TETRA TECH

Technical Memorandum

To:	Jeffrey Dhont, Superfund Project Manager, U.S. Environmental Protection Agency Region 9
From:	Tetra Tech, Inc.
Date:	August 12, 2022
Subject:	Refined Background Threshold Value (BTV) Calculations for Arsenic at the Iron King-Humboldt Smelter Superfund Site, Dewey-Humboldt, Arizona

1. PURPOSE AND OBJECTIVES

Under Contract W912P718D0001, the U.S. Environmental Protection Agency (USEPA) tasked Tetra Tech, Inc. (Tetra Tech) with re-evaluating background levels of arsenic concentrations in undisturbed soils near the Iron King Humboldt Smelter (IKHS) Superfund site (the site) in Dewey-Humboldt, Arizona. In Appendix E to the Remedial Investigation report (RI) regarding the site (CH2M 2016), CH2M, Inc. applied a statistical strategy and approach to calculate a background threshold value (BTV) of 112 mg/kg arsenic for the site. Tetra Tech has recalculated the BTV using subpopulations for the background data and statistical approaches not used in the original analysis. Based on the new analyses, Tetra Tech has recommended a revision to the original BTV derived by CH2M.

A BTV is an estimate of the upper limit of the background environmental concentration of a contaminant of interest (USEPA 2015). Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process, BTVs support risk assessment and development of remediation objectives. Arsenic BTVs based on soil measurements can be used to inform future cleanup decisions for the area impacted by arsenic contamination from IKHS.

The purpose of this technical memorandum is to recalculate the arsenic background via more sophisticated statistical approaches to support a decision whether or not to modify the background value of arsenic in soils derived in the RI. The goal is to recommend a BTV for arsenic based on statistical analysis. This technical memorandum provides estimates of BTVs for arsenic in soil around IKHS based on existing soil data and data obtained from (1) laboratory analysis of soil samples collected around the site, and (2) samples analyzed in the field by use of an X-ray fluorescence (XRF) spectrometer.

This technical memorandum seeks to achieve the following objectives:

- Describe approaches to calculate soil arsenic BTVs by application of multiple statistical models to calculate upper tolerance limits (UTLs).
- Present arsenic BTV calculations following several alternative approaches, including standard methods with ProUCL/Minitab, cluster analysis with ProUCL/Minitab, and weighted bootstrap models (including nonparametric weighted bootstrap models) in R statistical programming.
- Provide different scenarios for calculating BTVs using groupings of soil types and surface water drainage to compare options for selecting an appropriate arsenic BTV for soil cleanup near IKHS.

2. SITE LOCATION AND DESCRIPTION

IKHS is adjacent to the town of Dewey-Humboldt in Yavapai County, Arizona. The site consists of the Iron King Mine and the Humboldt Smelter. The Iron King Mine was active from the 1890s through 1968 (CH2M Hill 2016). Ores produced from the Iron King Mine included lead, zinc, copper, silver, and gold. The Humboldt Smelter conducted operations from 1876 to 1968, including three smelters and one smaller mine. Operations included processing of copper and additional recovery of gold, silver, zinc, and aluminum from ores.

Major site features at and near the IKHS site, including drainages near the site and the town of Dewey-Humboldt, appear on Figure 1. An area of potential site impact (APSI) has been identified around IKHS to delineate the approximate extent of contamination related to site operations as a part of the RI effort (CH2M Hill 2016). This boundary is distinguished from the potential effects zone (PEZ) of contamination, which was evaluated during a cultural resources survey prior to the RI (Archaeological Consulting Services, Ltd. 2008). The area including the combined APSI and PEZ represents the background boundary, outside of which assumedly has not been affected by contamination from IKHS.

An important regional feature is the Agua Fria River, adjacent to Dewey-Humboldt and flowing through the IKHS site boundary. Two major intermittent surface water drainages, Chaparral Gulch and Galena Gulch, are south of the town and flow through the APSI. Both drainages discharge into the Agua Fria River and have facilitated transport of contamination from IKHS outside of the background boundary.

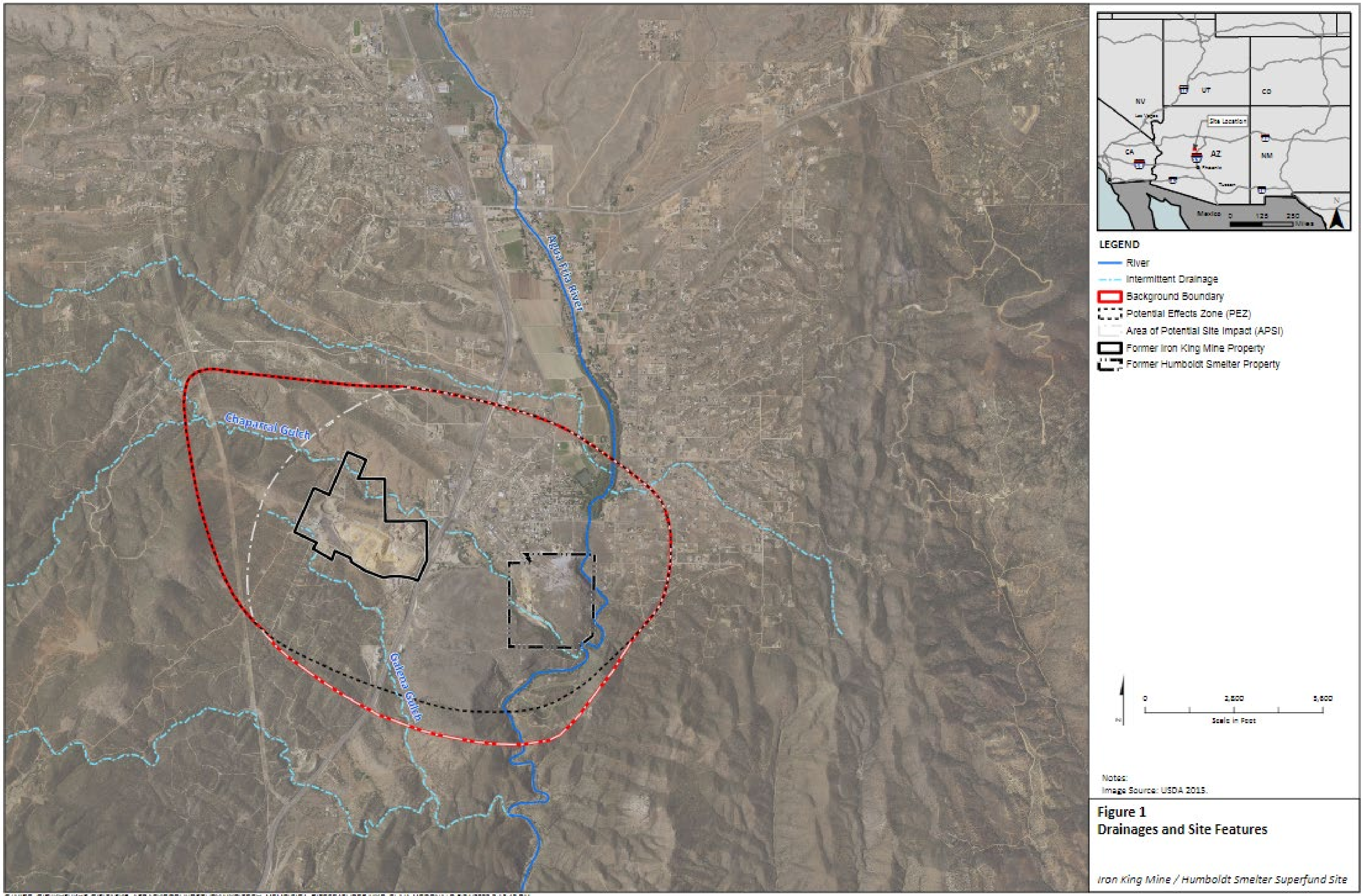

Figure 1. Drainages and Site Features

2.1 SITE GEOLOGY AND SOIL CLASSIFICATIONS

Figure 2 shows the underlying geology of the potential impacted area of interest around IKHS. Major geologic features of the region include Precambrian metamorphic rocks covered by Tertiary volcanic and sedimentary rocks from the Hickey Formation (CH2M Hill 2016). Further, quaternary alluvial deposits consisting of Hickey Formation materials are present along the Agua Fria River and active drainages, including Chaparral Gulch and Galena Gulch.

Tetra Tech reviewed the Web Soil Survey to determine the soils mapped by the U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS) for the IKHS site (USDA 2022). Table 1 lists the major soils mapped for an approximate 10,000-acre potential impacted area of interest surrounding and including the IKHS site. Soil mapping units were combined by soil series (Balon, Lonti, Alluvial, Moano) to provide manageable soil groupings. Because of similar characteristics, Lynx Soils (Ly) and Alluvial Land (Sa) were grouped together. For the purposes of this technical memorandum, this grouping is referred to as Alluvial. In Attachment B are Web Soil Survey output and official NRCS soil series descriptions of the major soils that occur at the IKHS site. Figure 3 is a map of the soil units identified for the potential impacted area of interest.

Table 1. Soil Classifications

Soil Grouping	Soil Unit Labels	Extent of Impacted Area (%)	Slopes	Source of Parent Material and Formation
Balon Soils	BgD	28.4	2 to 25	Formed in mixed alluvium dominantly from schist, granite, basalt, and related rocks.
Lonti Soils	LkD, LmB, LnC	17.8	2 to 25	Formed in old gravelly alluvium from mixed sources on alluvial fans.
Lynx Soils and Alluvial Land	Ly, Sa	15.4	0 to 8	Formed on flood plains and alluvial fans from mixed alluvium.
Moano Soils	MgD, MkF, MoD	32.9	8 to 60	Formed in residuum from phyllite and schist.
Springerville-Cabezon	SnD	3.9	0 to 10	Formed in alluvium from tuff, volcanic breccia, and basalt.
Others	n/a	2	n/a	n/a

Notes:

BgD Balon gravelly sandy clay loam, 5 to 30 percent slopes
LkD Lonti gravelly sandy loam, 15 to 30 percent slopes
LmB Lonti gravelly loam, 0 to 8 percent slopes
LnC Lonti cobbly loam, 0 to 15 percent slopes
Ly Lynx soils
MgD Moano gravelly loam, 0 to 30 percent slopes
MkF Moano very rocky loam, 15 to 60 percent slopes
MoD Moano extremely rocky loam, 15 to 30 percent slopes
Sa Sandy and Gravelly alluvial land
SnD Springerville-Cabezon complex, 3 to 30 percent slopes

2.1.1 Springerville

The Springerville-Cabezon Series soils are deep soils found south of the Humboldt Smelter. Springerville soils formed in alluvium from tuff, volcanic breccia, and basalt. Springerville soils are not represented outside the APSI, and no residences currently are built on these soils.

2.1.2 Lonti

Lonti Series soils are very deep soils but are mapped on nearly level plains and fans only on the east side of the Aqua Fria River. These soils developed in old gravelly alluvium from mixed sources.

2.1.3 Balon

Balon Series soils are very deep (> 6 feet) soils found on the fan terraces of the Aqua Fria River Valley. These soils are mapped on both the east and west side terraces but are most extensive west of the Aqua Fria River. Most of the Humboldt townsite is built on Balon Series soils.

2.1.4 Moano

Moano Series soils are found in the higher hills and mountain slopes east and west of the IKHS site. These very shallow soils developed in residuum (bedrock) materials and are typically less than 2 feet to hard schist bedrock.

2.1.5 Alluvial Land

The Lynx Series soils are found on flood plains and alluvial fans, and have characteristics similar to the soil mapping unit labeled sandy and gravelly alluvial land (Sa) found northeast of the site. These soils are deep and formed in mixed alluvium.

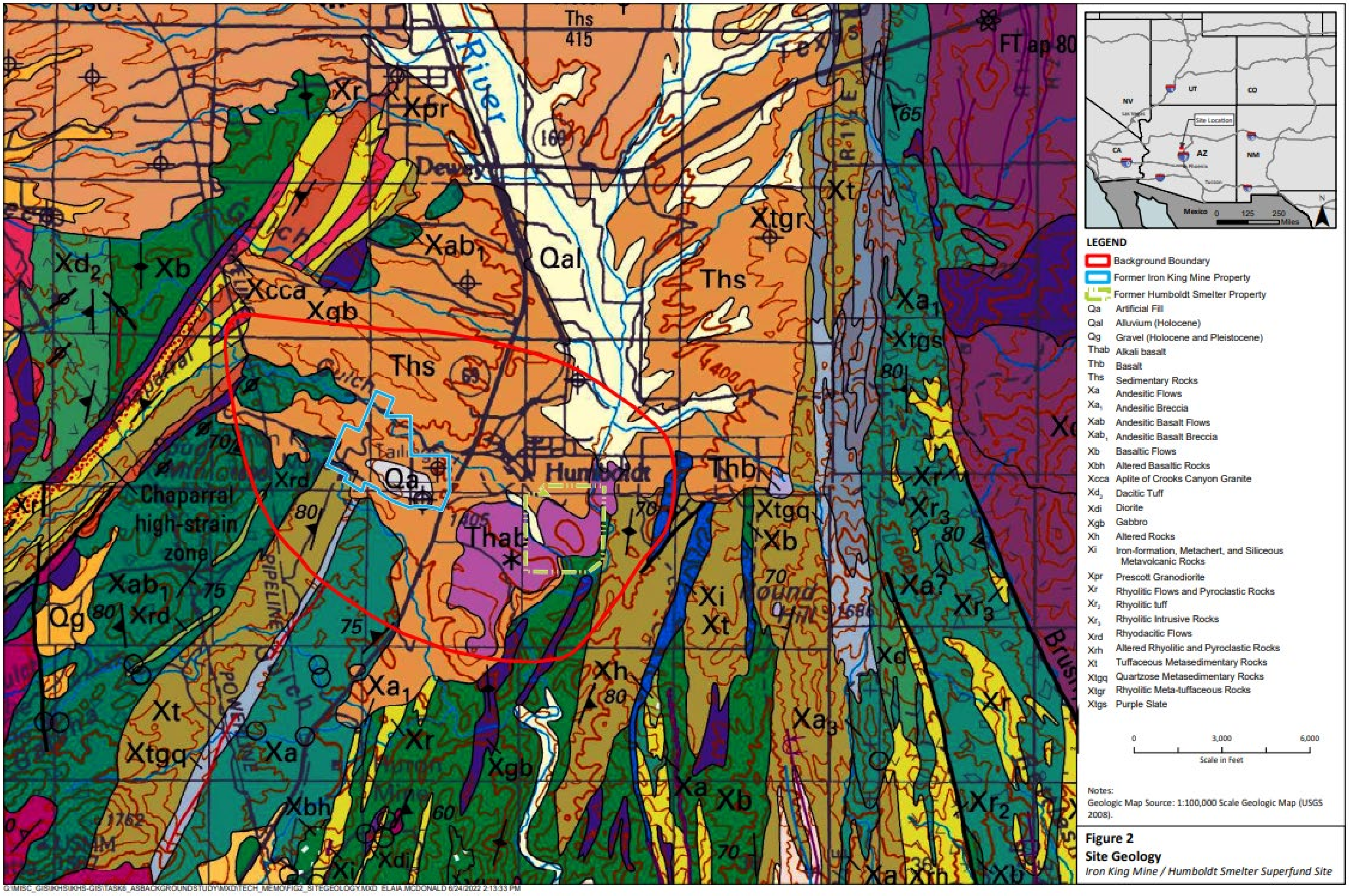

Figure 2. Site Geology

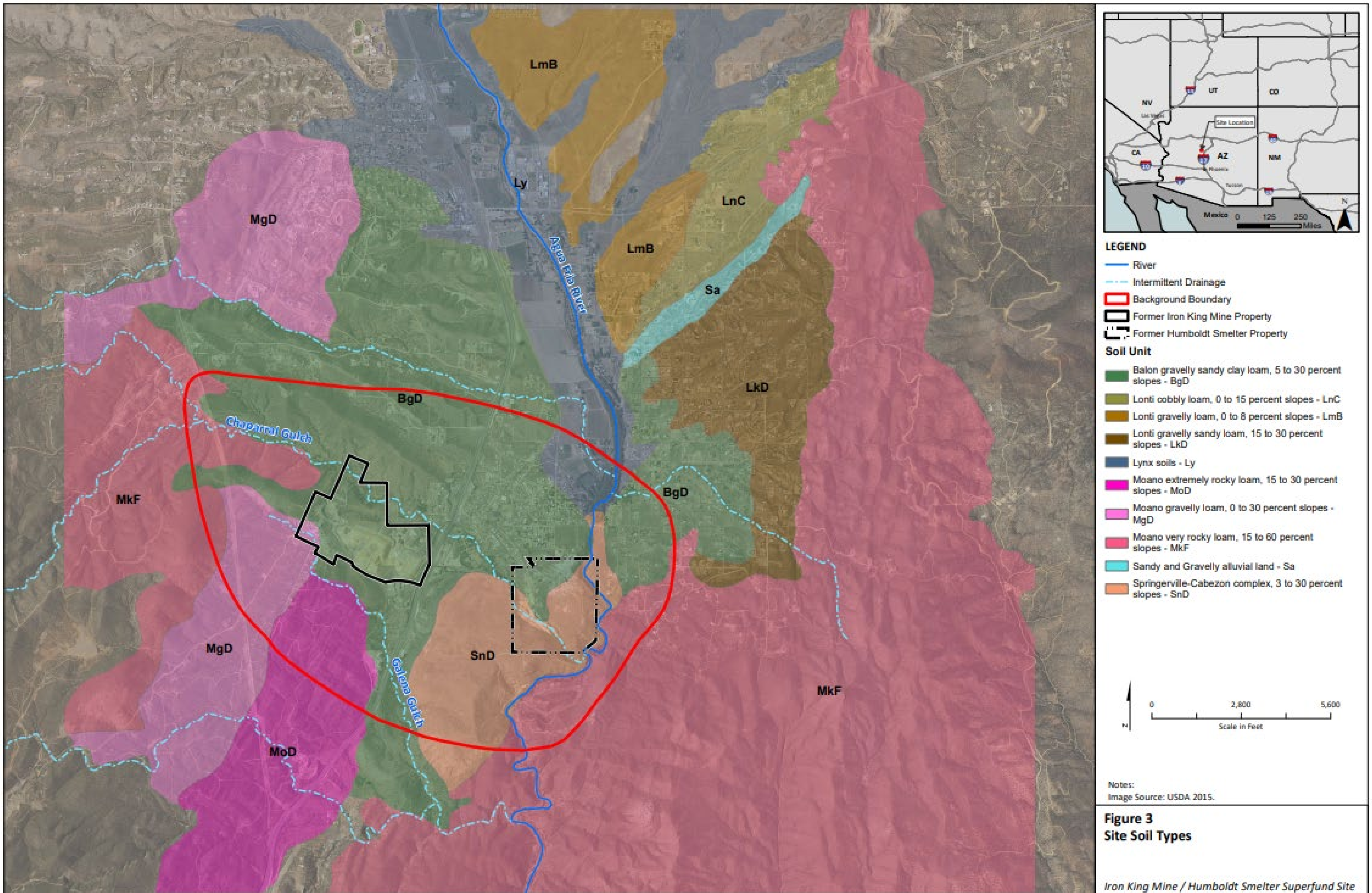

Figure 3. Site Soil Types

3. STATISTICAL APPROACHES AND METHODS FOR BTV CALCULATIONS

The following section describes (1) development of a database of background arsenic samples pertaining to the immediate area surrounding IKHS outside the background boundary, (2) treatment of outliers in the background sample database, (3) approaches for calculating BTVs with statistical software, and (4) scenarios used to group samples to calculate arsenic BTVs.

