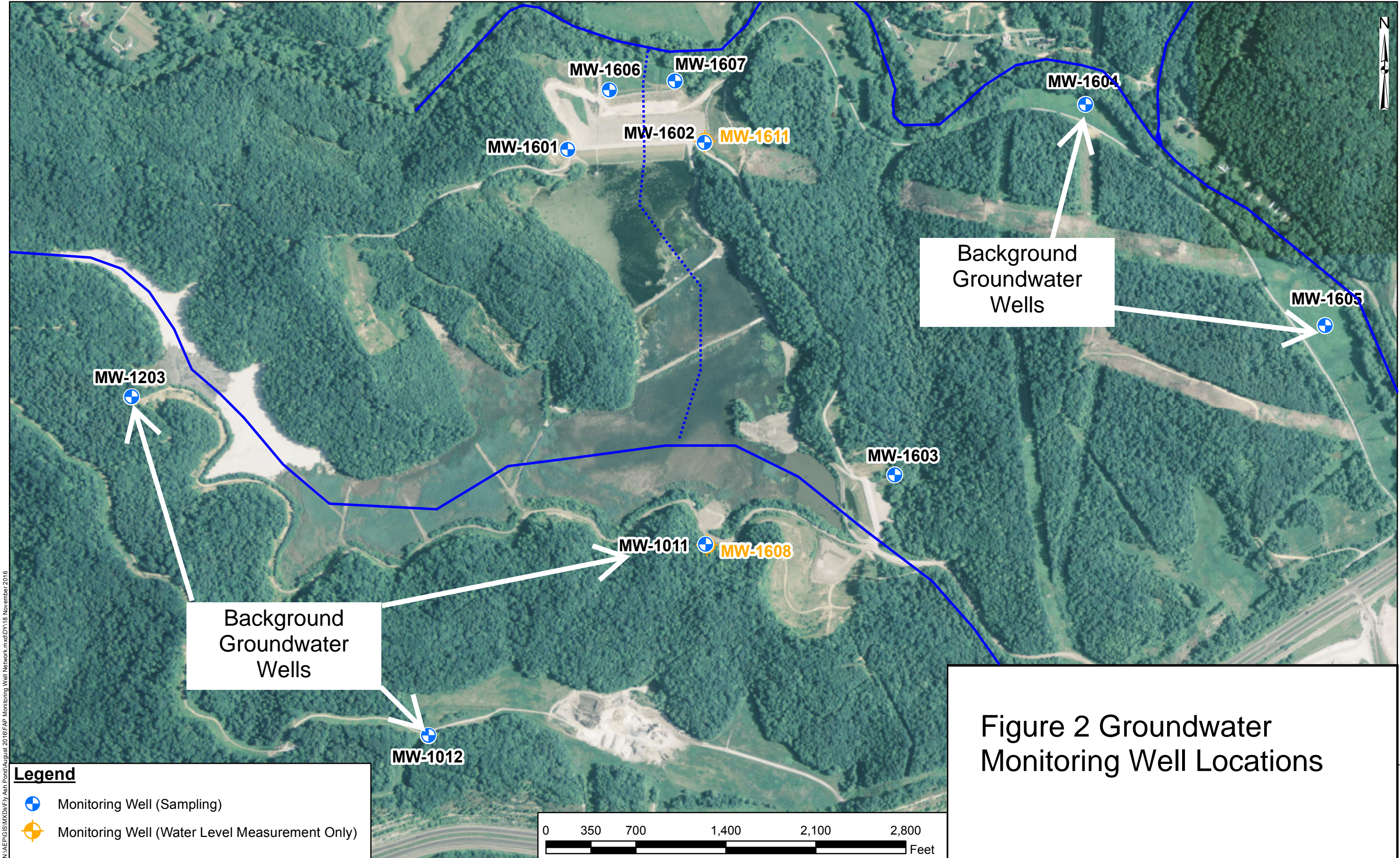


Figures



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Figure 1 Site Layout



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Legend

- ⊕ Monitoring Well (Sampling)
- ⊕ Monitoring Well (Water Level Measurement Only)

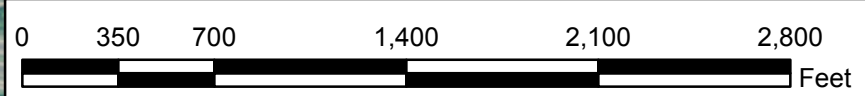
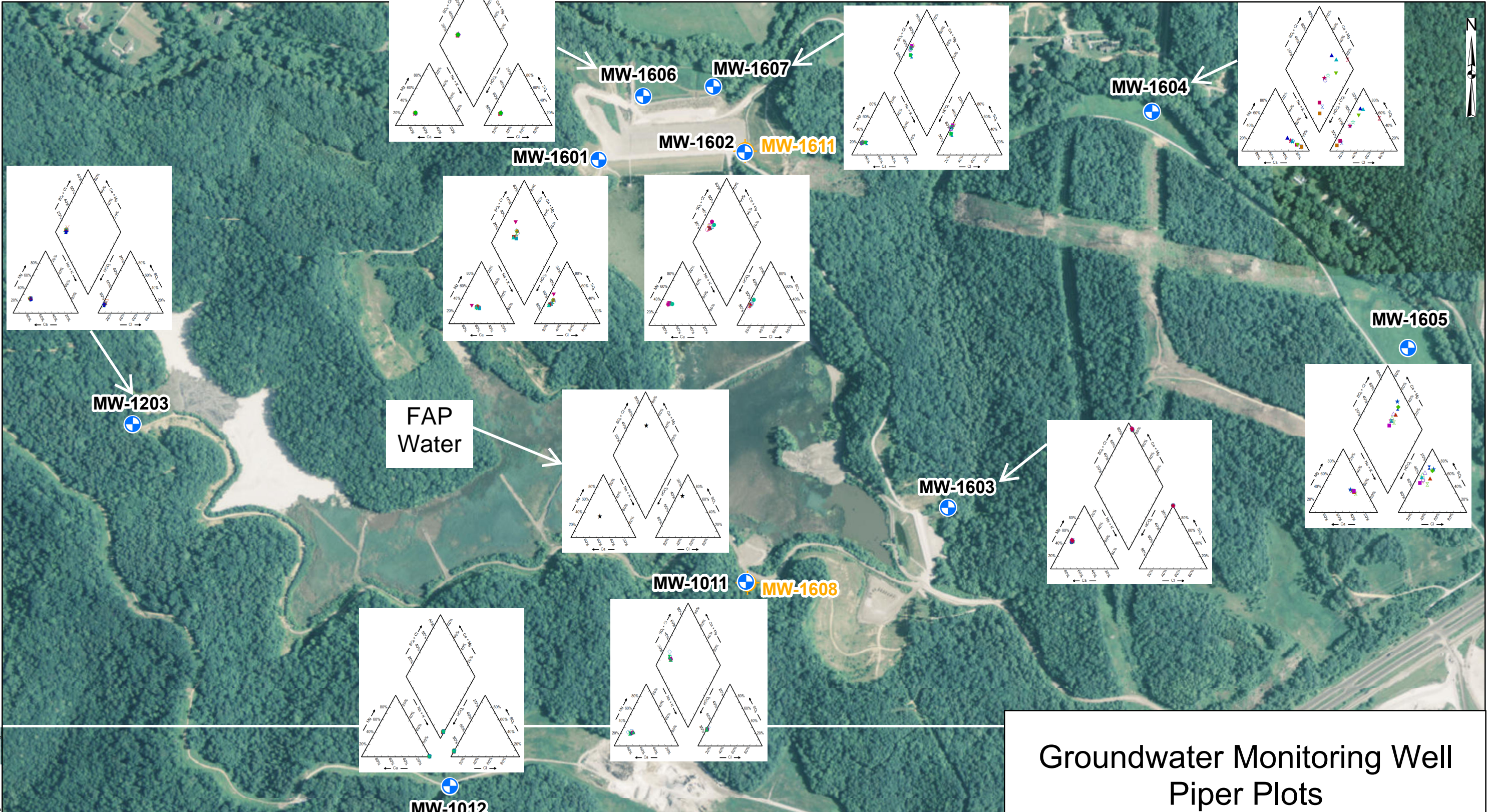




Figure 2 Groundwater Monitoring Well Locations

N:\EPG\GIS\MDa\Fly Ash Pond\August 2016\FAP_Monitoring_Well_Network.mxd\DY118 November 2016



Legend

-  Monitoring Well (Sampling)
-  Monitoring Well (Water Level Measurement Only)

