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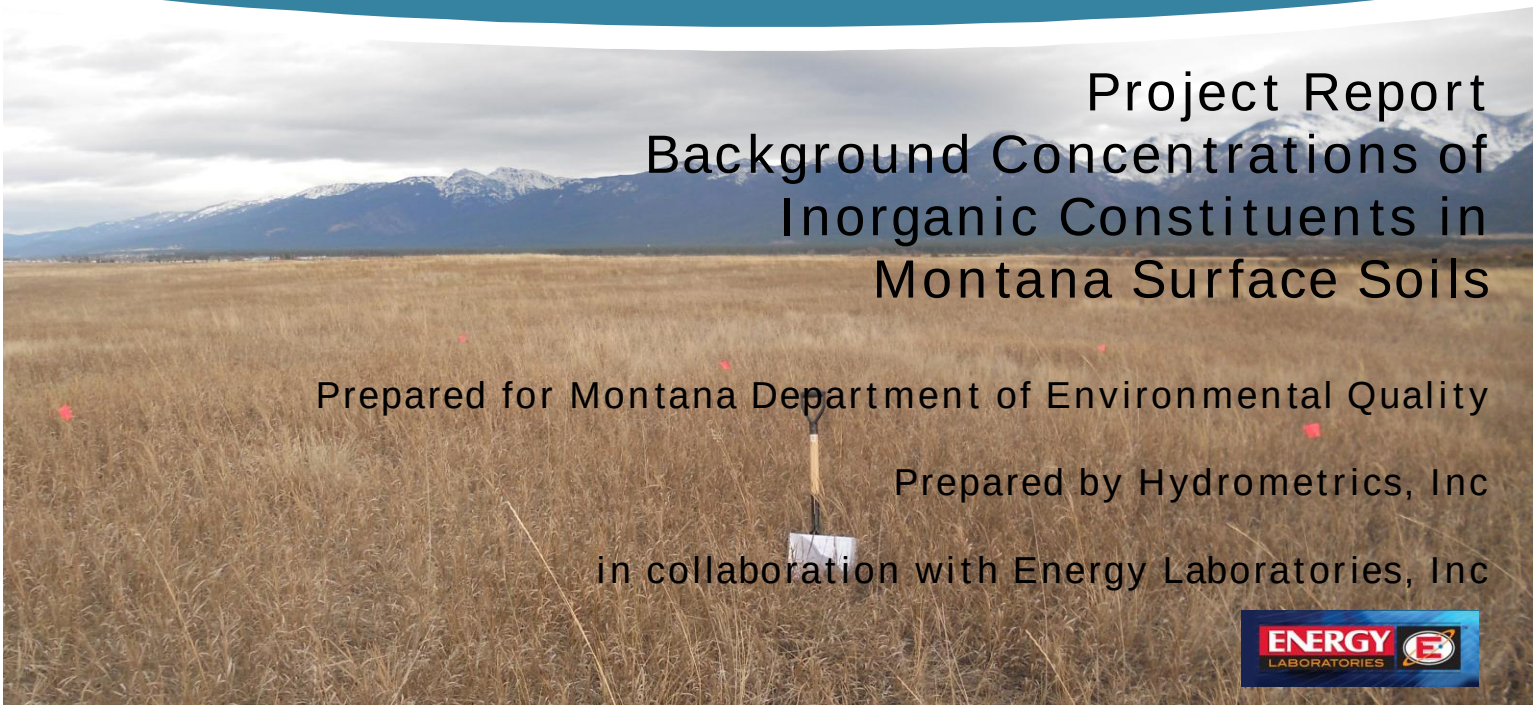
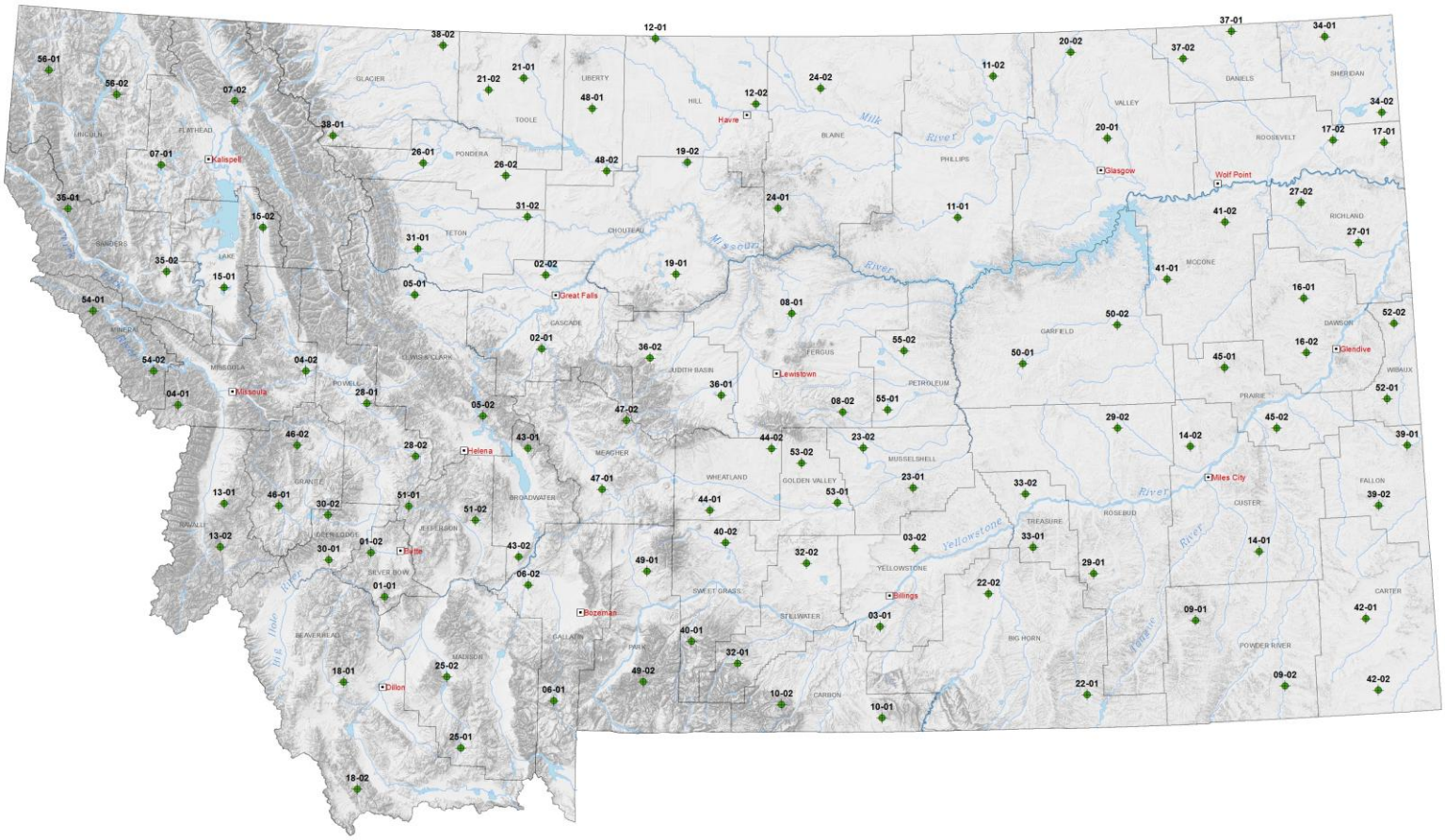


Project Report
Background Concentrations of Inorganic Constituents in Montana Surface Soils

Prepared for Montana Department of Environmental Quality

Prepared by Hydrometrics, Inc

in collaboration with Energy Laboratories, Inc



PROJECT REPORT

BACKGROUND CONCENTRATIONS OF INORGANIC CONSTITUENTS IN MONTANA SURFACE SOILS

Prepared for:

Montana Department of Environmental Quality
Remediation Division/Site Response Section
P.O. Box 200901
Helena, MT 59620-0901

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

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PROJECT REPORT

BACKGROUND CONCENTRATIONS OF INORGANIC CONSTITUENTS IN MONTANA SURFACE SOILS

1.0 INTRODUCTION

This report presents the results of an investigation of background concentrations of inorganic constituents in Montana surface soils implemented in 2012-2013, referred to herein as the Montana Background Soils Investigation (MBSI). As noted in the project Sampling, Analysis, and Quality Assurance Project Plan (SAP/QAPP) (Hydrometrics, 2012), the investigation was designed to address the following objectives:

1. Generate a dataset of background inorganic soil concentrations sufficient to statistically characterize the population of Montana surface soils;
2. Establish statistically valid background threshold values (BTVs) for the constituents of interest; and
3. Evaluate the relationship of bulk soil concentrations to fine-fraction (defined as <250 µm, or the soil fraction passing a 60-mesh sieve) soil concentrations for the constituents of interest.

Project activities were conducted in accordance with the approved SAP/QAPP (Hydrometrics, 2012), and consisted of three phases of work: (1) field investigation; (2) laboratory analysis and data review; and (3) statistical data evaluation. The results of these three work phases are presented in this summary report in the following sections:

- Section 1.1 – Project Background and Description;
- Section 2.0 – Field Sampling Summary;
- Section 3.0 – Summary of Analytical Results;
- Section 4.0 – Statistical Analysis;
- Section 5.0 – Summary and Conclusions; and
- Section 6.0 – References.

1.1 PROJECT BACKGROUND AND DESCRIPTION

Generic background concentrations of inorganic soil constituents that may be applicable to sites in Montana have previously been published by DEQ in a summary table available online (DEQ, 2007). This table includes background concentrations obtained from various statewide, regional, or national studies and investigations, including the frequently-cited work of Shacklette and Boerngen (1984). DEQ recognized the need for more state-specific information on background concentrations of arsenic in soils and established a generic action

level for arsenic in surface soil based on an assessment of "background" or unimpacted soil arsenic concentrations from across Montana (DEQ, 2005). As noted by DEQ in the 2005 paper, arsenic may occur naturally in Montana soils at levels above risk-based concentrations. Based on DEQ's dataset and analysis, the action level for arsenic was set at 40 milligrams/kilogram (mg/kg), compared with the generic EPA regional screening level (RSL) for residential soils of 0.61 mg/kg (EPA, 2013). Investigators in other states have also found that background values of arsenic (and potentially other constituents) may often exceed EPA or state-specific risk-based screening levels. For example, Vosnakis et al. (2009) determined BTVs (based on the 95th percentile of over 1,600 background samples) for arsenic in Kentucky, Maryland, New York, Ohio, Pennsylvania, Virginia, and West Virginia, and found that BTVs routinely exceeded state risk-based screening levels. These results highlight the need for an evaluation of background soil concentrations specific to Montana.

Interest in the utility of low-density (i.e., widely-spaced sampling locations) geochemical characterization of soils has continued since the report of Shacklette and Boerngen (1984), with an additional continental-scale effort recently being conducted by the USGS (Smith et al., 2005). The data obtained by Shacklette and Boerngen (1984) was later reanalyzed by Gustavsson et al. (2001), who determined that geochemical maps based on low-density sample distributions (similar to their dataset) are useful for a variety of purposes, including establishment of "general baselines against which more specific natural geochemical variations and human-induced perturbations can be appraised." As noted by Smith and Reimann (2008), datasets from a variety of locations around the world have shown that low-density geochemical mapping provides robust and reproducible geochemical patterns that may be related to "natural" processes such as climate and weathering. They concluded that such maps are "urgently needed as baseline data for many environmental investigations," as well as to clarify the large-scale processes determining elemental distribution in surface soils. Thus, while site-specific mapping is necessary for mineral exploration or characterization of local-scale contamination, lower density sampling, such as that conducted during the MBSI, has been shown to be an effective tool in the determination of typical background concentrations in soils.