3.1 BACKGROUND SAMPLE DATABASE

Under the CERCLA process, RI activities have occurred in several stages, including collection of background soil samples at locations near the site considered background areas. Background areas are designated as soils in the vicinity of the site not affected by mine- and smelter-related contamination from IKHS. USEPA and the Arizona Department of Environmental Quality (ADEQ) began scoping of background areas during the first CERCLA assessments of the site from 2002 to 2004. Arsenic data from one soil sample from the site inspection is included in the database developed for this analysis to calculate arsenic BTVs. This sample measured arsenic by laboratory analysis. EA Engineering, Science, and Technology, Inc. (EA) performed a supplemental RI in 2010 that included measurement of arsenic in bulk soil by laboratory analysis. As a part of this effort, nine samples were collected in areas estimated to be representative of background in the site vicinity. These background samples are included in the database.

USEPA conducted surface soil sampling in 2012 and 2013 in an area of approximately 20 square miles around the IKHS site to evaluate background concentrations of contaminants associated with the site. This sampling effort as a part of the RI intended to characterize contamination with arsenic and other metals in non-residential areas impacted by the site and at locations not expected to be impacted by the site that had not been previously characterized during sampling by EA (USEPA 2012). The background arsenic analysis presented in this technical memorandum includes 259 soil samples measured for arsenic in 2012 and 2013 by USEPA. These samples were analyzed for arsenic via both laboratory analysis of bulk soil and in-field measurement of unsieved samples by use of an XRF spectrometer (CH2M Hill 2016). In the dataset for background analysis, 105 samples underwent XRF measurements, and 154 samples were analyzed at the laboratory via analytical methods described in the USEPA background study (USEPA 2012).

In total, 269 background samples collected in the vicinity of IKHS have been reviewed for calculation of arsenic soil BTVs. Figure 4 shows locations of background samples included in the arsenic background sample database developed for this technical memorandum. The full background sample database of arsenic measurements, including sample groupings by soil unit and soil series, is in Attachment A.

3.1.1 Comparison of XRF Measurements and Bulk Soil Analytical Measurements

Because the background database consists of data from samples collected during multiple sampling efforts and analyzed for soil arsenic via both XRF screening and bulk soil laboratory analysis, it is important to compare characteristics of the data obtained by application of each method. Field XRF screening and soil analysis at the laboratory are not immediately comparable (Crumbling 2021). XRF measurements are more representative of total metals present in a soil sample because they provide a direct measurement of soil constituents. Laboratory soil analytical methods, including measurement by inductively coupled plasma (ICP), rely on partial digestion of a soil sample to extract metals. Accordingly, laboratory analysis of soil via ICP is representative only of the soluble fraction of an analyte of interest. Soil analysis via ICP provides insight into the amount of a contaminant that is bioavailable for potential receptors under a risk assessment scenario. Both approaches provide valuable information about extents of contamination at a site.

Comparability between XRF and ICP data sets should be established if XRF data are to be used to supplement or support ICP data. Comparing results obtained by applications of different methods of acquiring data also depends on calibration of the XRF instrument. XRF instruments are calibrated by the manufacturer. It cannot be assumed that XRF instruments will retain their calibration unless regular maintenance and quality control checks occur. The calibration status of an XRF spectrometer is determined by use of five or more certified reference materials (CRMs) that span the concentrations of interest to the project. Further, calibration of XRF instrumentation used in the future on these soils near the IKHS site must also be determined and compared with calibration of the XRF instruments originally used to collect data. The data from two different XRFs cannot be used interchangeably unless their calibrations are equivalent. The background XRF measurements obtained by USEPA have also been independently evaluated to assess their usability. In 2013, comparability of XRF and ICP data sets for arsenic was evaluated by use of linear regression and the Wilcoxon Signed-Rank test. Both statistical evaluations found the arsenic XRF and ICP data sets to be comparable. The following linear regression equation was obtained for the XRF (XRF-As) and ICP (ICP-As) data sets:

$$\text{XRF-As} = 0.9242(\text{ICP-As}) + 3.3$$

Both the slope of 0.9242 and the y-intercept of 3.3 indicate a comparable relationship. The Wilcoxon Signed-Rank test between the XRF and ICP data set found no difference between the two data sets ($p = 0.4247$).

Regarding the USEPA measurements taken in 2012 and 2013, five CRMs with concentrations ranging between 18 and 205 parts per million (ppm) were used, with calibration of the XRF spectrometer for arsenic measurements by linear regression determined to be:

$$\text{XRF-As} = 0.8667(\text{CRM-As}) + 3.37.$$

A slope of 0.8667 indicates that calibration of the XRF used to collect the data was biased low, which could have contributed to the comparability between this XRF instrument's results and the corresponding ICP results.

For the purposes of this technical memorandum, both field XRF and laboratory soil analytical measurements of arsenic are analyzed in the same dataset because of the limited number of samples collected outside the background boundary in the vicinity of IKHS. Section 4.8 compares BTV calculations for the full dataset with the dataset classified by analytical method and discusses the comparison between XRF and soil analytical measurements.

Table 2 lists summary statistics for the full background sample database for arsenic, calculated in Minitab. In addition, summary statistics are presented for the dataset classified by analytical method. To evaluate if the XRF and soil analytical datasets are statistically similar, a two-sample Student's t-test was performed in ProUCL software. At a confidence level of 95%, there is not a significant difference between the means of background arsenic data for each analytical method.

Table 2. Summary Statistics for Arsenic, IKHS Background Sample Database

	Total Count	Arsenic (mg/kg)										Outliers above 1.5*IQR + Q3	Extreme Outliers
		Mean	Standard Deviation	Coefficient of Variation	Minimum	Q1	Median	Q3	Maximum	Interquartile Range	1.5*IQR + Q3		
Full Dataset	269	49.34	156.46	317.09	3.4	16.5	30.12	52.48	2522.63	35.98	106.45	8	4
Extreme Outliers Removed	265	37.03	25.66	69.29	3.4	16.35	28.9	51.03	139	34.68			
XRF – Extreme Outliers Removed	102	38.02	21.77	57.27	5.73	21.08	34.74	47.81	104.75	26.73			
Lab – Extreme Outliers Removed	163	36.42	27.86	76.51	3.4	14.4	26.2	57.6	139	43.2			

Notes:

IQR Interquartile range

mg/kg Milligrams per kilogra

Q1 First quartile

Q3 Third quartile

XRF X-ray fluorescence

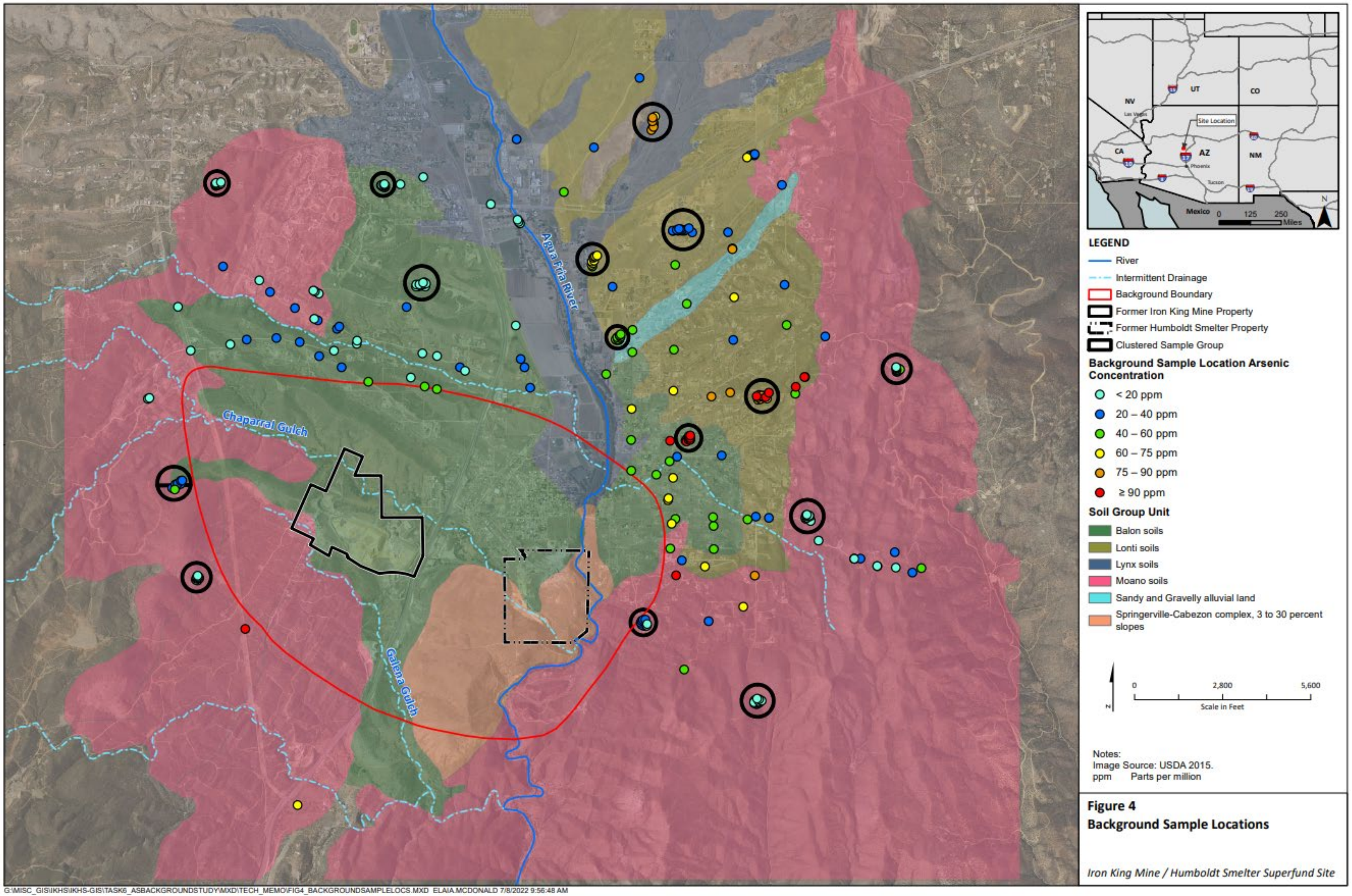

Figure 4. Background Sample Locations

3.2 IDENTIFICATION OF OUTLIERS IN BACKGROUND SAMPLES

Prior to analysis of the background dataset of arsenic soil concentrations, extreme outliers were identified and removed from the dataset to improve estimates of BTVs. Outliers are defined in USEPA (2002) as measurements not representative of a sample population. These values are frequently much larger or much smaller in comparison to the population from which they are drawn. Outliers distort statistics if used in any calculations. For statistical analysis of environmental data, USEPA (2002) advises a preliminary review of a dataset including identification of potential outliers.

Multiple approaches are available to evaluate outliers in environmental datasets. USEPA guidance (2006, 2015) highlights potential outlier analysis, or the interquartile range (IQR) fence method, as an initial approach. To evaluate for potential outliers measuring higher than would be representative of the sample population, measurements in a dataset that exceed an upper limit defined as the value for the IQR multiplied by 1.5 and added to the third quartile of the dataset (75th percentile) are classified as outliers. Visually, by displaying all data points on a boxplot, these observations are outside the fences on boxplots (above the upper bar and below the lower bar) and are considered potential outliers.

An additional method to evaluate outliers is to apply a judgmental approach to identify extreme outliers. Extreme outliers can be identified subjectively by multiple lines of evidence, including data visualization and comparative analysis of the highest measurements in a dataset with neighboring elevated measurements.

The outliers for elevated arsenic concentrations are identified in Table 3. These four samples identified as extreme outliers yielded greater than three times the average of the full dataset including the four outliers of 269 samples listed in Table 2. Further, these outliers exceeded the IQR fence calculated for the full dataset of 269 samples. For the purposes of this analysis, only extreme outliers are removed from the dataset used to calculate arsenic BTVs for the site. This decision intends to account for the wide variation in background arsenic concentrations present at the site while managing extreme values unlikely to represent conditions in background areas near the site.

Table 3. Outliers Removed from Background Sample Database

Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
XRF-079	612720	1278894	1/11/2012	XRF	2522.6	LkD	East	Lonti
BKG-497	608976	1276846	1/26/2012	Lab	421.0	BgD	East	Balon
XRF-077	612445	1278577	1/11/2012	XRF	306.2	LkD	East	Lonti
XRF-036	608641	1272594	1/10/2012	XRF	209.6	MkF	East	Moano

Notes:

BgD Balon gravelly sandy clay loam, 5 to 30 percent slopes

LkD Lonti gravelly sandy loam, 15 to 30 percent slopes

MkF Moano very rocky loam, 15 to 60 percent slopes

mg/kg Milligrams per kilogram

Lab Bulk soil sample analyzed in a lab setting

XRF Sample measured in-field by XRF

3.3 STATISTICAL METHODS FOR BTV CALCULATIONS

BTVs address statistical needs of soils background studies. Estimated site-specific or regional BTVs are used in background studies to (1) identify contaminants of potential concern at CERCLA sites, (2) identify site areas of concern, and (3) compare on-site contaminant concentrations to site-specific or regional background contaminant concentrations. BTVs are computed from upper limits of established datasets. These upper limits, such as UTLs, are used to estimate BTVs or not-to-exceed values (USEPA 1992, 2002, 2009). For the purposes of this study, the BTV is set to the 95 percent upper tolerance limit with 95 percent coverage (UTL95-95) for any given dataset. A UTL is designed to place a reasonable upper bound on the underlying background population. In this instance, the UTL technically represents a 95% upper confidence limit on the true background 95th percentile.

3.3.1 ProUCL

For this technical memorandum, USEPA's (2015) ProUCL 5.1 was the primary statistical tool used for calculating statistical limits. The procedure for identifying the appropriate BTV in this background sample evaluation included an initial analysis in ProUCL. If a parametric distribution was confirmed in ProUCL 5.1, the parametric UTL95-95 was selected from the ProUCL 5.1 for normal, lognormal, or gamma distributions. The order of selection preference was normal > gamma > lognormal as recommended in USEPA (2015).

An error was identified in the ProUCL 5.1 algorithm with respect to nonparametric tolerance limit calculations as summarized in a series of technical memorandums to USEPA (Tetra Tech unpublished[a], unpublished [b]). Accordingly, other statistical software is used to identify BTVs for datasets that do not fit a normal, lognormal, or gamma distribution as identified in ProUCL.

3.3.2 Minitab

Normal, lognormal, gamma, and nonparametric distributions were also evaluated in Minitab 21 software to calculate BTVs (Minitab, LLC 2022). Distributions were identified via Individual Distribution Analysis for each sampling grouping. The appropriate distribution was selected by identifying the lowest Anderson-Darling value and highest p-value as goodness-of-fit parameters. Following distribution identification, the UTL95-95 was calculated for the proper distribution.

Additional analysis of the background arsenic dataset for IKHS proceeded by identifying sample clusters and consolidating each cluster into a composite arsenic value. The goal of this approach was to reduce the weighting of similar arsenic values collected within a small surface area in calculating BTVs. Sixteen clusters were identified. Each cluster consisted of between five and 12 samples. For each cluster, the number of samples included in the cluster was replaced with the average of the samples represented in the cluster. Locations of each sample cluster are shown on Figure 5. Because of the effect on the size of the sample population by replacing groups of samples with clusters, cluster analysis was performed only under Scenarios A and B, as described in Section 4.

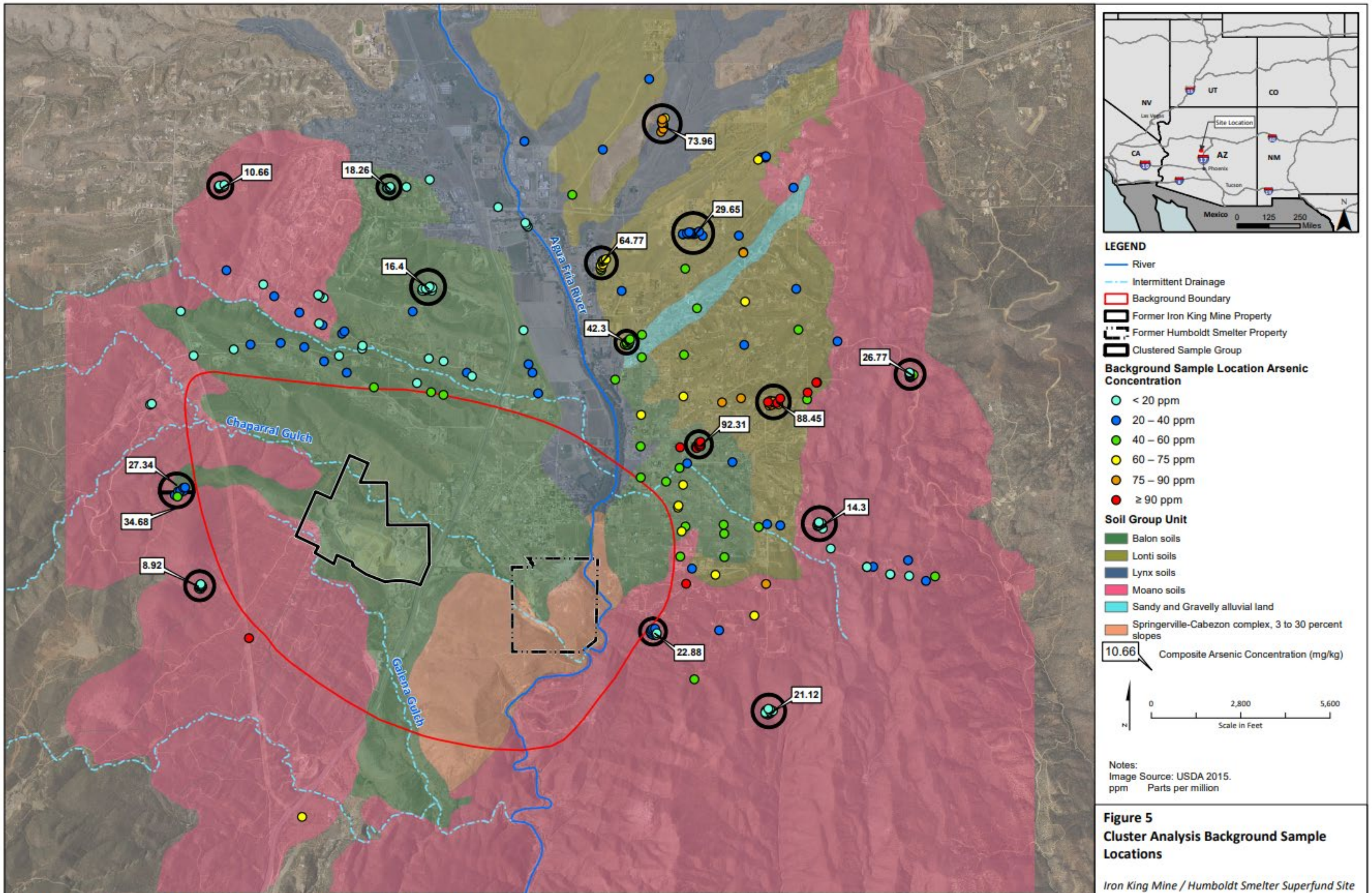

Figure 5. Cluster Analysis Background Sample Locations

3.3.3 R

Because of the irregular spatial pattern of the background measurements surrounding the Iron King remedial area, including relatively tight clustering of many of the soil samples, an alternative methodology for computing estimates of BTVs was developed and applied to the Iron King background data using R statistical programming.

This alternative strategy was predicated on weighting the individual observations differentially, based on a Voronoi tessellation of the separate background areas when classified by soil group. A Voronoi tessellation parcels a given background region into a series of non-overlapping polygons, each containing one of the sample measurements, and defined so that every point within a polygon is closer in distance to the contained observation than to any other background sample located outside the polygon (Ripley 1981, Arlinghaus and Kerski 2014, Baddeley and others 2016).