Groundwater Monitoring Well Piper Plots



Big Sandy Fly Ash Pond

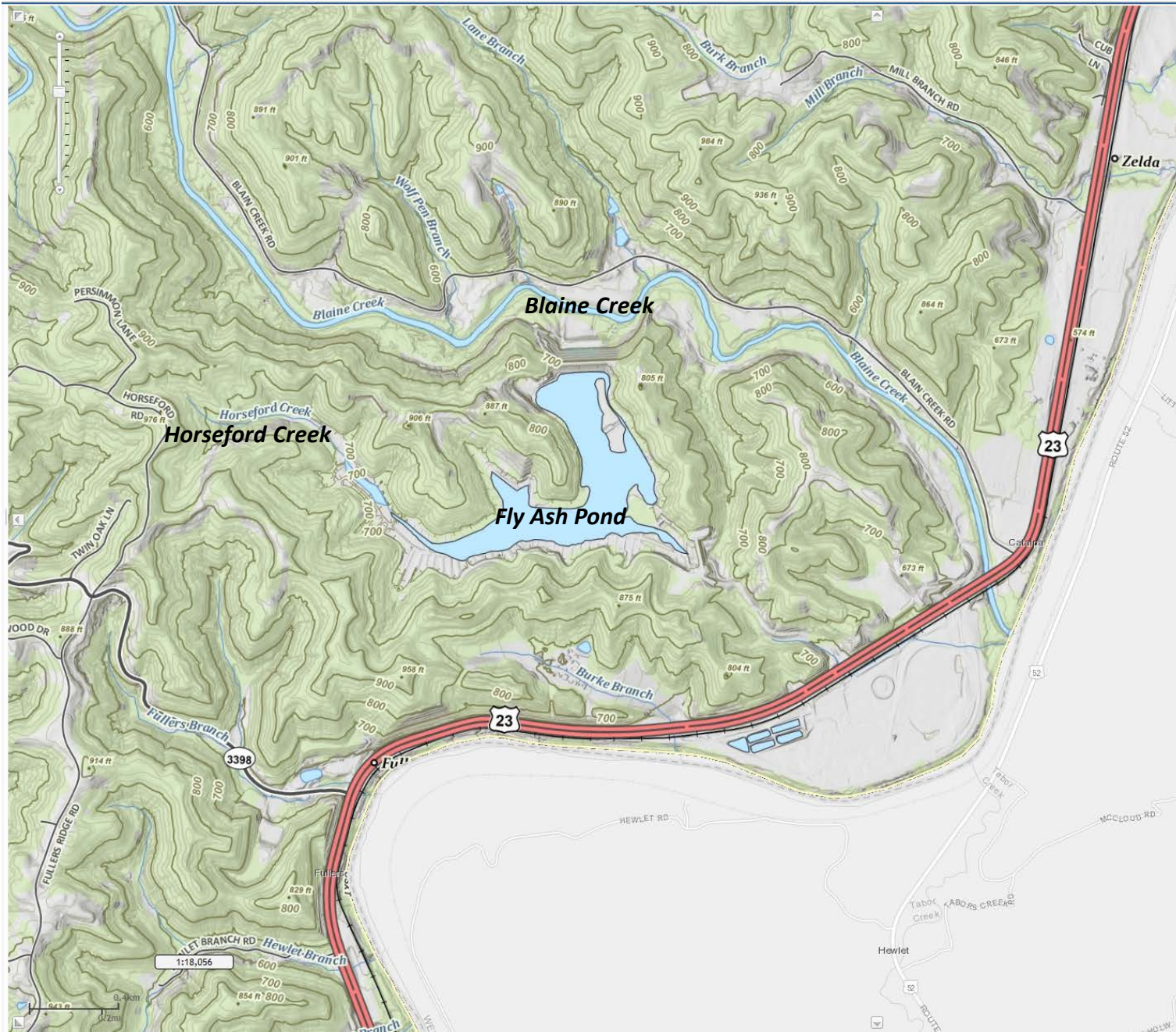
Louisa, Kentucky

Figure 3

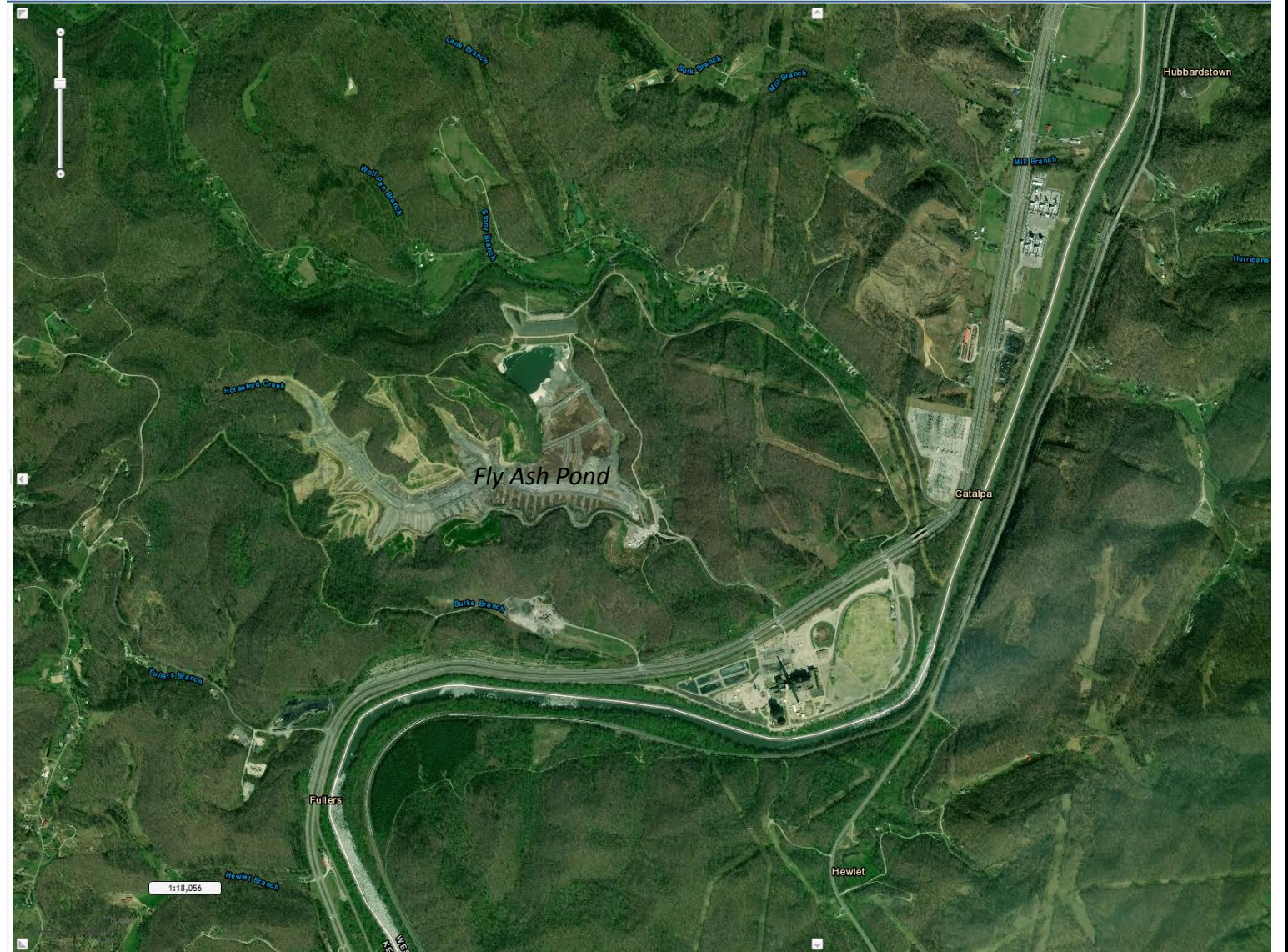


Appendix A Geologic Figures

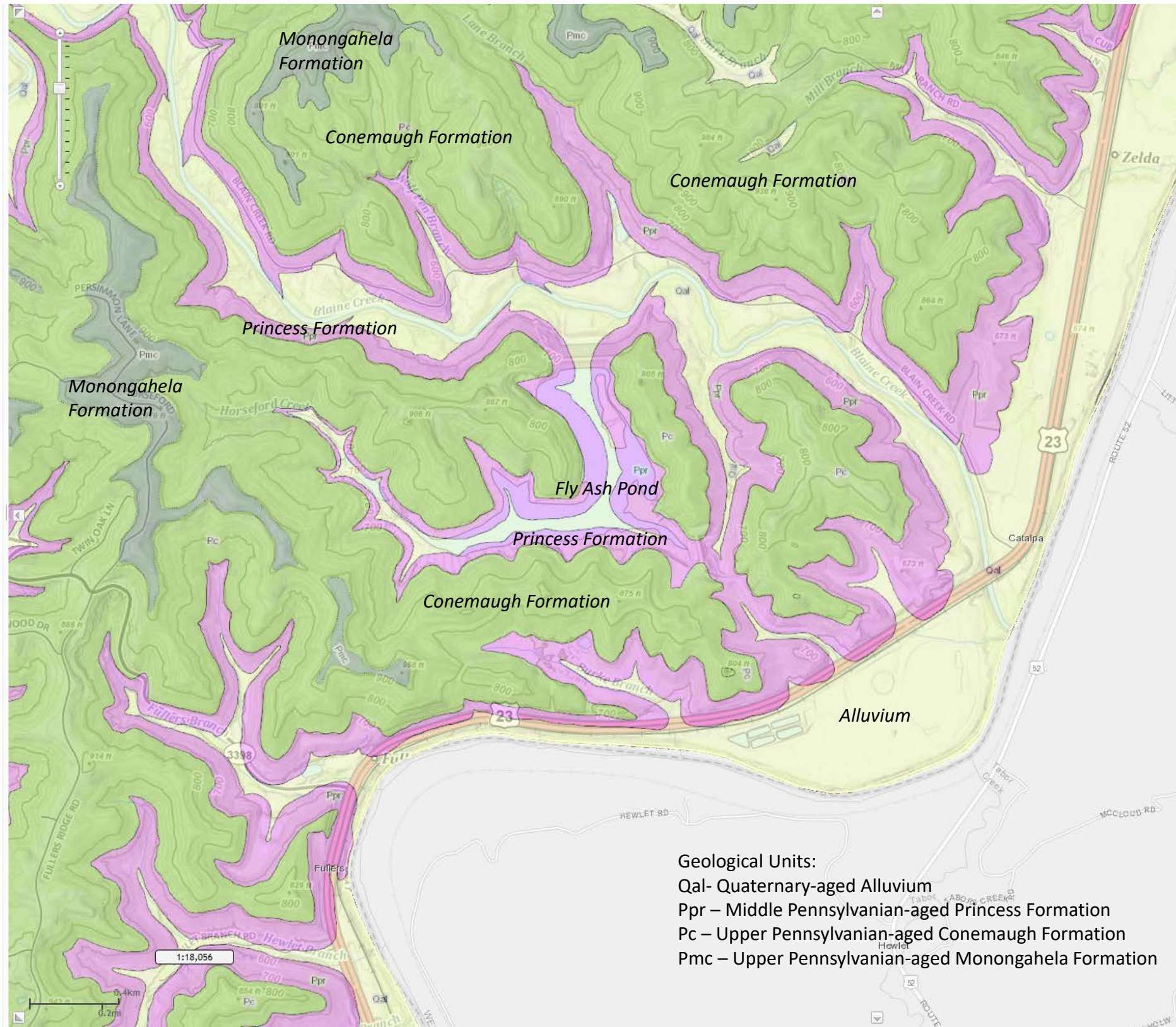
Topographical Map for Area



Aerial Photograph for Area



Taken from Kentucky Geologic Map Information Service
<https://bit.ly/2QN0Fby>



Taken from Kentucky Geologic Map Information Service
<https://bit.ly/2Aaahm4>

Regional Stratigraphical Framework

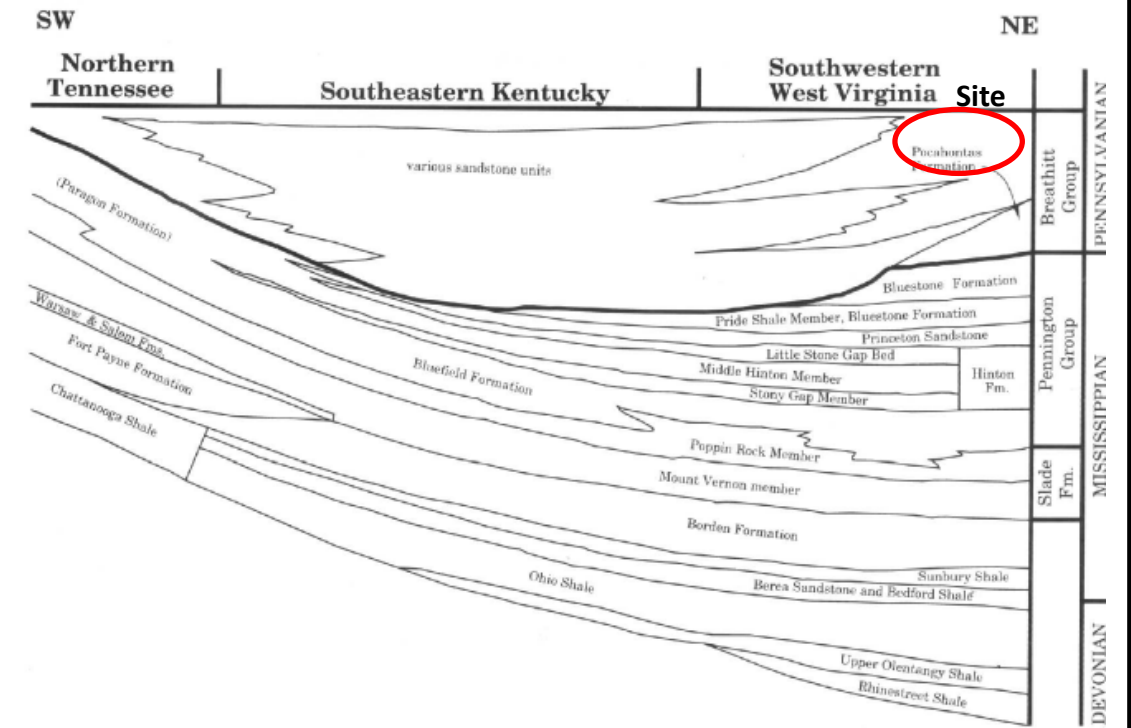


Figure 4. Stratigraphic framework of Mississippian rocks in the Central Appalachian Basin. Pennsylvanian and Devonian units are also shown.

Regional Stratigraphy Column of the Breathitt Group

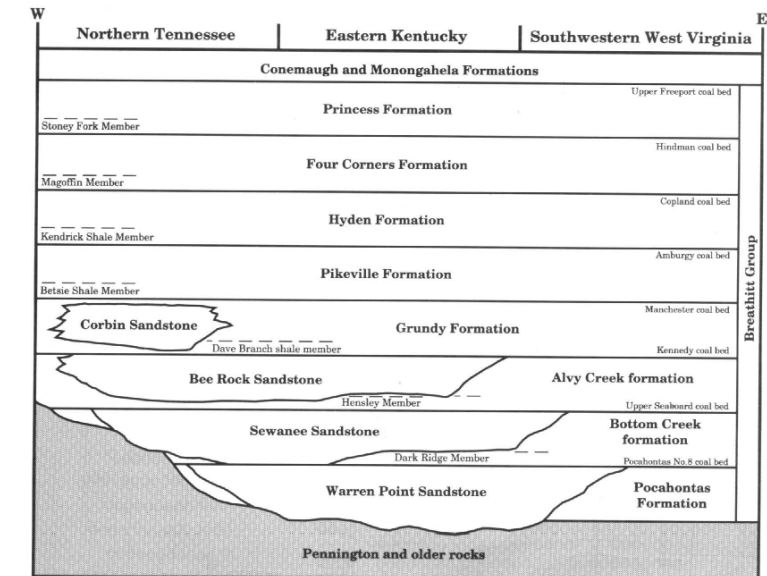
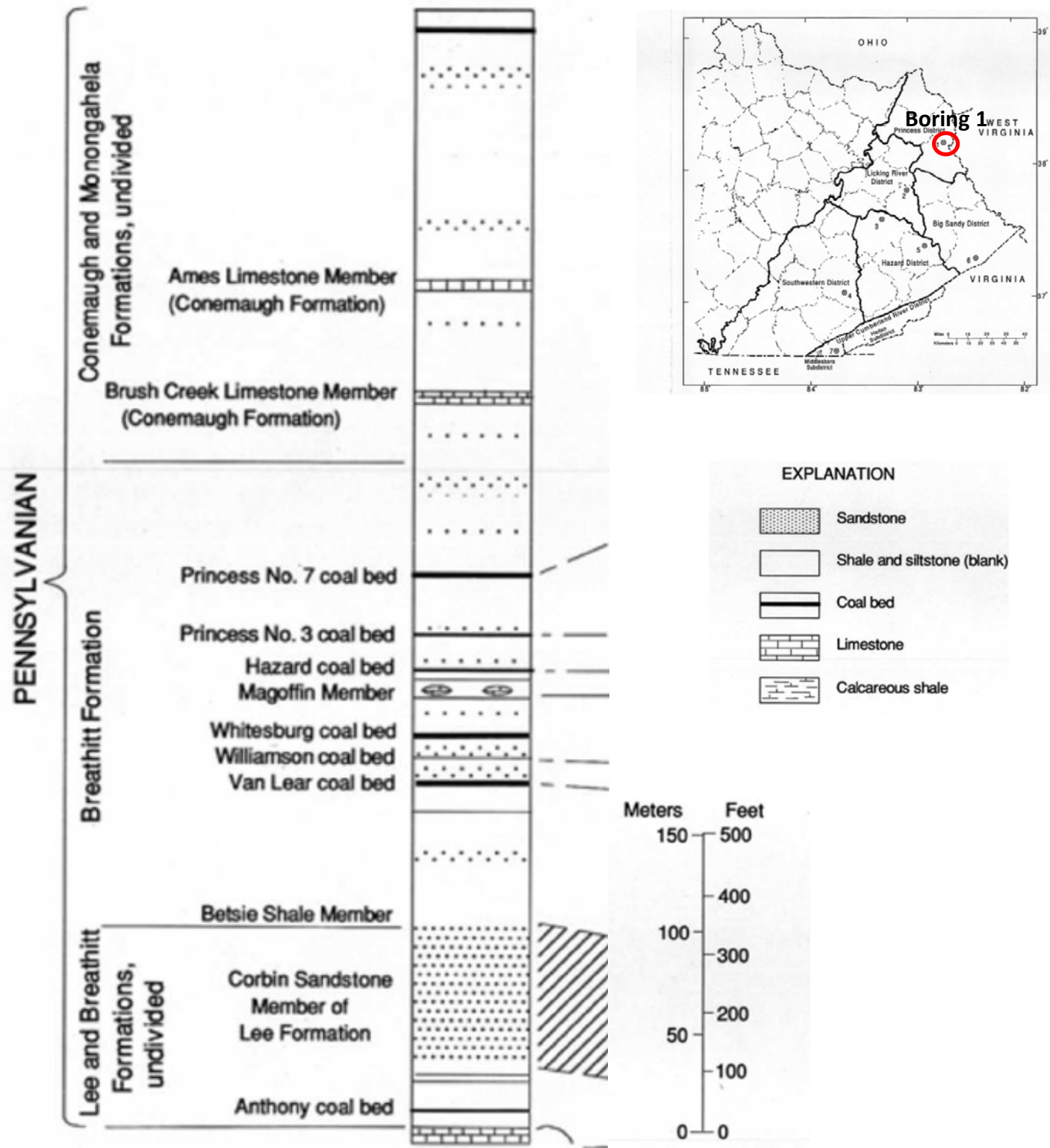


Figure 5. Stratigraphic framework of Pennsylvanian rocks in the Central Appalachian Basin.

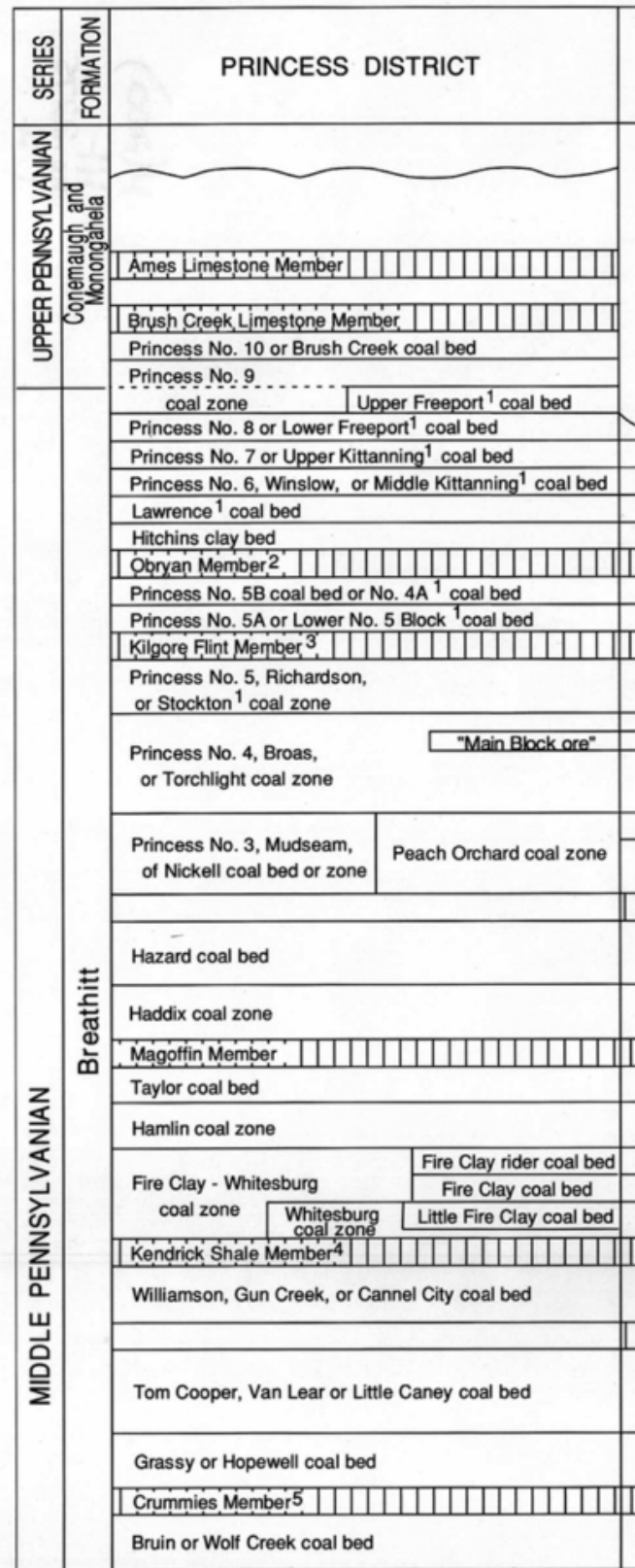
Taken from Chesnut (1992)

Stratigraphy Taken from Boring #1 in the Princess Coal District



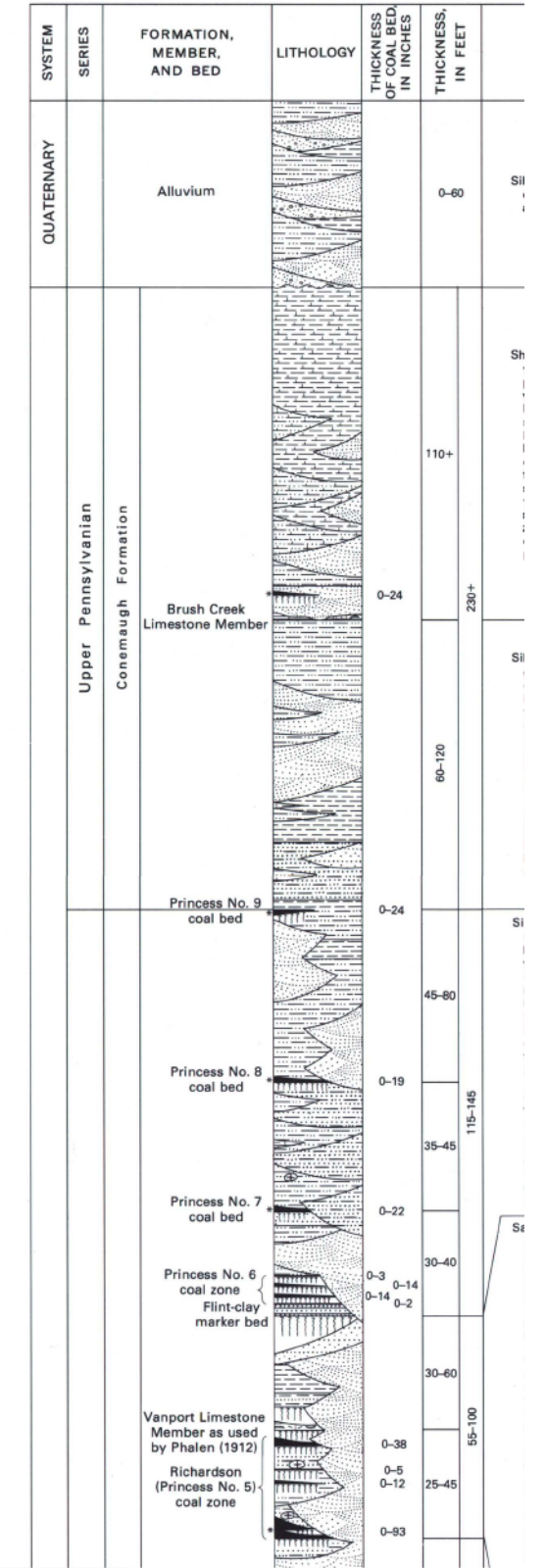
Taken from Rice and Hiatt (1994)

Stratigraphy Column of the Princess Coal District

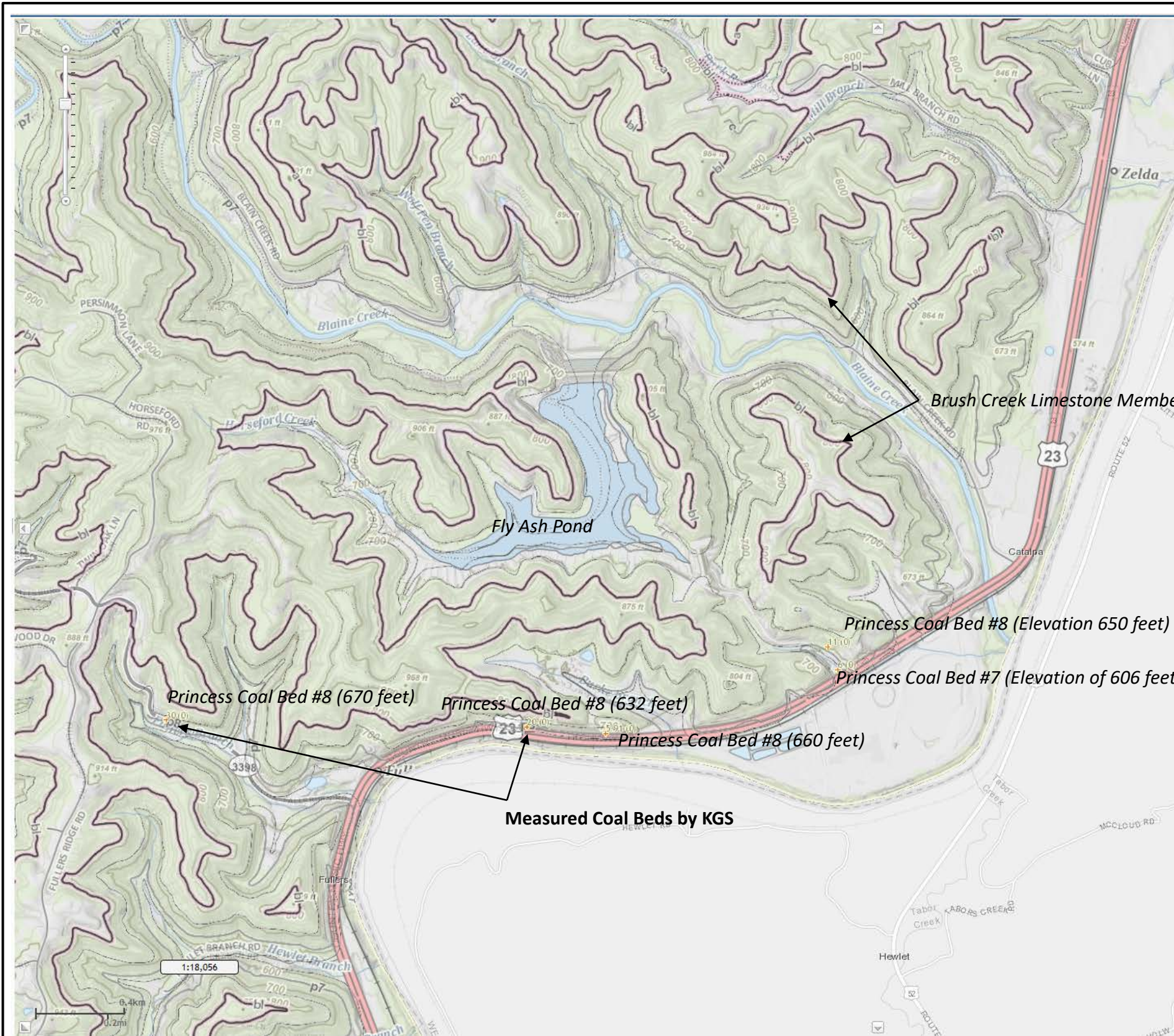


Taken from Rice and Hiatt (1994)