Many states have also conducted their own investigations into appropriate "state-scale" background soil concentrations, using a wide variety of sampling approaches and statistical methods for calculation of "background." Examples of such investigations include Oregon (ODEQ, 2013), Hawaii (Aecom, 2012), Ohio (Cox-Colvin, 1996), New Hampshire (Sanborn, Head & Associates, 1998), Washington (San Juan, 1994), Florida (Chen et al., 1998), and California (Bradford et al., 1996). The USGS recently determined the surface soil arsenic distribution in Wisconsin soils (Stensvold, 2011). As noted in Stensvold (2011), while states have used a variety of statistics to characterize baseline concentrations for cleanup purposes, a lack of data of sufficient quality and quantity in many states prevents rigorous estimation of baseline concentrations. In terms of applicability to potentially contaminated sites, background data collected near a site is usually preferable to a regionally-derived background value, due to natural concentration variations derived from local geology, climate, and land-use patterns (Cox-Colvin, 1996). However, a simple or statistical comparison to regionally-derived background may be appropriate or, in certain cases, even preferable, due to logistical considerations (lack of time or financial resources), access issues, or the lack of unaffected areas for sampling (Cox-Colvin, 1996).

The MBSI was designed to provide a coherent set of data for inorganic parameters in surface soils across the state, with representative samples collected using consistent procedures, analyzed using consistent methods, and distributed geographically to provide complete statewide coverage (see Section 2.3 for more information). The analytical results for these samples have been evaluated to determine statistically valid background surface soil concentrations that may be used in a generic way throughout the state as BTVs for screening potential contamination. This report presents the results of the MBSI, including calculated BTVs.

In addition, the tendency of certain inorganic trace elements to preferentially concentrate in finer size fractions of soils or sediments during natural weathering or other fate and transport processes is well-documented (e.g., Acosta et al., 2011). The partitioning of these elements into fine soil fractions may have implications for human and ecological exposure, since fine particles may be more readily transported, ingested, or inhaled, and bulk concentrations may not accurately capture exposure concentrations (Kim et al., 2011). DEQ typically requires analysis of the fine soil fraction (sieved through a 250 μm No. 60 sieve) for lead at sites where lead is likely to be a contaminant of concern. Therefore, the MBSI also assessed the relationship between bulk and fine fraction inorganic parameter concentrations in Montana background soils.

Constituents of interest for the MBSI included both bulk (unsieved) and fine fraction (60-mesh sieved) concentrations of the following inorganic constituents (element names are followed by their chemical symbol):

- aluminum (Al);
- antimony (Sb);
- arsenic (As);
- barium (Ba);
- beryllium (Be);
- cadmium (Cd);
- chromium (III) (Cr III);
- chromium (VI) (Cr VI);
- cobalt (Co);
- copper (Cu);
- iron (Fe);
- lead (Pb);
- manganese (Mn);
- mercury (Hg) (bulk sample analysis only);
- nickel (Ni);
- selenium (Se);
- silver (Ag);
- thallium (Tl);
- vanadium (V); and
- zinc (Zn).

2.0 FIELD SAMPLING SUMMARY

All MBSI field activities were conducted in accordance with the project SAP/QAPP (Hydrometrics, 2012). A total of 112 background soil samples, 13 field duplicate samples, and 6 equipment rinsate blank samples were collected from October 22 through December 3, 2012.

2.1 SAMPLING PROCEDURES

Detailed soil sampling methods and procedures for the background soil investigation are in the project SAP/QAPP (Hydrometrics, 2012). MBSI surface soil samples were collected as bulk five-point composite samples from the 0-6 inch depth interval. Five surface soil subsamples were collected and combined to provide a single bulk soil sample from each selected background location. A subsample from the bulk soil samples was then sieved by the laboratory for the fine fraction analysis. The soil sampling procedure consisted of the following steps:

1. Establish a center subsample point and mark the location (e.g., with a pin flag).
2. Establish four peripheral subsample locations approximately 20 feet north, 20 feet south, 20 feet east and 20 feet west of the center point, and mark these locations.
3. Remove surface debris (sticks, stones), sod, or other vegetation from each subsample location.
4. Excavate small pits at each of the five subsample location using decontaminated hand tools (shovel, spade, trowel, or similar implements). Place excavated soil in a pile for backfilling.
5. Collect a 0-6 inch grab sample from each pit by scraping material from the pit sidewalls and placing in a ziplock bag prelabeled with the unique sample identification number, date, and time of sample collection. Remove and discard loose vegetation and large rocks by hand during sample collection. Collect approximately equal volumes of soil from each subsample location, to provide a minimum total final composite volume of approximately 0.6 – 1.0 gallons (2 – 4 kilograms [kg]).
6. Thoroughly homogenize the bulk composite sample in the ziplock bag after all five subsamples have been collected.
7. Place the labeled ziplock bag in a second ziplock bag and store soil sample in a cooler with ice to achieve an approximate sample temperature of 4$\pm$ 2°C.
8. Complete field sample collection forms, photograph the sample location, and record GPS coordinates (latitude and longitude in decimal degrees) of the center point.
9. Backfill subsample locations.
10. Decontaminate reusable soil sampling equipment using sequential rinses with (a) non-phosphate detergent and tap water, (b) tap water, and (c) deionized or distilled water.

Unique sample identification numbers assigned to each sample conformed to the following format:

MBSI-XX-AA

where: MBSI = Montana Background Soils Investigation
XX = numeric Montana county code expressed as 2 digits
AA = 01 or 02 (natural samples), 03 (duplicate sample), or 04 (equipment rinsate blank sample).

For example, the two samples from Gallatin County (Montana county code 6) were designated MBSI-06-01 and MBSI-06-02.

Field records were checked for completeness at the end of each day of sampling by the members of the field sampling team, to ensure that all requirements for field activities were fulfilled, complete records were obtained for each field activity, and that the procedures specified in the SAP/QAPP were implemented appropriately.

Samples were handled using standard chain-of-custody protocols, and were stored in iced coolers or refrigerated following collection to maintain a sample temperature of approximately 4 ± 2°C. Samples were hand-delivered to Energy Laboratories in Helena, Montana for analysis, as soon as possible after acquisition. All sample deliveries were accompanied by the following documentation:

- Chain-of-custody form(s);
- Cover letter to the laboratory describing the accompanying samples; and
- Analytical parameter list with methods and required reporting limits (see Table 3-1).

2.2 FIELD QUALITY CONTROL SAMPLES

Field quality control (QC) samples were collected as described in the project SAP/QAPP, including field duplicates and equipment rinsate blanks. As noted above, field QC samples were designated with similar sample ID numbers to routine soil samples, except that the AA identifier was either **03** (for field duplicate samples) or **04** (for equipment rinsate blank samples). Target collection frequency for field duplicate samples for the MBSI project was 10% (1 field duplicate for every 10 natural samples collected), and target equipment rinsate blank sample frequency was 5% (1 rinsate blank for every 20 natural samples collected).

Locations for collection of duplicate samples were selected randomly by field crews, with the stipulation that only one duplicate sample be collected per county. Field duplicates were collected as splits of the regular soil sample. At each duplicate sample location, a double volume of raw sample was collected, mixed and homogenized to obtain one large raw composite, and two separate sample containers were then filled from the single large composite sample.

Equipment rinsate blanks were collected by pouring laboratory-provided reagent-grade (deionized) water over/into decontaminated sampling equipment (shovels, trowels, mixing

bowls), and capturing the rinse water in an appropriate sampling container for analysis of total aqueous concentrations of the parameters listed in Table 3-1. Rinsate blank samples were preserved with nitric acid to pH ≤ 2, and stored on ice in coolers or refrigerated until delivery to the laboratory.

2.3 SAMPLING LOCATIONS

In order to provide complete geographic coverage of the state of Montana, a sampling density of two surface soil samples per county was established for this investigation, or 112 total samples (excluding QC samples). Given the total area of Montana (376,980 square kilometers [km^2]) this corresponds to an approximate sample density of 1 site per 3400 km^2, or 1 site per 1300 square miles [mi^2]. While the selection of two sampling locations per county ensures a reasonable spatial distribution of samples throughout the state, sampling locations were not established using any sort of grid pattern. Random gridded sample locations would likely have needed adjustment due to access (locations of roads, private property issues) or other considerations, so true random sampling locations were not feasible. Instead, this investigation employed a sampling design that involved the selection of samples from a population readily available.

Sampling locations for the MBSI were established on public lands, typically state lands, Bureau of Land Management (BLM) parcels, or National Forest lands. Initial site selection strategy included screening proposed sampling locations against abandoned mine and remediation response site databases using the Montana Natural Resources Information System website[1] to ensure that proposed locations were not within close proximity (½-mile) of these known potential disturbances. However, it was not DEQ's intent to avoid all anthropogenic sources, but rather to obtain samples that reasonably represent conditions that may exist throughout the state. Sampling crews were allowed flexibility in determining exact sampling locations, depending on conditions encountered in the field. All field sampling conformed to the following procedures during sample collection:

- No samples were collected from any landscapes or landforms that did not appear natural or from excessively disturbed ground;
- No samples were collected where staining or other visual or olfactory evidence of contamination was present; and
- Sampling locations were located greater than 200 feet from major highways, and greater than 100 feet from structures or rural roads.

The 112 sampling locations visited during the background soils investigation are shown on Figure 2-1 and summarized in Table 2-1. Locations are based on GPS coordinates collected by field crews during sampling activities. Table 2-1 also indicates sampling dates for each location, and denotes locations where field duplicate samples were collected.

Completed field sampling forms and photo documentation forms for all sampling locations are provided in Appendix A. Field sampling forms include descriptive locations, site sketches, soil descriptions, dates and times of sampling, sampling personnel, GPS

[1] http://maps2.nris.mt.gov/mapper/.%5C

coordinates, and other relevant information. Associated photo documentation forms generally show the sampling location and surrounding landscape.

2.4 SAMPLING DEVIATIONS

Several minor deviations from the field sampling protocol outlined in the SAP/QAPP were implemented during the MBSI field work, as follows:

1. Sampling documentation was completed on project-specific field sampling forms, rather than on both field sampling forms and in project log books. Since multiple field crews were utilized to complete the sampling effort, use of the field sampling forms allowed for systematic collection of field information in a consistent format by sampling personnel.
2. Subsamples from individual soil pits were composited directly in ziplock bags by field personnel, rather than compositing in a mixing bowl and then transferring to ziplock bags. This modification reduced the amount of decontamination necessary between sampling sites (since the mixing bowl was removed from the process), and proved to be a more efficient method of collection and homogenization.
3. At a few locations, slight adjustments in sampling locations were necessary due to access issues or other field conditions such as active cropping of state land parcels. In these cases, sampling locations were generally moved to nearby similar public land parcels. Alternate locations were noted on field log forms.

None of these minor deviations had any effect on the completion of MBSI field activities or the collection of representative background soil samples.

3.0 SUMMARY OF ANALYTICAL RESULTS

3.1 LABORATORY ANALYSIS

All samples were submitted to and analyzed by Energy Laboratories in Helena, Montana. Upon arrival at the laboratory, soil samples were air dried so that concentrations could be reported on a dry-weight basis. An aliquot of soil was then removed for mercury analysis. The remaining soil was processed for analysis by further drying, homogenization, and disaggregation. A representative aliquot of the bulk sample was sieved through a 60-mesh (250 micrometers [µm]) sieve, with the portion passing through the sieve retained for analysis of the fine fraction. A representative aliquot of the bulk sample (unsieved) was also obtained for analysis. Therefore, each soil sample was analyzed for both bulk and fine fraction concentrations of all target parameters except mercury (analyzed on the bulk fraction only due to the potential for volatilization losses during sieving).