The net effect of a Voronoi tessellation is to construct smaller polygons for clustered samples and larger polygons for isolated or more sparsely distributed points. By assigning the area of each polygon to its contained observation as its statistical weight, the outcome is a differential, spatial weighting of the measurements in which each clustered value is down-weighted relative to the weights of non-clustered locations. Thus, clusters located in higher concentration subareas (e.g., hotspots) are not given undue statistical weight relative to other portions of the background.

With this spatial weighting scheme in hand, three different algorithms for computing BTVs were compared: (1) a standard, unweighted parametric (for reference); (2) a weighted bootstrap-t; and (3) a weighted nonparametric bootstrap. In each case, the outcome of the calculation was an estimate of the UTL95-95.

Violin plots showing the distribution of each sample grouping explored in Section 4 and the BTVs as calculated in R using these three methods are available in Attachment C. The three methods applied to estimate the BTVs for each background grouping are described in the following three subsections:

3.3.3.1 Unweighted Parametric UTL

In the parametric case, an attempt is made to find a known statistical distribution or model that closely fits the observed background data. In some instances, the well-known normal distribution may provide a good match to the data, but in many others a mathematical transformation of the data may be needed to "normalize" the measurements. Once an adequate model is found and tested for goodness of fit, a standard equation is employed for computing a parametric UTL, based on calculating the sum of the mean of the data plus a multiple (κ) of the standard deviation (SD):

$$\text{UTL} = \text{mean} + \kappa \text{ SD}$$

The value of the multiplier κ (also known as the tolerance factor) depends on the background sample size, and the chosen levels of confidence and coverage (i.e., the targeted upper percentile) for the UTL. If the data have been normalized via a transformation, the UTL equation is computed on the transformed data, then back-transformed to get an estimate in the original data scale.

3.3.3.2 Weighted Bootstrap-t UTL

The bootstrap is a modern resampling technique designed to enable statistical estimates of almost any sort, even if the underlying data are complex and may not fit a standard statistical distribution. At a general level, the bootstrap is computer-intensive, involving repeated resampling of the observed data with replacement to form a large series of bootstrap samples or replicates. Each bootstrap replicate contains the same number of values as the original background sample. Importantly, however, bootstrap resampling purposely allows any given measurement to occur possibly multiple times within the same bootstrap replicate, while other values are left out. This key aspect of the method can seem counter-intuitive, but actually leads to accurate statistical estimates even when the underlying population is unknown.

The bootstrap-t is a special case of the general bootstrap. It can be applied to unknown populations, but tends to work best when the underlying data are roughly symmetric (similar to the normal distribution), and not as well when the data are highly skewed. To avoid the problem of skewness, the bootstrap-t was applied only to data that were first normalized via a transformation. Under this framework, the same parametric equation for a UTL was used, but the multiplier (κ) was not selected from a statistical table. Instead, bootstrapping was used to compute a bootstrap multiplier. Then this bootstrap multiplier was combined with the mean and standard deviation of the background data to compute the estimated BTV. For calculation of the weighted bootstrap-t UTL, the statistical weights from the Voronoi tessellation were also employed in computing the bootstrap multiplier, so that the final estimate was not unduly influenced by the clustered background values. Further, the mean and standard deviation of the unweighted parametric case were replaced by a weighted mean and weighted standard deviation.

3.3.3.3 Weighted Nonparametric Bootstrap UTL

Unlike the bootstrap-t, the nonparametric bootstrap does not generally involve any model fitting or data transformation. Bootstrap replicates are formed by resampling with replacement from the original dataset. Then the statistic of interest is computed on each replicate. In this case, for a UTL95-95, the 95th percentile is calculated, leading to a long series of 95th percentile estimates (one per bootstrap replicate). Finally, since the UTL represents a 95% upper confidence limit on the 95th percentile, the 95th percentile of this bootstrap series is taken as the final UTL or BTV.

To calculate a weighted bootstrap, each element of the series of bootstrap 95th percentiles was computed as a weighted percentile instead of an unweighted percentile. Consequently, background values with smaller Voronoi weights have less impact on the percentile outcome than measurements with larger weights.

3.4 SCENARIOS FOR BTV CALCULATIONS

Seven scenarios are explored to calculate BTVs in this technical memorandum. Each scenario presents combinations of soil groupings and location relative to surface drainages near the site to compare effects of different groupings on arsenic BTVs.

Because soils have developed on top of landforms over the last few thousands of years, the geologic formations are much older and precede present soils where arsenic contamination is of concern around IKHS. Samples are classified by major soil group for the scenarios identified in this analysis of background study results to best represent the soil targets for cleanup near the IKHS site. In addition, tailings from impoundment failures at IKHS have been released to Chapparal Gulch and have reconstituted alluvial soils near the Agua Fria River. This choice also accounts for consideration of wind-blown dust from IKHS as a potential source of soil contamination around the site. More variations in surface soil types exist than variations in regional geology within the potential impacted area of interest. Thus, samples are grouped by soil series for the purposes of this analysis.

21 presents results of calculating arsenic BTVs by sample subgroupings under each scenario, and provides rationale for calculating BTVs from different sample groupings.

4. BTV CALCULATIONS BY SCENARIO

The following section presents the results of arsenic BTV calculations using ProUCL, Minitab, and R software for seven distinct scenarios organized by soil group. In addition, a comparison of arsenic BTVs calculated with field XRF and laboratory analytical data is provided.

4.1 SCENARIO A: ALL BACKGROUND SAMPLES

Scenario A calculates the arsenic BTV using the full database of 265 samples. Four extreme outliers, identified in Table 2, have been removed from all analyses. The purpose of calculating a BTV from the full database of background soil samples collected in the vicinity of IKHS is to provide a regional context for arsenic background concentrations. Further, this scenario provides the largest number of samples possible for BTV calculations.

Table 4 lists results of BTV calculations performed in ProUCL, Minitab, and R. Because ProUCL did not identify an appropriate distribution for the full dataset, Minitab and R BTVs are presented. The BTVs for the full dataset with extreme outliers removed range between 86.2 and 96.3 mg/kg. For the cluster analysis, the sample dataset with the 16 identified clusters consolidated to produce a smaller dataset of 128 samples yields a lower BTV of 86.2 mg/kg than is estimated by using the full dataset of 265 samples.

Table 4. Arsenic BTV Calculation Results for Scenario A

Sample Grouping	ProUCL			Minitab – Full Dataset			Minitab – Cluster Analysis			R – Weighted Bootstrap Model		R – Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
All Background Samples	265	n/a	Nonparametric	265	92.7	Nonparametric	128	86.2	Gamma	265	96.3	265	92.2

Notes:

BTV Background threshold value
mg/kg Milligrams per kilogram
n/a Not applicable

4.2 SCENARIO B: BACKGROUND SAMPLES CLASSIFIED BY SOIL GROUPING

Scenario B calculates arsenic BTVs by major soil grouping excluding extreme outliers. The four soil groupings associated with the background samples collected in the impacted area around IKHS are Alluvial Land, Balon Soils, Lonti Soils, and Moano Soils. This approach to calculating BTVs provides clarity on effects of different soil types and associated background levels of arsenic.

Table 5 lists results of BTV calculations performed in ProUCL, Minitab, and R for Scenario B. The population size widely varies between different soil groupings. As a result, the BTV calculation for Alluvial Land may be less representative of background conditions because only 23 samples are represented in this category. In contrast, the larger sample populations for Balon Soils, Lonti Soils, and Moano Soils likely provide a better estimate of the arsenic BTV for each soil grouping. Because the cluster analysis inherently reduces the sample size for each soil grouping, this approach may not be appropriate at this level of classification for calculating BTVs because of the small sample populations including consolidated clustered samples.

Table 5. Arsenic BTV Calculation Results for Scenario B

Sample Grouping	ProUCL			Minitab – Full Dataset			Minitab – Cluster Analysis			R – Weighted Bootstrap Model		R – Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
Alluvial	23	114.9	Normal	23	90.0	Nonparametric	14	100.8	Normal	23	86.1	23	86.0
Balon	76	n/a	Nonparametric	76	110.9	Lognormal	46	104.8	Lognormal	76	92.1	76	93.0
Lonti	69	n/a	Nonparametric	69	103.9	Gamma	30	89.8	Nonparametric	69	94.3	69	95.4
Moano	97	63.5	Lognormal	97	63.6	Lognormal	38	92.7	Lognormal	97	111.2	97	92.0

Notes:

BTV Background threshold value

mg/kg Milligrams per kilogram

n/a Not applicable

4.3 SCENARIO C: BACKGROUND SAMPLES RELATIVE TO AGUA FRIA RIVER

Scenario C divides the full sample dataset with extreme outliers removed based on location east or west of the Agua Fria River. This classification may be useful for identifying BTVs to be used for cleaning up arsenic in soil around IKHS because different background levels of arsenic are found on either side of the river due to proximity to IKHS and effects of transport of contamination from the site. Accordingly, different BTVs for east and west of the river could be set as different cleanup goals. In this analysis, these classifications are also useful because of the larger sample sizes by grouping, which yield greater confidence in BTV calculations.

Table 6 lists results of BTV calculations performed in ProUCL, Minitab, and R for Scenario C. The BTVs for the east side of the river range from 91.8 to 109.7 mg/kg arsenic, and the BTVs for the west side range from 52.6 to 123.3 mg/kg arsenic. The wide variation in calculations for the west side of the Agua Fria River may be attributed to application of spatial weighting to the BTV calculations performed in R and the effect of the smaller sample size for the west side grouping.

Table 6. Arsenic BTV Calculation Results for Scenario C

Sample Grouping	ProUCL			Minitab – Full Dataset			R – Weighted Bootstrap Model		R – Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
East of Agua Fria River	170	109.7	Gamma	170	108.0	Nonparametric	170	94.3	170	91.8
West of Agua Fria River	95	52.6	Lognormal	95	63.0	Nonparametric	95	123.3	95	91.6

Notes:

BTV Background threshold value

mg/kg Milligrams per kilogram

n/a Not applicable

4.4 SCENARIO D: BACKGROUND SAMPLES IN BALON AND MOANO SOIL GROUPINGS RELATIVE TO AGUA FRIA RIVER

Similar to Scenario C, Scenario D classifies samples by locations relative to the Agua Fria River but also further classifies samples by soil grouping. Moano and Balon Soils are the two soil types most prevalent in the potential impacted area of interest around IKHS. The four resulting groupings of Balon East, Balon West, Moano East, and Moano West intend to represent the combined effect of soil type and location relative to surface water drainage on arsenic BTVs.

Table 7 lists results of the arsenic BTV calculations in ProUCL, Minitab, and R for the Scenario D groupings. By sub-grouping, the BTV results across different approaches are very consistent, and the spatial weighting applied in the R analysis has less of an effect on the BTV result compared to standard methods for calculating BTVs in ProUCL and Minitab. However, the smaller sample sizes for each sub-grouping population reduce confidence in BTV calculations.

Table 7. Arsenic BTV Calculation Results for Scenario D

Sample Grouping	ProUCL			Minitab – Full Dataset			R – Weighted Bootstrap Model		R – Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
Balon East	24	126.4	Normal	24	126.4	Normal	24	123.6	24	109.5
Balon West	52	46.4	Lognormal	52	46.6	Lognormal	52	46.6	52	44.5
Moano East	59	62.8	Lognormal	59	62.9	Lognormal	59	86.1	59	81.5
Moano West	38	n/a	Nonparametric	38	92.7	Nonparametric	38	92.5	38	92.5

Notes:

BTV Background threshold value

mg/kg Milligrams per kilogram

n/a Not applicable

4.5 SCENARIO E: BACKGROUND SAMPLES IN BALON, MOANO, AND ALLUVIAL SOIL GROUPINGS

Scenario E consists of Balon Soils, Moano Soils, and Alluvial Land grouped together in one dataset with extreme outliers removed. These three soils are most representative of the soil types present within the APSI for which background samples outside the APSI are available.

Table 8 lists results of the arsenic BTV calculations in ProUCL, Minitab, and R for Scenario E. The arsenic BTVs range from 91.5 to 103.3 mg/kg.

Table 8. Arsenic BTV Calculation Results for Scenario E

Sample Grouping	ProUCL			Minitab – Full Dataset			R – Weighted Bootstrap Model		R – Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
Alluvial, Balon, and Moano	196	91.5	Lognormal	196	91.6	Lognormal	196	103.3	196	92.3

Notes:
BTV Background threshold value
mg/kg Milligrams per kilogram
n/a Not applicable

4.6 SCENARIO F: BACKGROUND SAMPLES IN BALON AND MOANO SOIL GROUPINGS

Scenario F consists of Balon Soils and Moano Soils grouped together in one dataset with extreme outliers removed. The two soil types are the top two by percentage surface area inside the APSI and in the overall potential impacted area of interest around IKHS.

Table 9 lists results of the arsenic BTV calculations in ProUCL, Minitab, and R for Scenario F. The arsenic BTVs range from 81.0 to 105.4 mg/kg.

Table 9. Arsenic BTV Calculation Results for Scenario F

Sample Grouping	ProUCL			Minitab - Full Dataset			R - Weighted Bootstrap Model		R - Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
Balon and Moano	173	81.0	Lognormal	173	81.1	Lognormal	173	105.4	173	93.1

Notes:

BTV Background threshold value

mg/kg Milligrams per kilogram

n/a Not applicable

4.7 SCENARIO G: BACKGROUND SAMPLES IN BALON AND LONTI SOIL GROUPINGS

Scenario G includes only Balon Soils and Lonti Soils grouped together to calculate arsenic BTVs. These soil types are highly prevalent outside the APSI where residences are located around the IKHS site.

Table 10 lists ProUCL, Minitab, and R arsenic BTV calculations results for Scenario G. The arsenic BTVs range from 90.8 to 117.1 mg/kg arsenic.

Table 10. Arsenic BTV Calculation Results for Scenario G

Sample Grouping	ProUCL			Minitab – Full Dataset			R – Weighted Bootstrap Model		R – Nonparametric Weighted Bootstrap Model	
	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	n	BTV (mg/kg)
Balon and Lonti	145	116.9	Lognormal	145	117.1	Lognormal	145	90.8	145	91.3

Notes:

BTV Background threshold value
mg/kg Milligrams per kilogram
n/a Not applicable

4.8 COMPARISON OF BTVS BY LABORATORY SOIL ANALYSIS AND FIELD XRF MEASUREMENTS

For Scenarios A, E, F, and G, the BTV calculations in Minitab for the full dataset calculated above were compared with subgroupings of each scenario classified by analytical method used to measure arsenic in each sample. These BTV calculations were performed with the four extreme outliers identified in Section 3.2 removed for all sample groupings. Scenarios A, E, F, and G were selected for this comparison because sufficient sample sizes were available in each scenario to subcategorize each scenario by in-field analysis with XRF and laboratory analysis of bulk soil.

Table 11 presents BTV calculations for Scenarios A, E, F, and G separated by analysis by field XRF or by laboratory methods, calculated using Minitab. For context, the BTV results for Scenarios A, E, F, and G calculated in Minitab using the combined dataset are also included. In general, the arsenic soil BTVs calculated from the datasets classified by analytical method are higher than the

BTV calculated for the full dataset for each scenario. The difference between BTVs calculated for these scenarios can be attributed to the smaller sample sizes for each grouping by analytical method.

Table 11. Comparison of XRF and Lab BTVs for Scenarios A, E, F, and G

Sample Grouping		Minitab – Full Dataset			Minitab – XRF				Minitab – Lab			
		n	BTV (mg/kg)	Distribution	n	BTV (mg/kg)	Distribution	% Difference from Full Dataset	n	BTV (mg/kg)	Distribution	% Difference from Full Dataset
All Samples	A	265	92.7	Nonparametric	102	101.3	Nonparametric	9%	163	108.0	Nonparametric	16%
Alluvial, Balon, and Moano	E	196	91.6	Lognormal	76	101.2	Lognormal	10%	120	110.0	Nonparametric	20%
Balon and Moano	F	173	81.1	Lognormal	67	99.6	Lognormal	23%	106	110.0	Nonparametric	36%
Balon and Lonti	G	145	117.1	Lognormal	66	92.4	Gamma	-21%	79	139.0	Nonparametric	19%

Notes:

BTV Background threshold value

mg/kg Milligrams per kilogram

n/a Not applicable

XRF X-ray fluorescence

5. SUMMARY OF BTV CALCULATIONS BY SOIL CLASSIFICATION AND GROUPING

A summary of BTVs calculated for each scenario with ProUCL, Minitab, and R using the full dataset of XRF measurements and laboratory soil analytical results is in Table 12.

Table 12. Summary of Arsenic BTV Calculation Results by Scenario

Scenario	Sample Grouping	Arsenic BTV (mg/kg)				
		ProUCL	Minitab – Full Dataset	Minitab – Cluster Analysis	R – Weighted Bootstrap Model	R – Nonparametric Weighted Bootstrap Model
A	All Background Samples	n/a	92.7	86.2	96.3	92.2
B	Alluvial	114.9	90.0	100.8	86.1	86.0
	Balon	n/a	110.9	104.8	92.1	93.0
	Lonti	n/a	103.9	89.8	94.3	95.4
	Moano	63.5	63.6	92.7	111.2	92.0
C	East of Agua Fria River	109.7	108.0		94.3	91.8
	West of Agua Fria River	52.6	63.0		123.3	91.6
D	Balon East	126.4	126.4		123.6	109.5
	Balon West	46.4	46.6		46.6	44.5
	Moano East	62.8	62.9		86.1	81.5
	Moano West	n/a	92.7		92.5	92.5
E	Alluvial, Balon, and Moano	91.5	91.6		103.3	92.3
F	Balon and Moano	81.0	81.1		105.4	93.1
G	Balon and Lonti	116.9	117.1		90.8	91.3

Notes:

BTV Background threshold value
mg/kg Milligrams per kilogram
n/a Not applicable

6. CONCLUSIONS AND RECOMMENDATIONS

Tetra Tech applied multiple statistical methods to calculate arsenic BTVs for soils in the vicinity of IKHS, including analyses of sample clusters, ProUCL, and Minitab for calculation of parametric and nonparametric UTL95-95 values as BTVs, and bootstrap models for spatial weighting to calculate parametric and nonparametric BTVs in R. Further, under eight scenarios (A through G), to understand effects of different geologic and hydrologic conditions on background soil arsenic, Tetra Tech combined different soil type groupings and surface water drainage to assign background sample results to groups.

Tetra Tech recommends Scenario A for estimating the arsenic BTV for risk assessment and remedial operations near IKHS. This grouping includes all soil samples collected and XRF measurements acquired in undisturbed areas outside the IKHS background boundary between 2004 and 2013. Because of the limited number of samples available from the background studies, Scenario A provides the best account of local variability in background soil arsenic measurements by soil type, and the largest pool of samples from which to estimate background concentrations.

Arsenic BTVs for the full dataset of background soil samples, under Scenario A in Table 12, range between 86.2 and 96.3 mg/kg. These values are lower than the arsenic BTV established in the RI of 112 mg/kg. Tetra Tech recommends 92.2 mg/kg arsenic—the BTV calculated in R with the nonparametric weighted bootstrap UTL95-95—as the soil arsenic BTV for the area outside the IKHS background boundary.

We selected the nonparametric weighted bootstrap model for calculating the UTL95-95 statistic based on its account of the spatial distribution of samples by application of Voronoi tessellation. Standard methods of calculating BTVs by use of ProUCL and Minitab do not account for weighting of sample measurements. Because this method retains all samples included in the dataset, it is a more rigorous analytical approach to cluster analysis than the manual cluster analysis via visual inspection of sample locations described in Section 3.3.2.