Stratigraphy Column for Adams Quadrangle



Taken from Ward (1978)



Taken from Kentucky Geologic Map Information Service
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Beryllium Content of the Upper Freeport Coal/Princess Number 9

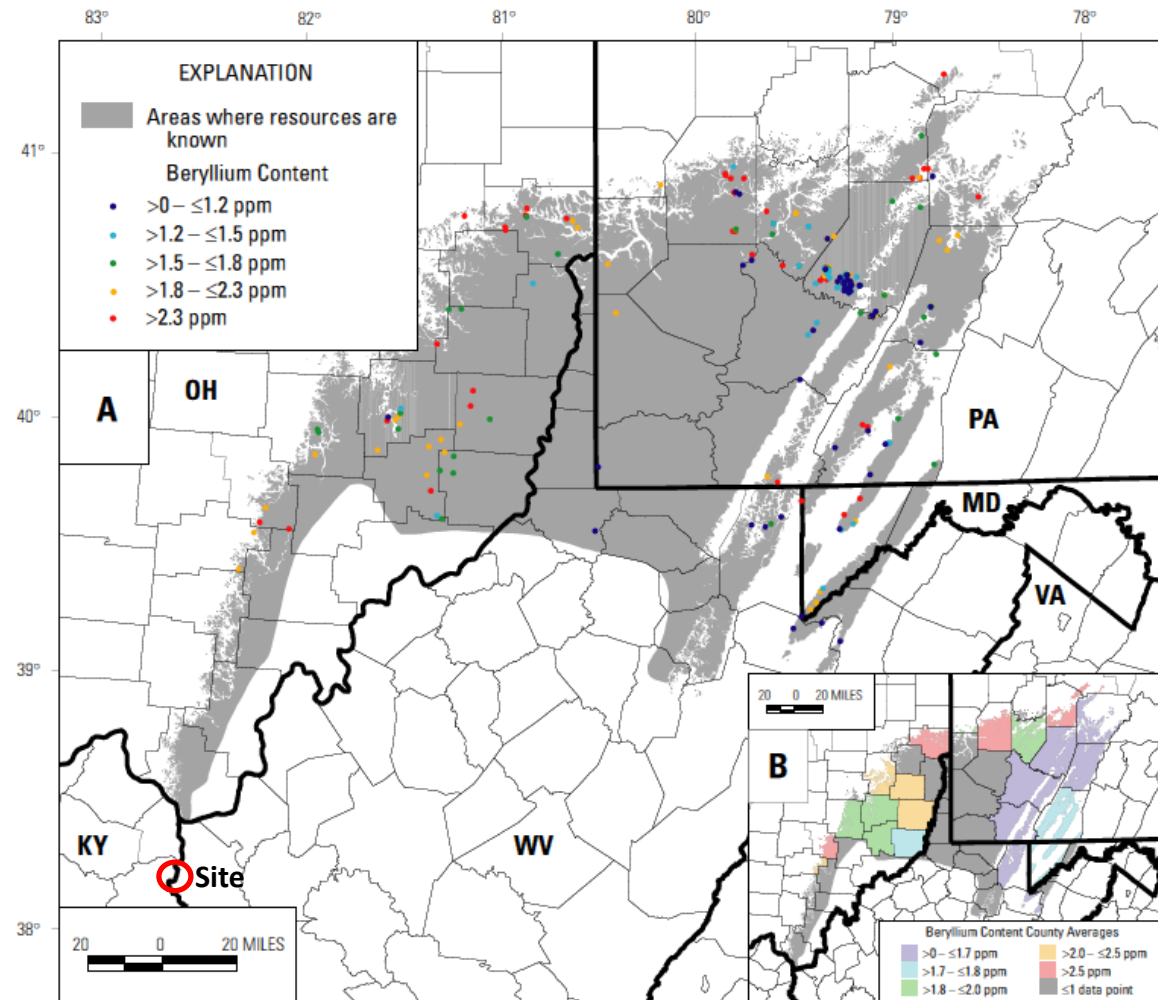


Figure 38. Maps showing beryllium content (parts per million (ppm), as-received whole-coal basis) of the Upper Freeport coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows beryllium contents of 226 samples for which geochemical records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for beryllium con-

tents using 257 records in the geochemical database, including those that are located only to a county level; beryllium contents range from 0.21 to 5.0 ppm with a mean value of 1.8 ± 0.81 (table 8). The values are classified into five categories, each representing 20 percent of the data values. See figure 3 for county names.

Cobalt Content of the Upper Freeport Coal/Princess Number 9

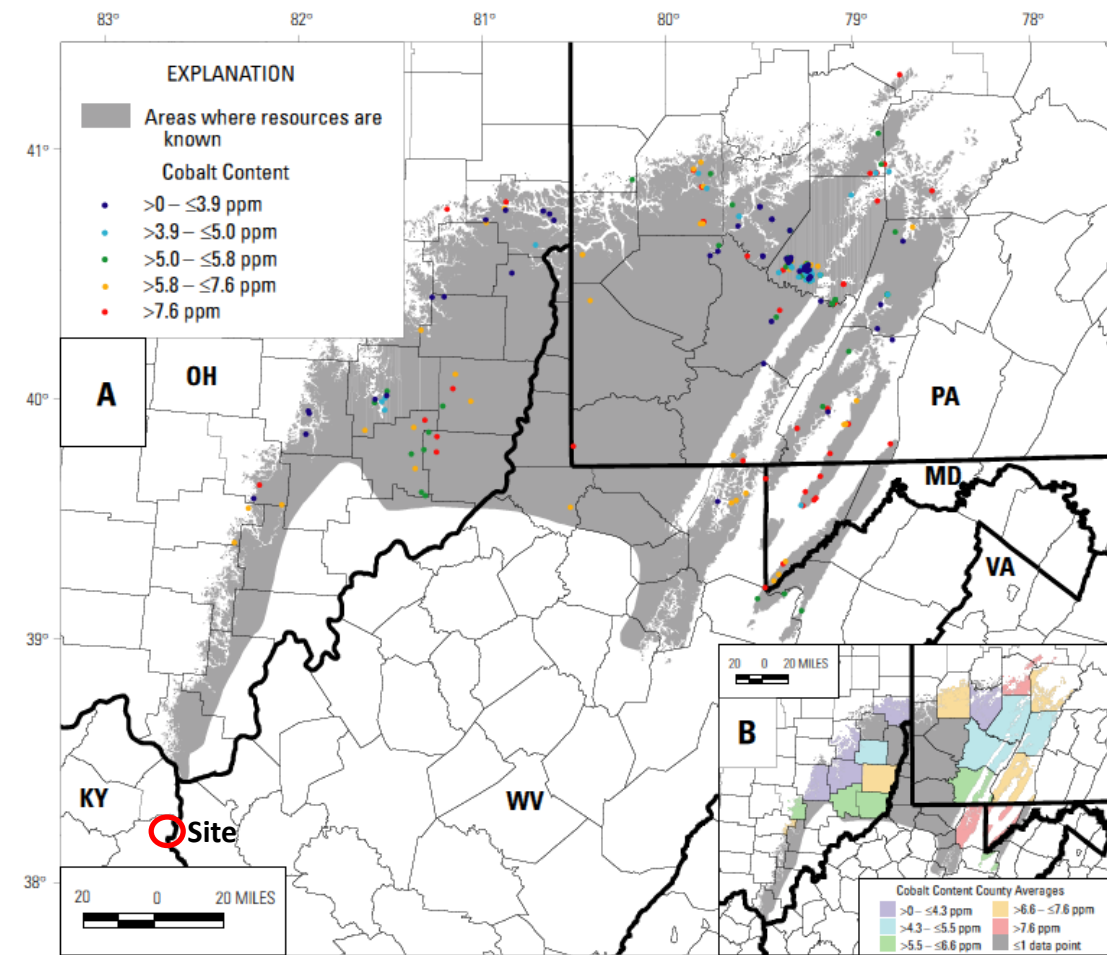


Figure 42. Maps showing cobalt content (parts per million (ppm), as-received whole-coal basis) of the Upper Freeport coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows cobalt contents of 225 samples for which geochemical records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for cobalt contents using all 254

records in the geochemical database, including those that are located only to a county level; cobalt contents range from 0.76 to 20 ppm with a mean value of 6.1 ± 3.1 ppm (table 12). The values are classified into five categories, each representing 20 percent of the data values. See figure 3 for county names.

Taken from Ruppert et al. 2000

Lead Content of the Upper Freeport Coal/Princess Number 9

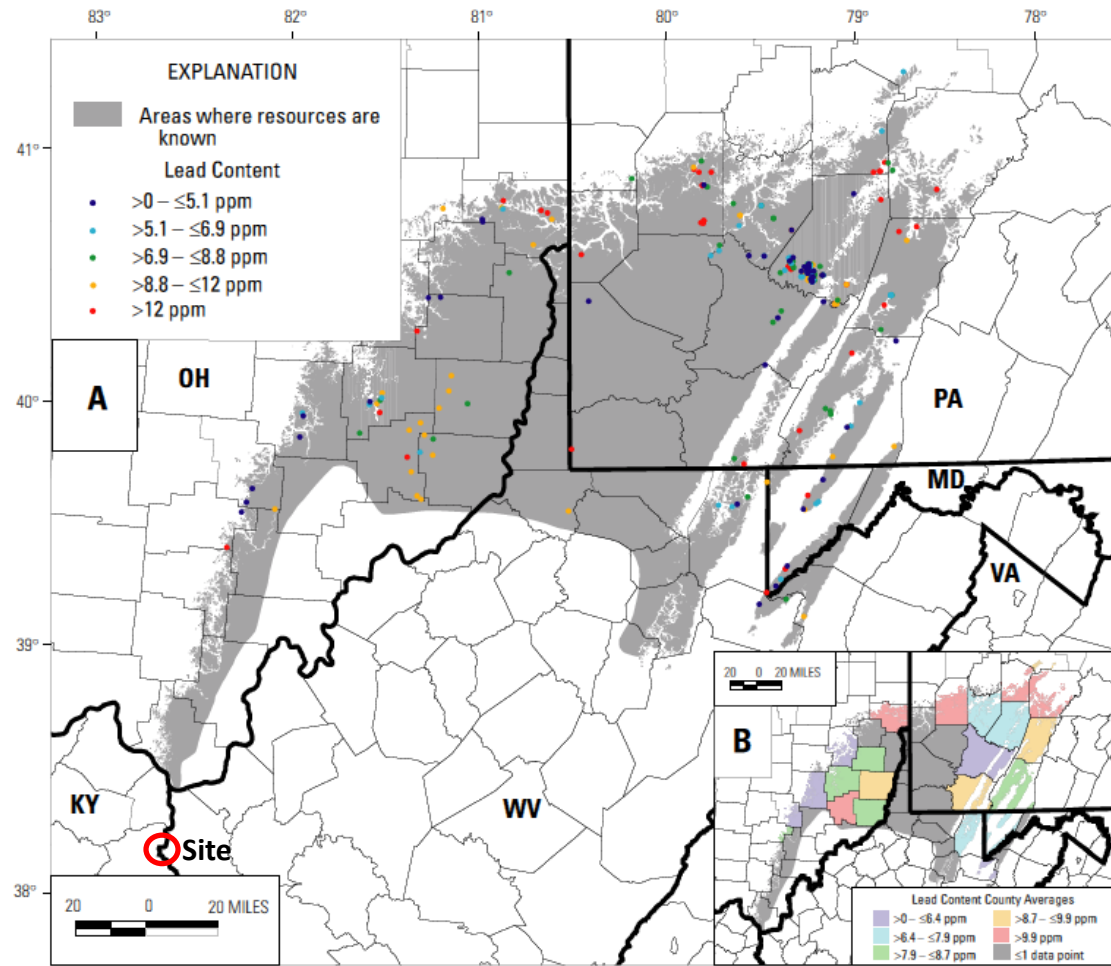


Figure 43. Maps showing lead content (parts per million (ppm), as-received whole-coal basis) of the Upper Freeport coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows lead contents of 225 samples for which geochemical records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for lead contents using all 254

records in the geochemical database, including those that are located only to a county level; lead contents range from 1.3 to 27 ppm with a mean value of 8.6 ± 4.4 ppm (table 13). The values are classified into five categories, each representing 20 percent of the data values. See figure 3 for county names.

Cobalt Content of the Upper Freeport Coal/Princess Number 9

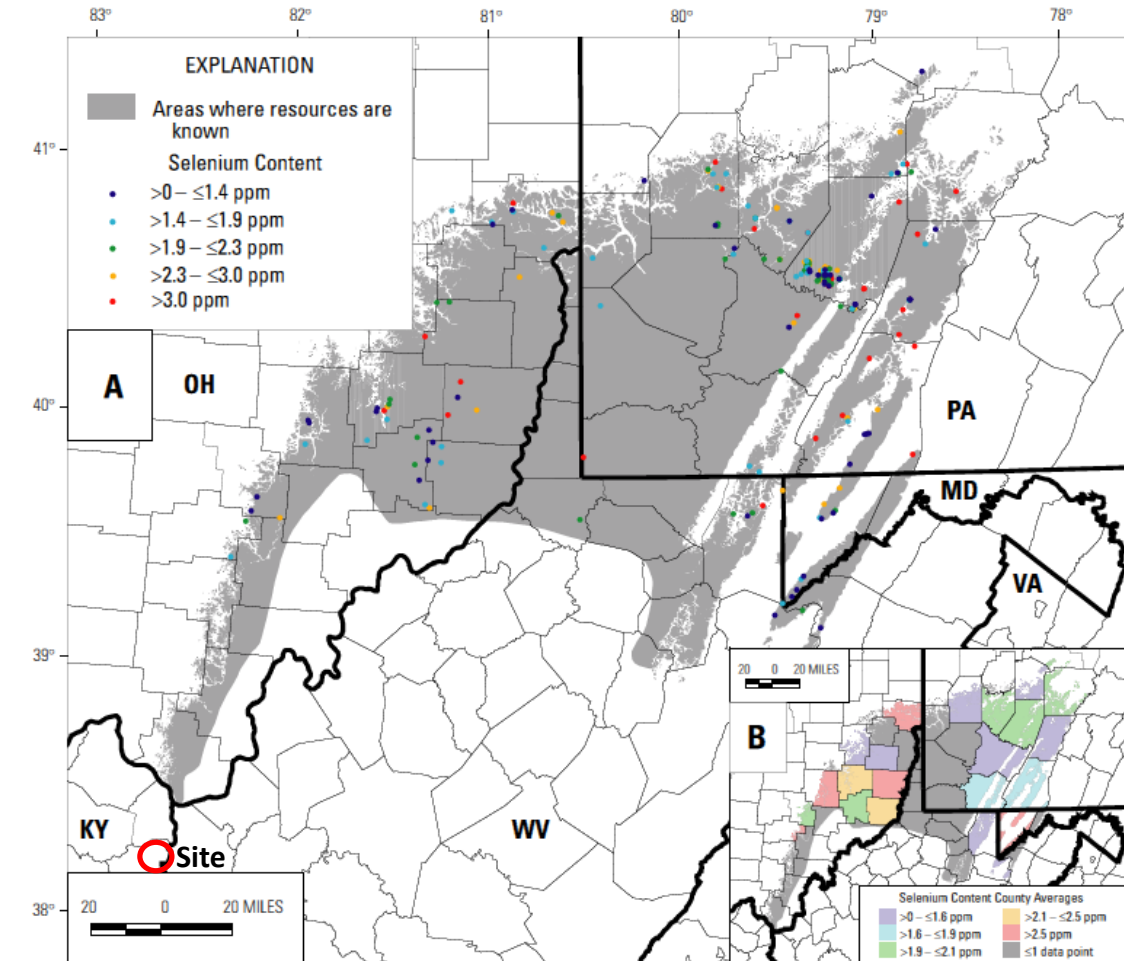
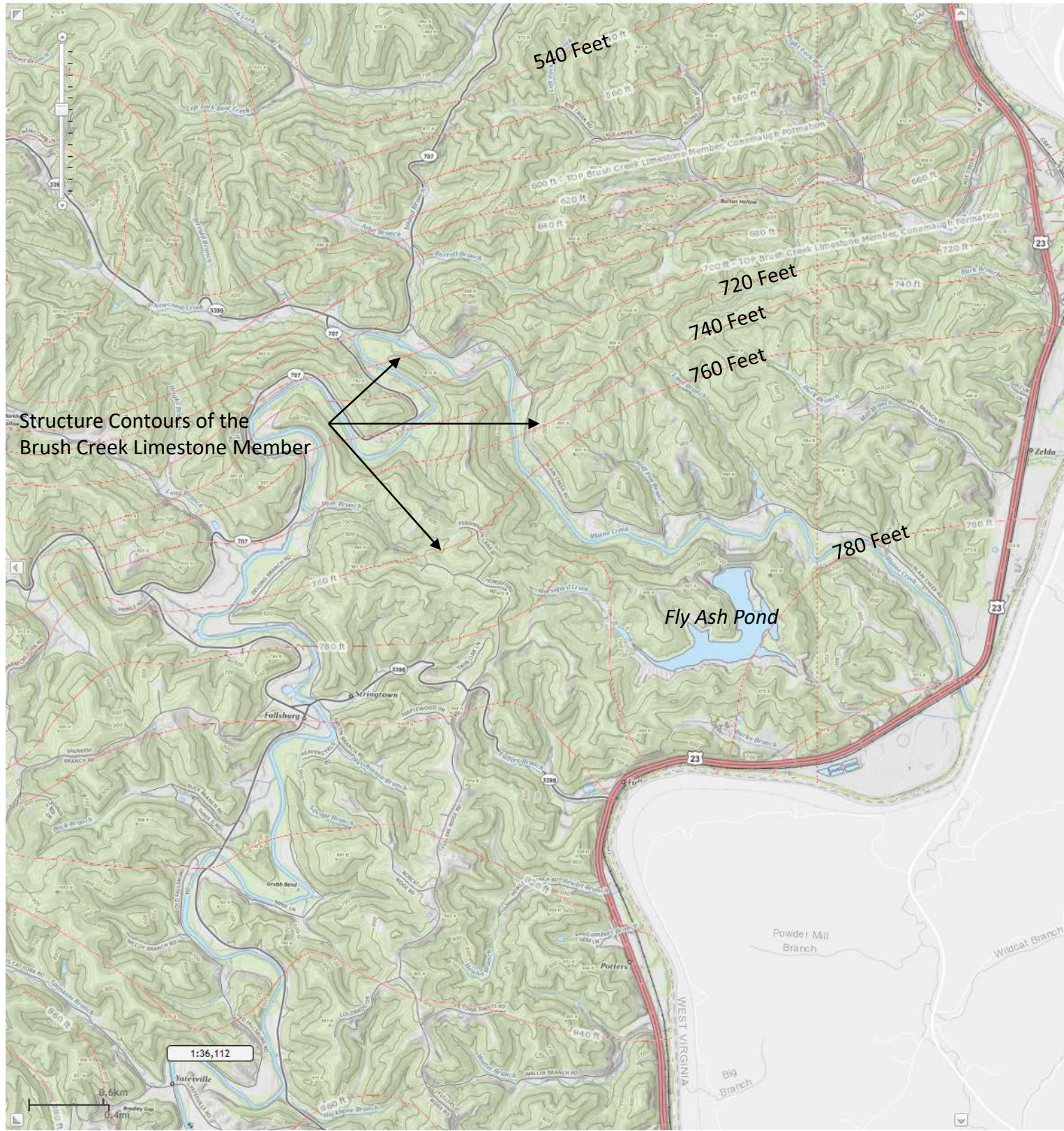


Figure 46. Maps showing selenium content (parts per million (ppm), as-received whole-coal basis) of the Upper Freeport coal bed in Pennsylvania, West Virginia, Ohio, and Maryland. Map A shows selenium contents of 224 samples for which geochemical records are publicly available and located by latitude and longitude (Appendix 8). Map B shows county averages for selenium con-

tents using all 250 records in the geochemical database, including those located only to a county level; selenium contents range from 0.098 to 6.0 ppm with a mean value of 2.0 ± 1.1 ppm (table 16). The values are classified into five categories, each representing 20 percent of the data values. See figure 3 for county names.