Laboratory analysis consisted of determination of total concentrations of the parameters listed in Table 3-1, using appropriate digestion procedures. All laboratory analysis was conducted in accordance with the Energy Laboratories' approved laboratory quality assurance plan. Requested project reporting limits and analytical methods used for individual constituents are also presented in Table 3-1. Low-level reporting limits were requested for many constituents, in order to minimize (to the extent possible) the reporting of metals as not detected.

3.2 BACKGROUND SOIL CONCENTRATIONS

Analytical results for all soil samples collected as part of the MBSI (including field duplicate samples) are summarized in Table 3-2. Both bulk and fine fraction (<250 µm) results are presented. Original laboratory reports for MBSI samples are provided in Appendix B.

The statewide spatial distribution of constituents analyzed as part of the MBSI is presented on the sequence of figures provided in Appendix C, for both bulk samples and fine fraction samples (Figures C-1 through C-20). For each parameter, results are represented by a symbol proportional in size to the concentration observed. Sample-duplicate pair results are also shown on the Appendix C maps for each parameter.

3.3 DATA VALIDATION SUMMARY

Overall completeness, adherence to project procedures, and data quality of the information collected during the MBSI was assessed through a program of validation and verification. As described in the project SAP/QAPP (Hydrometrics, 2012), verification includes confirmation of adherence to sample design, collection, handling, custody, shipping, transmittal, and documentation procedures, while validation includes the confirmation of adherence to specific analytical procedure criteria and protocols, and the assessment of data quality in terms of usability.

Data validation for the MBSI project was conducted by Hydrometrics in accordance with the SAP/QAPP, the principles of the USEPA national functional guidelines for inorganic data

review (EPA, 2010), and DEQ's data validation guidelines (DEQ, 2010). Data assessment criteria were used to aid in the evaluation of overall data quality for data generated during the MBSI, including evaluation of the data quality indicators (DQIs) precision, accuracy, representativeness, completeness, and comparability. The details of the MBSI data verification and validation process are presented in the project Data Validation Report, included in Appendix D. A brief summary of data validation results is presented below.

- Precision – 95% of all field duplicate parameters met target relative percent difference (RPD) control limits, with 15 of 286 total analyses exceeding limits. In addition, 97% of all laboratory sieve duplicates met target RPD limits, with 7 out of 247 total analyses exceeding limits. For laboratory matrix spike/matrix spike duplicates, >99.9% of samples met RPD targets (only 1 MS/MSD pair exceeded control limits).
- Accuracy – No parameters were detected in field or laboratory blanks at concentrations that could significantly affect results. Laboratory control sample (LCS) results associated with reported sample results were all within control limits, with the exception of one lead result and one nickel result. MS/MSD percent recoveries showed some minor control limit exceedances. Antimony recoveries were consistently low, as expected based on the sample digestion matrix. The analytical laboratory (Energy Laboratories) notes that antimony recoveries in a solid matrix which has undergone an EPA Method 3050 digestion may be biased low due to solubility limitations addressed within the analytical method. These recovery issues are not associated with the MBSI project specifically, but are generally observed in solid matrix samples digested using this procedure.
- Sample collection, handling, and analytical procedures for the MBSI were designed to maximize the representativeness of both sample collection and analytical results, within the fiscal, logistical, and practical constraints typically encountered during environmental investigations. Collection of representative samples of Montana surface soils was achieved by:
    - Establishment of appropriate general sampling locations;
    - Collection of five-point composite samples using standardized, consistent, and fully-documented procedures; and
    - Providing flexibility in designating specific sampling locations, to allow field crews and project managers to adjust sampling locations if necessary to avoid areas of known or suspected soil contamination.
- Comparability of MBSI data was ensured by adherence to standard and fully-documented sample collection procedures, standard laboratory analysis and EPA-approved reporting methods, including consistent units, and the use of the same analytical laboratory.
- Project and data completeness for the MBSI project is 100%, since all planned samples were collected, all samples were analyzed for the intended parameter suite, and no data were rejected as unusable.

Data associated with quality control sample exceedances were qualified as described in the Data Validation Report (Appendix D). Quality control issues resulting in data qualification including the following:

- Fifteen field duplicate RPD exceedances (RPD>35%), indicating potential lack of precision in associated results;
- Seven laboratory sieve duplicate RPD exceedances (RPS>35%), indicating potential lack of precision in associated results;
- Consistently low matrix spike/matrix spike duplicate percent recoveries for antimony, indicating potential low bias in associated results; and
- Two high laboratory control samples (LCS) percent recoveries, one for lead and one for nickel, indicating potential high bias in associated results.

In the judgment of the data reviewers, the qualified data may be used without restriction, since no systematic quality control deficiencies (with the exception of consistently low antimony recoveries and the associated potential low bias discussed above) were encountered.

4.0 STATISTICAL ANALYSIS

The overall objective of the MBSI project was to collect a set of statewide soil samples using consistent field procedures, to be analyzed using consistent laboratory methods, ultimately providing a high quality set of inorganic constituent data that could then be statistically analyzed to determine appropriate statewide background (unimpacted or ambient) concentration levels for use in screening potentially contaminated sites. As noted in the project SAP/QAPP (Hydrometrics, 2012), EPA's ProUCL software was proposed as the primary tool to be used for statistical analysis of the validated data set, to be supplemented by additional statistical software as necessary. ProUCL (version 5.0.00) includes methods for assessing data distributions and calculating BTVs, and also allows for robust treatment of nondetects by extrapolating estimated values for nondetects using regression on order statistics or Kaplan-Meier methods.

ProUCL provides a number of options for calculating BTVs to be used in site vs. background comparisons, including upper percentiles, upper prediction limits (UPLs), and upper tolerance limits (UTLs). All of these methods yield concentration thresholds that can be expected to be exceeded only rarely by individual samples from other locations that are obtained from the same population. However, there is no generally accepted "best" method for determining a BTV, and a survey of policies in other states shows that a wide range of methods have been applied. For example, Washington has long used the 90th percentile of the background data set as a background threshold (San Juan, 1994), while New York uses the 98th percentile for rural soils (NYDEC/NYDH, 2006), and Oregon recently published background values based on the 95% UPL (ODEQ, 2013). Hawaii (Aecom, 2012) used a somewhat more subjective approach of inspecting probability plot inflection points, univariate plots, and outliers to determine background concentrations.

This section of the project report discusses the data assessment and calculation of BTVs for each parameter. Summary descriptive statistics are presented, followed by a statistical comparison of bulk and fine fraction concentrations. Finally, BTVs and associated calculation methods are described and summarized.

4.1 SUMMARY STATISTICS

Summary statistics for the MBSI data set are shown in Table 4-1, including the number and percentage of nondetects, median and mean concentrations, and the minimum and maximum values observed. Separate statistics are presented for the bulk and fine soil fractions for all parameters except mercury (which was analyzed on the bulk fraction only). For the purpose of calculating basic descriptive statistics, field sample-duplicate pair results were reduced to a single value for each constituent by retaining the higher of the two values. In addition, mean concentrations were calculated by replacing nondetect results with the detection limit.

As shown in Table 4-1, the majority of the inorganic constituents analyzed as part of the background soils investigation were present at detectable concentrations in all samples (0% nondetects). Two parameters were reported as below detection limits in almost all samples, including hexavalent chromium (Cr (VI)), with 98 out of 112 results in the bulk fraction

(88%) and 100% of the fine fraction results reported as <0.29 mg/kg, and mercury, with 111 out of 112 results (99%) reported as <0.05 mg/kg. Other parameters reported with nondetect results included antimony (21% nondetect in bulk samples, 31% nondetect in fine fraction samples), cadmium (13% nondetect in bulk samples, 9% nondetect in fine fraction samples), selenium (21% nondetect in bulk samples, 15% nondetect in fine fraction samples), and silver (74% nondetect in bulk samples, 61% nondetect in fine fraction samples) (Table 4-1). One chromium (III) result was reported at <5 mg/kg. Parameters reported with significant fractions of nondetect values all exhibited low absolute concentrations, with median values <0.5 mg/kg (Table 4-1).

An assessment of how the MBSI concentrations compare with regional background values provided in a previous regional study is in Table 4-2, which compares the mean concentrations of constituents obtained from bulk fraction samples during this study with the mean for Western U.S. soils presented by the USGS (Shacklette and Boerngen (1984)). The similarities in average concentrations of these two disparate data sets are notable, with the MBSI and USGS values agreeing closely for many constituents (Table 4-2). The general agreement of the MBSI and USGS data sets in terms of mean concentrations suggests that MBSI samples are not dissimilar from the samples evaluated by Shacklette and Boerngen (1984), which have frequently been used as generic regional "background" benchmarks.

4.2 BULK AND FINE FRACTION COMPARISON

A statistical comparison between bulk and fine fraction soil results to determine whether constituent concentrations tended to be higher in one fraction or the other was conducted on the MBSI soil data set using the nonparametric matched-pair sign test at a 95% confidence level, as described in Helsel and Hirsch (2002). The sign test is a fully nonparametric test that determines whether one variable is generally different from (larger or smaller than) another variable, regardless of the distribution of the differences. In this case, the sign test was used to determine whether the concentrations of constituents in bulk soil samples were significantly different from concentrations in associated fine fraction soil samples, for the MBSI data set as a whole.

The sign test results are summarized in Table 4-3. Sign test statistical calculations were conducted as outlined in detail in Helsel and Hirsch (2002), using Microsoft Excel® and Statistica® software from Statsoft. For each constituent, the difference between bulk and fine concentrations (bulk – fine) was calculated, and the total number of positive and negative differences for the whole MBSI data set was calculated. Tied values (difference of 0) were ignored, and, as with the calculation of summary statistics, nondetects were replaced with the detection limit. In order to ensure direct comparison of bulk results with associated fine fraction results (i.e., bulk and fine fraction results obtained from the same physical sample), field duplicate pair results were not reduced to a single value by retaining the higher of the two values. Field duplicate sample results were not evaluated as part of the bulk/fine fraction comparison, to avoid biasing the overall data set comparison toward those locations where duplicate samples were collected.

Using a large-sample normal approximation appropriate for sample sizes greater than 20 (Helsel and Hirsch, 2002), a Z-value for the sign test was determined based on the relative

number of positive differences (S statistic) observed (see Table 4-3). The p-value for the test was then determined from the associated Z-value using the standard normal distribution. For a test at the 95% confidence level (α=0.05), the test result is significant if the p-value is less than 0.05. The "direction" of the significant difference is determined by the Z-value; if the Z-value is positive and p is <0.05, then significantly more positive than negative bulk-fine differences were observed, and bulk concentrations can be considered significantly greater than fine fraction concentrations. Conversely, if the Z-value is negative and p is <0.05, then significantly more negative than positive bulk-fine differences were observed, and fine fraction concentrations can be considered significantly greater than bulk concentrations. If the p-value is >0.05, no significant difference between bulk and fine concentrations is indicated by the sign test.

As shown in Table 4-3, the majority of MBSI constituents showed either no significant difference in bulk and fine fraction concentrations (arsenic, iron, manganese, nickel, selenium, thallium, and vanadium) or significantly higher fine fraction concentrations (aluminum, barium, beryllium, cadmium, chromium, chromium (III), copper, lead, zinc). Two parameters (antimony and cobalt) showed significantly higher bulk fraction concentrations, according to the sign test results. The sign test was not conducted for chromium (VI) (all fine fraction results were below detection limits), mercury (only bulk concentrations were determined) or silver (the high proportion of nondetects and reporting at multiple detection limits precluded meaningful statistical analysis using the sign test).