7. REFERENCES

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ATTACHMENT A

IKHS BACKGROUND SOIL ARSENIC DATABASE

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Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
HS-47	596602.349	1265297.914	1/27/2004	Lab	63.0	MoD	West	Moano
OFS-200-6	607518.183	1271093.577	5/7/2010	Lab	32.1	MkF	East	Moano
OFS-200-4	607603.137	1270989.239	5/7/2010	Lab	31.4	MkF	East	Moano
OFS-200-9	607665.809	1271188.111	5/7/2010	Lab	26.0	MkF	East	Moano
OFS-200-3	607657.372	1270989.074	5/7/2010	Lab	22.4	MkF	East	Moano
OFS-200-5	607545.096	1271026.170	5/7/2010	Lab	22.1	MkF	East	Moano
OFS-200-8	607592.278	1271183.967	5/7/2010	Lab	21.8	MkF	East	Moano
OFS-200-7	607549.384	1271148.433	5/7/2010	Lab	20.8	MkF	East	Moano
OFS-200-1	607719.624	1271048.932	5/7/2010	Lab	16.6	MkF	East	Moano
OFS-200-2	607711.608	1270988.910	5/7/2010	Lab	12.7	MkF	East	Moano
XRF-036	608641.259	1272593.527	1/10/2012	XRF	209.6	MkF	East	Moano
XRF-039	611142.429	1272585.977	1/10/2012	XRF	87.6	MkF	East	Moano
XRF-038	609557.194	1272872.552	1/10/2012	XRF	65.1	LkD	East	Lonti
XRF-020	616439.027	1272822.292	1/10/2012	XRF	46.1	MkF	East	Moano
XRF-026	608615.067	1274386.163	1/10/2012	XRF	44.6	BgD	East	Balon
XRF-024	610909.913	1274369.655	1/10/2012	XRF	41.6	LkD	East	Lonti
XRF-025	609814.492	1274441.253	1/10/2012	XRF	40.8	BgD	East	Balon
XRF-008	614308.365	1273118.035	1/10/2012	XRF	38.3	MkF	East	Moano
XRF-012	615038.576	1272883.270	1/10/2012	XRF	35.0	MkF	East	Moano
XRF-003	611591.676	1274420.453	1/10/2012	XRF	34.3	LkD	East	Lonti
XRF-042	597930.988	1280492.426	1/10/2012	XRF	31.4	BgD	West	Balon
XRF-022	611175.683	1274456.524	1/10/2012	XRF	30.7	LkD	East	Lonti
XRF-016	615596.101	1273329.154	1/10/2012	XRF	30.1	MkF	East	Moano
XRF-044	596519.478	1281080.691	1/10/2012	XRF	30.0	MgD	West	Moano
XRF-004	612916.958	1274334.721	1/10/2012	XRF	28.1	MkF	East	Moano
XRF-045	595731.618	1281589.544	1/10/2012	XRF	26.5	MgD	West	Moano
XRF-010	614501.375	1273123.078	1/10/2012	XRF	21.9	MkF	East	Moano
XRF-018	616154.731	1272682.911	1/10/2012	XRF	21.1	MkF	East	Moano
XRF-009	614305.039	1273119.966	1/10/2012	XRF	20.3	MkF	East	Moano
XRF-043	597138.472	1280741.926	1/10/2012	XRF	19.2	MgD	West	Moano
XRF-011	615031.756	1272888.894	1/10/2012	XRF	15.9	MkF	East	Moano
XRF-007	614308.296	1273118.145	1/10/2012	XRF	15.7	MkF	East	Moano
XRF-053	601039.691	1279558.492	1/10/2012	XRF	14.3	BgD	West	Balon
XRF-006	613171.015	1273694.045	1/10/2012	XRF	13.4	MkF	East	Moano

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XRF-013	615630.488	1272841.361	1/10/2012	XRF	11.6	MkF	East	Moano
XRF-048	598485.582	1279946.887	1/10/2012	XRF	11.0	BgD	West	Balon
XRF-005	612919.353	1274318.531	1/10/2012	XRF	5.7	MkF	East	Moano
XRF-079	612720.332	1278894.020	1/11/2012	XRF	2522.6	LkD	East	Lonti
XRF-077	612444.881	1278577.191	1/11/2012	XRF	306.2	LkD	East	Lonti
XRF-075	611587.539	1278397.411	1/11/2012	XRF	104.7	LkD	East	Lonti
XRF-072	609764.449	1278270.537	1/11/2012	XRF	89.8	LkD	East	Lonti
XRF-109	610432.991	1282953.781	1/11/2012	XRF	85.8	Sa	East	Alluvial
XRF-082	610358.813	1278398.743	1/11/2012	XRF	79.8	LkD	East	Lonti
XRF-058	608382.402	1274980.476	1/11/2012	XRF	71.1	BgD	East	Balon
XRF-069	607228.535	1277880.093	1/11/2012	XRF	68.6	BgD	East	Balon
XRF-059	608542.842	1275691.095	1/11/2012	XRF	67.6	BgD	East	Balon
XRF-071	608553.658	1278453.827	1/11/2012	XRF	64.0	LkD	East	Lonti
XRF-054	608496.367	1274231.241	1/11/2012	XRF	63.5	BgD	East	Balon
XRF-110	610485.765	1281425.905	1/11/2012	XRF	60.8	LkD	East	Lonti
XRF-100	605074.648	1284765.934	1/11/2012	XRF	59.7	LmB	East	Lonti
XRF-063	607213.810	1276894.120	1/11/2012	Lab	56.0	Ly	East	Alluvial
XRF-074	612428.071	1278363.736	1/11/2012	XRF	55.2	LkD	East	Lonti
XRF-061	607214.876	1275921.600	1/11/2012	XRF	55.1	BgD	East	Balon
XRF-093	607256.494	1280390.854	1/11/2012	XRF	50.9	Sa	East	Alluvial
XRF-088	612158.251	1280542.570	1/11/2012	XRF	47.5	LkD	East	Lonti
XRF-090	607251.382	1279680.118	1/11/2012	XRF	46.6	Sa	East	Alluvial
XRF-060	608014.348	1275790.351	1/11/2012	XRF	44.8	BgD	East	Balon
XRF-112	608979.439	1281215.129	1/11/2012	XRF	43.4	Sa	East	Alluvial
XRF-066	608430.754	1276214.713	1/11/2012	XRF	43.2	BgD	East	Balon
XRF-096	608612.842	1282457.363	1/11/2012	XRF	43.0	LnC	East	Lonti
XRF-092	606416.224	1278981.426	1/11/2012	XRF	42.9	Ly	East	Alluvial
XRF-081	612746.640	1278892.895	1/11/2012	XRF	41.5	LkD	East	Lonti
XRF-086	610457.049	1280068.178	1/11/2012	XRF	39.7	LkD	East	Lonti
XRF-106	610290.458	1283492.241	1/11/2012	XRF	39.7	LnC	East	Lonti
XRF-094	606620.033	1281758.051	1/11/2012	XRF	39.4	LmB	East	Lonti
XRF-098	608539.433	1283532.285	1/11/2012	XRF	38.5	LmB	East	Lonti
XRF-108	610428.597	1282975.014	1/11/2012	XRF	35.7	Sa	East	Alluvial
XRF-114	613383.308	1280181.161	1/11/2012	XRF	34.5	MkF	East	Moano

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XRF-099	608533.618	1283539.014	1/11/2012	XRF	34.1	LmB	East	Lonti
XRF-065	610087.444	1276403.111	1/11/2012	XRF	31.6	BgD	East	Balon
XRF-102	611141.447	1285973.748	1/11/2012	XRF	30.7	LnC	East	Lonti
XRF-115	612086.378	1281820.308	1/11/2012	XRF	28.1	LkD	East	Lonti
XRF-103	611122.691	1285934.813	1/11/2012	XRF	27.1	LnC	East	Lonti
XRF-104	612007.254	1284991.037	1/11/2012	XRF	24.3	MkF	East	Moano
XRF-101	606029.984	1286183.571	1/11/2012	XRF	24.0	LmB	East	Lonti
BKG-418	599386.562	1284921.328	1/21/2012	Lab	22.4	BgD	West	Balon
BKG-419	599387.329	1284984.451	1/21/2012	Lab	20.6	BgD	West	Balon
BKG-415	599336.900	1284945.365	1/21/2012	Lab	20.2	BgD	West	Balon
BKG-411	599259.290	1284978.684	1/21/2012	Lab	19.9	BgD	West	Balon
BKG-416	599304.985	1284944.082	1/21/2012	Lab	18.6	BgD	West	Balon
BKG-412	599283.364	1284988.245	1/21/2012	Lab	18.4	BgD	West	Balon
BKG-417	599329.462	1284926.637	1/21/2012	Lab	17.9	BgD	West	Balon
BKG-414	599342.802	1284996.261	1/21/2012	Lab	16.4	BgD	West	Balon
BKG-413	599310.329	1284978.766	1/21/2012	Lab	14.4	BgD	West	Balon
BKG-420	599365.216	1285018.349	1/21/2012	Lab	13.8	BgD	West	Balon
BKG-653	610896.431	1285864.947	1/22/2012	Lab	63.2	LnC	East	Lonti
BKG-652	610984.040	1285930.025	1/22/2012	Lab	26.6	LnC	East	Lonti
BKG-651	611112.104	1285972.871	1/22/2012	Lab	26.5	LnC	East	Lonti
BKG-612	597161.864	1281609.721	1/22/2012	Lab	11.9	MgD	West	Moano
BKG-611	597109.193	1281636.152	1/22/2012	Lab	11.0	MgD	West	Moano
BKG-613	597284.026	1281541.716	1/22/2012	Lab	10.3	MgD	West	Moano
BKG-559	612760.500	1274466.846	1/23/2012	Lab	21.2	MkF	East	Moano
BKG-552	612876.100	1274494.123	1/23/2012	Lab	17.7	MkF	East	Moano
BKG-551	612891.160	1274461.538	1/23/2012	Lab	16.2	MkF	East	Moano
BKG-554	612816.195	1274477.278	1/23/2012	Lab	14.3	MkF	East	Moano
BKG-555	612798.712	1274426.319	1/23/2012	Lab	13.4	MkF	East	Moano
BKG-558	612763.033	1274392.704	1/23/2012	Lab	12.5	MkF	East	Moano
BKG-560	612785.698	1274488.667	1/23/2012	Lab	12.3	MkF	East	Moano
BKG-556	612752.486	1274426.126	1/23/2012	Lab	11.2	MkF	East	Moano
BKG-553	612800.702	1274518.774	1/23/2012	Lab	10.4	MkF	East	Moano
BKG-557	612779.025	1274508.079	1/23/2012	Lab	8.6	MkF	East	Moano
BKG-468	605989.038	1282507.623	1/24/2012	Lab	74.2	LmB	East	Lonti

ATTACHMENT A
IKHS BACKGROUND SOIL ARSENIC DATABASE

Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
BKG-461	606129.626	1282750.437	1/24/2012	Lab	69.4	LmB	East	Lonti
BKG-469	605954.233	1282452.018	1/24/2012	Lab	68.6	LmB	East	Lonti
BKG-467	605962.870	1282559.858	1/24/2012	Lab	67.5	LmB	East	Lonti
BKG-466	606033.048	1282587.713	1/24/2012	Lab	67.5	LmB	East	Lonti
BKG-462	606073.553	1282724.987	1/24/2012	Lab	62.6	LmB	East	Lonti
BKG-464	606007.164	1282678.077	1/24/2012	Lab	62.5	LmB	East	Lonti
BKG-463	606033.377	1282714.673	1/24/2012	Lab	60.7	LmB	East	Lonti
BKG-465	606016.765	1282631.676	1/24/2012	Lab	57.7	LmB	East	Lonti
BKG-470	605981.102	1282404.477	1/24/2012	Lab	57.0	LmB	East	Lonti
BKG-436	600538.310	1281791.067	1/24/2012	Lab	24.3	BgD	West	Balon
BKG-432	600643.124	1281900.845	1/24/2012	Lab	23.9	BgD	West	Balon
BKG-438	600431.988	1281766.637	1/24/2012	Lab	23.5	BgD	West	Balon
BKG-434	600610.884	1281831.008	1/24/2012	Lab	17.0	BgD	West	Balon
BKG-435	600669.622	1281766.532	1/24/2012	Lab	16.6	BgD	West	Balon
BKG-431	600684.692	1281861.911	1/24/2012	Lab	15.1	BgD	West	Balon
BKG-621	603679.665	1283770.820	1/24/2012	Lab	14.5	Ly	West	Alluvial
BKG-437	600477.432	1281832.455	1/24/2012	Lab	13.9	BgD	West	Balon
BKG-433	600598.920	1281889.884	1/24/2012	Lab	13.2	BgD	West	Balon
BKG-623	603599.587	1283887.452	1/24/2012	Lab	13.2	Ly	West	Alluvial
BKG-622	603631.506	1283818.697	1/24/2012	Lab	13.0	Ly	West	Alluvial
BKG-439	600381.310	1281826.401	1/24/2012	Lab	8.6	BgD	West	Balon
BKG-440	600366.046	1281767.456	1/24/2012	Lab	7.9	BgD	West	Balon
BKG-497	608975.843	1276845.868	1/26/2012	Lab	421.0	BgD	East	Balon
BKG-548	611491.057	1278254.682	1/26/2012	Lab	139.0	LkD	East	Lonti
BKG-498	609041.929	1276899.826	1/26/2012	Lab	122.0	BgD	East	Balon
BKG-494	609091.543	1277032.994	1/26/2012	Lab	110.0	BgD	East	Balon
BKG-542	611205.884	1278280.684	1/26/2012	Lab	108.0	LkD	East	Lonti
BKG-499	609093.141	1276900.267	1/26/2012	Lab	94.3	BgD	East	Balon
BKG-500	609084.823	1276956.099	1/26/2012	Lab	91.7	BgD	East	Balon
BKG-496	608942.974	1276863.838	1/26/2012	Lab	88.4	BgD	East	Balon
BKG-550	611360.762	1278301.752	1/26/2012	Lab	87.3	LkD	East	Lonti
BKG-547	611437.863	1278300.617	1/26/2012	Lab	86.1	LkD	East	Lonti
BKG-492	609037.006	1276979.414	1/26/2012	Lab	85.5	BgD	East	Balon
BKG-493	608973.788	1276912.262	1/26/2012	Lab	84.8	BgD	East	Balon

ATTACHMENT A
IKHS BACKGROUND SOIL ARSENIC DATABASE

Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
BKG-491	609039.678	1277010.634	1/26/2012	Lab	81.4	BgD	East	Balon
BKG-546	611423.577	1278249.103	1/26/2012	Lab	78.4	LkD	East	Lonti
BKG-545	611320.505	1278185.351	1/26/2012	Lab	75.8	LkD	East	Lonti
BKG-543	611242.401	1278241.210	1/26/2012	Lab	75.6	LkD	East	Lonti
BKG-549	611529.124	1278208.473	1/26/2012	Lab	74.8	LkD	East	Lonti
BKG-544	611241.547	1278168.860	1/26/2012	Lab	73.8	LkD	East	Lonti
BKG-495	609014.911	1276942.444	1/26/2012	Lab	72.7	BgD	East	Balon
BKG-541	611280.860	1278323.348	1/26/2012	Lab	69.4	LkD	East	Lonti
BKG-481	609152.349	1283485.482	1/26/2012	Lab	35.9	LnC	East	Lonti
BKG-482	609048.193	1283620.317	1/26/2012	Lab	32.6	LnC	East	Lonti
BKG-486	608807.169	1283539.564	1/26/2012	Lab	31.1	LnC	East	Lonti
BKG-483	608947.179	1283565.270	1/26/2012	Lab	27.5	LnC	East	Lonti
BKG-485	608834.996	1283571.337	1/26/2012	Lab	27.3	LnC	East	Lonti
BKG-487	608776.655	1283583.122	1/26/2012	Lab	26.4	LnC	East	Lonti
BKG-484	608883.676	1283533.459	1/26/2012	Lab	26.2	LnC	East	Lonti
BKG-490	608661.274	1283563.379	1/26/2012	Lab	26.0	LnC	East	Lonti
BKG-489	608706.759	1283535.191	1/26/2012	Lab	25.6	LnC	East	Lonti
BKG-488	608733.453	1283596.803	1/26/2012	Lab	24.6	LnC	East	Lonti
XRF-067	608449.834	1276867.815	1/31/2012	XRF	101.3	BgD	East	Balon
XRF-056	608397.537	1275038.418	1/31/2012	XRF	69.7	BgD	East	Balon
XRF-084	608573.431	1279759.629	1/31/2012	XRF	49.4	LkD	East	Lonti
XRF-047	594235.633	1282402.149	1/31/2012	XRF	37.6	MgD	West	Moano
XRF-064	608674.270	1276362.133	1/31/2012	XRF	35.2	BgD	East	Balon
XRF-041	598496.277	1280046.663	1/31/2012	XRF	19.3	BgD	West	Balon
XRF-050	599875.650	1285014.082	1/31/2012	XRF	13.6	BgD	West	Balon
XRF-046	595387.467	1281959.334	1/31/2012	XRF	10.0	MgD	West	Moano
XRF-051	600602.962	1285241.203	1/31/2012	XRF	7.7	Ly	West	Alluvial
XRF-211	594939.606	1270888.944	4/17/2012	XRF	92.7	MgD	West	Moano
XRF-243	610778.029	1271596.142	4/18/2012	XRF	64.5	MkF	East	Moano
XRF-247	608899.470	1269603.808	4/18/2012	XRF	53.1	MkF	East	Moano
XRF-241	609837.053	1273428.331	4/18/2012	XRF	51.9	BgD	East	Balon
XRF-251	608452.696	1273445.912	4/18/2012	XRF	51.1	MkF	East	Moano
XRF-239	609832.288	1274159.809	4/18/2012	XRF	45.8	BgD	East	Balon
XRF-249	608823.952	1273067.047	4/18/2012	XRF	34.1	LkD	East	Lonti