Taken from Ruppert et al. 2000

Structural Contour Map



Taken from Kentucky Geologic Map Information Service
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Regional Geological Structural Map

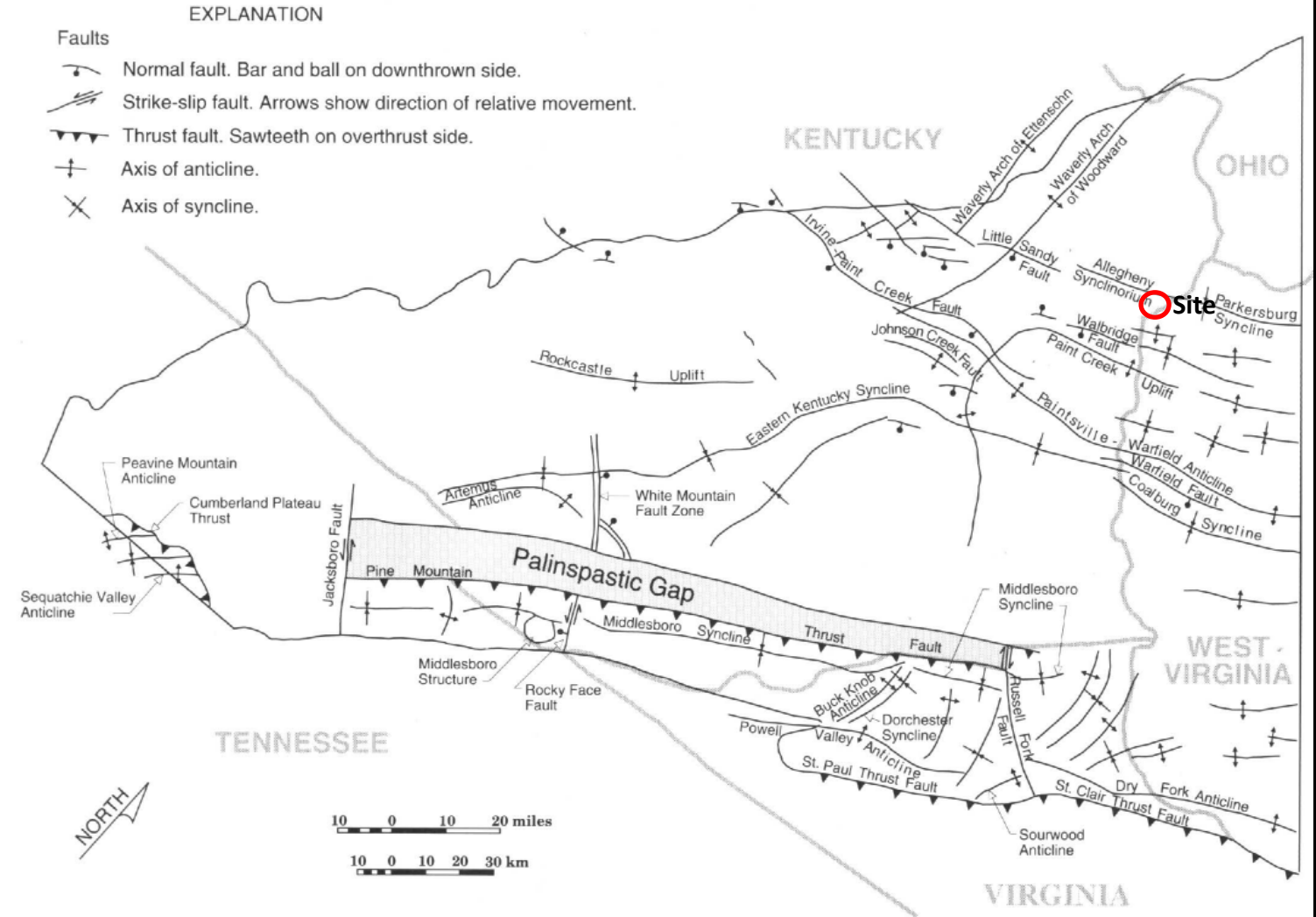


Figure 14. Near-surface structural features of part of the Central Appalachian Basin, compiled from maps prepared by Stearns (1954), Woodward (1961), Huddle and others (1963), Miller (1974), Etensohn (1975), and Arkle and others (1979). Base map has been reconstructed to show original position of Pine Mountain Thrust Fault.

Taken from Chesnut (1992)

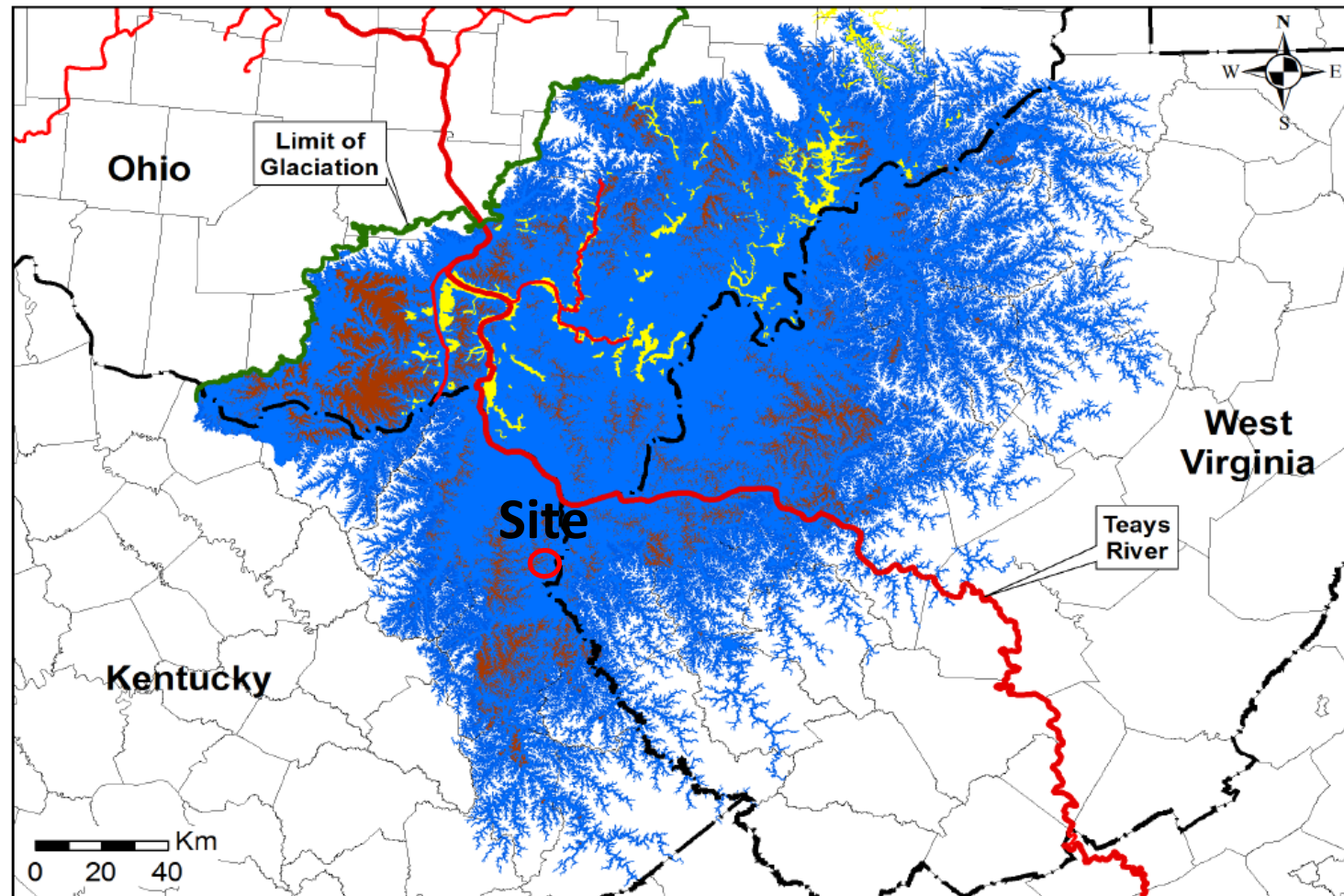
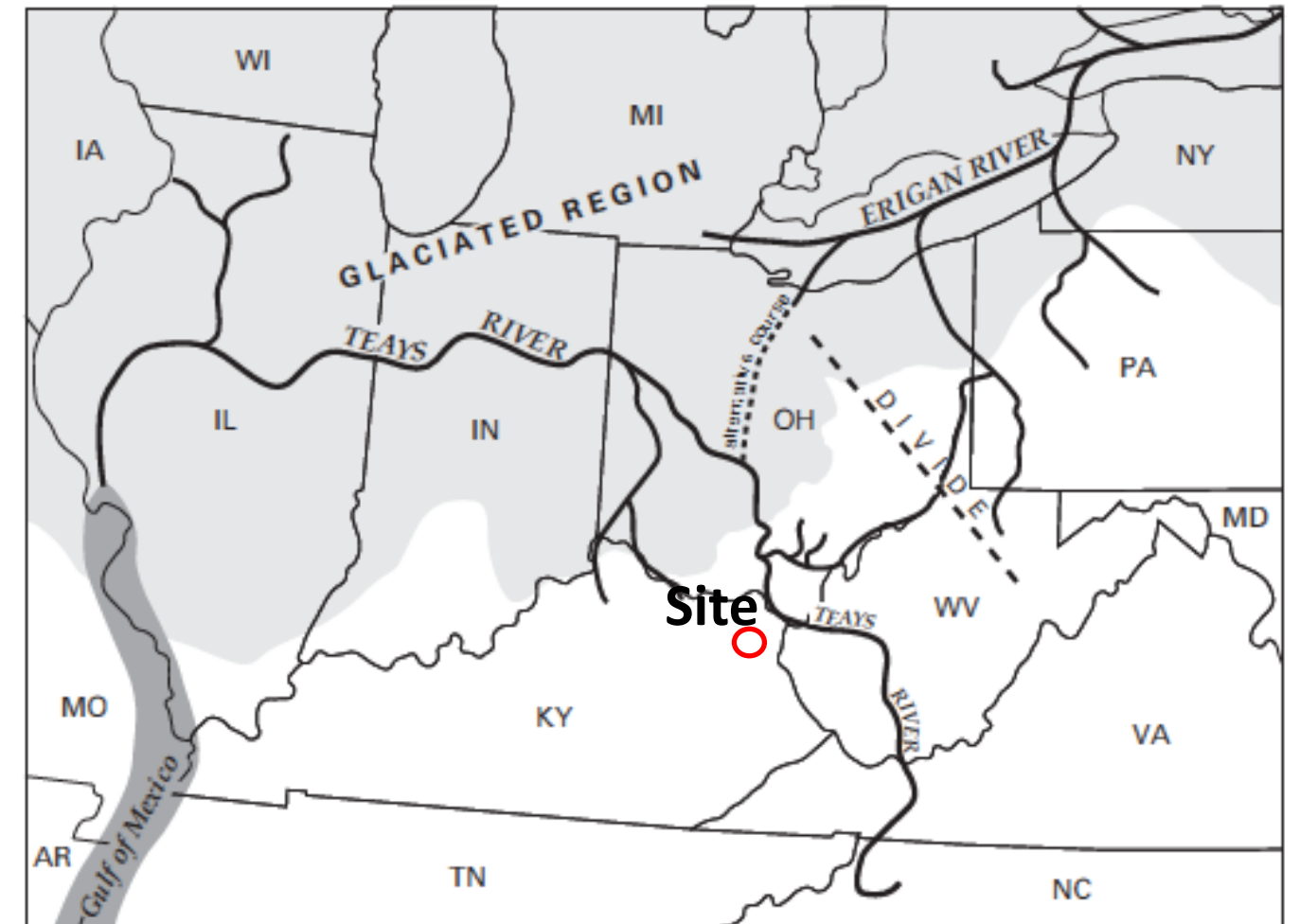


FIGURE 3. GIS model of Proglacial Lake Tight in blue. Islands in dark brown. Mapped exposures of lacustrine sediments (mostly Minford Clay) are in yellow (from Pavay et al. 1999). Boundaries within the states are county outlines.

Taken from Erjavec, 2018



Classic interpretation of the preglacial Teays River and an alternative course (dashed line) favored by some geologists. The entire extent of the Teays and its tributaries north of the glacial border is buried beneath thick glacial drift. Northern Ohio was drained by the Erigan River, which followed the axis of what is now Lake Erie, and flowed into the ancestral St. Lawrence River. Neither the Great Lakes nor the Ohio River existed at this time.

Taken from Hansen, 1995



Appendix B MW-1603 Boring Log

Drilling Start Date: 04/25/2016	Boring Depth (ft): 40	Well Depth (ft): 32
Drilling End Date: 06/01/2016	Boring Diameter (in): 8	Well Diameter (in): 4
Drilling Company: Layne	Sampling Method(s): SS & Core Barrel	Screen Slot (in): 0.010
Drilling Method: HSA/Rock Coring	DTW During Drilling (ft): 3.8	Riser Material: Sch 40 PVC
Drilling Equipment: SCR-13	DTW After Drilling (ft): 21.8	Screen Material: Sch 40 PVC Slotted
Driller: Keith Fehrman	Top of Casing Elev. (ft msl): 675.75	Seal Material(s): Bentonite Pellets
Logged By: N. Tilahun/J. Ivanowski	Location (X,Y): 2107344.43, 251596.53*	Filter Pack: Global Filter Pack #5

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	ELEV. (ft msl)
				Sample Type	Date & Time	Blow Counts	Recovery (ft)	N Value RQD (%)			
0										673.24	
0.0				SS	04/25 13:54	10	2.0	26	(0.0') Well-graded SAND with silt (SW-SM); mostly fine-coarse grained sand, few fine-coarse gravel, little silt, little clay, loose, dry, light brown, 7.5YR/7/4, FILL.		
4				SS	04/25 14:13	6	1.5	16	(4') Well-graded SAND (SW); mostly medium grained sand, few coarse gravel, few silt, dense, moist, light brown, 7.5YR/5/8.		
8				SS	04/25 15:50	4	2.0	9			
10				SS	04/25 16:00	5	1.5	10	(7') Fat CLAY with sand (CH); trace coarse gravel, some medium-coarse sand, some silt, mostly clay, high plasticity, stiff, moist, dark gray, GLEY2/4/10B, abundant roots, reduced (decomposed) soil odor.		
12				SS	04/25 16:07	6	1.0	14			
14				SS	04/25 16:10	6	2.0	13	(13') SED ROCK (SANDSTONE); medium sand, massive, intensely weathered, very hard, light brown, moist, 7.5YR/7/3.		
15				CO			0.0	108	(15.5') No Recovery.		
20									06/01/2016 - removed hollow-stem auger and advanced borehole using rotasonic drilling. 06/01/2016 - advanced borehole using wireline rock coring inside of hollow stem auger (surface to 15 ft bgs).	655	

NOTES: *Northing and easting are in NAD83 Kentucky North. Elevation is in ft MSL NAVD88.
Top of casing (TOC) is 2.51 ft above ground surface. Ground surface elevation is 673.24 ft MSL.

Drilling Start Date: 04/25/2016	Boring Depth (ft): 40	Well Depth (ft): 32
Drilling End Date: 06/01/2016	Boring Diameter (in): 8	Well Diameter (in): 4
Drilling Company: Layne	Sampling Method(s): SS & Core Barrel	Screen Slot (in): 0.010
Drilling Method: HSA/Rock Coring	DTW During Drilling (ft): 3.8	Riser Material: Sch 40 PVC
Drilling Equipment: SCR-13	DTW After Drilling (ft): 21.8	Screen Material: Sch 40 PVC Slotted
Driller: Keith Fehrman	Top of Casing Elev. (ft msl): 675.75	Seal Material(s): Bentonite Pellets
Logged By: N. Tilahun/J. Ivanowski	Location (X,Y): 2107344.43, 251596.53*	Filter Pack: Global Filter Pack #5