The results of the bulk-fine fraction statistical comparison in Table 4-3 are depicted visually by the set of boxplots included in Appendix E. The boxplots show the distribution of bulk and fine fraction sample data obtained during the MBSI in a side-by-side comparison, along with an additional boxplot showing the distribution of the differences in bulk and fine concentrations (i.e., the distribution of [bulk – fine] values for the entire data set). For example, the Appendix E boxplots for a constituent showing no significant difference between bulk and fine concentrations (arsenic) shows a generally similar distributional shape for both the bulk and fine fraction data sets, with very similar median concentrations for both. The boxplot of [bulk – fine] differences for arsenic shows that the median difference is very close to zero. In contrast, the Appendix E boxplots for a parameter such as zinc, which did show a significant difference in bulk and fine fraction concentrations, present a slightly different picture. While the shape of the data distributions for bulk and fine fraction zinc are similar, the medians are offset slightly, with the fine fraction median higher than the bulk fraction median. This difference is also reflected in the boxplot of [bulk – fine] results for zinc (Appendix E), showing a median difference less than zero (near -10), reflecting the statistically significant difference in bulk and fine fraction zinc concentrations.

It should be noted that the statistical test results summarized in Table 4-3 do not necessarily reflect the magnitude of the difference between bulk and fine fraction soil concentrations, only the fact that one fraction tends to yield higher or lower concentrations than the other. As shown in Table 4-3, some of the parameters exhibiting statistically significant differences in concentration nevertheless have similar median concentrations. Lead, for example, shows a statistically significant difference in concentrations, with fine fraction concentrations higher than bulk fraction concentrations based on the sign test results; however, the median

concentration of lead in bulk samples (14.5 mg/kg) is very similar to the median concentration of lead in fine fraction samples (15 mg/kg). The significant sign test results only indicate the "consistency" of the differences (whether they tend to be positive or negative more frequently than expected by chance), and give no indication of the magnitude of the differences.

Given the results of the background sample sign test, the prevalence of constituents for which fine fraction concentrations are either equivalent to or significantly greater than bulk fraction concentrations, and since fine particles may be more readily transported, ingested, or inhaled and bulk concentrations may not accurately capture exposure concentrations, the resulting background values are based on the fine soil fraction (<250 µm or 60-mesh sieved). To directly compare to the BTVs, use the fine soil fraction of soil samples collected from a site. The exception to this practice is mercury, which is based on bulk fraction samples only to prevent potential volatilization losses during sample processing.

4.3 CALCULATION OF BACKGROUND THRESHOLD VALUES

ProUCL software, developed under EPA supervision, is a commonly used tool for (among other applications) estimating environmental parameters of interest such as BTVs (Singh and Singh, 2013). BTVs may be described as a concentration level defining an upper limit of expected background concentrations; thus, samples exhibiting concentrations greater than a BTV are "greater than background" and may indicate potential contamination. Methods for calculating appropriate BTVs in ProUCL include various parametric and nonparametric UPLs and UTLs, along with upper percentiles (such as the 90^{th} or 95^{th} percentile). Procedures for calculating BTVs in ProUCL are generally based on the observed data distribution.

The ProUCL guidance also emphasizes the importance of addressing potential "outliers" in background data sets prior to calculation of BTVs. For the MBSI, the sample collection effort was designed and implemented specifically to target background (uncontaminated) areas. Therefore, while a range of parameter concentrations were obtained during the MBSI sampling effort, the results of the data quality analysis (Section 3.3) and comparison of MBSI average concentrations with the regional averages reported by Shacklette and Boerngen (1984) (Table 4-2) suggest that the MBSI data set is representative of a statewide range of background concentrations, with data variability due to natural variation in background rather than inclusion of any "contaminated" samples. There were no reasons for any samples to be deemed unrepresentative of background conditions; therefore, no formal outlier testing was conducted as part of the data analysis.

As noted above, based on the statistical comparison of bulk and fine fraction samples, the MBSI data evaluation and calculation of BTVs is based on results for the fine soil fraction (<250 µm). For the purposes of BTV calculation, field sample-duplicate pair results were reduced to a single value for each constituent by retaining the higher of the two values.

Initial assessment of the MBSI background inorganic data set using ProUCL indicated a mixture of data distributions for various constituents (normal, lognormal, gamma, and no distribution indicated). In addition, initial calculations showed that differences between the

most common BTV calculation methods (UPLs and UTLs) and between parametric and nonparametric methods were generally minimal. Given the desire for a relatively conservative BTV to be used as an initial screening level, the variety of data distributions observed, and the familiarity and common application of ProUCL software to determination of background values, the ProUCL UTL with 95% confidence and 90% coverage (referred to as a UTL 95/90) was selected as the method for calculating Montana statewide BTVs based on the MBSI dataset. As described in Singh and Singh (2013), the UTL 95/90 simply represents an upper 95% confidence limit on the 90th percentile; that is, the UTL 95/90 is a value that should be greater than 90% of the data from a given distribution 95% of the time, when samples are drawn from the same population. In order to match the calculated UTL 95/90 with the observed characteristics of the data for a particular constituent, the following procedure was used for parameters with no nondetects:

1. Test data distribution in ProUCL;
2. If normal, lognormal, or gamma distribution is indicated, calculate UTL 95/90 based on the observed distribution; and
3. If no distribution is indicated, calculate UTL 95/90 using nonparametric bootstrap method.

For parameters including nondetects, the UTL 95/90 was calculated using the Kaplan-Meier method for as described in Singh and Singh (2013).

As a check on the reasonableness of the UTL 95/90 calculated using ProUCL, an alternative method developed by the British Geological Survey (BGS) was also applied to the MBSI data set to provide a comparative analysis. The BGS method (Cave et al. 2012) utilizes a systematic approach outlined in a methodology flow diagram to address the question "what is the highest concentration of contaminant in this domain that is likely to come from normal background?" In summary, the BGS method consists of the following steps:

1. The distribution of the constituent is characterized using histograms and summary statistics (skewness coefficient and octile skewness coefficient) to determine whether the distribution is Gaussian (normal) and whether outliers are present;
2. If the distribution is not Gaussian, data are transformed in an attempt to produce a Gaussian distribution, using either a natural logarithm transformation or a Box-Cox transformation; and
3. The normal background concentration (NBC) is set by the BGS as the upper 95% confidence limit of the 95th percentile of the distribution.

The BGS calculations are carried out using scripts developed in the R programming language (R Development Core Team, 2011) that are available from the BGS project website[2]. For the purposes of the comparative analysis with the ProUCL UTL 95/90 (an upper 95% confidence limit on the 90th percentile), the BGS script was modified slightly to highlight the same statistic (upper 95% confidence limit on the 90th percentile) as the "normal background concentration." Since the BGS method does not include robust procedures for handling

[2] (http://www.bgs.ac.uk/gbase/NBCDefraProject.html)

nondetect data, the comparative BGS background calculations were not conducted for MBSI constituents that included nondetects.

A summary of the Montana BTVs obtained using ProUCL applied to the fine fraction results for the MBSI samples is in Table 4-4. Table 4-4 also shows the normal background concentrations (NBCs) obtained using the BGS comparative method, along with EPA Regional Screening Levels (RSLs) for soil. Supporting materials for the information presented in Table 4-4 are in Appendices F, G, and H. Appendix F contains the ProUCL software output for goodness-of-fit distribution testing and BTV calculations for each of the constituents tested. Appendix G contains the BGS method output. Appendix H includes figures for each tested constituent showing (a) the actual MBSI data points, ranked from lowest to highest concentration, (b) the calculated ProUCL BTV, and (c) the calculated BGS method NBC for comparison.

For two constituents (chromium (VI) and mercury), BTVs were not calculated using ProUCL (Table 4-4). All fine fraction concentrations for chromium (VI) were below the laboratory reporting limit (<0.29 mg/kg). Mercury was analyzed on bulk samples only, and all values except one (0.068 mg/kg) were below the laboratory reporting limit (<0.05 mg/kg). Low concentrations of chromium (VI) were reported in 13 out of the 112 bulk samples analyzed (12%), ranging from 0.32 to 1.2 mg/kg. The infrequent presence of chromium (VI) in bulk background soil samples, and its complete absence in background fine fraction samples, suggests that, in the absence of known potential chromium (VI) sources at a site, total chromium can be considered equivalent to chromium (III). For mercury, the reporting limit used during this study (0.05 mg/kg) can be considered a maximum background concentration.

The results in Table 4-4 show the mixture of data distributions exhibited by various fine fraction constituents in the MBSI data set. Aluminum and cobalt are normally distributed, barium, chromium, chromium (III), lead, nickel, thallium, and vanadium are lognormally distributed, manganese fits a gamma distribution, and arsenic, beryllium, copper, iron, and zinc showed no discernible distribution. Antimony, cadmium, selenium, and silver distributions were not tested; since these parameters included nondetects (at several different reporting limits, in the case of silver), Kaplan-Meier nonparametric methods were used to calculate the UTL 95/90. Based on the ProUCL distribution testing results, BTVs for constituents with no nondetects (UTL 95/90) were calculated for each constituent using either normal, lognormal, gamma, or nonparametric bootstrap methods.

Overall, the Montana statewide BTVs generated using ProUCL calculation of the UTL 95/90 in Table 4-4 show good agreement with the comparative values generated using the BGS method, with the two results generally within ±10% of one another, and in many cases significantly less. The similarity of the ProUCL and BGS background values, and their relationship to the distribution of the constituent data sets as a whole, are shown on the plots in Appendix H. The Appendix H data and BTV plots indicate that the calculated BTVs are within the upper tail of the observed background data distribution, as intended; therefore, the majority of future samples collected using similar methods from background (i.e., uncontaminated) locations may be expected to exhibit concentrations lower than the BTV.

The results in Table 4-4 and Appendices F, G, and H suggest that the calculated background values are reasonable upper boundaries on expected background inorganic concentrations in Montana.

5.0 SUMMARY AND CONCLUSIONS

1. Background soil samples from across the state of Montana (two samples from each of the 56 Montana counties) were collected in 2012, in accordance with the procedures outlined in the project SAP/QAPP (Hydrometrics 2012), to provide a uniform data set for calculation of Montana-specific background soil concentrations (the Montana Background Soil Investigation or MBSI). All planned samples were collected and analyzed using consistent field and laboratory procedures. Total concentrations of target analytes, except mercury, were determined on both bulk and fine fraction (<250 µm or 60-mesh sieved) samples.

2. Data quality review indicated all data are usable as reported by the laboratory, with only minor exceedances of field or laboratory quality control (QC) data noted. Consistently low antimony recoveries in laboratory control samples and matrix spike samples are attributable to the digestion methodology (EPA Method 3050). This phenomenon is not specific to the matrices encountered during the MBSI, but occurs frequently when solid matrix samples are subjected to strong acid digestion. Antimony values determined during this investigation may be biased low; however, antimony values for other samples to be compared with the concentrations obtained during this investigation will likely be subject to the same bias, if similar acid digestion procedures are used.

3. Statistical testing showed that, for the majority of parameters, fine fraction (<250 µm or 60-mesh sieved) soil concentrations were greater than or equivalent to bulk sample concentrations. Given fine particles may be more readily transported, ingested, or inhaled and bulk concentrations may not accurately capture exposure concentrations, the resulting background values are based on the fine soil fraction. **To directly compare to the BTVs, use the fine soil fraction of soil samples collected from a site.** The exception to this practice is mercury, which is based on bulk fraction samples only to prevent potential volatilization losses during sample processing.