ATTACHMENT A
IKHS BACKGROUND SOIL ARSENIC DATABASE

Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
XRF-245	609676.309	1271137.963	4/18/2012	Lab	25.0	MkF	East	Moano
XRF-309	598853.816	1278742.153	4/19/2012	XRF	47.7	BgD	West	Balon
XRF-317	597292.837	1279552.357	4/19/2012	XRF	39.8	BgD	West	Balon
XRF-305	607477.665	1288393.145	4/19/2012	XRF	38.7	LmB	East	Lonti
XRF-315	598002.253	1279200.254	4/19/2012	XRF	24.3	BgD	West	Balon
XRF-297	604003.721	1278551.159	4/19/2012	XRF	23.6	BgD	West	Balon
XRF-303	603572.638	1286440.458	4/19/2012	XRF	22.3	Ly	East	Alluvial
XRF-307	601929.643	1279091.638	4/19/2012	XRF	19.4	BgD	West	Balon
XRF-341	591842.140	1278198.544	4/19/2012	XRF	18.4	MkF	West	Moano
XRF-321	593204.308	1279732.387	4/19/2012	XRF	16.9	BgD	West	Balon
XRF-301	602748.713	1284380.384	4/19/2012	XRF	14.9	Ly	West	Alluvial
XRF-319	594466.818	1279927.389	4/19/2012	XRF	14.4	BgD	West	Balon
XRF-337	592799.530	1281121.408	4/19/2012	XRF	14.0	BgD	West	Balon
XRF-299	603545.470	1280526.137	4/19/2012	XRF	14.0	BgD	West	Balon
XRF-339	591894.966	1278229.289	4/19/2012	XRF	8.8	MkF	West	Moano
BKG-511	611138.728	1268625.496	5/14/2012	Lab	51.6	MkF	East	Moano
BKG-513	611129.249	1268528.348	5/14/2012	Lab	30.5	MkF	East	Moano
BKG-514	611200.432	1268498.988	5/14/2012	Lab	27.2	MkF	East	Moano
BKG-512	611122.441	1268558.909	5/14/2012	Lab	18.2	MkF	East	Moano
BKG-518	611359.389	1268610.972	5/14/2012	Lab	15.8	MkF	East	Moano
BKG-515	611230.461	1268547.488	5/14/2012	Lab	15.5	MkF	East	Moano
BKG-516	611276.420	1268540.413	5/14/2012	Lab	14.7	MkF	East	Moano
BKG-517	611271.984	1268595.956	5/14/2012	Lab	14.5	MkF	East	Moano
BKG-520	611217.055	1268680.797	5/14/2012	Lab	11.9	MkF	East	Moano
BKG-519	611279.054	1268655.629	5/14/2012	Lab	11.3	MkF	East	Moano
BKG-584	607890.678	1287011.220	5/29/2012	Lab	90.0	Ly	East	Alluvial
BKG-582	607895.643	1287133.371	5/29/2012	Lab	87.1	Ly	East	Alluvial
BKG-590	607853.072	1286732.298	5/29/2012	Lab	86.2	Ly	East	Alluvial
BKG-588	607924.600	1286832.034	5/29/2012	Lab	82.2	Ly	East	Alluvial
BKG-581	607973.878	1287172.005	5/29/2012	Lab	73.1	Ly	East	Alluvial
BKG-583	607877.040	1287059.850	5/29/2012	Lab	67.3	Ly	East	Alluvial
BKG-586	607927.209	1286934.756	5/29/2012	Lab	66.9	Ly	East	Alluvial
BKG-589	607880.790	1286780.802	5/29/2012	Lab	65.6	Ly	East	Alluvial
BKG-585	607915.842	1286975.050	5/29/2012	Lab	63.6	Ly	East	Alluvial

ATTACHMENT A
IKHS BACKGROUND SOIL ARSENIC DATABASE

Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
BKG-587	607922.479	1286890.347	5/29/2012	Lab	57.6	Ly	East	Alluvial
BKG-561	615761.173	1279135.164	5/29/2012	Lab	50.1	MkF	East	Moano
BKG-573	592703.595	1275321.969	5/29/2012	Lab	40.9	MkF	West	Moano
BKG-574	592682.982	1275342.865	5/29/2012	Lab	36.1	MkF	West	Moano
BKG-564	615699.053	1279110.348	5/29/2012	Lab	35.4	MkF	East	Moano
BKG-572	592705.943	1275335.843	5/29/2012	Lab	35.0	MkF	West	Moano
BKG-565	615692.035	1279065.944	5/29/2012	Lab	34.9	MkF	East	Moano
BKG-571	592618.693	1275362.527	5/29/2012	Lab	31.2	MkF	West	Moano
BKG-578	592885.780	1275493.470	5/29/2012	Lab	30.8	BgD	West	Balon
BKG-575	592754.504	1275418.967	5/29/2012	Lab	30.2	MkF	West	Moano
BKG-577	592791.577	1275503.519	5/29/2012	Lab	28.9	BgD	West	Balon
BKG-566	615648.339	1279054.959	5/29/2012	Lab	27.7	MkF	East	Moano
BKG-563	615694.545	1279142.290	5/29/2012	Lab	27.1	MkF	East	Moano
BKG-579	592886.127	1275592.034	5/29/2012	Lab	26.6	BgD	West	Balon
BKG-580	592934.443	1275605.747	5/29/2012	Lab	25.8	BgD	West	Balon
BKG-576	592717.929	1275476.014	5/29/2012	Lab	24.6	BgD	West	Balon
BKG-562	615731.362	1279158.847	5/29/2012	Lab	24.5	MkF	East	Moano
BKG-569	615641.783	1279177.142	5/29/2012	Lab	19.0	MkF	East	Moano
BKG-570	615639.565	1279206.301	5/29/2012	Lab	17.6	MkF	East	Moano
BKG-567	615655.403	1279116.022	5/29/2012	Lab	16.3	MkF	East	Moano
BKG-568	615639.404	1279147.995	5/29/2012	Lab	15.1	MkF	East	Moano
BKG-443	594127.842	1284999.991	6/20/2012	Lab	61.5	MgD	West	Moano
BKG-453	606867.974	1280163.366	6/20/2012	Lab	45.3	LnC	East	Lonti
BKG-458	606745.864	1280062.398	6/20/2012	Lab	43.7	LnC	East	Lonti
BKG-457	606720.648	1280083.299	6/20/2012	Lab	42.8	LmB	East	Lonti
BKG-455	606766.819	1280151.181	6/20/2012	Lab	42.6	LnC	East	Lonti
BKG-452	606840.549	1280213.427	6/20/2012	Lab	42.3	LnC	East	Lonti
BKG-459	606821.706	1280063.554	6/20/2012	Lab	42.1	LnC	East	Lonti
BKG-451	606879.719	1280246.625	6/20/2012	Lab	41.6	LnC	East	Lonti
BKG-460	606840.180	1280092.651	6/20/2012	Lab	41.4	LnC	East	Lonti
BKG-456	606787.328	1280094.201	6/20/2012	Lab	41.3	LnC	East	Lonti
BKG-454	606815.139	1280170.469	6/20/2012	Lab	39.9	LnC	East	Lonti
BKG-528	593373.906	1272450.123	6/20/2012	Lab	12.7	MkF	West	Moano
BKG-442	594162.424	1285033.188	6/20/2012	Lab	12.2	MgD	West	Moano

ATTACHMENT A
IKHS BACKGROUND SOIL ARSENIC DATABASE

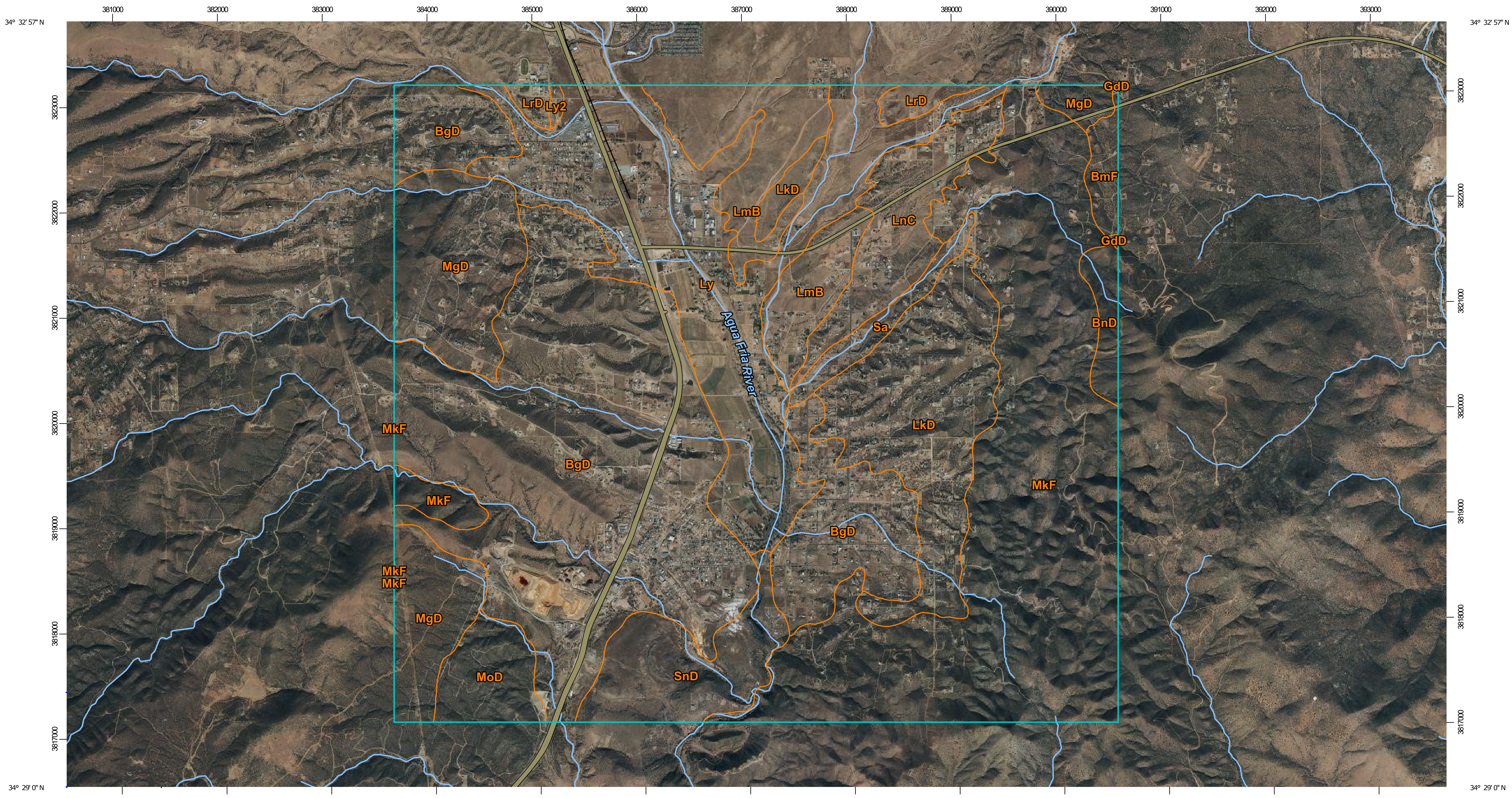
Sample Name	Easting	Northing	Sample Date	Analytical Method	Arsenic (mg/kg)	Soil Unit	Direction from Agua Fria River	Soil Series
BKG-526	593404.018	1272515.265	6/20/2012	Lab	12.0	MkF	West	Moano
BKG-446	594033.542	1284973.942	6/20/2012	Lab	12.0	MgD	West	Moano
BKG-449	593997.000	1285037.929	6/20/2012	Lab	11.8	MgD	West	Moano
BKG-447	594003.608	1284955.999	6/20/2012	Lab	11.5	MgD	West	Moano
BKG-448	593987.698	1285006.031	6/20/2012	Lab	10.6	MgD	West	Moano
BKG-450	594010.850	1285055.928	6/20/2012	Lab	10.6	MgD	West	Moano
BKG-445	594084.160	1284993.201	6/20/2012	Lab	10.1	MgD	West	Moano
BKG-527	593380.958	1272494.522	6/20/2012	Lab	9.7	MkF	West	Moano
BKG-521	593482.120	1272499.721	6/20/2012	Lab	9.1	MkF	West	Moano
BKG-441	594167.193	1285083.149	6/20/2012	Lab	9.0	MgD	West	Moano
BKG-524	593427.247	1272584.595	6/20/2012	Lab	8.8	MkF	West	Moano
BKG-529	593422.111	1272430.519	6/20/2012	Lab	8.6	MkF	West	Moano
BKG-525	593404.105	1272540.253	6/20/2012	Lab	8.6	MkF	West	Moano
BKG-522	593466.116	1272524.765	6/20/2012	Lab	8.5	MkF	West	Moano
BKG-444	594079.632	1285012.652	6/20/2012	Lab	8.1	MgD	West	Moano
BKG-530	593429.216	1272490.188	6/20/2012	Lab	7.8	MkF	West	Moano
BKG-523	593445.510	1272548.437	6/20/2012	Lab	3.4	MkF	West	Moano
XRF-913	601769.996	1279201.761	5/23/2013	XRF	24.7	BgD	West	Balon
XRF-917	600068.777	1281116.754	5/23/2013	XRF	23.0	BgD	West	Balon
XRF-925	596669.766	1280001.076	5/23/2013	XRF	21.3	BgD	West	Balon
XRF-921	597250.681	1280690.917	5/23/2013	XRF	21.0	MgD	West	Moano
XRF-919	597858.701	1280419.583	5/23/2013	XRF	20.5	BgD	West	Balon
XRF-915	600573.823	1279644.445	5/23/2013	XRF	13.5	BgD	West	Balon
XRF-923	597764.817	1279725.988	5/23/2013	XRF	9.6	BgD	West	Balon
XRF-897	601037.046	1278505.427	5/28/2013	XRF	48.1	BgD	West	Balon
XRF-901	600647.221	1278588.968	5/28/2013	XRF	45.4	BgD	West	Balon
XRF-929	594986.434	1280082.230	5/28/2013	XRF	35.6	BgD	West	Balon
XRF-927	595933.219	1280133.496	5/28/2013	XRF	34.1	BgD	West	Balon
XRF-969	603701.522	1279466.661	5/28/2013	XRF	27.9	BgD	West	Balon
XRF-967	603822.504	1279202.523	5/28/2013	XRF	27.3	BgD	West	Balon
XRF-911	600207.764	1278877.470	5/28/2013	XRF	17.8	BgD	West	Balon

Notes:

BgD	Balon gravelly sandy clay loam, 5 to 30 percent slopes
Lab	Bulk soil sample analyzed in a lab setting
LkD	Lonti gravelly sandy loam, 15 to 30 percent slopes
LmB	Lonti gravelly loam, 0 to 8 percent slopes
LnC	Lonti cobbly loam, 0 to 15 percent slopes
Ly	Lynx soils
MgD	Moano gravelly loam, 0 to 30 percent slopes
MkF	Moano very rocky loam, 15 to 60 percent slopes
MoD	Moano extremely rocky loam, 15 to 30 percent slopes
Sa	Sandy and gravelly alluvial land
XRF	Sample measured in-field by XRF

ATTACHMENT B

WEB SOIL SURVEY RESULTS AND SOIL SERIES DESCRIPTIONS



Map Scale: 1:35,500 if printed on B landscape (17" x 11") sheet.

Meters: 0, 500, 1000, 2000, 3000

Feet: 0, 1500, 3000, 6000, 9000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:31,700.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Yavapai County, Arizona, Western Part
Survey Area Data: Version 14, Sep 16, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Nov 26, 2021—Dec 11, 2021

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BgD	Balon gravelly sandy clay loam, 5 to 30 percent slopes	2,949.0	28.4%
BmF	Barkerville cobbly sandy loam, 20 to 60 percent slopes	76.3	0.7%
BnD	Barkerville very stony sandy loam, 5 to 25 percent slopes	90.1	0.9%
GdD	Gaddes gravelly sandy loam, 3 to 25 percent slopes	2.5	0.0%
LkD	Lonti gravelly sandy loam, 15 to 30 percent slopes	825.2	8.0%
LmB	Lonti gravelly loam, 0 to 8 percent slopes	563.3	5.4%
LnC	Lonti cobbly loam, 0 to 15 percent slopes	376.0	3.6%
LrD	Lonti-Abra complex, 8 to 30 percent slopes	80.6	0.8%
Ly	Lynx soils	1,474.1	14.2%
Ly2	Lynx soils, eroded	11.1	0.1%
MgD	Moano gravelly loam, 0 to 30 percent slopes	818.8	7.9%
MkF	Moano very rocky loam, 15 to 60 percent slopes	2,383.1	23.0%
MoD	Moano extremely rocky loam, 15 to 30 percent slopes	204.9	2.0%
Sa	Sandy and Gravelly alluvial land	111.6	1.1%
SnD	Springerville-Cabezon complex, 3 to 30 percent slopes	399.6	3.9%
Totals for Area of Interest		**10,366.7**	**100.0%**

Established Series
Rev. GEW/YHH
05/2006

BALON SERIES

The Balon series consists of very deep, well drained soils that formed in mixed fan alluvium dominantly from schist, granite, basalt and related rocks. Balon soils are on fan terraces. Slopes are 2 to 25 percent. The mean annual precipitation is about 14 inches and the mean annual temperature is about 54 degrees F
TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Ustic Haplargids

TYPICAL PEDON: Balon gravelly sandy clay loam, grassland. (Colors are for dry soil unless otherwise noted.)

A--0 to 3 inches; dark grayish brown (10YR 4/2) gravelly sandy clay loam, very dark grayish brown (10YR 3/2) moist; moderate medium granular structure; slightly hard, friable, nonsticky and slightly plastic; few fine roots; many fine interstitial pores; moderately acid (pH 6.0); abrupt smooth boundary. (1 to 4 inches thick).

Bt1--3 to 7 inches; dark grayish brown (10YR 4/2) heavy clay loam, dark brown (7.5YR 3/2) moist; moderate fine subangular blocky structure; hard, friable, slightly sticky and plastic; common fine roots; common fine tubular pores; few thin clay films on ped faces and lining pores; 5 to 15 percent gravel; noneffervescent; neutral (pH 7.0); clear smooth boundary. (3 to 5 inches thick)

Bt2--7 to 15 inches; brown (7.5YR 5/4) gravelly clay loam, brown (7.5YR 4/4) moist; moderate medium subangular blocky structure; very hard, friable, sticky and plastic; many fine roots; common fine tubular pores; common thin clay films on ped faces 25 percent gravel; noneffervescent; neutral (pH 7.0); clear wavy boundary. (7 to 12 inches thick)

BC1--15 to 23 inches; mottled brownish yellow (10YR 6/6), yellowish brown (10YR 5/4) and pale brown (10YR 6/3) gravelly sandy clay loam, mottled dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) and brown (10YR 5/3) moist; weak medium subangular structure; very hard, friable, sticky and plastic; common fine roots; common fine tubular; noneffervescent; slightly alkaline (pH 7.5); clear wavy boundary. (5 to 9 inches thick)

BC2--23 to 36 inches; light yellowish brown (10YR 6/4), yellowish brown (10YR 5/4) and pale brown (10YR 6/3) gravelly sandy loam, yellowish brown (10YR 5/4), brownish yellow (10YR 6/6) and dark yellowish brown (10YR 4/4) moist, mottles are many fine and medium faint and distinct; massive breaking to weak medium subangular blocky structure; very hard, friable, sticky and plastic; common fine medium and coarse roots; few fine and medium tubular and many fine interstitial pores; oriented clay occurs as bridges holding mineral grains together; few thin clay films on ped faces; noneffervescent; neutral (pH 7.2); clear wavy boundary. (8 to 15 inches thick)

C1--36 to 54 inches; mottled light yellowish brown (10YR 6/4), brownish yellow (10YR 6/6) and dark yellowish brown (10YR 4/4) gravelly sandy loam, dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), brownish yellow (10YR 6/6) and dark brown (10YR 3/3) moist; massive; hard, friable, slightly sticky and plastic; common fine roots; many fine interstitial pores; noneffervescent; neutral (pH 7.2); gradual wavy boundary. (12 to 20 inches thick)

C2--54 to 73 inches; very pale brown (10YR 8/4) gravelly sandy loam, yellowish brown (10YR 5/4) moist; massive; hard, friable, nonsticky and slightly plastic; few fine and medium roots; many fine interstitial pores;

noneffervescent; neutral (pH 7.2).

TYPE LOCATION: Yavapai County, Arizona. .7 mile west and .3 mile south of NE corner sec. 5, T.12N., R.1E., about 1/2 mile NE of Poland Junction Substation on south exposure of ridge.

RANGE IN CHARACTERISTICS:
Mean annual soil temperature: about 56 degrees F.

Soil Moisture: These soils are usually dry especially during the months of May, June, October and November. Ustic aridic moisture regime

A horizon
Hue: 10YR and 7.5YR
Value: 4 and 5 dry and 2 and 3 moist
Chroma: 2 to 4
Texture: sandy loam, gravelly sandy loam, gravelly sand clay loam and gravelly clay loam.
Reaction: 6.0 to 7.0

Bt horizons
Hue: 10YR and 7.5YR
Value: 4 to 6 dry and 3 to 5 moist
Chroma: 2 to 4
Texture: clay loam, clay, gravelly clay loam and gravelly clay.