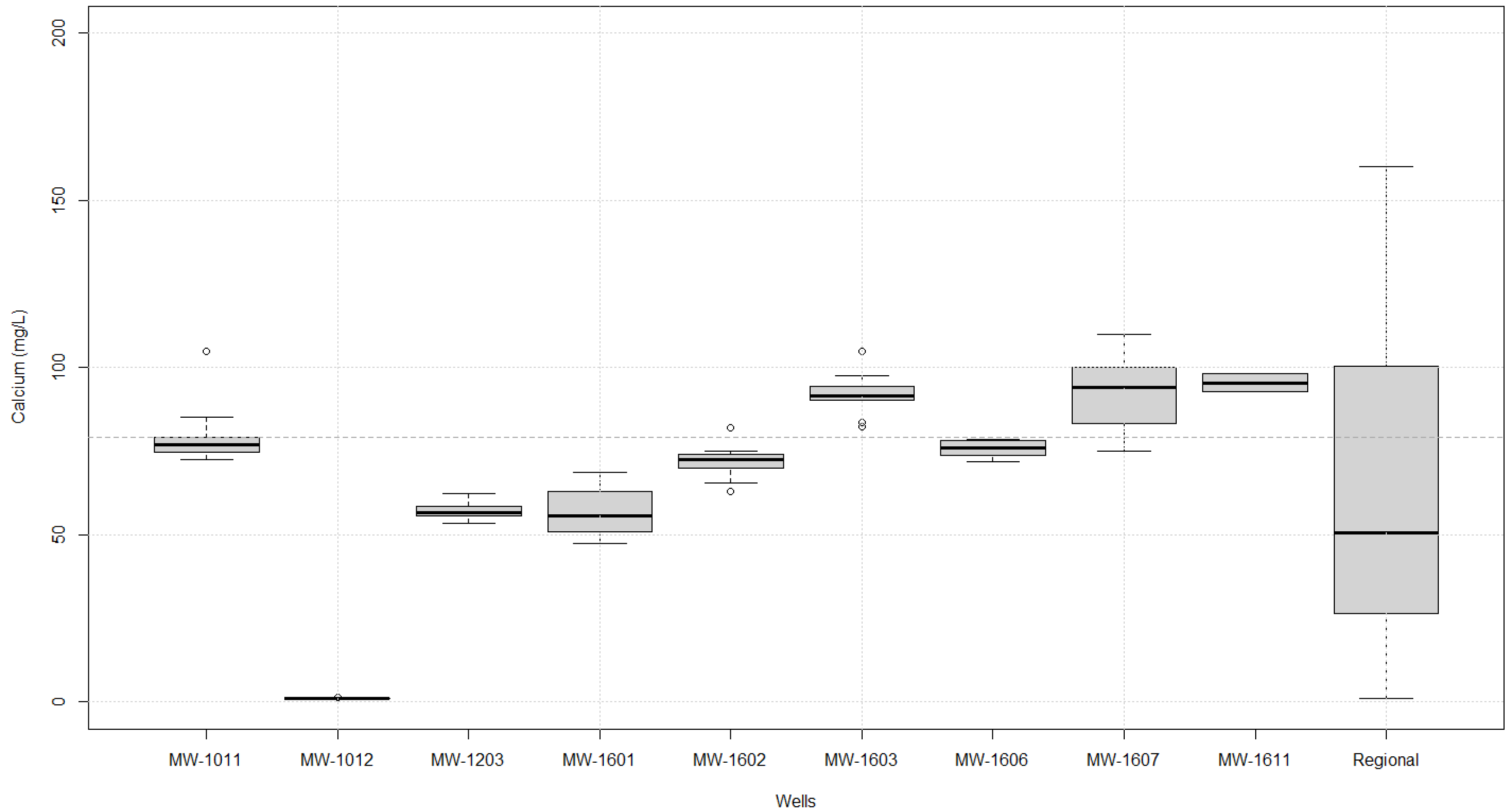
DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT					SOIL/ROCK VISUAL DESCRIPTION	REMARKS	ELEV. (ft msl)
				Sample Type	Date & Time	Blow Counts	Recovery (ft)	N Value RQD (%)			
20				CO	06/01 18:16		5.0	20	(20') Well-graded SAND (SW); mostly fine grained sand, loose, saturated, light yellowish-brown.		
									(22') SED ROCK (SANDSTONE); fine sand, massive, slightly weathered, hard, unfractured, light yellowish-brown, wet.		650
25				CO			4.5	24	(23') SED ROCK (SHALE); silt, laminated, decomposed, soft, intensely fractured, dark gray, wet, iron oxide staining; organic matter.		
									(24') SED ROCK (SHALE); silt, laminated, decomposed, very soft, intensely fractured, black, wet, nearly all organic matter; slight coaly texture.		645
30				CO			4.6	70	(25') SED ROCK (CLAYSTONE); clay, moderately bedded, intensely weathered, moderately soft, slightly fractured, pale bluish-gray, wet.		
									(29') SED ROCK (SANDSTONE); very fine sand, very thinly bedded, intensely weathered, moderately hard, very intensely fractured, light reddish-brown, wet.	(31') Bedding Joint: 5°-10° Dip. Open; Surface (Slightly Rough, Planar); Filling (Clay).	
35				CO			5.0	90	(30') SED ROCK (SANDSTONE); very fine sand, laminated, slightly weathered, very hard, moderately fractured, dark bluish-gray, wet, some micaceous minerals.		640
									(32') SED ROCK (SANDSTONE); very fine sand, laminated, fresh, very hard, unfractured, dark bluish-gray, moist.		
									(35.5') Fractured zone; slight iron-oxide staining on surface.		635
40									(39.5') As Above. End of Boring.		

NOTES: *Northing and easting are in NAD83 Kentucky North. Elevation is in ft MSL NAVD88.
Top of casing (TOC) is 2.51 ft above ground surface. Ground surface elevation is 673.24 ft MSL.



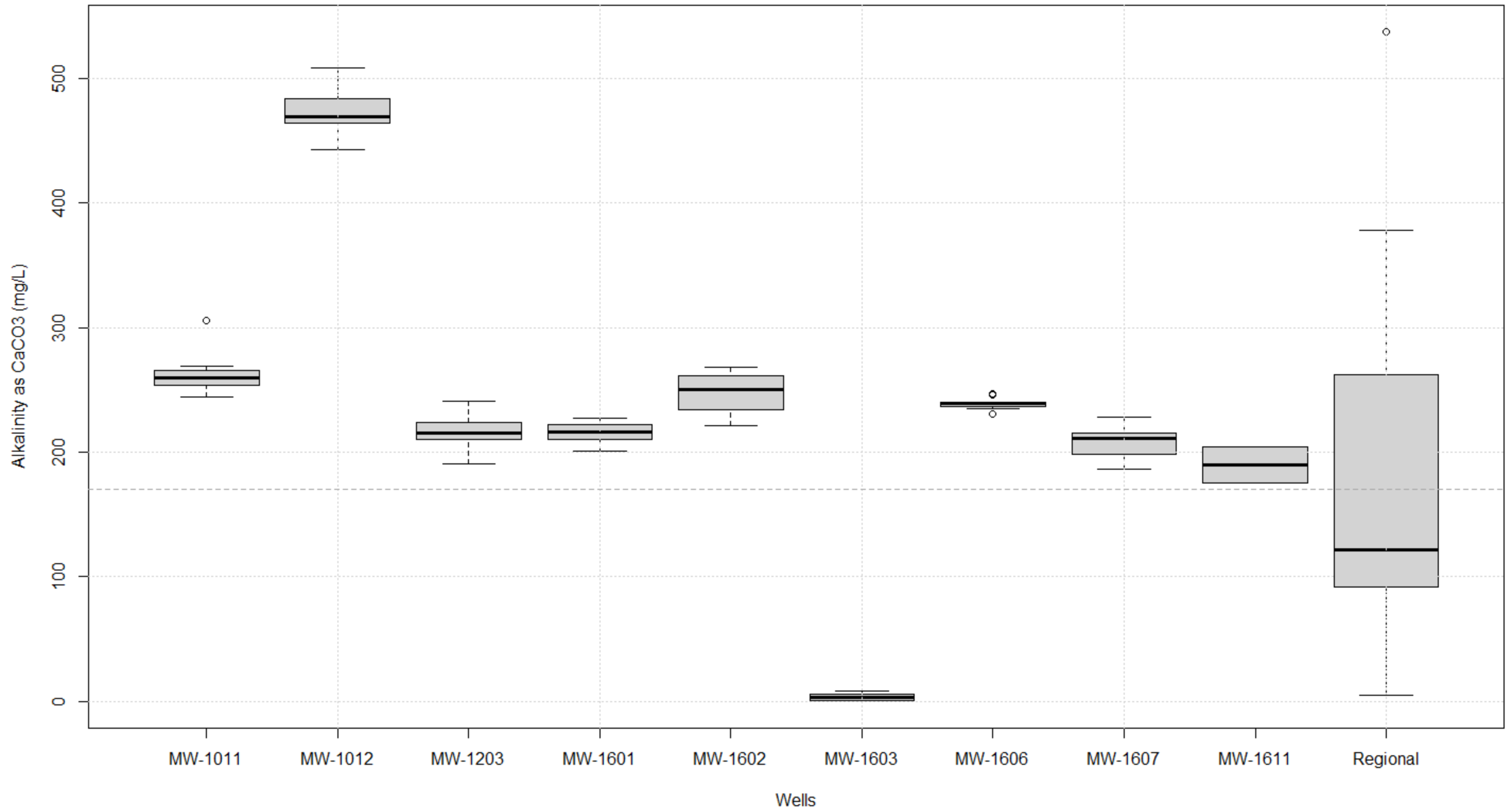
Appendix C Box Plots

Boxplot for Calcium



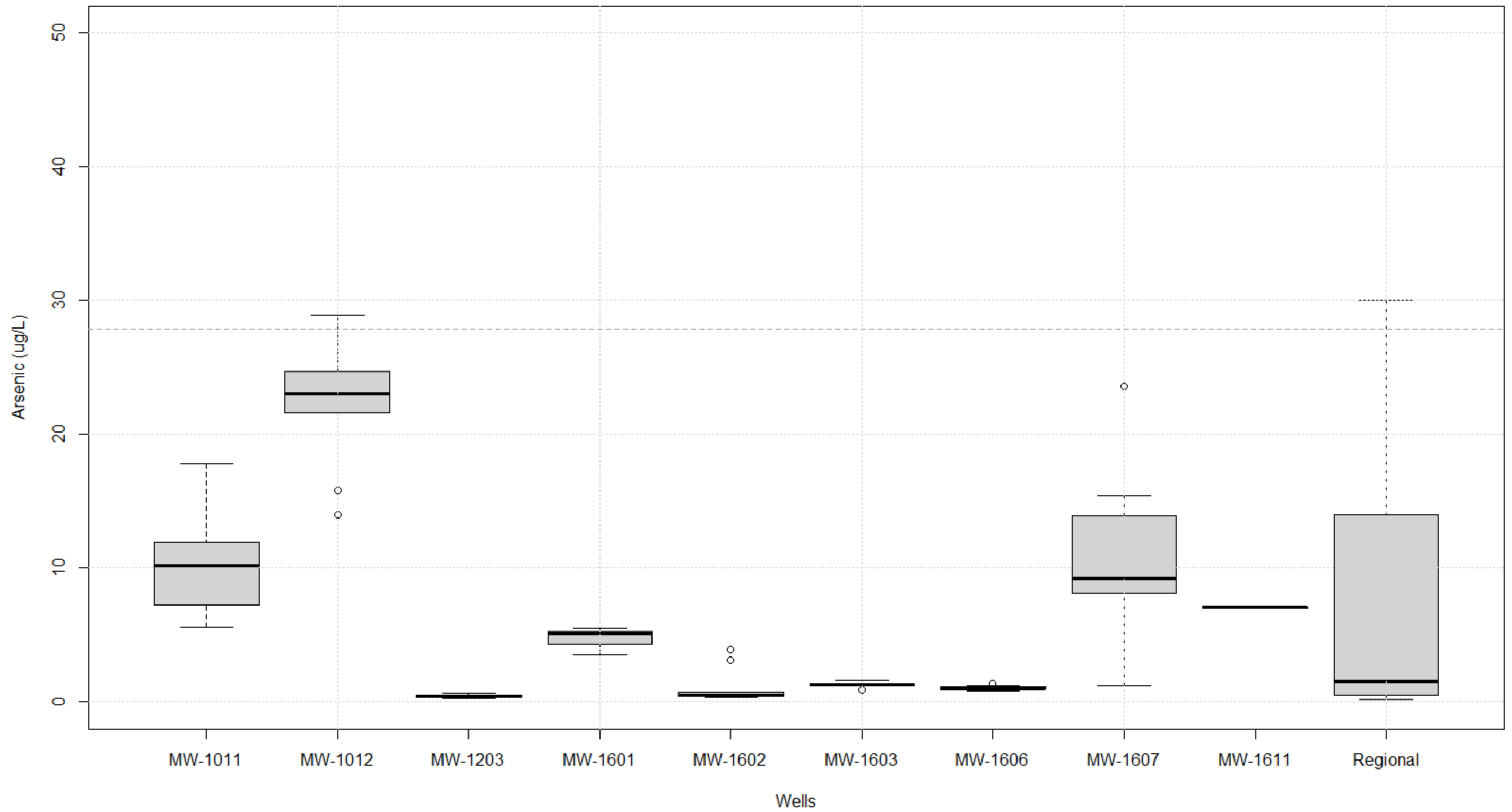
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Alkalinity



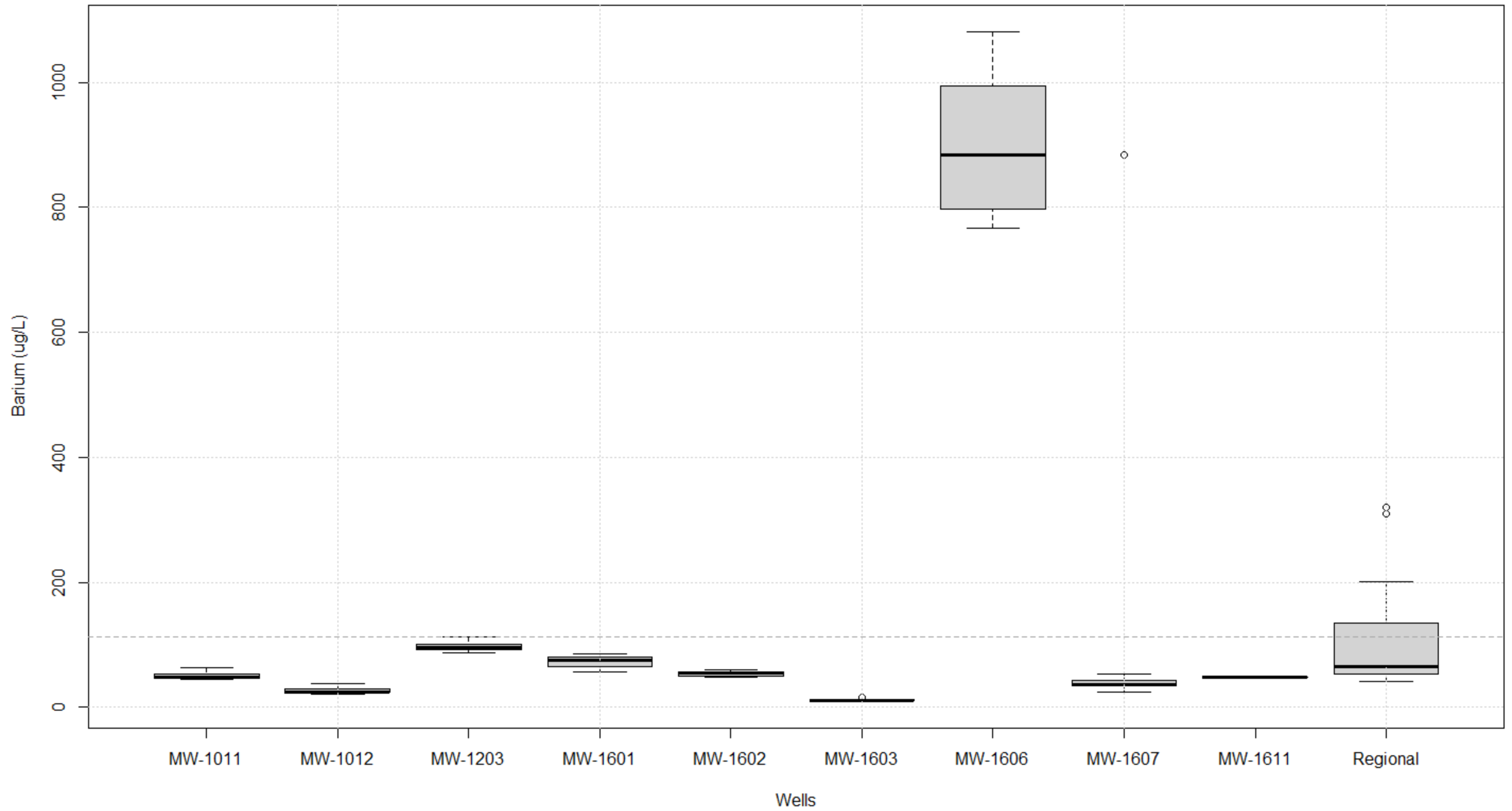
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Arsenic



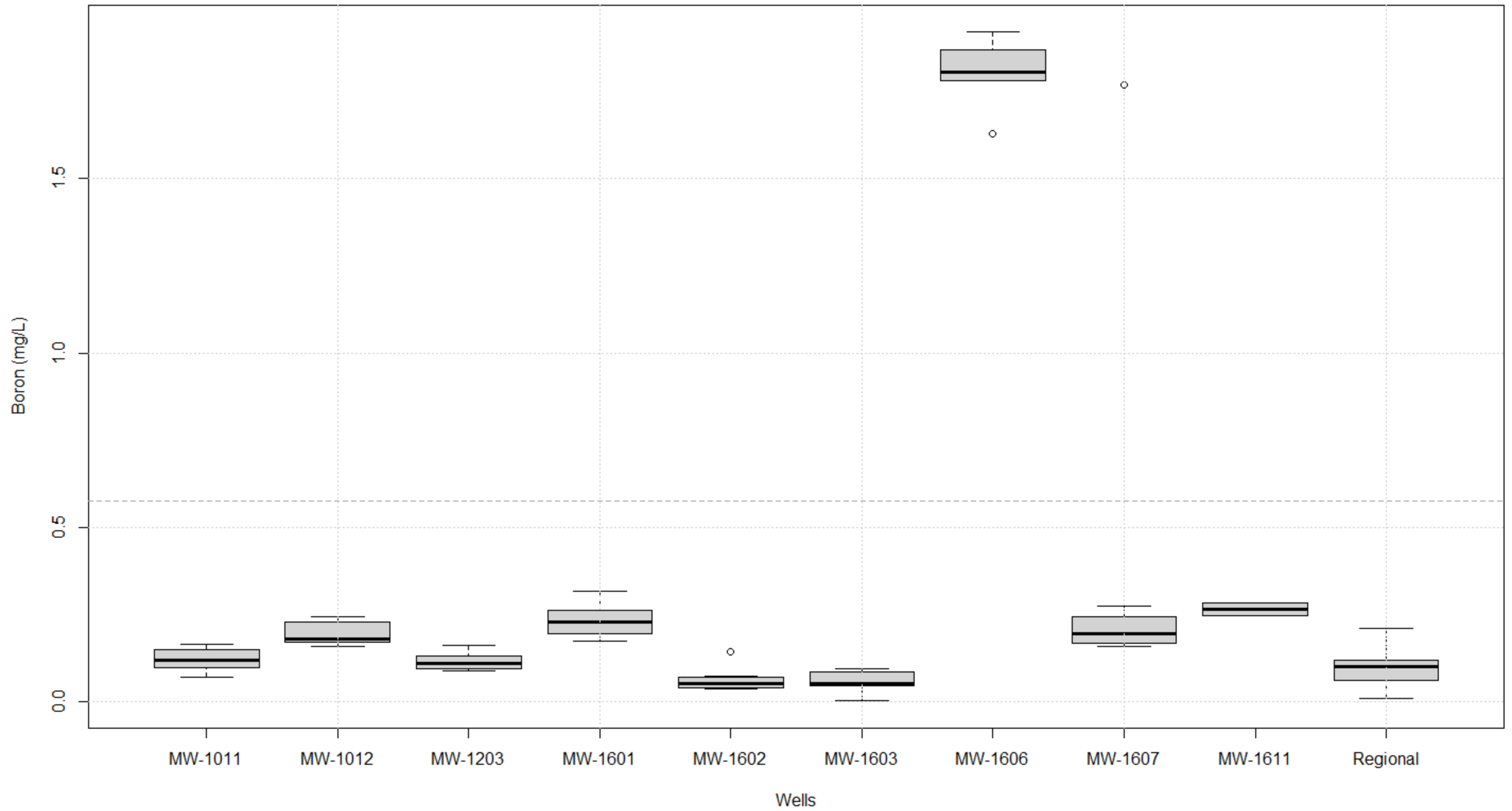
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Barium