4. ProUCL (Version 5.0.00) was used to analyze the distribution of the MBSI data sets for target constituents. Based on the results, background threshold values (BTVs) for constituents were calculated as 95% upper tolerance limits with 90% coverage (upper 95% confidence limits on the 90th percentile or UTL 95/90) using ProUCL. Comparisons with an alternative method for evaluating an upper limit for "normal background" developed by the British Geological Survey showed that the two methods yielded very similar results. Comparisons of the calculated BTVs with the data distribution for each constituent also showed that the BTVs are reasonably positioned in the upper tail of the background data set distribution.

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TABLES

Table 2-1. Soil Sampling Locations, Dates, and Sample Identification Numbers

Site ID[1]	Sample ID	Sample Date	County	Latitude[2]	Longitude[2]
01-01	MBSI-01-01	11/4/2012	Silver Bow	45.73663	-112.64711
01-02	MBSI-01-02	11/4/2012	Silver Bow	45.98556	-112.77536
02-01	MBSI-02-01	11/2/2012	Cascade	47.18928	-111.41137
02-02	MBSI-02-02	11/2/2012	Cascade	47.61425	-111.39015
03-01	MBSI-03-01	10/26/2012	Yellowstone	45.60543	-108.58112
03-02	MBSI-03-02[3]	10/26/2012	Yellowstone	46.05137	-108.28700
04-01	MBSI-04-01	11/15/2012	Missoula	46.77630	-114.44270
04-02	MBSI-04-02	11/25/2012	Missoula	47.01200	-113.38700
05-01	MBSI-05-01	12/1/2012	Lewis & Clark	47.47746	-112.49671
05-02	MBSI-05-02[3]	11/29/2012	Lewis & Clark	46.79416	-111.88772
06-01	MBSI-06-01	11/6/2012	Gallatin	45.16925	-111.24097
06-02	MBSI-06-02	11/4/2012	Gallatin	45.83139	-111.47264
07-01	MBSI-07-01	11/16/2012	Flathead	48.14633	-114.71499
07-02	MBSI-07-02	11/14/2012	Flathead	48.53940	-114.11814
08-01	MBSI-08-01	11/1/2012	Fergus	47.40952	-109.29953
08-02	MBSI-08-02	11/1/2012	Fergus	46.84075	-108.87507
09-01	MBSI-09-01	10/22/2012	Powder River	45.59023	-105.99588
09-02	MBSI-09-02	10/22/2012	Powder River	45.18838	-105.29282
10-01	MBSI-10-01	11/1/2012	Carbon	45.07971	-108.57640
10-02	MBSI-10-02	11/1/2012	Carbon	45.16067	-109.38926
11-01	MBSI-11-01	11/19/2012	Phillips	47.94988	-107.87728
11-02	MBSI-11-02	11/19/2012	Phillips	48.75618	-107.54531
12-01	MBSI-12-01	11/19/2012	Hill	48.98377	-110.48345
12-02	MBSI-12-02	11/19/2012	Hill	48.61324	-109.60615
13-01	MBSI-13-01	11/20/2012	Ravalli	46.22700	-114.01020
13-02	MBSI-13-02	11/20/2012	Ravalli	45.97700	-114.01890
14-01	MBSI-14-01	10/24/2012	Custer	45.96881	-105.44765
14-02	MBSI-14-02	10/24/2012	Custer	46.59034	-105.97697
15-01	MBSI-15-01[3]	11/19/2012	Lake	47.46467	-114.11517
15-02	MBSI-15-02	11/20/2012	Lake	47.82352	-113.81235
16-01	MBSI-16-01	10/23/2012	Dawson	47.40635	-104.96160
16-02	MBSI-16-02	10/23/2012	Dawson	47.09474	-104.96287
17-01	MBSI-17-01	11/20/2012	Roosevelt	48.27071	-104.19360
17-02	MBSI-17-02	11/20/2012	Roosevelt	48.30321	-104.62847
18-01	MBSI-18-01	11/28/2012	Beaverhead	45.23563	-112.95400

Table 2-1. Soil Sampling Locations, Dates, and Sample Identification Numbers

Site ID[(1)]	Sample ID	Sample Date	County	Latitude[(2)]	Longitude[(2)]
18-02	MBSI-18-02	11/28/2012	Beaverhead	44.62473	-112.80510
19-01	MBSI-19-01	11/2/2012	Choteau	47.63228	-110.28213
19-02	MBSI-19-02	11/2/2012	Choteau	48.27475	-110.19435
20-01	MBSI-20-01	11/19/2012	Valley	48.37984	-106.57342
20-02	MBSI-20-02	11/19/2012	Valley	48.88077	-106.86103
21-01	MBSI-21-01	11/7/2012	Toole	48.74321	-111.62385
21-02	MBSI-21-02	11/7/2012	Toole	48.66938	-111.92344
22-01	MBSI-22-01[(3)]	10/22/2012	Big Horn	45.18695	-106.90467
22-02	MBSI-22-02	10/22/2012	Big Horn	45.78382	-107.68815
23-01	MBSI-23-01	10/26/2012	Musselshell	46.40100	-108.29217
23-02	MBSI-23-02	10/26/2012	Musselshell	46.63397	-108.70547
24-01	MBSI-24-01	11/18/2012	Blaine	48.01320	-109.41500
24-02	MBSI-24-02	11/18/2012	Blaine	48.70027	-109.04452
25-01	MBSI-25-01[(3)]	11/7/2012	Madison	44.88363	-111.98439
25-02	MBSI-25-02	11/6/2012	Madison	45.29046	-112.11507
26-01	MBSI-26-01[(3)]	11/7/2012	Pondera	48.23589	-112.46653
26-02	MBSI-26-02	11/7/2012	Pondera	48.18018	-111.75270
27-01	MBSI-27-01	11/16/2012	Richland	47.70800	-104.46590
27-02	MBSI-27-02	11/16/2012	Richland	47.95733	-104.93631
28-01	MBSI-28-01	12/1/2012	Powell	46.84187	-112.86141
28-02	MBSI-28-02	12/1/2012	Powell	46.54958	-112.43751
29-01	MBSI-29-01	10/24/2012	Rosebud	45.88203	-106.81997
29-02	MBSI-29-02	10/24/2012	Rosebud	46.71188	-106.57806
30-01	MBSI-30-01	11/28/2012	Deer Lodge	45.93330	-113.12053
30-02	MBSI-30-02[(3)]	12/2/2012	Deer Lodge	46.19162	-113.14290
31-01	MBSI-31-01	11/7/2012	Teton	47.74169	-112.48475
31-02	MBSI-31-02[(3)]	11/7/2012	Teton	47.94678	-111.55824
32-01	MBSI-32-01	11/1/2012	Stillwater	45.39612	-109.74739
32-02	MBSI-32-02	11/1/2012	Stillwater	45.97165	-109.18260
33-01	MBSI-33-01	10/25/2012	Treasure	46.04377	-107.31175
33-02	MBSI-33-02	11/14/2012	Treasure	46.35194	-107.36083
34-01	MBSI-34-01	11/20/2012	Sheridan	48.90100	-104.64736
34-02	MBSI-34-02[(3)]	11/20/2012	Sheridan	48.44565	-104.19415
35-01	MBSI-35-01	11/28/2012	Sanders	47.85718	-115.48344
35-02	MBSI-35-02[(3)]	11/28/2012	Sanders	47.53700	-114.60940

Table 2-1. Soil Sampling Locations, Dates, and Sample Identification Numbers

Site ID[1]	Sample ID	Sample Date	County	Latitude[2]	Longitude[2]
36-01	MBSI-36-01	11/1/2012	Judith Basin	46.93870	-109.89188
36-02	MBSI-36-02	11/1/2012	Judith Basin	47.14937	-110.49427
37-01	MBSI-37-01	11/20/2012	Daniels	48.96103	-105.45402
37-02	MBSI-37-02	11/19/2012	Daniels	48.81720	-105.88916
38-01	MBSI-38-01	11/7/2012	Glacier	48.37041	-113.25389
38-02	MBSI-38-02	11/7/2012	Glacier	48.91492	-112.33386
39-01	MBSI-39-01	10/23/2012	Fallon	46.52623	-104.16955
39-02	MBSI-39-02	10/23/2012	Fallon	46.19323	-104.43881
40-01	MBSI-40-01	11/1/2012	Sweet Grass	45.52258	-110.12362
40-02	MBSI-40-02	11/3/2012	Sweet Grass	46.08969	-109.85061
41-01	MBSI-41-01	11/16/2012	McCone	47.55612	-106.11110
41-02	MBSI-41-02	11/16/2012	McCone	47.86897	-105.59581
42-01	MBSI-42-01	10/22/2012	Carter	45.54785	-104.60370
42-02	MBSI-42-02	10/22/2012	Carter	45.13266	-104.54046
43-01	MBSI-43-01	11/29/2012	Broadwater	46.61672	-111.50393
43-02	MBSI-43-02	11/4/2012	Broadwater	45.99038	-111.55549
44-01	MBSI-44-01	11/3/2012	Wheatland	46.27715	-109.98071
44-02	MBSI-44-02	11/3/2012	Wheatland	46.63158	-109.47188
45-01	MBSI-45-01	10/23/2012	Prairie	47.03391	-105.65880
45-02	MBSI-45-02[3]	10/23/2012	Prairie	46.67083	-105.24983
46-01	MBSI-46-01	11/23/2012	Granite	46.23111	-113.55528
46-02	MBSI-46-02	11/23/2012	Granite	46.58361	-113.42889
47-01	MBSI-47-01	11/2/2012	Meagher	46.38831	-110.87886
47-02	MBSI-47-02	11/2/2012	Meagher	46.78672	-110.68305
48-01	MBSI-48-01	11/19/2012	Liberty	48.57729	-111.02209
48-02	MBSI-48-02	11/16/2012	Liberty	48.21973	-110.88744
49-01	MBSI-49-01	11/2/2012	Park	45.92156	-110.49799
49-02	MBSI-49-02	11/2/2012	Park	45.28689	-110.51603
50-01	MBSI-50-01[3]	11/16/2012	Garfield	47.09986	-107.35516
50-02	MBSI-50-02	11/16/2012	Garfield	47.30562	-106.54629
51-01	MBSI-51-01	11/4/2012	Jefferson	46.26180	-112.47982
51-02	MBSI-51-02	11/4/2012	Jefferson	46.19451	-111.92352
52-01	MBSI-52-01	10/23/2012	Wibaux	46.80005	-104.31134
52-02	MBSI-52-02[3]	10/23/2012	Wibaux	47.23016	-104.21310
53-01	MBSI-53-01	11/3/2012	Golden Valley	46.31881	-108.92450

Table 2-1. Soil Sampling Locations, Dates, and Sample Identification Numbers

Site ID[(1)]	Sample ID	Sample Date	County	Latitude[(2)]	Longitude[(2)]
53-02	MBSI-53-02	11/3/2012	Golden Valley	46.54800	-109.21991
54-01	MBSI-54-01	11/28/2012	Mineral	47.28230	-115.20560
54-02	MBSI-54-02	12/3/2012	Mineral	46.96140	-114.66370
55-01	MBSI-55-01	11/21/2012	Petroleum	46.85007	-108.49579
55-02	MBSI-55-02	11/21/2012	Petroleum	47.18939	-108.35252
56-01	MBSI-56-01	11/15/2012	Lincoln	48.64274	-115.73981
56-02	MBSI-56-02	11/15/2012	Lincoln	48.53257	-115.13951

NOTES:
(1) All sampling locations are shown on Figure 2-1.
(2) Coordinates in decimal degrees, WGS84 datum.
(3) Denotes field duplicate sample collected at this location.