BC horizons
Hue: 10YR through 5YR but are dominantly 7.5YR and 10YR
Value: 4 to 6 dry and 3 to 5 moist
Chroma: 3 to 6
Texture: averages less than 35 percent clay and is usually gravelly.
Structure: ranges from subangular blocky and angular blocky in the gravelly clay loam type to prismatic in the sandy loam type.

C horizons
Texture: gravelly loamy sand, gravelly sandy loam, gravelly loam, gravelly sandy clay loam and gravelly clay loam
Reaction: 6.5 to 8.0.

COMPETING SERIES: These are the Blancot (NM), Bowbac (WY), Buckle (NM), Cambria (WY), Chilerojo (NM), Cushman (WY), Decolney (WY), Doakum (NM), Forkwood (WY), Fort (CO), Gaddes (AZ), Gapbutte (AZ), Gapmesa (CO), Hagerman (NM), Hagerwest (NM), Hiland (WY), Mentmore (NM), Oelop (NM), Olney (CO), Palacid (NM), Penistaja (NM), Pokeman (WY), Potts (WY), Pugsley (WY), Quagwa (AZ), Redpen (NM), Spangler (WY), Sundance (CO), Tamarindo (NM), Teckla (WY) and Yenlo (CO) series.

Blancot and Mentmore soils have hues yellower than 10YR.

Bowbac, Cushman, Fattig, Flaco, Gaddes, Gapbutte, Gapmesa, Hagerman, Hagerwest, Pokeman, Progresso, Pugsley, Spangler, and Threetop soils have bedrock at depths of 20 to 40 inches.

Buckle soils have sola over 40 inches thick.

Cambria soils are dry in all parts of the moisture control section for at least 60 consecutive days and at least 90 cumulative days from July 15 to October 25.

Decolney soils have a MAST of 47 to 52 degrees F.

Forkwood soils are dry in all parts of the moisture control section for 60 consecutive days or more from July 15 to October 25.

Olney soils have a mean annual soil temperature greater than 52 degrees F., and are in a climatic setting that receives 3/4 of their precipitation between April and September and have a PE Index of about 20.

Oelop soils have a C horizon with hues redder than 7.5YR.

Palacid soils have less than 35 percent fine sand or coarser.

Penistaja soils typically have hue of 5YR or redder in the upper part of the B2t horizon.

Potts soils have less than 35 percent fine and coarser sand in the control section.

Quagwa soils have mean annual soil temperature of 54 to 57 degrees F.

Redpen soils have hue of 5YR or redder.

Sundance soils have lithic discontinuities formed from eolian sands on top of loess and the argillic horizon formed in part, in both materials.

Teckla soils have fragmental discontinuity below the Bt with over 35 percent rock fragments.

Yenlo soils have Ck horizons, hues 10YR and yellower, and MAST 47 to 52 degrees F.

In addition, the Bowbac, Cushman, Decolney, Fort, Hagerman, Olney, Pokeman, Potts, Pugsley, Spangler, Sundance and Tekla series are in LRR-G and are more moist in May and June.

GEOGRAPHIC SETTING: The Balon soils are at elevations of 4,000 to 5,000 feet on fan terraces. Slopes range from 2 to 25 percent. The regolith consists of mixed fan alluvium dominantly from schist, granite, basalt and related rocks. These soils are in a cool, semi-arid, continental climate, having a mean annual temperature of 50 degrees to 58 degrees F. The average annual precipitation ranges from 12 to 16 inches and occurs as thunderstorms in July through September and as rain and snow during the winter months. The frost-free period ranges from 144 and 223 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the Abra, Arp, Cordes, Lynx, Moano and Pastura in addition to the Lonti and Wineg series. Abra soils have a high lime content throughout and do not have an argillic horizon. Arp soils are redder, having hues of 5YR and 2.5YR and are fine-textured. Cordes soils are moderately coarse-textured and have a mollic epipedon. Lynx soils are in a fine-loamy family but are dark-colored and have a mollic epipedon. Moano soils have a lithic contact at shallow depths and are residual on schist. Pastura soils lack a Bt horizon and have a petrocalcic horizon at shallow depths.

DRAINAGE AND PERMEABILITY: Well-drained. Surface runoff ranges from slow to medium. Permeability is moderately slow to slow.

USE AND VEGETATION: Used mainly as rangeland. Native vegetation consists of oak brush, catclaw, Nolina, snakeweed and cacti with an understory of blue grama, sideoats grama, black grama and three-awns.

DISTRIBUTION AND EXTENT: Central and southern Yavapai Co., Arizona. These soils are moderately extensive. Approximately 26,000 acres have been mapped in the Western Yavapai Co. Soil Survey Area. MLRA 35.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Western Yavapai County Area, Yavapai County, Arizona, 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric Epipedon - The zone from the surface of the soil to a depth of 3 inches (A horizon).

Argillic horizon - The zone from 3 to 15 inches (Bt horizons).

Classified according to Keys to Soil Taxonomy Ninth Edition, 2003.

Established Series
Rev. GEW/JEJ
12/2008

LONTI SERIES

The Lonti series consists of very deep, well drained soils that formed in old gravelly alluvium from mixed sources. These soils are on nearly level plains to steep alluvial fans. The mean annual precipitation is about 15 inches and the mean annual air temperature is about 54 degrees F.

TAXONOMIC CLASS: Fine, mixed, superactive, mesic Ustic Haplargids

TYPICAL PEDON: Lonti gravelly sandy loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A--0 to 2 inches; grayish brown (10YR 5/2) gravelly sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium and thick platy structure; slightly hard, very friable, slightly sticky and slightly plastic; common very fine and fine roots; many very fine and fine vesicular pores; 25 percent gravel and few cobbles; noneffervescent; neutral (pH 6.9); clear wavy boundary. (1 to 5 inches thick)

Bt1--2 to 5 inches; dark brown (10YR 3/3) dry and moist gravelly sandy clay loam; moderate very fine and fine subangular blocky structure; hard, friable, sticky and plastic; many very fine and fine roots; many fine and very fine interstitial and common very fine and fine tubular pores; few thin clay films on peds; 20 percent gravel; noneffervescent; neutral (pH 6.6); clear wavy boundary. (2 to 6 inches thick)

Bt2--5 to 10 inches; reddish brown (5YR 4/3) gravelly clay, reddish brown (5YR 4/4) moist; weak fine and medium subangular blocky structure; very hard, firm, sticky and plastic; many very fine and fine roots; common fine interstitial pores; common thin clay films on peds; 25 percent gravel; noneffervescent; neutral (pH 6.6); clear smooth boundary. (5 to 14 inches thick)

Bt3--10 to 26 inches; reddish brown (5YR 4/4) gravelly clay, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; very hard, firm, sticky and plastic; common fine and medium roots; common very fine and fine tubular and many fine interstitial pores; common moderately thick clay films on peds; 25 percent gravel; noneffervescent; moderately alkaline (pH 7.9); clear wavy boundary. (6 to 16 inches thick)

Bt4--26 to 45 inches; reddish brown (5YR 5/4) gravelly clay loam, reddish brown (5YR 4/4) moist; 25 percent of horizon consists of pockets of pink (5YR 7/4) gravelly clay loam, reddish brown (5YR 4/4) moist; similar to Bk1 horizon but noneffervescent; weak medium subangular blocky structure; very hard, firm, sticky and plastic; few fine and very fine roots; few very fine and fine tubular and common fine interstitial pores; common moderately thick clay films on peds and common pressure faces; 30 percent gravel; noneffervescent; moderately alkaline (pH 8.0); gradual wavy boundary. (4 to 20 inches thick)

Bk1--45 to 55 inches; pink (5YR 7/3) very gravelly sandy clay loam, yellowish red (5YR 5/6) moist; massive; very hard, firm, slightly sticky and plastic; few fine and very fine roots; few fine tubular and common fine interstitial pores; few pressure faces; 40 percent gravel; slightly effervescent; moderately alkaline (pH 8.0); gradual irregular boundary. (8 to 20 inches thick)

Bk2--55 to 68 inches; light reddish brown (5YR 6/4) extremely gravelly sandy clay loam, reddish brown (5YR 5/4) moist; massive; hard, friable, slightly sticky and plastic; few fine roots; common fine tubular and many interstitial pores; 60 percent gravel; noneffervescent to strongly effervescent; moderately alkaline (pH 8.0).

TYPE LOCATION: Yavapai County, Arizona; about 1 mile NW of the junction of the Rancho Moano and Williamson Valley roads; 1/2 mile west and 3/10 mile north of SE corner of sec. 3, T.15N., R.4W.

RANGE IN CHARACTERISTICS:

Soil moisture: Intermittently moist in some part of the soil moisture control section during July through September and December through March. Driest during May and June. Ustic aridic soil moisture regime.

Mean annual soil temperature: 54 degrees to 59 degrees F.

Thickness of the solum: 18 to 45 inches

Rock fragments: 5 to 35 percent by volume

Organic matter: more than 1 percent

A and upper B horizons
Hue: 5YR through 10YR but are dominantly 7.5YR or 10YR
Texture: A horizon is sandy loam, gravelly sandy loam, gravelly loam or cobbly loam
Reaction: slightly acid to neutral

Bt horizons
Hue: 5YR, 7.5YR
Value: 4 or 5 dry, 3 or 4 moist
Chroma: 3 through 6, dry or moist
Texture: clay loam, clay, gravelly heavy clay loam, gravelly clay
Structure: medium prismatic to weak fine and medium subangular blocky

Bk horizons
Hue: 5YR, 7.5YR, 10YR
Value: 5 through 8 dry
Chroma: 4 through 6, dry or moist
Texture: gravelly clay loam, gravelly sandy loam, gravelly loamy sand
Calcium carbonate: occurs as medium to large pockets but the horizon has less than 15 percent CaC03 equivalent.

COMPETING SERIES: These are the Mags (CO), Padilla (AZ), Servilleta (NM), Silver (NM), and Tobish (UT) series. Chafin soils have less than 5 percent rock fragments and are effervescent throughout the profile. Mags, Padilla and Silver soils have secondary carbonates in the argillic horizon. The Silver series attempts to reflect the effects of soil forming agents unique to the Great Plains. Servilleta and Tobish soils have bedrock at moderate depths.

GEOGRAPHIC SETTING: Lonti soils are on nearly level plains to steep alluvial fans. The soils are formed in old gravelly alluvium from granite, schist, sandstone, limestone, shale and basaltic materials. These soils are at elevations of 4,000 to 5,500 feet in a continental climate with an annual precipitation of 12 to 20 inches. The mean annual air temperature ranges from 52 degrees to 57 degrees F. The frost-free period is 140 to 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Abra, Cordes, Lynx, Pastura and Wineg soils and the competing Balon and Poley soils. Abra, Lynx and Cordes soils lack fine-textured argillic horizons. Pastura soils are shallow to an indurated calcic horizon. Wineg soils have a moderately fine-textured control section and a mollic epipedon.

DRAINAGE AND PERMEABILITY: Well-drained; medium to slow runoff; slow permeability.

USE AND VEGETATION: These soils are used mainly for livestock grazing and wildlife habitat. Small areas are irrigated. Vegetation is oakbrush, deerbrush and squaw bush with an understory of grama grasses, muhly grasses and squirreltail. At higher elevations some pinon pine and juniper occur. At lower elevations the grasses are dominant and include tobosa grass in addition to those mentioned above.

DISTRIBUTION AND EXTENT: Western Yavapai County Area, Yavapai County, Arizona. These soils are extensive. MLRA 38 & 39.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Western Yavapai County Area, Yavapai County, Arizona, 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from 0 to 2 inches (A horizon)

Argillic horizon - The zone from 2 to 45 inches (Bt horizons)

Classified according to Soil Taxonomy, Second Edition, 1999; Keys to Soil Taxonomy, Tenth Edition, 2006.

The mean annual precipitation of 12 to 20" p.z. described in the GEOGRAPHIC SETTING section crosses two moisture regimes - Ustic aridic and Aridic ustic. The soil mapped in the Aridic ustic moisture regime (16 to 20" p.z.) would classify as Aridic Haplustalfs. When Western Yavapai County Area, Yavapai County, Arizona soil survey is updated, this series should be evaluated to decide which moisture regime is typical.

Update and revisions for the competing series section 2/08 DWD

National Cooperative Soil Survey
U.S.A.

Established Series
Rev. DRT-MSY-PDC
11/2006

LYNX SERIES

The Lynx series consists of deep, well drained soils that formed in mixed alluvium. Lynx soils are on flood plains and alluvial fans and have slopes of 0 to 8 percent. The mean annual precipitation is about 12 inches and the mean annual temperature is about 53 degrees F.

TAXONOMIC CLASS: Fine-loamy, mixed, superactive, mesic Cumulic Haplustolls

TYPICAL PEDON: Lynx loam - rangeland. (Colors are for dry soil unless otherwise noted.)

A1--0 to 2 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; moderate medium platy structure parting to moderate fine granular; soft, friable, slightly sticky and slightly plastic; many fine roots; many fine vesicular pores; neutral (pH 7.0); clear wavy boundary. (1 to 6 inches thick)

A2--2 to 14 inches; brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) moist; weak thick platy structure; slightly hard, friable, slightly sticky and plastic; many fine and medium roots; many fine and medium tubular pores; neutral (pH 7.0); clear wavy boundary. (10 to 18 inches thick)

C--14 to 60 inches; dark grayish brown (10YR 4/2) clay loam, very dark brown (10YR 2/2) moist; massive; slightly hard, friable, sticky and plastic; few fine and medium roots; many fine, medium and coarse tubular pores; 10 percent pebbles; common small stress surfaces; slightly alkaline (pH 7.5).

TYPE LOCATION: Yavapai County, Arizona; 250 feet north of the southwest corner, sec. 9, T. 12 N., R. 1 E.

RANGE IN CHARACTERISTICS:

Soil Moisture: Intermittently moist in some part of the soil moisture control section during July-September and December-February. The soil is driest during May and June. Ustic aridic moisture regime.

Rock Fragments: 0 to 15 percent pebbles

Organic Matter: Averages 1 percent or more in the surface; decreases irregularly with depth

Carbonates: Noncalcareous to depths of 40 inches or more

Reaction: Neutral to moderately alkaline

A horizon
Hue: 7.5YR, 10YR
Value: 2 to 5 dry, 3, 4 or 5 moist
Chroma: 2 or 3, dry or moist

C horizon
Hue: 7.5YR, 10YR
Value: 2 to 6 dry, 3, 4 or 5 moist
Chroma: 2, 3 or 4, dry or moist
Texture: Loam, silt loam, clay loam, sandy clay loam
Clay content: 18 to 35 percent

A Bw horizon may be present in some pedons.

COMPETING SERIES: These are the Bon (SD), Frazwell (), Manzano (NM), Maskell (NE), Mauricanyon (CO), Merrick (NE), Pack (UT), Shanta (NM), St. Onge (SD) and Umbarg (CO) series. Bon, Draper, Humbarger, Shanta, St. Onge and Umbarg soils are calcareous throughout. Draper and Pack soils have mottles at depths less than 40 inches. Frazwell soils have a stone line containing 40 to 55 percent rock fragments that overlies buried horizons. Manzano soils have Bw horizons and segregated lime in the lower control section. Maskell, Merrick and Mauricanyon soils are moist in the moisture control section during May and June.

GEOGRAPHIC SETTING: Lynx soils are on flood plains and alluvial fans and have slopes of 0 to 8 percent. These soils formed in alluvium from mixed sources. Elevations range from 3,500 to 6,900 feet. The mean annual precipitation ranges from 10 to 14 inches. The mean annual air temperature is 47 to 59 degrees F. The frost-free period is 120 to 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Abra, Arp, Balon, Deama, Dye, Gaddes, Lonti, Moano, Pastura, Showlow, and Wineg soils. Abra soils have a calcic horizon. Arp, Balon, Gaddes, Showlow, Lonti, and Wineg soils have an argillic horizon. Deama, Dye, and Moano soils have bedrock at depths less than 20 inches. Pastura soils have a petrocalcic horizon at depths less than 20 inches.

DRAINAGE AND PERMEABILITY: Well drained. Slow runoff. Moderately slow permeability.

USE AND VEGETATION: Lynx soils are used for grazing and irrigated cropland. The present vegetation is blue grama, sideoats grama, alkali sacaton, spike muhly, vine mesquite, rabbitbrush, tobosa, big galleta, fourwing saltbush, snakeweed, western wheatgrass, and muttongrass.

DISTRIBUTION AND EXTENT: North-central Arizona. This series is extensive. MLRA is 35, 39 & 61. Use in MLRA 61 should be discontinued.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Beaver Creek Area, Arizona, 1965.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Mollic epipedon: The zone from the surface to a depth of 60 inches (A and C horizons).
The fact that this soil is in a 10 to 14 inch precipitation zone (Ustic aridic) and irrigation is required for cropland, it is doubtful that soil is moist long enough to meet the requirement for a Mollisol. Classification of this soil should be re-evaluated when the area is updated.

Established Series
Rev. JEJ/GEW/YHH
11/2006

MOANO SERIES

The Moano series consists of very shallow and shallow, well drained soils that formed in residuum from phyllite or schist. Moano soils are on gently rolling to steep schist hills. Slopes are 8 to 60 percent. Mean annual precipitation is about 12 inches. Mean annual air temperature is about 53 degrees F.

TAXONOMIC CLASS: Loamy, mixed, superactive, nonacid, mesic Lithic Ustic Torriorthents

TYPICAL PEDON: Moano gravelly loam - grassland (Colors are for dry soil unless otherwise noted).

A--0 to 3 inches; brown (7.5YR 4/4) gravelly loam, dark brown (7.5YR 3/2) moist; moderate very fine and fine granular structure; soft, friable, slightly sticky and slightly plastic; common very fine and fine roots; many fine interstitial pores; noneffervescent; neutral (pH 7.2); clear irregular boundary. (2 to 4 inches thick).

C--3 to 9 inches; brown (7.5YR 4/4) gravelly heavy loam, brown (7.5YR 4/4) moist; massive; slightly hard, friable, slightly sticky and plastic; many fine and medium and few coarse roots; many fine interstitial pores; noneffervescent; moderately alkaline (pH 8.0); clear irregular boundary. (3 to 8 inches thick).

Cr--9 to 14 inches; olive (5Y 4/4) to olive brown (2.5Y 4/4) hard vertically oriented phyllite and schist bedrock with thin tongues of soil material in fractures (soil material is slightly heavier than in the B horizon); common fine roots in fractures; common thin clay coatings on rock faces; noneffervescent; moderately alkaline (pH 8.0); clear irregular boundary. (3 to 8 inches thick).

R--14 to 15 inches; pale yellow (2.5Y 7/4) extremely hard schist bedrock.

TYPE LOCATION: Yavapai County, Arizona. 2/10 mile E. and 1/ 10 mile S. of NW corner of Sec. 23, T12N, R1E, about 1 mile NE of Mayer, Arizona.

RANGE IN CHARACTERISTICS:

Depth to bedrock: 6 to +16 inches but may be 20 inches in some areas, due to variability in hardness of the parent rock.

Reaction: slightly acid to moderately alkaline due to the variability of the parent rock.

Mean annual soil temperature: 52 degrees to 58 degrees F.

Soil moisture: These soils are usually dry especially during the months of May, June, October and November. Ustic aridic moisture regime.

A horizon
Hue: 10YR and 7.5YR
Value: 4 and 5 dry and 3 and 4 moist
Chroma: 2 through 4
Texture: gravelly loam and very gravelly loam
Structure: weak platy to granular

C horizon
Hue: 10YR through 5YR
Value: 4 through 6 dry and 3 and 4 moist
Chroma: 4 through 6
Texture: gravelly loam and gravelly light clay loam Structure: usually massive or rock controlled but may range to weak subangular blocky
Gravel content: 15 to 35 percent by volume
Clay coatings may or may not be present in the C&R horizon.