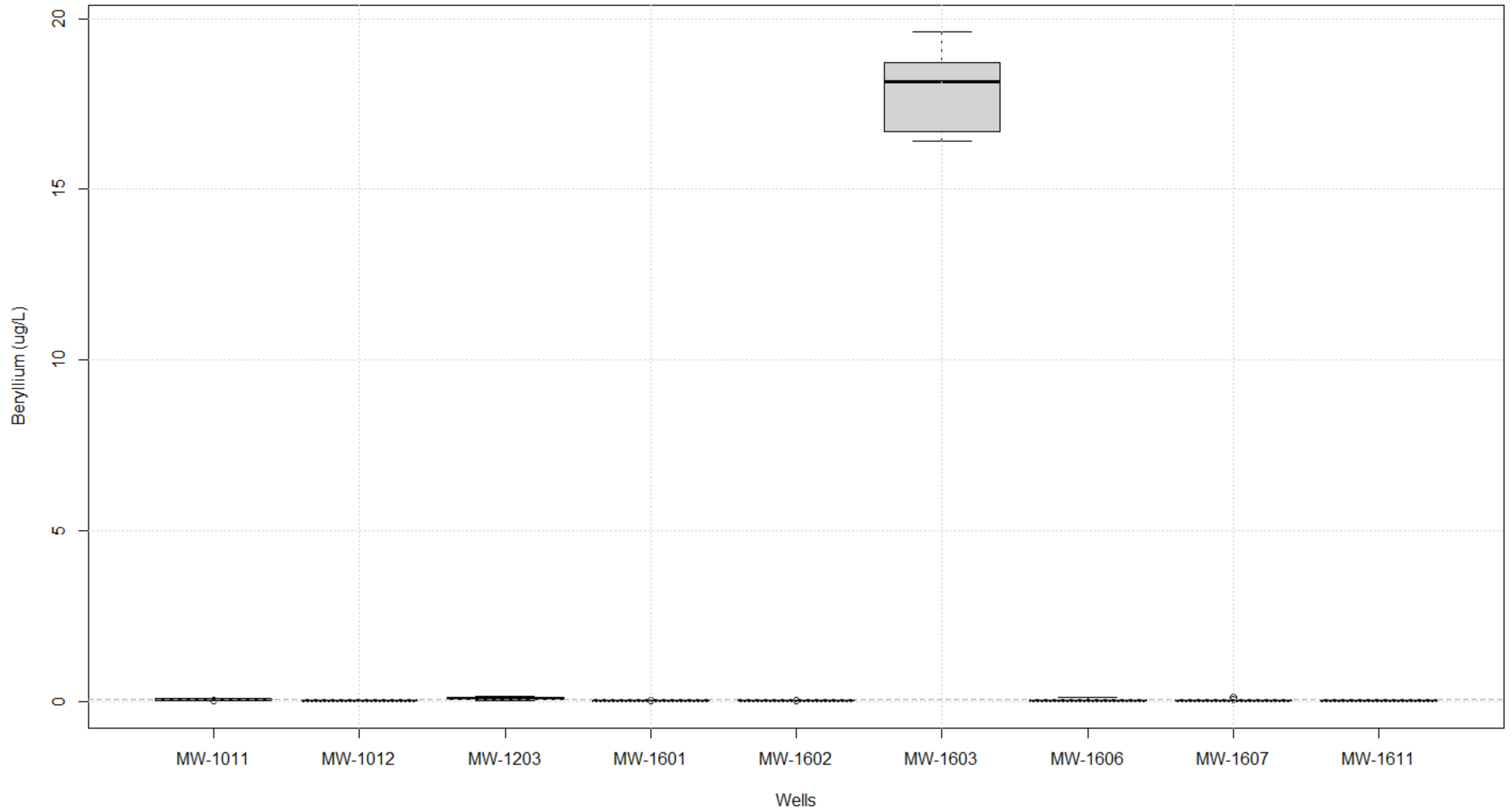
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Boron



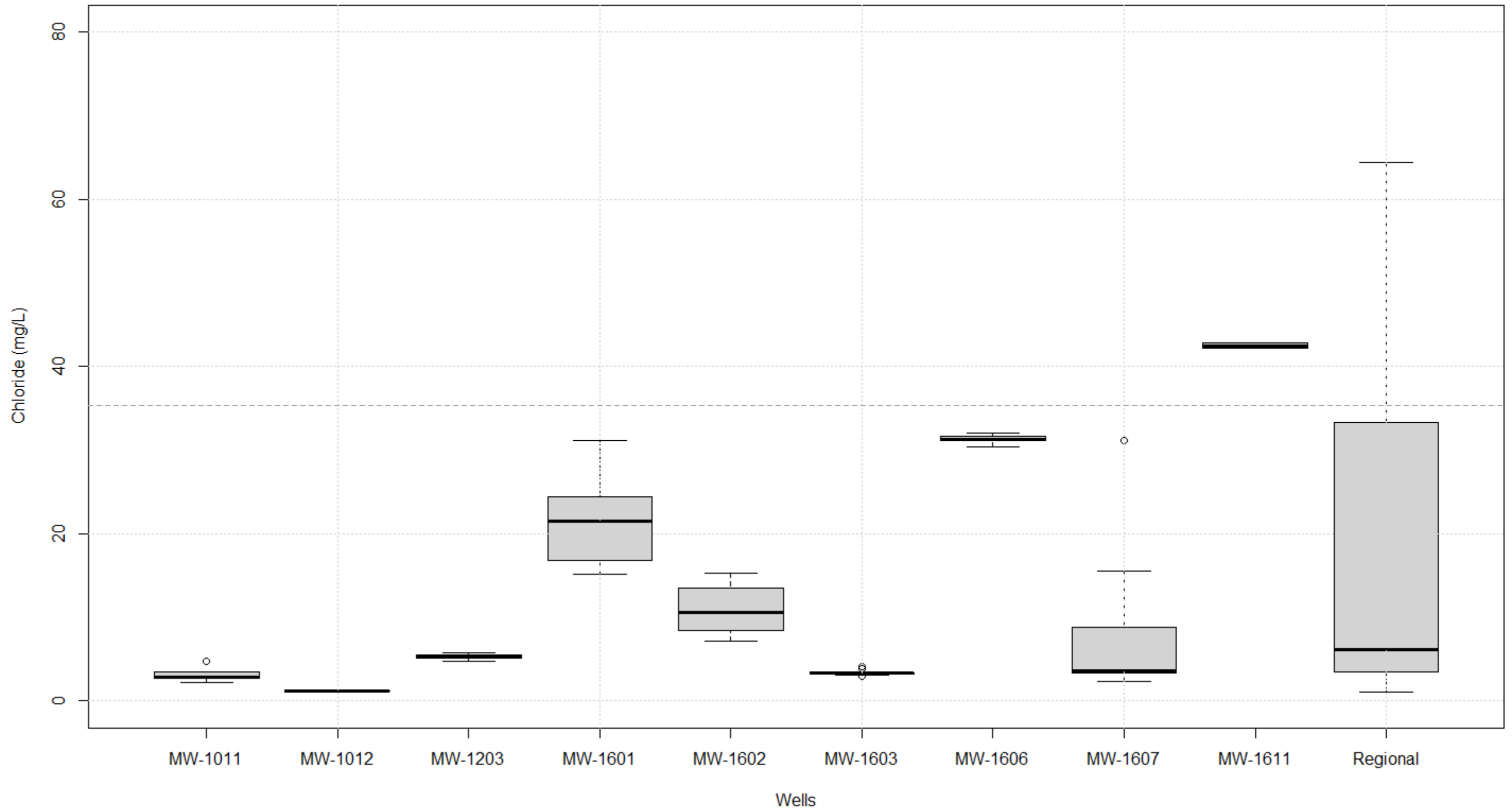
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Beryllium



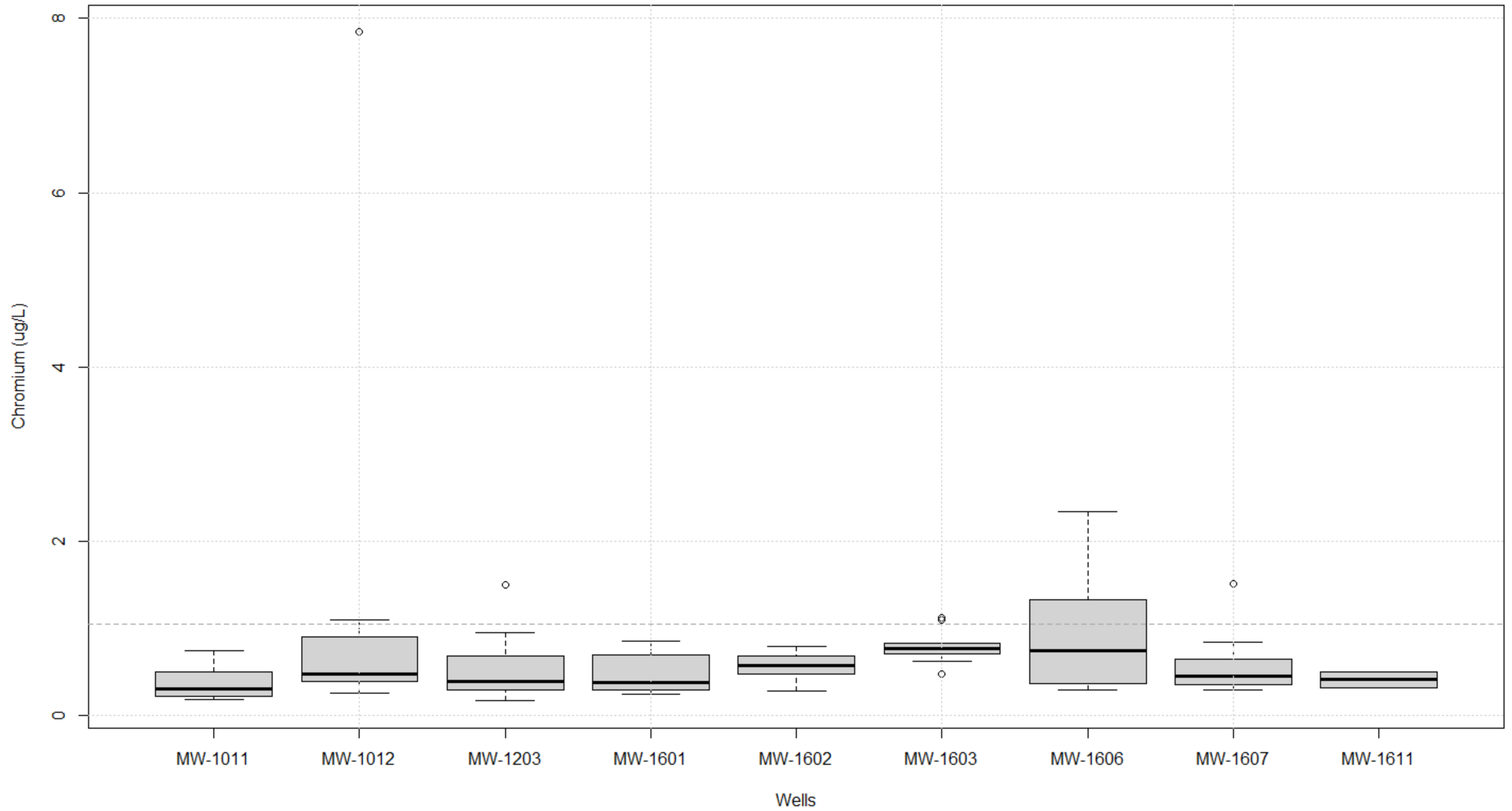
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Chloride



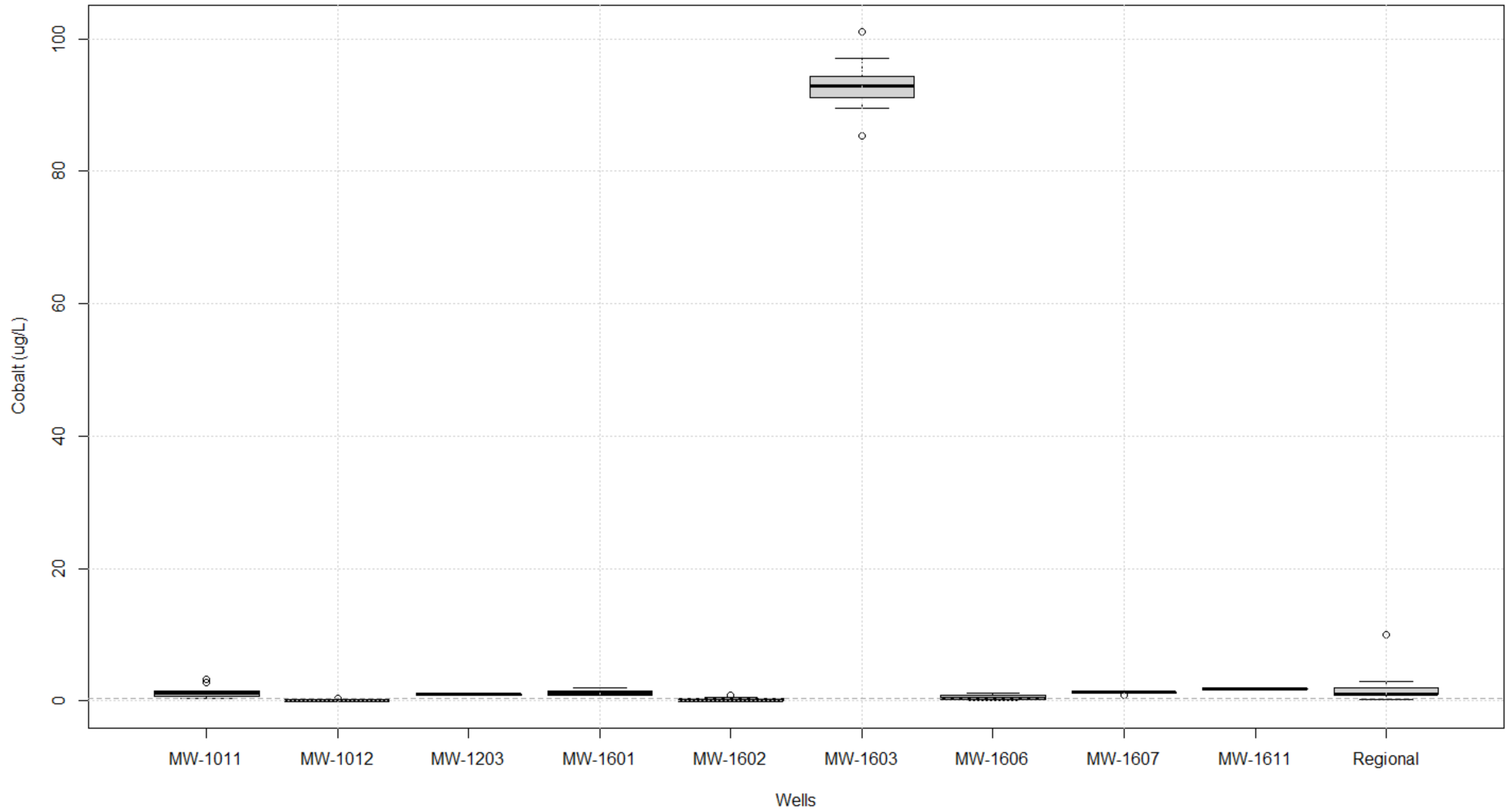
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Chromium



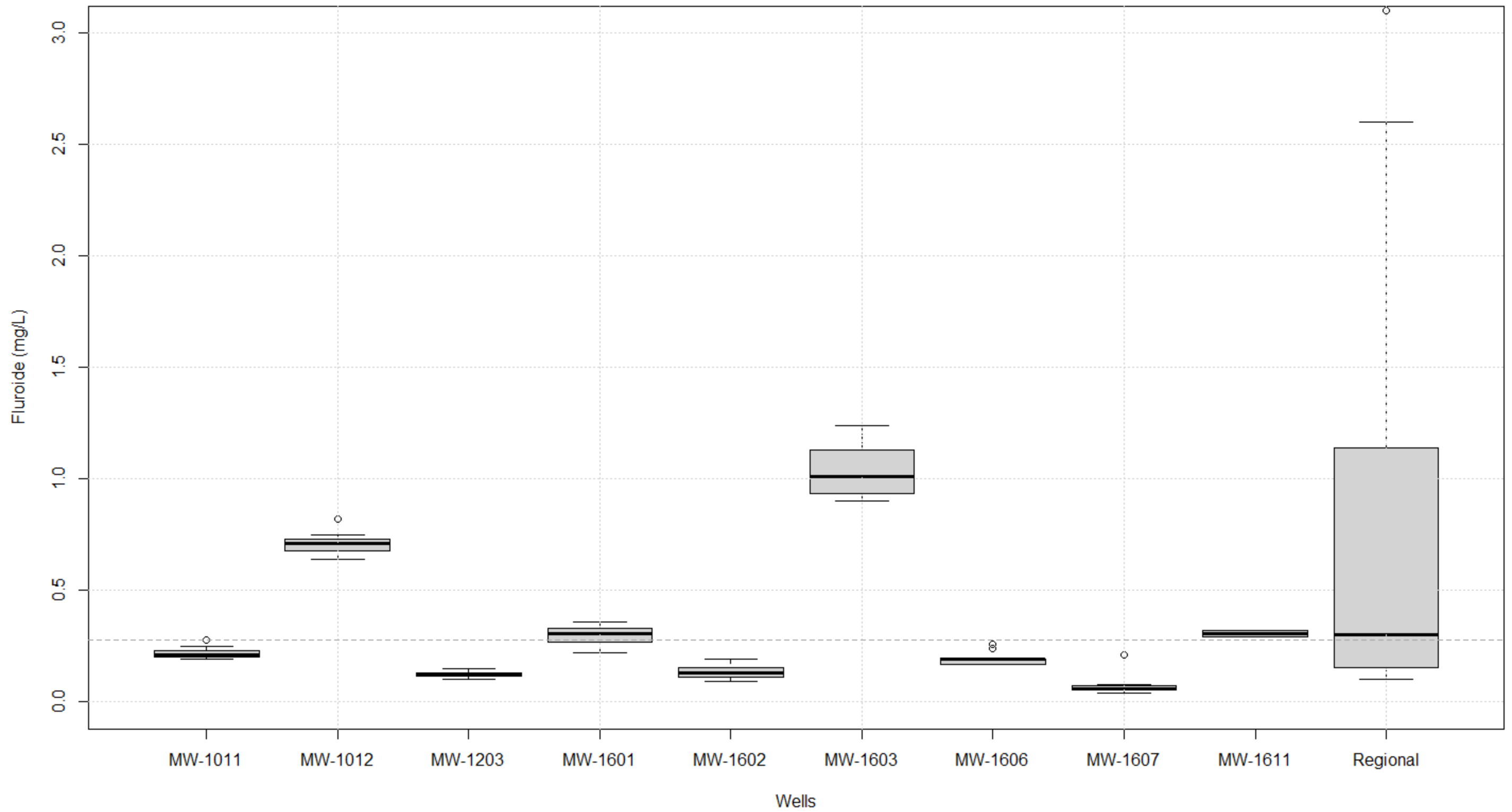
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Cobalt