TABLE 3-1. ANALYTICAL PARAMETERS, METHODS, AND DETECTION LIMITS FOR MBSI SOIL SAMPLES

Total Metals Analysis						
Parameter[1]	**Digestion Method[2]**	**Analytical Method[2]**	**Required Reporting Limit (mg/kg)**	**EPA Regional Screening Level (RSL)[3] (mg/kg)**	**Maximum Holding Time (days)**	**Preservation**
Aluminum (Al)	3050B	6010/6020	5	7700	180	Cool to 4± 2°C
Antimony (Sb)	3050B	6010/6020	0.1	3.1	180	Cool to 4± 2°C
Arsenic (As)	3050B	6010/6020	0.1	0.61	180	Cool to 4± 2°C
Barium (Ba)	3050B	6010/6020	1	1500	180	Cool to 4± 2°C
Beryllium (Be)	3050B	6010/6020	0.1	16	180	Cool to 4± 2°C
Cadmium (Cd)	3050B	6010/6020	0.1	7	180	Cool to 4± 2°C
Chromium III (Cr III)[4]	3050B	6010/6020	0.1	12000	180	Cool to 4± 2°C
Chromium VI (Cr VI)	3060	7196A	0.1	0.29	180	Cool to 4± 2°C
Cobalt (Co)	3050B	6010/6020	0.1	2.3	180	Cool to 4± 2°C
Copper (Cu)	3050B	6010/6020	0.1	310	180	Cool to 4± 2°C
Iron (Fe)	3050B	6010/6020	1	5500	180	Cool to 4± 2°C
Lead (Pb)	3050B	6010/6020	0.1	400	180	Cool to 4± 2°C
Manganese (Mn)	3050B	6010/6020	1	180	180	Cool to 4± 2°C
Mercury (Hg)[5]	7471A	7471A	0.05	1	28	Cool to 4± 2°C
Nickel (Ni)	3050B	6010/6020	0.5	150	180	Cool to 4± 2°C
Selenium (Se)	3050B	6010/6020	0.2	39	180	Cool to 4± 2°C
Silver (Ag)	3050B	6010/6020	0.1	39	180	Cool to 4± 2°C
Thallium (Tl)	3050B	6010/6020	0.05	0.078	180	Cool to 4± 2°C
Vanadium (V)	3050B	6010/6020	0.1	39	180	Cool to 4± 2°C
Zinc (Zn)	3050B	6010/6020	1	2300	180	Cool to 4± 2°C

(1) All parameters except mercury (Hg) were analyzed on both bulk soil samples, and on fine fraction samples (portion of sample passing 60-mesh sieve). Sieving was conducted by the analytical laboratory. Due to the volatility of mercury and potential losses during sieving, mercury was analyzed on air-dried bulk samples only.

(2) Laboratory analytical methods are from EPA's Test Methods for Analysis of Solid Waste (SW-846) (EPA, 2007) or Methods for Chemical Analysis of Water and Wastes (EPA, 1983).

(3) EPA RSL for residential soil obtained from www.epa.gov/region9/superfund/prg (updated May 2013). RSLs were obtained from EPA table with target hazard quotient (THQ) = 0.1.

(4) Chromium (III) concentrations were determined by analyzing total chromium and calculating the difference between total chromium and chromium (VI) results for all samples.

(5) Mercury was analyzed on bulk samples only (see footnote (1)).

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Bulk Soil Concentrations (mg/kg)																			
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-01-01	<0.1	7080	8.7	116	0.2	0.2	2.1	3.2	<5	<0.29	6.2	10600	<0.05	805	1.6	6	<0.1	<0.2	0.2	6.7	34
MBSI-01-02	0.2	16100	29	374	0.6	1.1	6.1	25.9	26	<0.29	43.6	12000	<0.05	344	13.9	28	0.3	<0.2	0.35	18.7	67
MBSI-02-01	0.2	18800	17	458	0.9	0.5	12.9	25.4	25	<0.29	27.2	24000	<0.05	773	27.4	17.2	0.4	0.6	0.27	54.8	101
MBSI-02-02	<0.1	18800	16.6	213	1	0.3	6.8	18	18	<0.29	18.1	18000	<0.05	372	18.7	13.5	0.2	0.6	0.39	35.3	80
MBSI-03-01	<0.1	16400	10.5	214	0.8	0.3	8.7	26.3	26	<0.29	15.1	20100	<0.05	417	17.3	16	0.1	0.4	0.37	36.6	58
MBSI-03-02	<0.1	15000	8.1	136	0.6	0.2	7.4	18.1	18	<0.29	13.2	15900	<0.05	492	13.7	10	0.2	0.3	0.18	25	47
MBSI-03-03	<0.2	14900	8.4	145	0.6	0.2	7.9	17.9	18	<0.29	15	16200	<0.05	544	13.2	22	0.1	0.3	0.18	25.3	46
MBSI-04-01	0.5	17800	5.6	139	0.8	<0.1	5.3	32.5	32	<0.29	14	16900	<0.05	251	22.5	6	0.1	<0.2	0.24	20.7	16
MBSI-04-02	<0.3	14500	4.5	160	0.5	<0.1	3.9	10	10	<0.29	9.3	10800	<0.05	348	7.1	9	0.1	<0.2	0.11	11	35
MBSI-05-01	0.2	21900	14.2	227	0.8	0.3	6.9	19.4	19	<0.29	25.4	22800	<0.05	479	18.3	20	0.3	0.4	0.32	39.1	70
MBSI-05-02	<0.3	11500	15.6	135	0.6	0.3	5.7	18.8	19	<0.29	16.7	13700	<0.05	513	15.3	19	0.2	0.3	0.21	17.9	58
MBSI-05-03	<0.3	11300	16.1	140	0.7	0.4	6.5	17.3	17	<0.29	17.4	14100	<0.05	510	16	19	0.2	0.4	0.22	18.3	60
MBSI-06-01	<0.1	10600	8	160	0.6	0.4	5.5	22.2	22	<0.29	11.1	14900	<0.05	858	13.9	9.8	0.1	0.3	0.46	22.9	74
MBSI-06-02	0.1	15500	6.3	132	1.1	0.4	6.6	18.7	19	<0.29	19	15500	<0.05	591	12.4	19	0.2	0.2	0.31	29.6	57
MBSI-07-01	<0.2	25600	5.1	157	1	<0.1	6.6	14.2	14	<0.29	31.7	18000	<0.05	212	22.6	19.8	<0.1	0.6	0.45	19.4	55
MBSI-07-02	<0.2	29800	6.1	279	0.8	0.1	5.7	13.7	14	<0.29	14.5	20600	<0.05	639	13.8	11.3	0.1	0.3	0.24	26.3	94
MBSI-08-01	0.2	22700	8.3	207	0.9	0.3	8.2	21.5	22	<0.29	18.8	20800	<0.05	501	17.5	14.5	0.2	0.5	0.33	39.7	84
MBSI-08-02	0.1	7960	5.1	108	0.4	0.4	3.9	14.5	14	<0.29	14	8210	<0.05	171	7.6	8.7	0.1	0.6	0.12	42.6	51
MBSI-09-01	<0.2	12400	13.8	123	1.1	0.5	12.9	21.4	21	<0.29	29.7	42600	<0.05	642	28.3	20.3	0.3	0.6	0.24	36.1	86
MBSI-09-02	<0.1	9770	6	88	0.6	0.2	7.1	15.4	15	<0.29	14.2	13700	<0.05	373	11.2	13.8	0.1	0.4	0.2	21.9	46
MBSI-10-01	<0.1	9360	4.3	81	0.4	0.2	3.9	17.1	17	<0.29	8.2	9550	<0.05	176	10.9	7	<0.1	0.2	0.11	21.4	30
MBSI-10-02	<0.1	5770	1.5	32	0.1	<0.1	3.1	12.8	13	<0.29	4	8550	<0.05	102	7.3	11	<0.1	<0.2	0.08	11.3	22
MBSI-11-01	<0.2	9980	8.9	241	0.5	0.2	4.8	13.3	12	1.2	9.7	13300	<0.05	250	12.7	15	0.2	0.4	0.21	30.9	43
MBSI-11-02	<0.1	13300	9.6	165	0.5	0.2	5.4	16	16	<0.29	10.5	14800	<0.05	289	12.9	16	0.1	0.4	0.23	29.9	39
MBSI-12-01	<0.1	10900	5.5	112	0.5	0.2	5.6	13.3	13	<0.29	8	12200	<0.05	337	12.1	8	0.1	0.2	0.2	22.5	47
MBSI-12-02	<0.2	17100	9.7	138	0.7	0.2	7.8	22.5	22	<0.29	17.4	18000	<0.05	326	23.7	10.4	0.2	0.5	0.29	40.5	60
MBSI-13-01	<0.3	11200	2.7	104	0.4	0.1	3.7	9.2	9	<0.29	7.4	9740	<0.05	377	4.8	8	0.1	<0.2	0.15	11.1	20
MBSI-13-02	<0.4	10600	2.2	88	0.5	<0.1	3.5	6.7	7	<0.29	13	12800	<0.05	387	4	8	<0.1	<0.2	0.2	18.3	26
MBSI-14-01	<0.1	4150	2.9	43	0.3	<0.1	3.7	9.5	10	<0.29	3.8	7320	<0.05	143	5.3	6.8	<0.1	0.3	0.07	10.4	24
MBSI-14-02	<0.1	7320	9.1	505	0.5	0.2	6.9	13.7	14	<0.29	11.4	23600	<0.05	383	13.6	15.3	0.2	0.5	0.11	35.3	43
MBSI-15-01	<0.1	23300	4	182	0.7	0.1	4.5	8.1	8	0.39	13.7	13400	<0.05	524	7.4	17	<0.1	<0.2	0.18	17.4	51
MBSI-15-03	<0.1	23300	4	183	0.7	0.2	6.6	8.2	8	0.36	14.1	13500	<0.05	526	6.8	19	<0.1	<0.2	0.18	18.3	50
MBSI-15-02	<0.2	16300	4.9	107	0.4	<0.1	4.2	9.4	9	<0.29	8.5	13900	<0.05	230	9.2	17	<0.1	<0.2	0.14	19.4	48
MBSI-16-01	<0.1	14800	24.6	405	0.8	0.2	8.4	17.7	17	0.32	15.2	19500	<0.05	372	14.1	15.4	0.4	0.5	0.26	26.2	52
MBSI-16-02	<0.1	12200	7.5	190	0.5	0.2	6.5	18	18	<0.29	13	13600	<0.05	231	14.8	9.4	0.1	0.4	0.14	25.9	38
MBSI-17-01	<0.1	11400	7.1	225	0.5	0.2	7.5	18.4	18	<0.29	15.1	15100	<0.05	353	22.6	13	0.2	0.5	0.2	29.4	49
MBSI-17-02	<0.1	6850	6	77	0.3	0.2	3.9	9.9	10	<0.29	5.7	9600	<0.05	286	9.1	8	<0.1	0.3	0.15	19.2	34