COMPETING SERIES: This is the Moret (WY) series. Moret soils have a lithic contact of slate-like shale.

GEOGRAPHIC SETTING: The Moano soils are on gently rolling to steep schist hills with slopes ranging from 8 to 60 percent. These soils are formed in place on phyllite or schist bedrock and are at elevations of 4000 to 5500 feet in a semiarid continental climate. The average annual precipitation ranges from 10 to 14 inches and occurs mainly as rain in July, August and September and as rain and some snow in January and February. The mean annual temperature ranges from 50 degrees to 57 degrees F.

GEOGRAPHICALLY ASSOCIATED SOILS: These include the Balon, Dandrea, Lynx and Showlow in addition to the Arp and Barkerville series. Balon soils have an argillic horizon. The Dandrea and Showlow soils are deep, have fine-textured control sections and argillic horizons. Lynx soils are deep and have a mollic epipedon.

DRAINAGE AND PERMEABILITY: Well-drained with medium runoff. Permeability of the soil is moderate.

USE AND VEGETATION: Used entirely as rangeland. Vegetation at higher elevations is oak brush, deerbrush, mountain mahogany, squawbush, manzanita and snakeweed with an understory of sideoats grama, blue grama, squirreltail, tridens, three-awns and annuals. Vegetation at lower elevations is black grama, sideoats grama, three-awns, tridens, squirreltail, snakeweed and annuals.

DISTRIBUTION AND EXTENT: Central Arizona in semiarid regions. The soil is extensive in central Yavapai County. MLRA 39.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Western Yavapai County Area, Yavapai County, Arizona, 1971. Name taken from Rancho Moano in Yavapai County, Arizona.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from 0 to 3 inches (A horizon)

Particle size control section - the zone from 0 to 9 inches (A and C horizons)

Entisol feature - The absence of diagnostic subsurface horizons

Lithic contact - The boundary at 14 inches (2R horizon)

Classification changed from Lithic subgroup to Lithic Ustic subgroup in 2006 to be consistent with the moisture regime.

Classified according to Keys to Soil Taxonomy Tenth Edition, 2006.

TYPE LOCATION: Yavapai County, Arizona; about 1 mile NW of the junction of the Rancho Moano and Williamson Valley roads; 1/2 mile west and 3/10 mile north of SE corner of sec. 3, T.15N., R.4W.

RANGE IN CHARACTERISTICS:

Soil moisture: Intermittently moist in some part of the soil moisture control section during July through September and December through March. Driest during May and June. Ustic aridic soil moisture regime.

Mean annual soil temperature: 54 degrees to 59 degrees F.

Thickness of the solum: 18 to 45 inches

Rock fragments: 5 to 35 percent by volume

Organic matter: more than 1 percent

A and upper B horizons
Hue: 5YR through 10YR but are dominantly 7.5YR or 10YR
Texture: A horizon is sandy loam, gravelly sandy loam, gravelly loam or cobbly loam
Reaction: slightly acid to neutral

Bt horizons
Hue: 5YR, 7.5YR
Value: 4 or 5 dry, 3 or 4 moist
Chroma: 3 through 6, dry or moist
Texture: clay loam, clay, gravelly heavy clay loam, gravelly clay
Structure: medium prismatic to weak fine and medium subangular blocky

Bk horizons
Hue: 5YR, 7.5YR, 10YR
Value: 5 through 8 dry
Chroma: 4 through 6, dry or moist
Texture: gravelly clay loam, gravelly sandy loam, gravelly loamy sand
Calcium carbonate: occurs as medium to large pockets but the horizon has less than 15 percent CaC03 equivalent.

COMPETING SERIES: These are the Mags (CO), Padilla (AZ), Servilleta (NM), Silver (NM), and Tobish (UT) series. Chafin soils have less than 5 percent rock fragments and are effervescent throughout the profile. Mags, Padilla and Silver soils have secondary carbonates in the argillic horizon. The Silver series attempts to reflect the effects of soil forming agents unique to the Great Plains. Servilleta and Tobish soils have bedrock at moderate depths.

GEOGRAPHIC SETTING: Lonti soils are on nearly level plains to steep alluvial fans. The soils are formed in old gravelly alluvium from granite, schist, sandstone, limestone, shale and basaltic materials. These soils are at elevations of 4,000 to 5,500 feet in a continental climate with an annual precipitation of 12 to 20 inches. The mean annual air temperature ranges from 52 degrees to 57 degrees F. The frost-free period is 140 to 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Abra, Cordes, Lynx, Pastura and Wineg soils and the competing Balon and Poley soils. Abra, Lynx and Cordes soils lack fine-textured argillic horizons. Pastura soils are shallow to an indurated calcic horizon. Wineg soils have a moderately fine-textured control section and a mollic epipedon.

DRAINAGE AND PERMEABILITY: Well-drained; medium to slow runoff; slow permeability.

USE AND VEGETATION: These soils are used mainly for livestock grazing and wildlife habitat. Small areas are irrigated. Vegetation is oakbrush, deerbrush and squaw bush with an understory of grama grasses, muhly grasses and squirreltail. At higher elevations some pinon pine and juniper occur. At lower elevations the grasses are dominant and include tobosa grass in addition to those mentioned above.

DISTRIBUTION AND EXTENT: Western Yavapai County Area, Yavapai County, Arizona. These soils are extensive. MLRA 38 & 39.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Western Yavapai County Area, Yavapai County, Arizona, 1971.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from 0 to 2 inches (A horizon)

Argillic horizon - The zone from 2 to 45 inches (Bt horizons)

Classified according to Soil Taxonomy, Second Edition, 1999; Keys to Soil Taxonomy, Tenth Edition, 2006.

The mean annual precipitation of 12 to 20" p.z. described in the GEOGRAPHIC SETTING section crosses two moisture regimes - Ustic aridic and Aridic ustic. The soil mapped in the Aridic ustic moisture regime (16 to 20" p.z.) would classify as Aridic Haplustalfs. When Western Yavapai County Area, Yavapai County, Arizona soil survey is updated, this series should be evaluated to decide which moisture regime is typical.

Update and revisions for the competing series section 2/08 DWD

National Cooperative Soil Survey
U.S.A.

Established Series
Rev. DRT/PDC
04/2007

SPRINGERVILLE SERIES

The Springerville series consists of deep, well drained soils that formed in alluvium from tuff, volcanic breccia and basalt. Springerville soils are on plateaus and mesas and have slopes of 0 to 10 percent. The mean annual precipitation is about 16 inches and the mean annual air temperature is about 51 degrees F.

TAXONOMIC CLASS: Fine, smectitic, mesic Aridic Haplusterts

TYPICAL PEDON: Springerville stony silty clay - woodland. (Colors are for dry soil unless otherwise noted.)

A1--0 to 1 inch; brown (7.5YR 4/2) stony silty clay, dark brown (7.5YR 3/2) moist; strong very fine granular structure; hard, friable, very sticky and very plastic; few fine roots; many fine irregular pores; 25 percent stones; slightly alkaline (pH 7.5); abrupt smooth boundary. (1 to 2 inches thick)

A2--1 to 4 inches; brown (7.5YR 4/2) stony silty clay, dark brown (7.5YR 3/2) moist; strong medium and fine subangular blocky structure parting to moderate fine granular; very hard, firm, very sticky and very plastic; many fine roots; common very fine and fine tubular and irregular pores; 25 percent stones; slightly alkaline (pH 7.6); clear wavy boundary. (3 to 6 inches thick)

Ass1--4 to 9 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium and fine angular blocky and subangular blocky structure; extremely hard, very firm, very sticky and very plastic; many fine roots; few fine and very fine tubular pores; common irregular pores; common medium slickensides; slightly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (5 to 10 inches thick)

Ass2--9 to 15 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; moderate medium and fine angular blocky and subangular blocky structure; extremely hard, very firm, very sticky and very plastic; many fine roots; common fine tubular and irregular pores; common medium slickensides; 10 percent gravel; slightly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (4 to 12 inches thick)

ACss--15 to 25 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; massive; extremely hard, very firm, very sticky and very plastic; many fine and very fine roots; few very fine tubular pores; many medium slickensides; few black concretions; few fine calcium carbonate nodules; slightly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (7 to 15 inches thick)

Css1--25 to 35 inches; brown (7.5YR 4/2) silty clay, dark brown (7.5YR 3/2) moist; massive; extremely hard, very firm, very sticky and very plastic; few fine roots; few pores; many intersecting slickensides; few fine calcium carbonate nodules; few stones; slightly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (6 to 15 inches thick)

Css2--35 to 42 inches; brown (7.5YR 4/2) stony silty clay, dark brown (7.5YR 3/2) moist; massive; extremely hard, very firm, very sticky and very plastic; many intersecting slickensides; common fine calcium carbonate nodules and few soft calcium carbonate accumulations; 25 percent stones; slightly effervescent; slightly alkaline (pH 7.7); abrupt irregular boundary. (3 to 10 inches thick)

2R--42 inches; basalt.

TYPE LOCATION: Yavapai County, Arizona; 50 feet west of the center of U.S. Highway 89 at a point 0.6 miles south of Milepost 350, 14.8 miles south of the junction of U.S. Highway 66 and 89; near the center of section 20, T. 19 N., R. 1 W.

RANGE IN CHARACTERISTICS:

Soil Moisture: Intermittently moist in some part of the soil moisture control section during July-September and December-February. Driest during May and June. Aridic ustic soil moisture regime.

Rock Fragments: 5 to 40 percent gravel, cobble and stones

Soil Temperature: 47 to 59 degrees F.

Organic matter: More than 1 percent in the surface

Cracking: Deep, wide cracks are open more than 210 days cumulative

Reaction: Slightly or moderately alkaline

Depth to bedrock: 40 to 60 inches

A and Ass horizons
Hue: 5YR, 7.5YR, 10YR
Value: 3, 4 or 5 dry, 2, 3 or 4 moist
Chroma: 2, 3 or 4, dry or moist

Css, Bss and Bk horizons
Hue: 5YR, 7.5YR, 10YR
Value: 3, 4 or 5 dry, 2, 3 or 4 moist
Chroma: 2 through 6, dry or moist
Texture: Clay, silty clay, clay loam
Calcium carbonate equivalent: less than 15 percent

COMPETING SERIES: These are the Albers (AZ), Antelopeflat (CO), Arboles (C), Dominquez (CO), Ritoazul (CO), and Sideshow (CO) series. Albers soils are very deep. Antelopeflat have accumulations of gypsum in the profile. Arboles soils formed in parent material derived from shale. Dominquez soils have hue of 5YR or 2.5YR. Ritoazul soils are moderately deep to shale and have accumulations of gypsum in the profile. Sideshow soils are effervescent at 10 inches, contain less than 5 percent calcium carbonates equivalents and do not have 5YR hue.

GEOGRAPHIC SETTING: Springerville soils are on plateaus and mesas and have slopes of 0 to 10 percent. These soils formed in alluvium from tuff, volcanic breccia and basalt. Elevations range from 4,200 to 7,500 feet. The mean annual precipitation ranges from 14 to 18 inches. The mean annual air temperature is 45 to 57 degrees F. The frost-free period is 120 to 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Cabezon, Showlow, Tajo and Thunderbird soils. These soils do not have intersecting slickensides.

DRAINAGE AND PERMEABILITY: Well drained; slow runoff; very slow permeability.

USE AND VEGETATION: Springerville soils are used for livestock grazing, fuelwood production and wildlife habitat. The present vegetation is blue grama, sideoats grama, snakeweed, juniper and pinon pine.

DISTRIBUTION AND EXTENT: Northern Arizona. This series is extensive. MLRAs 35 & 39.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Phoenix, Arizona

SERIES ESTABLISHED: Navajo County (Holbrook - Show Low Area), Arizona; 1961.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

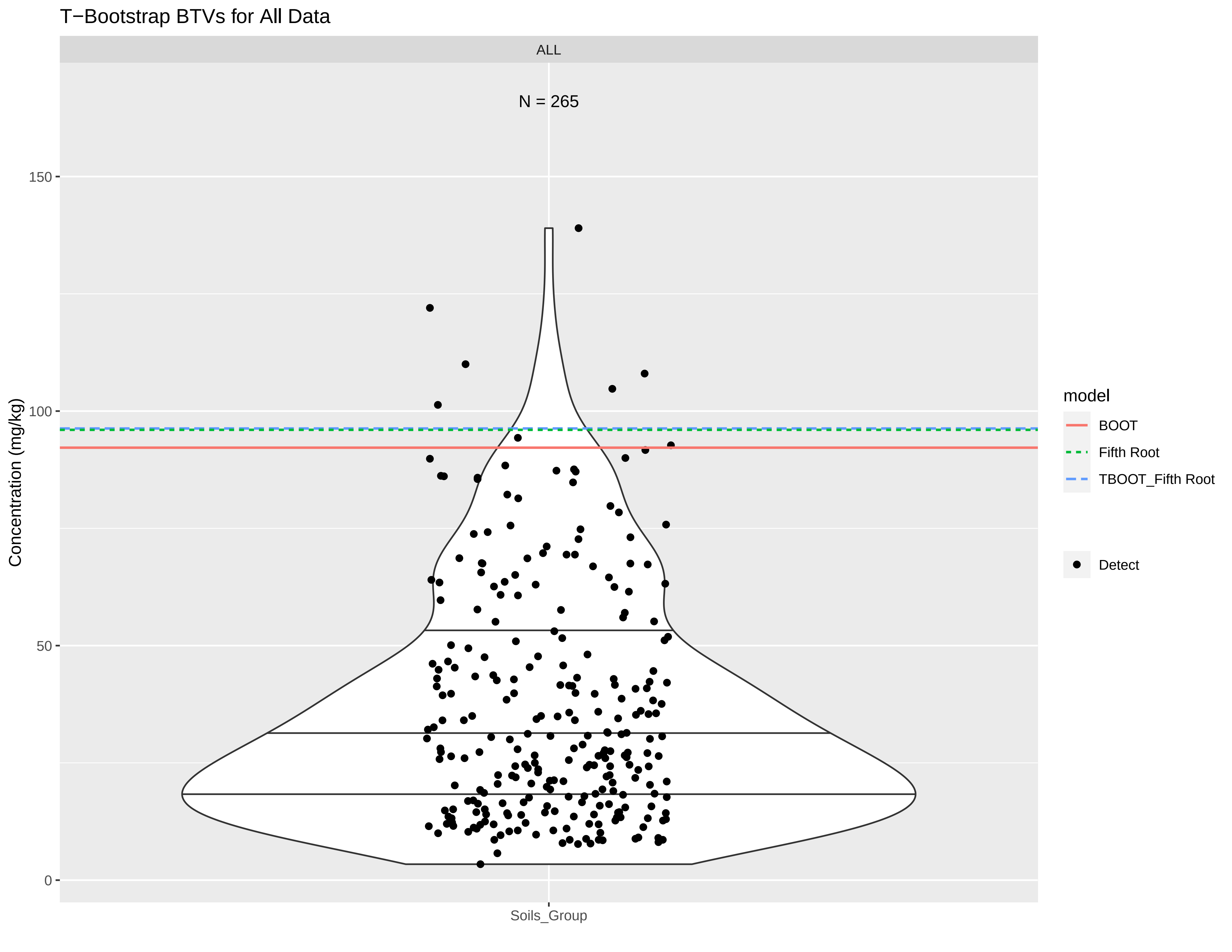
Ochric epipedon - The zone from 0 to 15 inches (A1, A2, Ass1, Ass2 horizons)

Intersecting slickensides - The zone from 25 to 42 inches (Css1, Css2 horizons)

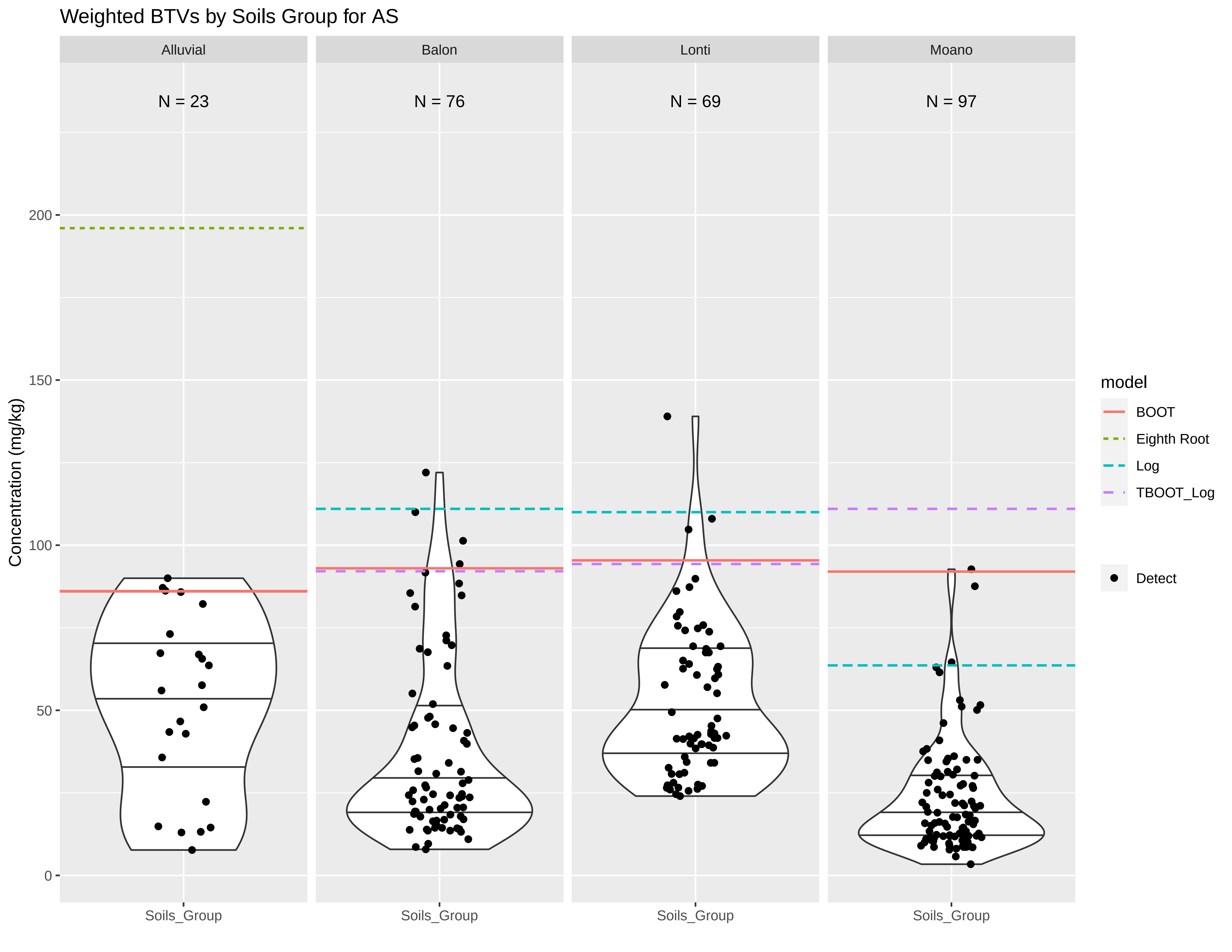
Lithic contact - The boundary at 42 inches (2R horizon)