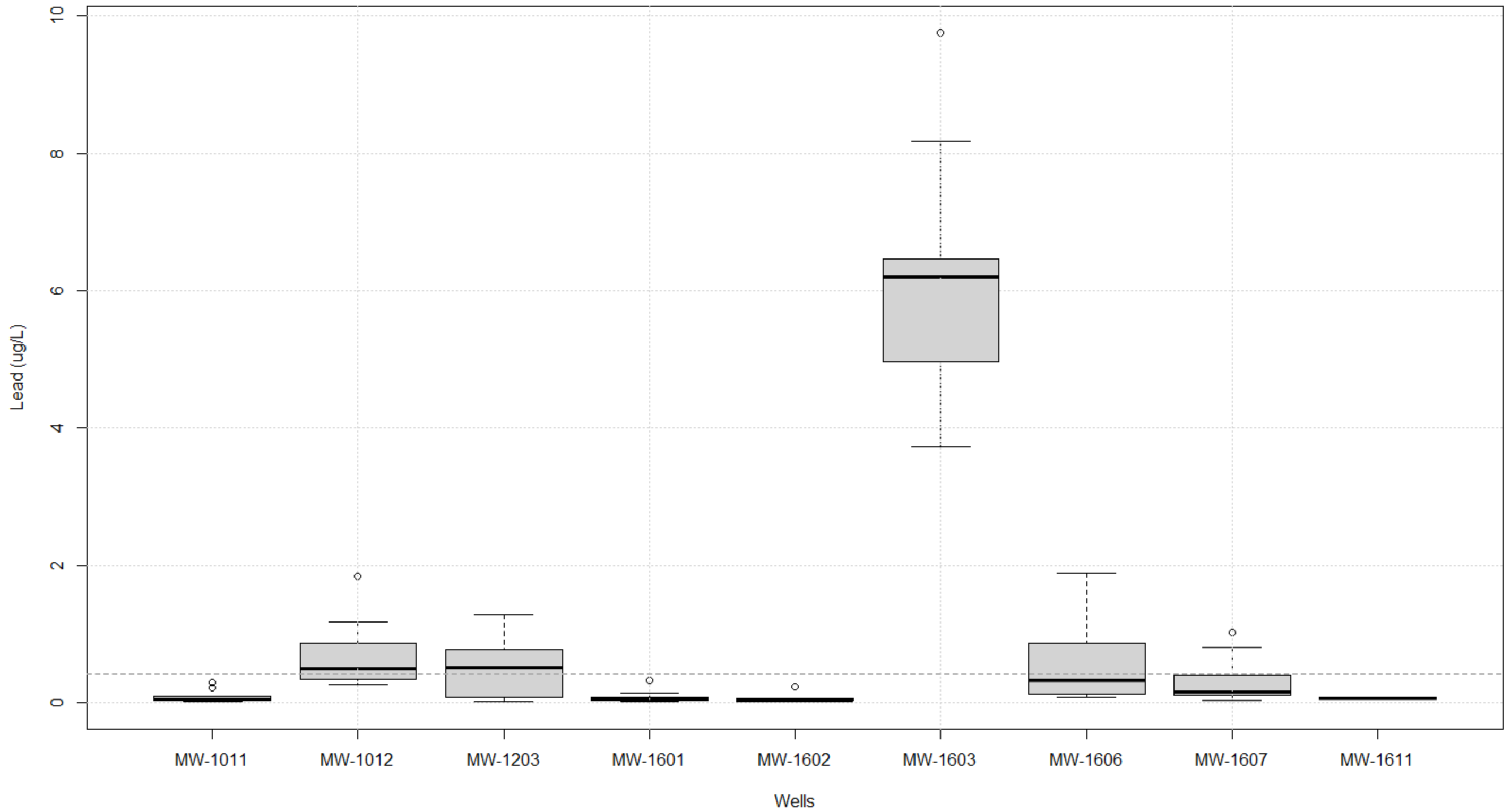
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Fluoroide



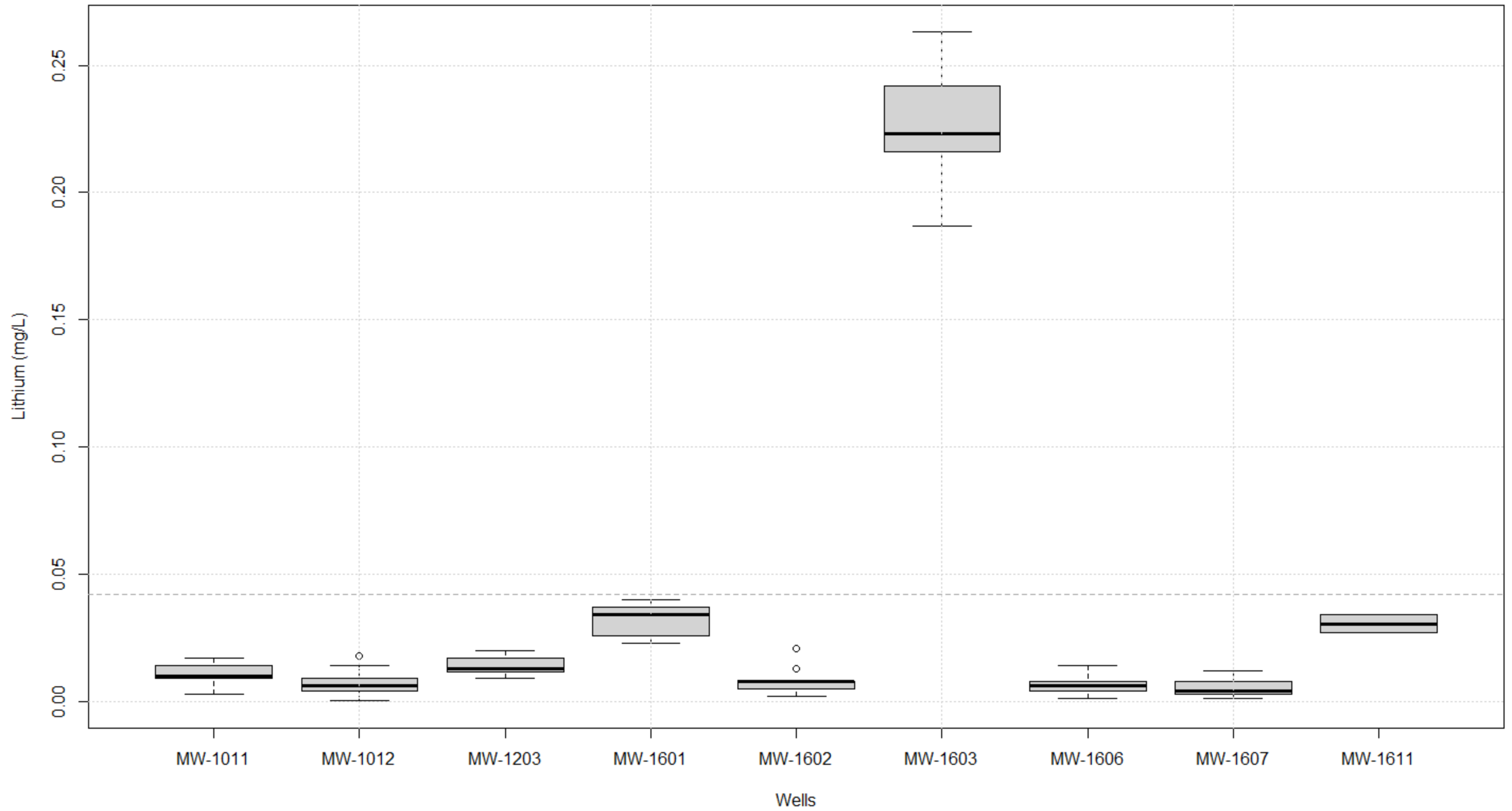
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Lead



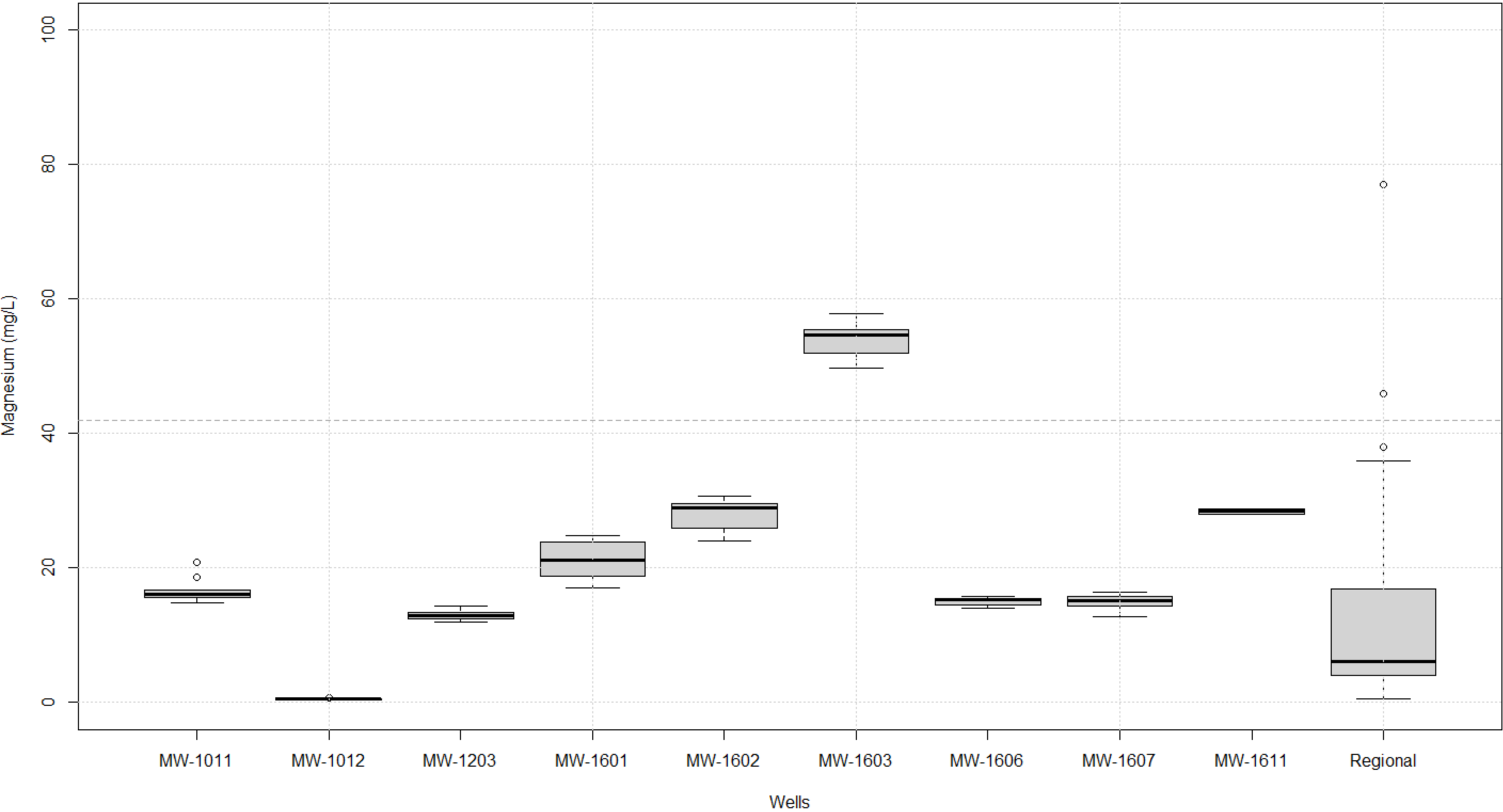
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Lithium



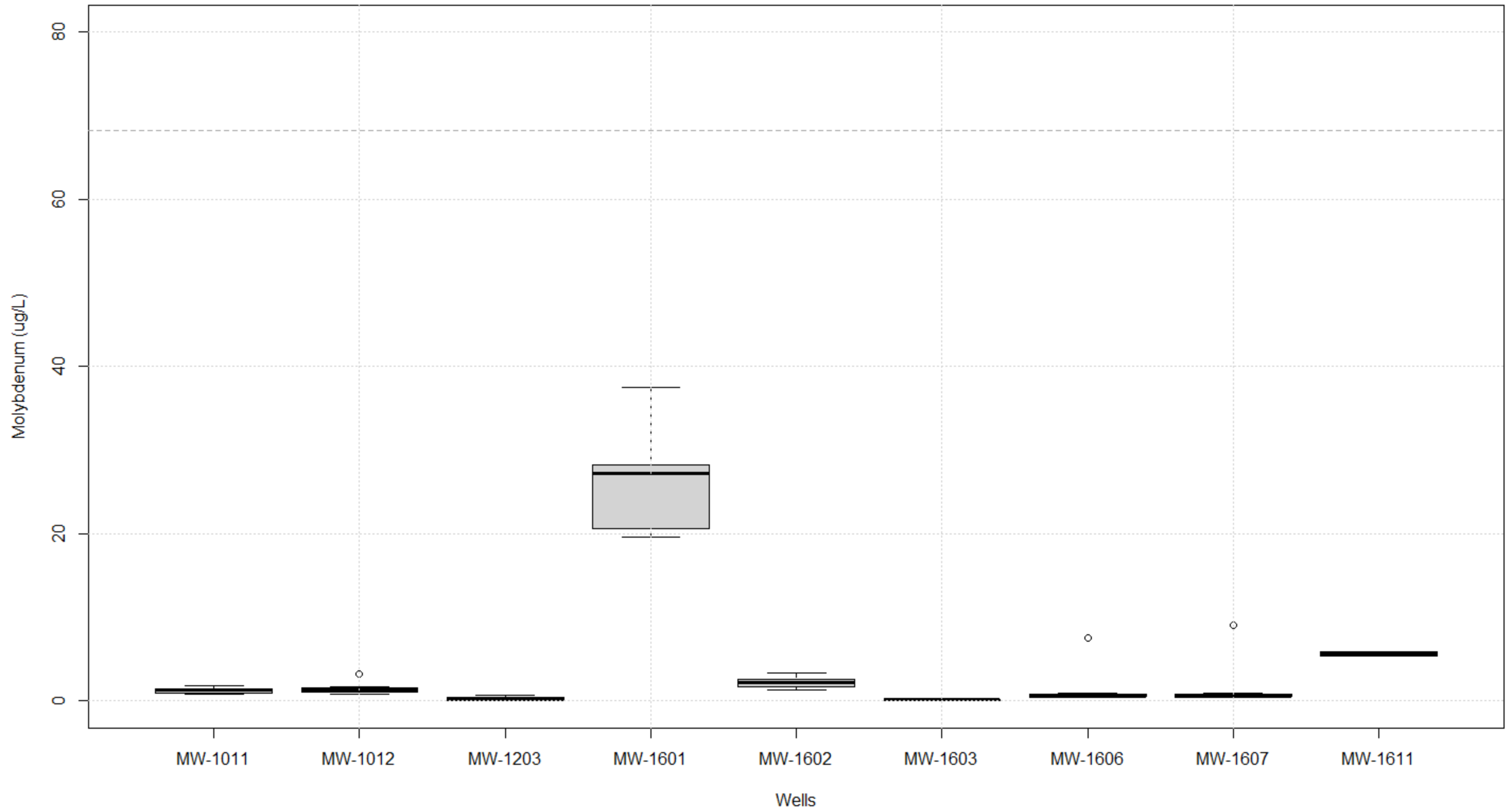
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Magnesium



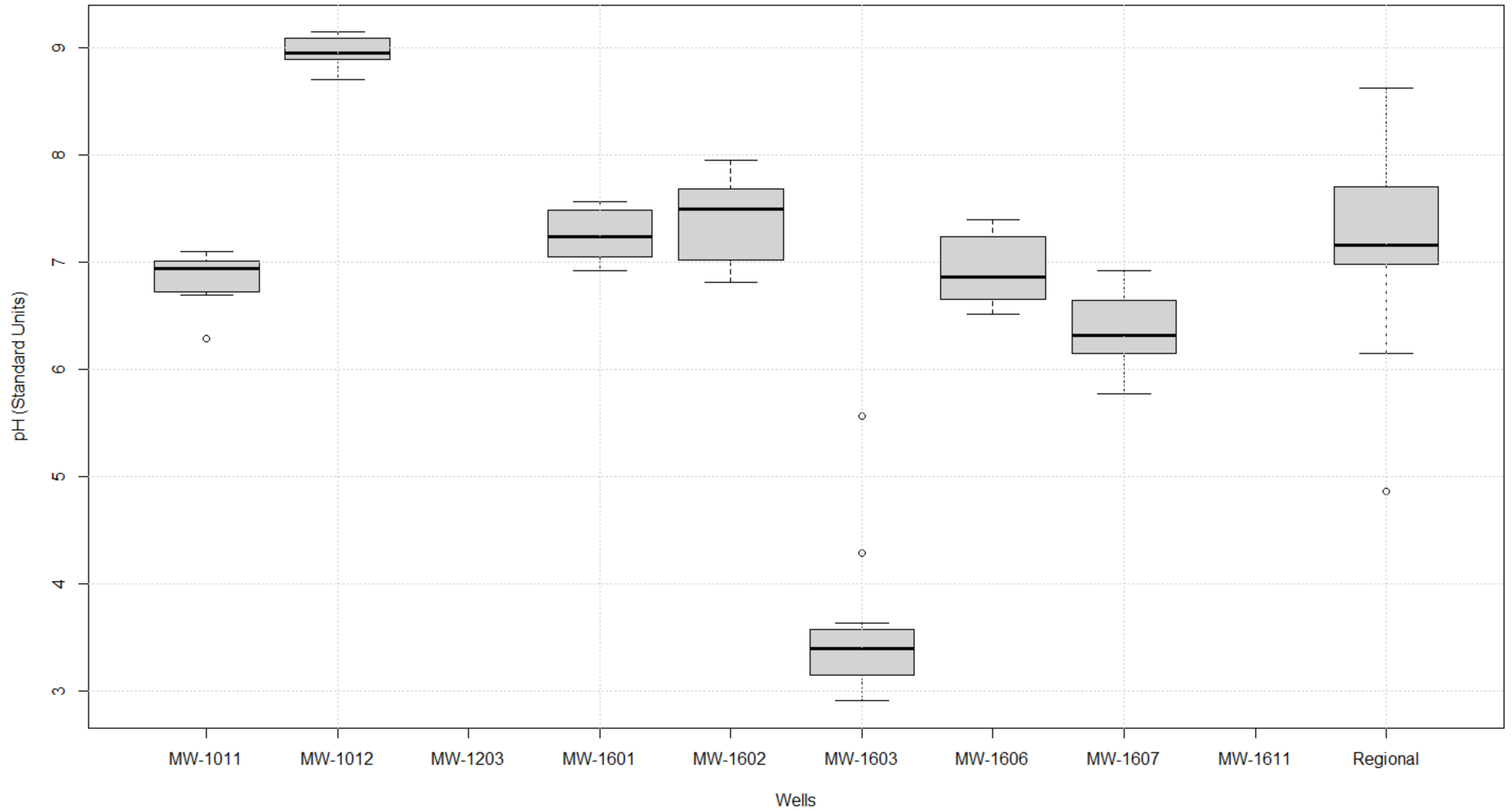
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Molybdenum