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Bulk Soil Concentrations (mg/kg)																			
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-18-01	<0.3	16800	33.3	191	0.6	0.7	5.2	19.2	19	<0.29	16.7	14100	<0.05	567	10.9	17	0.5	0.7	0.52	23.9	69
MBSI-18-02	<0.3	7950	9.2	111	0.3	0.4	2.6	16.2	16	<0.29	8.9	6430	<0.05	181	7.1	7	<0.1	0.6	0.16	12.7	30
MBSI-19-01	<0.1	18300	10	176	0.7	0.2	8	22.3	22	<0.29	17	19700	<0.05	316	20	11.5	0.2	0.8	0.27	48.1	60
MBSI-19-02	<0.1	12900	6	136	0.5	0.3	7	16.7	17	<0.29	13.9	15600	<0.05	388	15.4	9.3	0.1	0.4	0.22	28.9	62
MBSI-20-01	<0.1	10400	10.2	318	0.5	0.1	5.1	17.2	17	<0.29	7.2	13500	<0.05	291	9.2	11	0.1	0.4	0.16	32.5	31
MBSI-20-02	<0.1	7740	4.3	118	0.3	0.2	4.6	11.3	11	<0.29	8.1	10200	<0.05	298	7.5	6.1	<0.1	0.4	0.14	21.3	44
MBSI-21-01	0.1	10900	20.8	281	0.7	0.1	5.4	22.3	21	1	27.4	24900	<0.05	84	19.7	14.2	0.1	1.6	0.33	48.8	94
MBSI-21-02	0.2	15200	11.9	339	0.7	0.1	5.6	25.8	25	0.97	28.1	23200	<0.05	74	18.9	19.4	<0.1	0.7	0.37	48.4	94
MBSI-22-01	<0.2	22100	6.9	212	0.9	0.4	7.2	23.6	24	<0.29	16.2	20500	<0.05	450	15.6	12.2	0.2	0.3	0.26	32.1	46
MBSI-22-03	<0.2	21700	6.8	218	0.9	0.3	6.9	22.7	23	<0.29	16.1	17800	<0.05	409	14.9	12	0.2	0.3	0.25	29.4	46
MBSI-22-02	0.3	14400	10.1	142	0.7	0.2	7.2	17.8	18	<0.29	12.9	19500	<0.05	362	14.6	14.5	0.1	0.7	0.27	39.8	61
MBSI-23-01	<0.2	15700	8.3	125	0.8	0.2	7.3	18.6	19	<0.29	14.5	17600	<0.05	471	13.3	20	0.2	0.3	0.2	22.2	48
MBSI-23-02	<0.2	17300	13.1	155	0.8	0.3	7.7	19.7	20	<0.29	18.8	18100	<0.05	327	15.6	19	0.2	0.7	0.25	35.5	55
MBSI-24-01	<0.2	7880	2.3	186	0.6	<0.1	14.6	130	130	<0.29	42.8	27700	<0.05	364	81.5	6	<0.1	<0.2	0.2	88	51
MBSI-24-02	<0.2	12600	9.2	153	0.6	0.2	6.3	15.4	15	<0.29	13.6	16100	<0.05	287	16.5	16	0.1	0.4	0.24	32.5	49
MBSI-25-01	0.1	18200	6.3	308	0.7	0.6	8.3	17.2	17	<0.29	19.9	18500	<0.05	800	19.5	12.8	0.2	<0.2	0.25	30.4	83
MBSI-25-03	0.1	19700	6.7	349	0.8	0.6	8.4	17.5	17	0.36	18.6	18300	<0.05	813	18.5	14.1	0.1	0.2	0.29	30.1	87
MBSI-25-02	0.2	13200	8.8	169	0.6	0.3	9.1	27	27	<0.29	24.7	17600	<0.05	674	25	9.2	0.2	0.3	0.22	31.6	48
MBSI-26-01	0.2	16500	8.8	177	0.6	0.3	6.1	19.9	20	<0.29	14.9	15800	<0.05	406	15.7	10.7	0.1	0.4	0.24	32.5	60
MBSI-26-03	0.2	17500	8.8	178	0.7	0.3	6.4	19.9	20	<0.29	15.7	16300	<0.05	422	16.7	10.9	0.2	0.4	0.24	32	61
MBSI-26-02	0.1	13800	9.5	219	0.6	0.3	7.7	19.9	20	<0.29	19	18000	<0.05	375	22.5	12.8	0.1	0.5	0.26	40.7	86
MBSI-27-01	<0.1	9150	12.6	206	0.5	0.1	4.8	14.1	14	<0.29	8.4	15500	<0.05	248	9.6	11	0.3	0.5	0.14	26	35
MBSI-27-02	<0.5	13600	10.3	304	0.7	0.2	7	18.6	19	<0.29	18.8	18000	<0.05	436	20.9	12	0.2	0.5	0.26	33.1	53
MBSI-28-01	<0.1	14400	35.7	275	0.5	0.2	8.7	20.3	20	0.43	18.3	18300	<0.05	1240	16.9	12	1.1	<0.2	0.55	20.4	53
MBSI-28-02	0.2	13200	32.6	235	0.7	0.5	5.8	14.3	14	<0.29	24.2	20600	<0.05	874	8.4	23	0.4	<0.2	0.23	34.5	84
MBSI-29-01	<0.1	8650	8	120	0.5	0.2	5.7	12.2	12	<0.29	9.2	12500	<0.05	234	8.4	9.7	0.1	0.3	0.13	15.6	32
MBSI-29-02	<0.1	5160	3.7	55	0.3	<0.1	4.8	8.1	8	0.43	7.4	8060	<0.05	252	7.5	8.3	<0.1	<0.2	0.1	16.8	24
MBSI-30-01	<0.3	19000	80.8	233	0.9	1	4.3	12.6	12	0.64	70.7	12800	<0.05	1260	7.7	26	0.7	0.2	0.25	18.5	74
MBSI-30-02	<0.3	18100	79.9	163	0.4	0.7	8.4	13.3	13	0.67	56.1	22000	<0.05	493	11.3	23	0.4	0.2	0.19	39.6	75
MBSI-30-03	<0.3	17500	81.9	166	0.5	0.8	7.1	13.8	13	0.49	56.8	20700	<0.05	498	9.7	17	0.3	0.2	0.18	36.5	74
MBSI-31-01	0.2	21700	12.5	285	0.7	0.3	6.9	19.6	20	<0.29	16.4	17700	<0.05	375	17.6	13.2	0.2	0.4	0.25	38	61
MBSI-31-02	0.1	28100	10.8	273	1	0.3	10.7	37.4	37	<0.29	25.2	22100	<0.05	446	30	15.8	0.2	0.5	0.32	75.6	89
MBSI-31-03	0.1	28000	10.3	274	1	0.3	10.5	36.3	36	<0.29	24.6	22100	<0.05	447	28.9	15.5	0.2	0.5	0.33	74.7	89
MBSI-32-01	<0.1	15400	8.8	111	0.7	0.4	8	20.6	21	<0.29	13.3	16300	<0.05	470	15.4	27	0.2	0.3	0.23	27.3	61
MBSI-32-02	0.2	20100	8	171	0.8	0.3	8.7	23.2	23	<0.29	15	20100	<0.05	429	17.3	18	0.2	0.4	0.27	37.3	69
MBSI-33-01	<0.1	10700	5.2	175	0.5	0.2	7.3	20.9	21	<0.29	11.6	15300	<0.05	346	14.3	11	<0.1	0.3	0.17	24.9	46
MBSI-33-02	<0.1	12200	6	251	0.4	<0.1	3.6	14.6	15	<0.29	7.6	11600	<0.05	153	9.9	7.9	<0.1	0.3	0.18	29.5	37

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Bulk Soil Concentrations (mg/kg)																			
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-34-01	<0.1	9950	6.6	132	0.4	0.3	5.5	13.3	13	<0.29	9.1	13500	<0.05	572	11.6	9	<0.1	0.6	0.19	25.1	52
MBSI-34-02	<0.1	9510	5.6	89	0.4	0.2	4.1	13.6	14	<0.29	8.4	11500	<0.05	345	11.1	10	<0.1	0.6	0.2	26.9	41
MBSI-34-03	<0.1	9430	5.4	91	0.4	0.2	4.4	13.2	13	<0.29	8.8	11800	<0.05	341	11.4	7	<0.1	0.5	0.19	27.7	40
MBSI-35-01	0.4	16300	13.4	233	0.7	0.4	10.1	14.6	15	<0.29	26.9	29000	<0.05	921	34.6	35	0.2	<0.2	0.23	25.7	147
MBSI-35-02	0.2	22200	7	212	0.9	0.1	9.2	21.4	21	0.46	25.7	23500	<0.05	750	16.1	15	0.2	<0.2	0.42	28.4	75
MBSI-35-03	<0.3	22200	7.3	215	0.9	0.2	9.5	20.4	20	0.51	26.4	24300	<0.05	794	13.9	18	0.2	<0.2	0.44	29.6	76
MBSI-36-01	0.1	17600	13.5	199	0.8	0.4	8.2	23	23	<0.29	19	20300	<0.05	454	20	14.5	0.2	0.6	0.24	40.2	89
MBSI-36-02	0.1	16800	11.6	185	1.1	0.6	8.9	29.3	29	<0.29	15.7	20100	<0.05	520	28.2	16.9	0.2	0.6	0.28	37.7	76
MBSI-37-01	<0.1	9380	6.5	145	0.4	0.3	4.3	12.6	13	<0.29	9.1	13700	<0.05	490	9.7	9	0.1	0.5	0.16	21.3	47
MBSI-37-02	<0.1	13100	6.2	133	0.5	0.2	6.5	19.9	20	<0.29	10.9	16500	<0.05	514	16.5	10	0.1	0.4	0.18	30.5	52
MBSI-38-01	0.2	13200	5.2	216	0.7	0.8	8.8	17.2	17	<0.29	19.6	21600	<0.05	499	19.9	14.8	0.2	0.3	0.2	33.4	107
MBSI-38-02	<0.1	15000	5.5	229	0.5	0.4	7.2	18.4	18	<0.29	16	16100	<0.05	658	13.8	10.1	0.1	0.5	0.21	32.4	82
MBSI-39-01	<0.2	12600	17	567	1	0.4	13.6	24.2	24	<0.29	21.4	59200	<0.05	1590	28.5	16.4	0.4	1.2	0.34	40.9	74
MBSI-39-02	<0.2	8850	6.3	74	0.5	0.1	6	15.1	15	<0.29	8.7	13500	<0.05	271	11.9	8.7	0.2	0.3	0.11	20.1	37
MBSI-40-01	<0.1	33700	4	126	0.4	0.3	13.6	29.6	30	<0.29	23.8	18000	<0.05	529	41.3	11	<0.1	<0.2	0.1	29.6	56
MBSI-40-02	0.1	23500	6.9	227	0.9	0.3	12.5	29.2	29	<0.29	26.6	23900	<0.05	497	28.1	22	0.1	0.3	0.21	36.4	64
MBSI-41-01	<0.5	12100	9.5	81	0.7	0.2	6.1	16.5	16	<0.29	16.2	22600	<0.05	506	13.9	25	0.2	0.4	0.24	29.7	50
MBSI-41-02	<0.5	18200	10.1	115	0.8	0.3	7.2	21.5	22	<0.29	18.3	19600	<0.05	542	19.1	25	0.2	0.6	0.32	36.4	64
MBSI-42-01	<0.2	29300	13.1	154	1	0.2	15.8	35.2	35	<0.29	29.5	30400	<0.05	246	29.1	19.9	0.3	1.1	0.3	92.2	93
MBSI-42-02	<0.1	9940	10.5	131	0.6	<0.1	5.6	16.6	17	<0.29	10.2	14200	<0.05	107	11.9	10.5	<0.1	0.6	0.19	38.7	55
MBSI-43-01	<0.3	22500	6.2	225	1.2	0.2	7.2	18	18	<0.29	19.1	18600	<0.05	427	16.8	21	0.4	<0.2	0.17	15.6	67
MBSI-43-02	0.1	18000	10.8	163	0.9	0.4	7.7	20.2	20	<0.29	37.9	17000	<0.05	466	13.6	21	0.2	0.2	0.28	27.7	67
MBSI-44-01	0.1	13200	9.5	111	0.6	0.3	6.9	16.5	16	<0.29	12.4	17900	<0.05	388	11.5	20	0.2	0.4	0.16	30.7	54
MBSI-44-02	<0.1	17200	8.2	121	0.7	0.3	6.6	19.5	19	0.37	14.5	15800	<0.05	329	13.4	18	0.2	0.4	0.19	25.8	53
MBSI-45-01	<0.1	12000	18.8	203	0.7	0.3	8.1	20	20	<0.29	14.2	27900	<0.05	532	14.4	14.7	1.2	0.4	0.17	33.2	48
MBSI-45-02	<0.1	12600	6.6	116	0.6	0.2	6.8	17.5	18	<0.29	13.2	17800	<0.05	402	13.1	11.5	0.1	0.4	0.19	25.2	46
MBSI-45-03	<0.1	12400	6.1	114	0.6	0.2	6.8	16.4	16	<0.29	12.4	17700	<0.05	396	13.6	11	0.1	0.4	0.18	25	45
MBSI-46-01	<0.3	9620	19.1	129	0.7	0.2	8.3	10.5	10	<0.29	17.5	20700	0.068	434	8.8	18	0.7	<0.2	0.32	24.7	70
MBSI-46-02	<0.3	17500	23.4	334	1.2	0.5	6.1	16.8	17	<0.29	23	17400	<0.05	611	12.6	11	0.4	<0.2	0.64	27.9	82
MBSI-47-01	<0.1	20400	8.3	249	0.9	0.5	8.7	13.8	14	<0.29	19.1	17600	<0.05	760	9.4	18	0.2	0.3	0.35	24.9	57
MBSI-47-02	<0.1	22800	11.3	98	1.4	0.2	12.7	26.7	26	0.9	18.1	25300	<0.05	640	21.9	27	0.2	0.4	0.24	26.8	51
MBSI-48-01	<0.1	15600	9.7	157	0.6	0.3	7.4	19.3	19	<0.29	13.6	17600	<0.05	423	19.4	21	0.1	0.5	0.26	36.6	71
MBSI-48-02	<0.1	22300	8.5	186	1	0.3	8.1	25.2	25	<0.29	17.8	19500	<0.05	386	23.2	13.2	0.3	0.3	0.32	48.8	70
MBSI-49-01	0.1	27300	7.9	225	0.9	0.3	12.1	31	31	<0.29	26.4	25000	<0.05	735	21.8	21	0.2	0.3	0.25	46.4	69
MBSI-49-02	<0.1	24500	7.4	172	1.4	0.3	12	32.8	33	<0.29	19.4	23500	<0.05	726	21.9	24	0.2	0.3	0.3	29.6	84
MBSI-50-01	<0.1	20900	6	533	0.9	0.3	16.4	29.5	30	<0.29	18.9	24300	<0.05	1680	36.8	29	0.1	0.3	0.35	40.4	64
MBSI-50-03	<0.1	19700	6.4	532	0.8	0.2	11.1	27.9	28	<0.29	19	20600	<0.05	1020	26.4	25	0.1	0.3	0.26	35.3	62