ATTACHMENT C

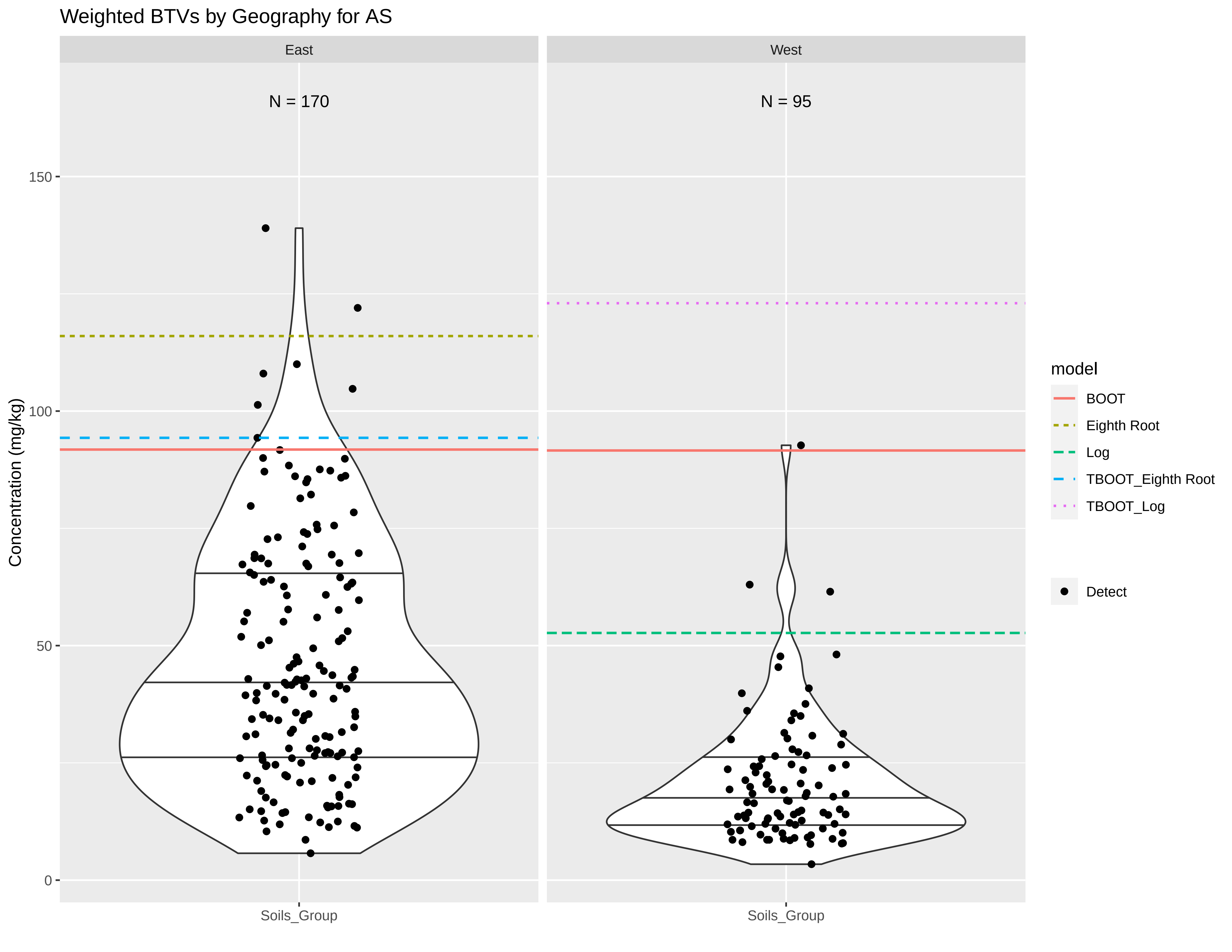
VIOLIN PLOTS OF BACKGROUND SOIL ARSENIC BY SCENARIO



T−Bootstrap BTVs for All Data
ALL
N = 265
150
100
50
0
Concentration (mg/kg)
Soils_Group
model
BOOT
Fifth Root
TBOOT_Fifth Root
Detect

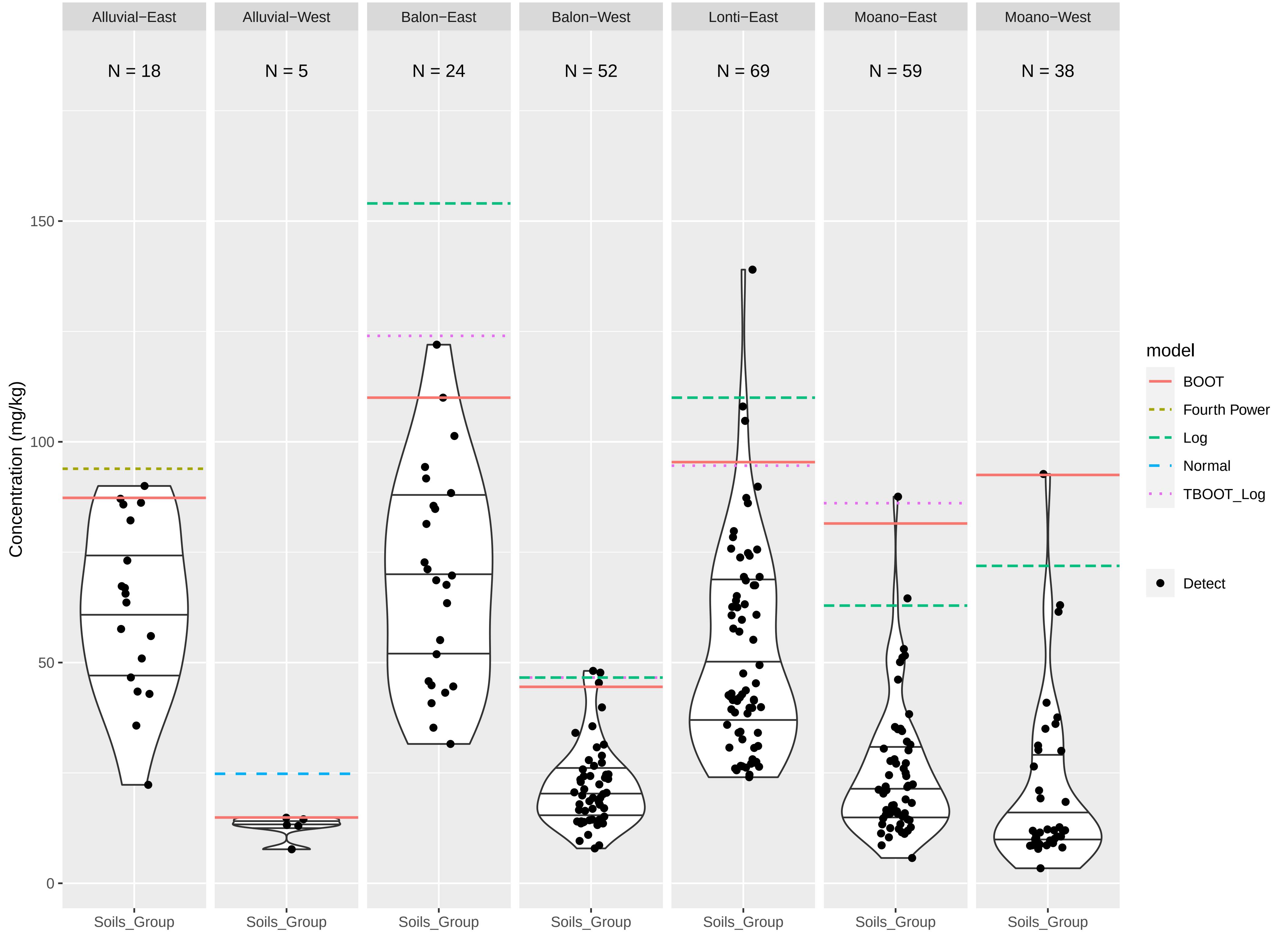


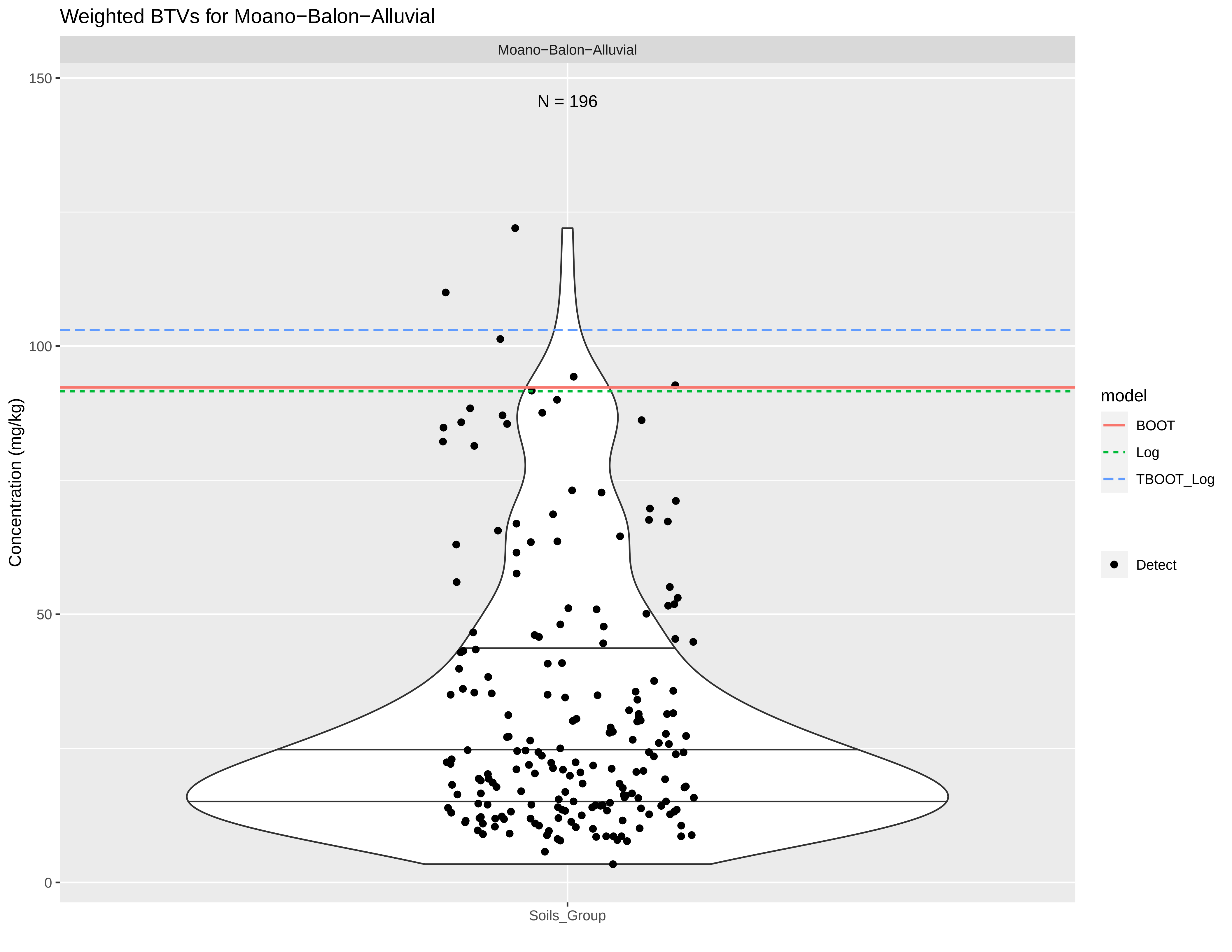
Weighted BTVs by Soils Group for AS
Alluvial
Balon
Lonti
Moano
N = 23
N = 76
N = 69
N = 97
Concentration (mg/kg)
0
50
100
150
200
Soils_Group
Soils_Group
Soils_Group
Soils_Group
model
BOOT
Eighth Root
Log
TBOOT_Log
Detect

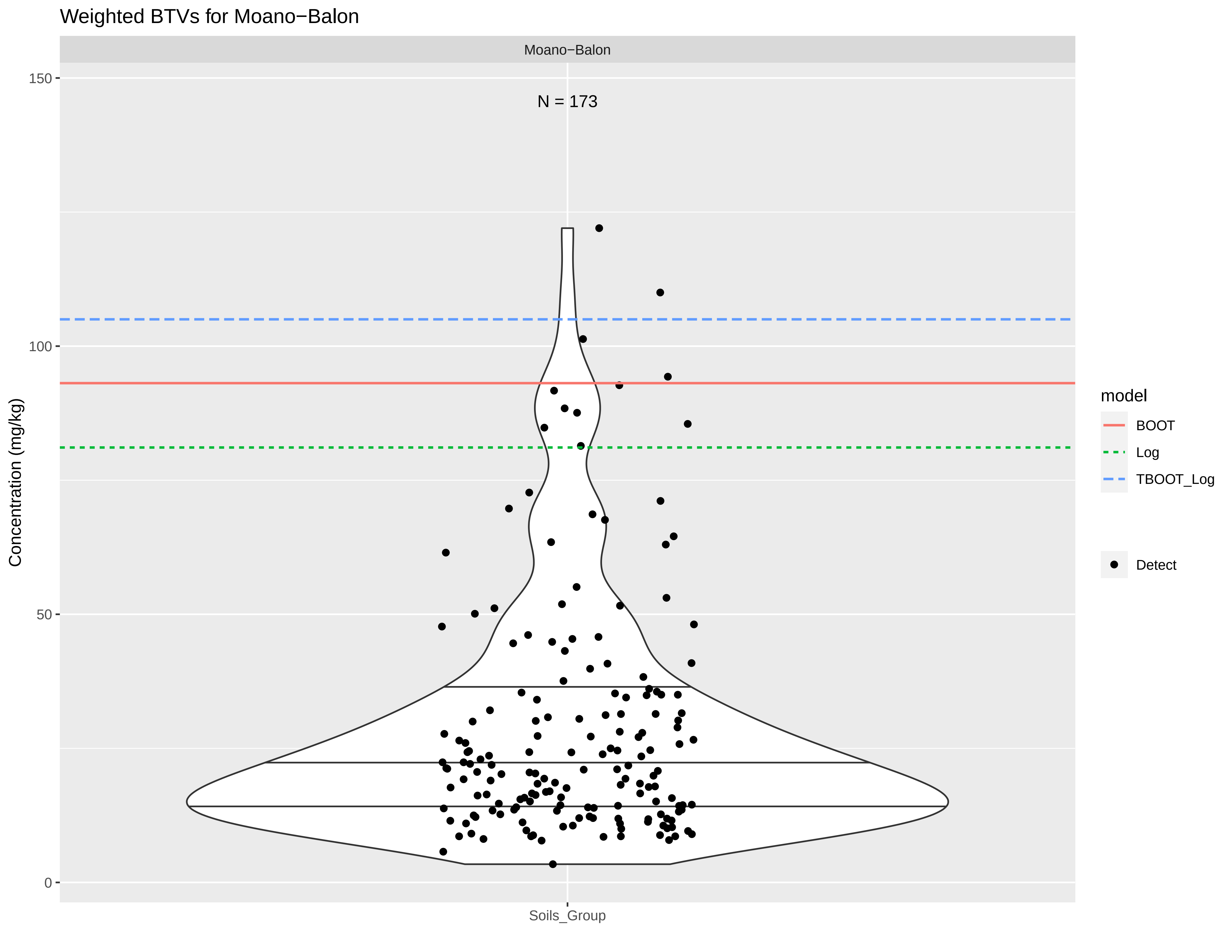


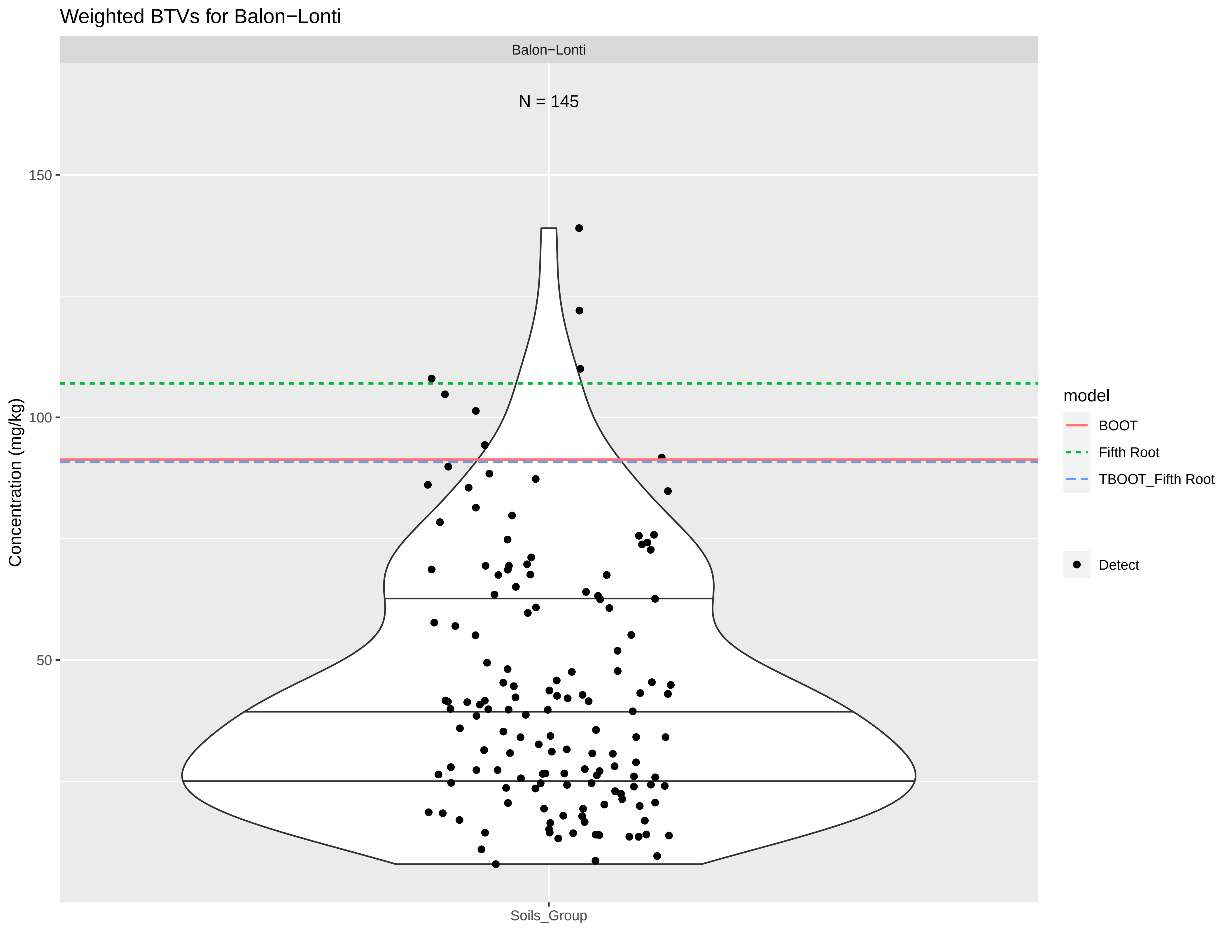
Weighted BTVs by Geography for AS
East
West
N = 170
N = 95
150
100
50
0
Concentration (mg/kg)
Soils_Group
Soils_Group
model
BOOT
Eighth Root
Log
TBOOT_Eighth Root
TBOOT_Log
Detect

Weighted BTVs by Side of River and Soils Group for AS




Weighted BTVs for Moano−Balon−Alluvial
Moano−Balon−Alluvial
N = 196
150
100
50
0
Concentration (mg/kg)
Soils_Group
model
BOOT
Log
TBOOT_Log
Detect


Weighted BTVs for Moano−Balon
Moano−Balon
N = 173
150
100
50
0
Concentration (mg/kg)
Soils_Group
model
BOOT
Log
TBOOT_Log
Detect



Weighted BTVs for Balon−Lonti
Balon−Lonti
N = 145
150
100
50
Concentration (mg/kg)
Soils_Group
model
BOOT
Fifth Root
TBOOT_Fifth Root
Detect