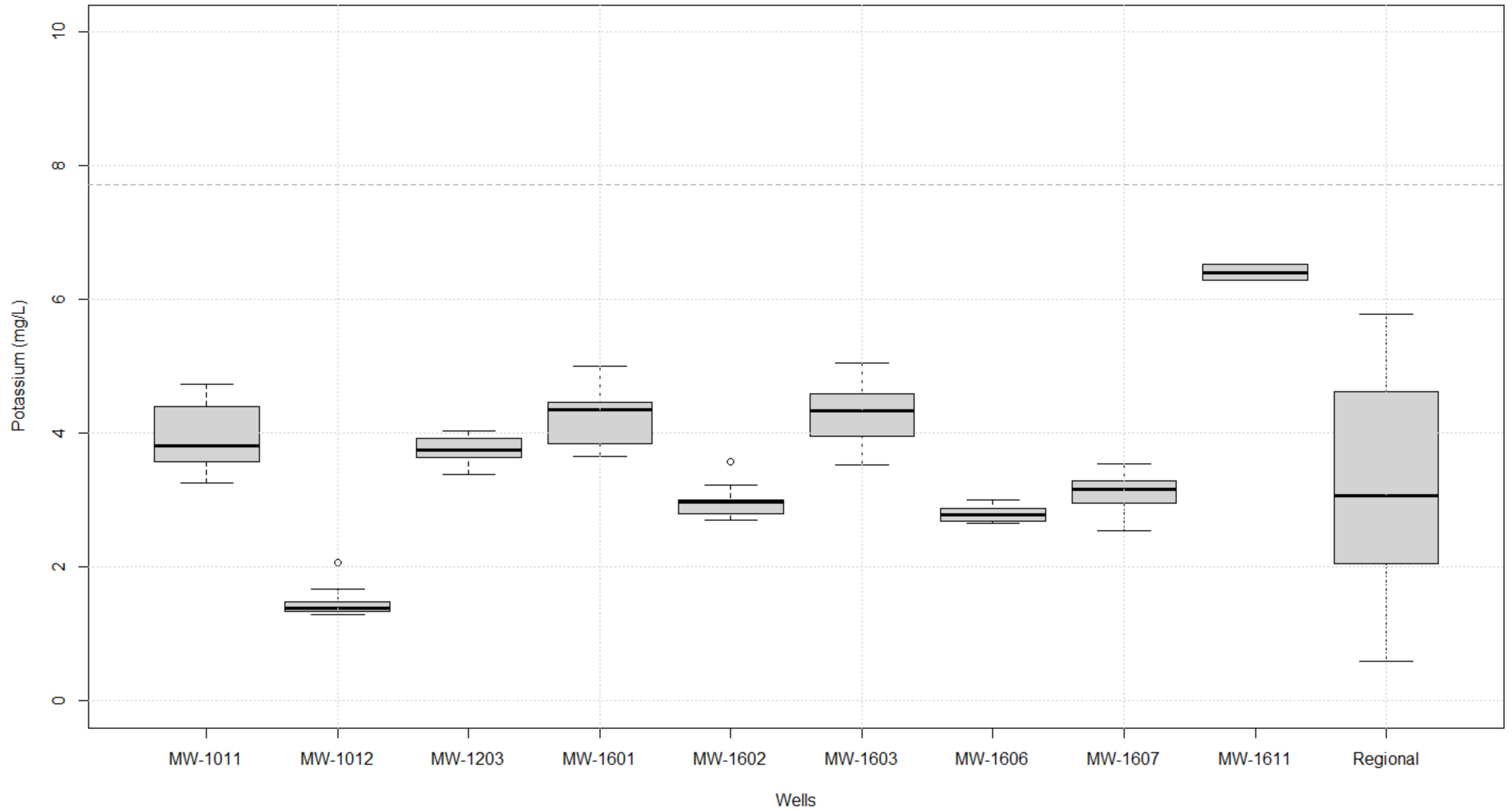
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for pH



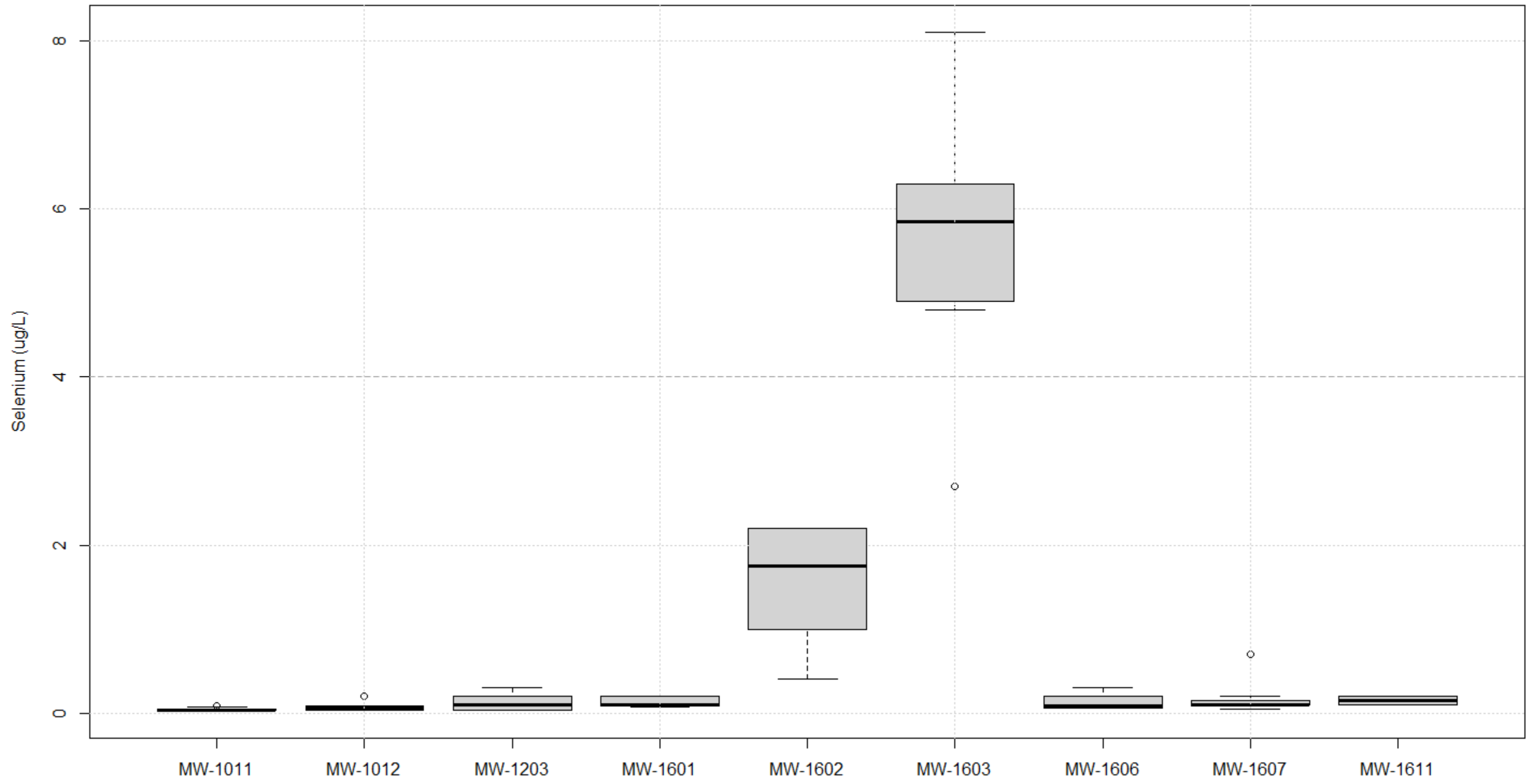
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Potassium



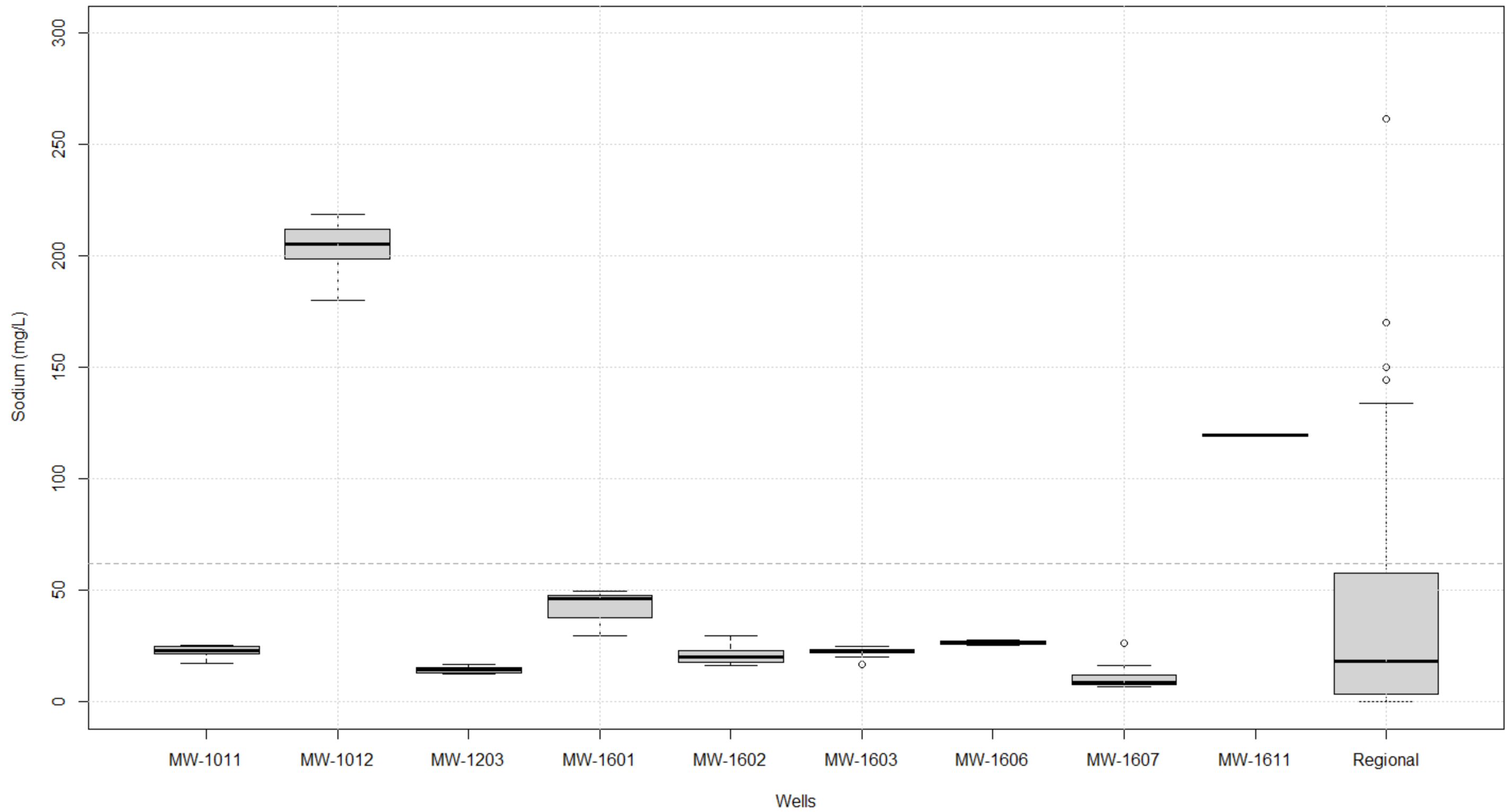
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Selenium



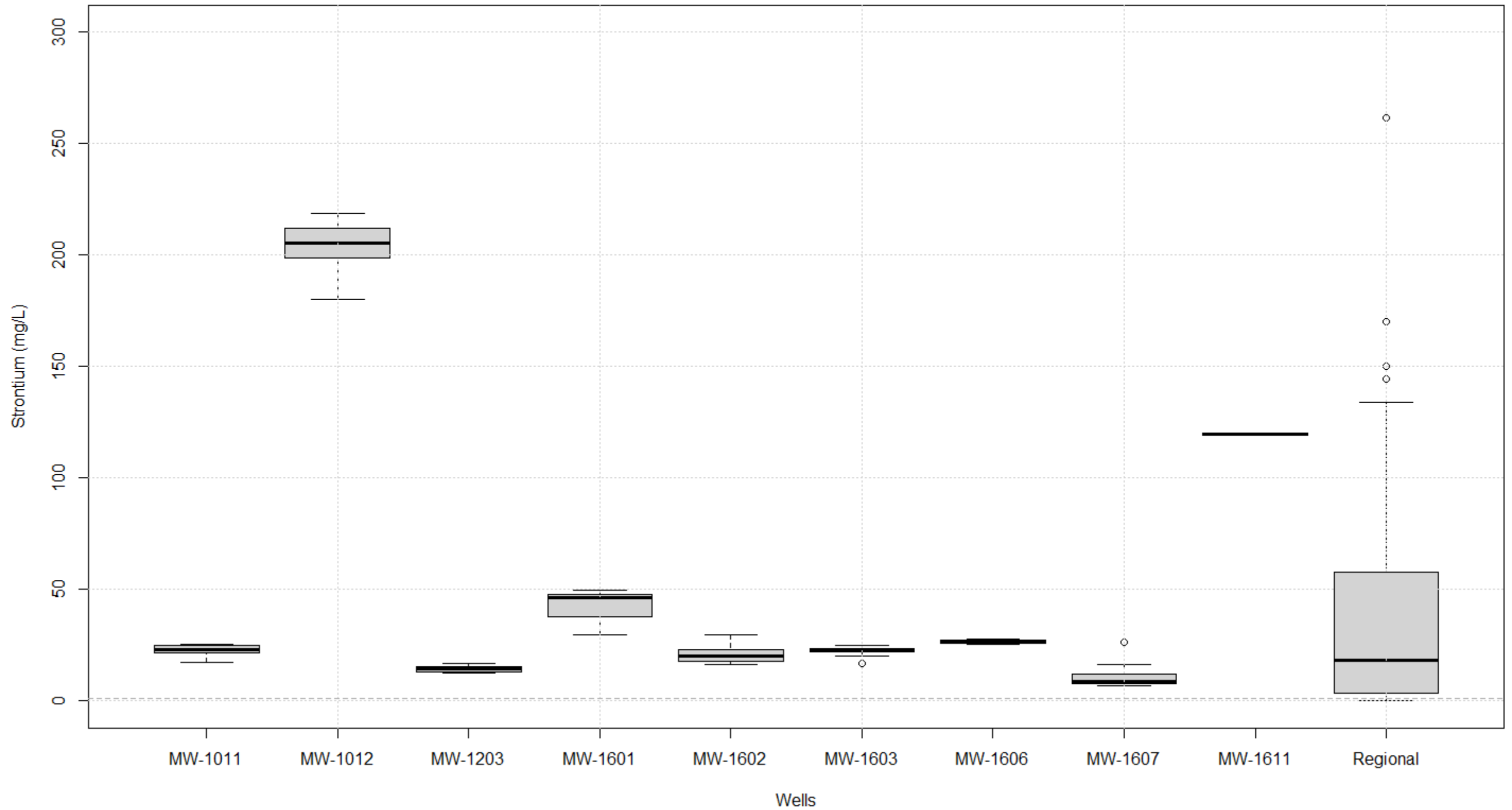
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Sodium



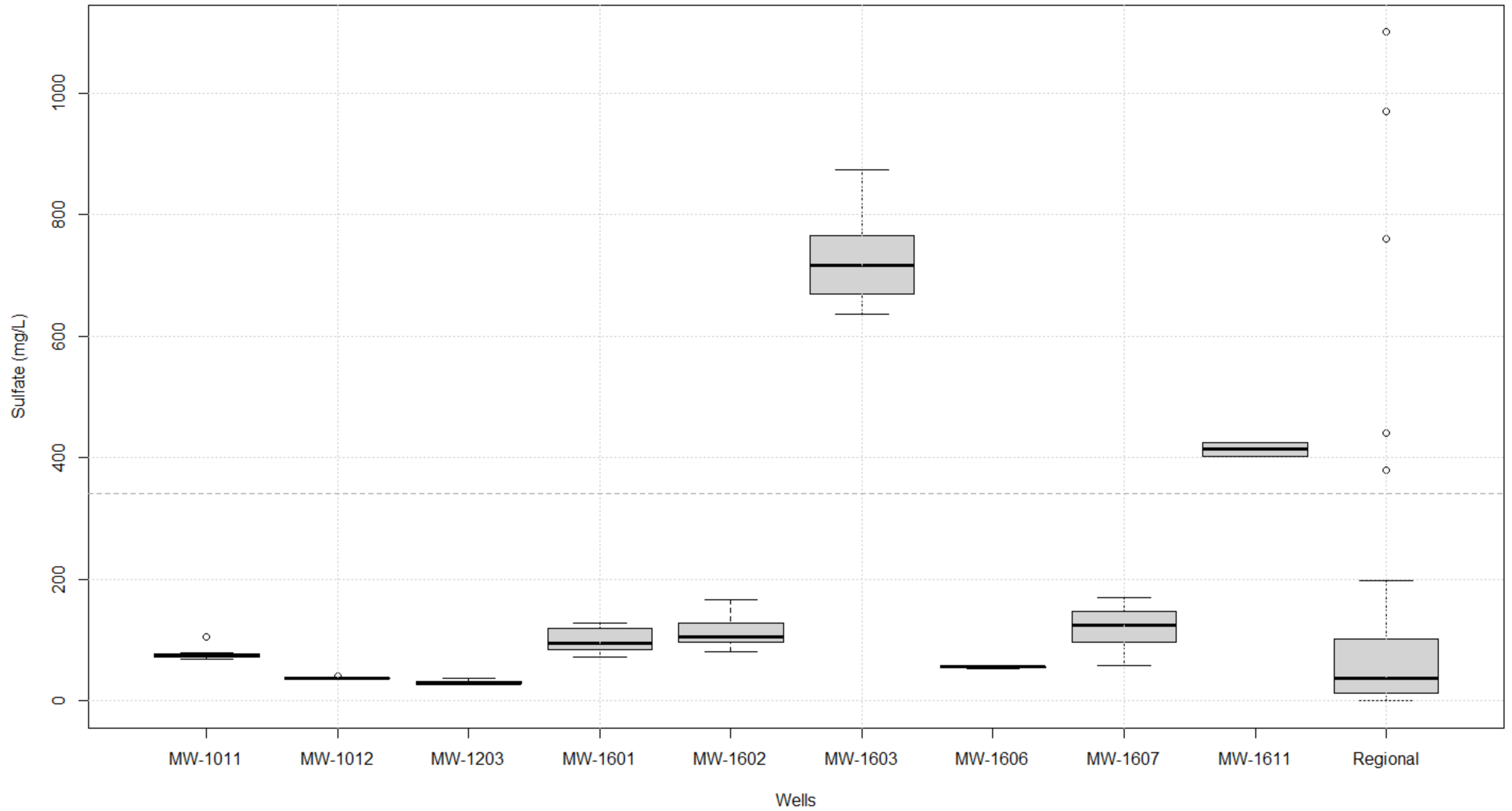
----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Strontium



----- Dotted line is Big Sandy Fly Ash Pond water sample result.

Boxplot for Sulfate



----- Dotted line is Big Sandy Fly Ash Pond water sample result.