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Bulk Soil Concentrations (mg/kg)																			
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-50-02	<0.5	15000	8.3	470	0.8	0.2	10.4	26.5	26	<0.29	21.2	30100	<0.05	773	27.1	21	0.2	0.5	0.2	41.1	56
MBSI-51-01	0.1	18100	33.3	161	0.6	0.6	6.8	11.8	12	<0.29	25.7	17000	<0.05	620	5.7	20	0.2	<0.2	0.23	31.5	99
MBSI-51-02	0.4	19600	23.3	198	0.9	0.9	9.2	23.2	23	<0.29	45.2	21000	<0.05	678	20.7	36.9	0.8	0.4	0.29	39.6	107
MBSI-52-01	<0.2	18600	9.4	214	1	0.4	10.7	26.3	26	<0.29	18.8	19100	<0.05	452	20.8	16.1	0.1	0.7	0.32	30.8	69
MBSI-52-02	<0.2	12400	6.9	135	0.7	0.3	6.3	16.1	16	<0.29	13.5	14600	<0.05	306	13.6	12.1	0.2	0.4	0.2	24	50
MBSI-53-01	<0.1	21900	10.7	201	0.8	0.2	9.8	22.4	22	<0.29	16.5	22200	<0.05	257	19.5	22	0.2	0.5	0.28	42.4	73
MBSI-53-02	0.1	21700	9.6	137	0.8	0.4	7.6	23.5	24	<0.29	15.8	18000	<0.05	418	15.9	24	0.1	0.4	0.29	33.4	68
MBSI-53-03	<0.1	20500	9.5	130	0.8	0.4	7.5	22.7	23	<0.29	15.3	17600	<0.05	414	16.4	14	0.1	0.4	0.27	31.4	68
MBSI-54-01	<0.3	24800	4	268	0.6	<0.1	5.1	14.5	14	<0.29	12	21200	<0.05	780	16	20	<0.1	<0.2	0.3	19.5	105
MBSI-54-02	<0.1	8630	7.1	66	0.4	<0.1	5.1	15.1	15	<0.29	8.1	14100	<0.05	272	11	3	<0.1	<0.2	0.09	16.9	21
MBSI-55-01	<0.2	20200	21	575	1.3	0.8	9.5	23.4	23	0.6	20.4	27200	<0.05	2920	32.2	20	0.2	0.8	0.84	64.2	83
MBSI-55-02	<0.1	15300	8.3	138	0.6	<0.1	6.2	12.7	13	<0.29	8	13800	<0.05	304	12	9	0.1	0.3	0.18	23.6	42
MBSI-56-01	<0.2	14500	3.6	197	0.5	<0.1	6.2	12.6	13	<0.29	10.1	17100	<0.05	961	10	13.6	0.1	<0.2	0.24	24.8	46
MBSI-56-02	<0.2	19500	5	335	0.6	0.3	10	12.9	13	<0.29	18.9	23800	<0.05	1600	21.4	10.7	<0.1	<0.2	0.41	20	133

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Fine Fraction (<250 µm) Concentrations (mg/kg)																		
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-01-01	0.2	15600	19.7	293	0.6	0.4	3	8.5	8	<0.29	50.3	21700	1560	6.1	24	0.2	0.2	0.42	18	89
MBSI-01-02	0.6	21500	40.5	496	1	1.6	7.5	36	36	<0.29	103	15700	387	19.2	36.5	0.6	0.2	0.53	29.6	121
MBSI-02-01	<0.1	19200	14	475	0.9	0.5	11.4	21.9	22	<0.29	47.6	22000	840	24.2	15.4	0.3	0.5	0.28	52	98
MBSI-02-02	0.1	22100	15.4	229	1.1	0.4	7.1	18	18	<0.29	108	18100	401	19.2	14.2	0.2	0.6	0.44	42.5	94
MBSI-03-01	0.2	17500	9.6	213	0.8	0.3	8.1	27.5	28	<0.29	37.3	18300	393	17.2	17	<0.1	0.4	0.36	37.6	74
MBSI-03-02	0.1	15100	7.4	135	0.6	0.2	7.2	18.4	18	<0.29	22.8	15900	505	13.2	17	0.1	0.3	0.17	25.1	58
MBSI-03-03	<0.1	15700	7	148	0.6	0.2	7.4	18.3	18	<0.29	25.6	17300	564	14.3	14	0.1	0.3	0.15	25.9	54
MBSI-04-01	<0.3	19200	4.8	144	0.8	<0.1	4.4	28.6	29	<0.29	26.5	18600	293	19.1	7	<0.1	<0.2	0.24	24.4	20
MBSI-04-02	<0.1	21800	6.7	297	0.8	0.1	4.5	10.6	11	<0.29	35.1	14900	533	9.1	18	0.1	<0.2	0.14	19.6	60
MBSI-05-01	<0.3	22400	14.9	267	0.8	0.4	6.2	38.1	38	<0.29	71.9	21900	519	23.8	30	0.2	0.4	0.33	46	95
MBSI-05-02	<0.1	11400	16.6	161	0.6	0.4	6.5	38.7	39	<0.29	48	15900	546	25.6	22	0.2	0.4	0.22	20.4	78
MBSI-05-03	<0.1	10100	16.4	151	0.6	0.4	6.2	41.6	42	<0.29	57.8	15400	549	25.5	17	0.2	0.4	0.2	18.8	78
MBSI-06-01	<0.1	9920	6.5	138	0.5	0.4	4.1	21	21	<0.29	50.4	13700	739	10.9	8.6	<0.1	0.3	0.25	19.8	64
MBSI-06-02	0.1	17600	6.5	139	1.2	0.3	5	23.3	23	<0.29	32.1	16800	615	12.8	23	0.3	0.2	0.36	33.9	59
MBSI-07-01	<0.5	25400	5.1	164	0.9	<0.1	6.8	15.7	16	<0.29	71.9	17700	229	21.8	18	0.1	0.4	0.43	15.9	57
MBSI-07-02	0.2	32700	6.4	360	0.8	0.2	6.1	14	14	<0.29	48.7	18700	731	13.2	23	0.1	<0.2	0.21	23	98
MBSI-08-01	0.1	20600	8.2	206	0.8	0.3	8	17.2	17	<0.29	29.6	19700	526	17.4	14.4	0.1	0.5	0.31	33.6	82
MBSI-08-02	0.2	10400	6.1	124	0.5	0.5	4.9	17.3	17	<0.29	34.1	8640	177	7.8	11.5	0.1	0.6	0.17	58.4	63
MBSI-09-01	0.1	16100	11.4	144	0.8	0.4	8.3	27.5	28	<0.29	52.8	24800	490	26.8	18	0.2	0.4	0.25	34.1	81
MBSI-09-02	<0.1	11800	6.1	97	0.6	0.2	4.8	16.3	16	<0.29	23.4	14600	381	11.5	12	<0.1	0.5	0.21	22.9	45
MBSI-10-01	0.2	10400	4.1	84	0.4	0.2	3.4	19.2	19	<0.29	113	9800	177	10	15	<0.1	0.2	0.14	21.6	47
MBSI-10-02	0.2	10000	3	59	0.2	<0.1	4.5	26	26	<0.29	298	13700	178	12.4	19	<0.1	<0.2	0.15	20.6	86
MBSI-11-01	0.3	15600	10	300	0.7	0.2	7.6	34.5	34	<0.29	33.1	19300	283	27.8	11.2	0.2	0.4	0.22	45.7	63
MBSI-11-02	<0.2	16400	9.8	206	0.6	0.2	7.5	29.9	30	<0.29	32.2	18400	333	20.8	9.3	0.2	0.5	0.21	39.2	53
MBSI-12-01	<0.5	11000	5.6	122	0.4	0.2	5.1	14.3	14	<0.29	22	12700	356	11	12	0.1	0.2	0.18	19.4	50
MBSI-12-02	<0.5	17900	10.2	153	0.7	0.3	6.8	22.5	22	<0.29	43.2	18500	323	19.9	11	0.2	0.5	0.27	37.3	58
MBSI-13-01	<0.3	12500	3.4	102	0.5	<0.1	3.3	10.2	10	<0.29	20.6	12500	353	5.8	8	<0.1	<0.2	0.17	16.6	31
MBSI-13-02	<0.3	15800	3.6	155	0.7	<0.1	6.4	9.6	10	<0.29	50.4	19300	625	5.9	9.2	<0.1	<0.2	0.31	34.6	56
MBSI-14-01	<0.1	5200	2.8	48	0.3	<0.1	2.8	11.9	12	<0.29	42.6	7230	134	6.3	8	<0.1	0.3	0.07	11.9	30
MBSI-14-02	<0.1	12200	7.5	693	0.6	0.2	6.1	18.1	18	<0.29	108	18000	252	15.5	13	<0.1	0.4	0.14	31.9	59
MBSI-15-01	<0.2	23100	4.5	198	0.6	0.2	6.4	13.8	14	<0.29	44.6	16100	558	11.4	13	<0.1	<0.2	0.14	19.7	65
MBSI-15-03	<0.1	24400	4.4	207	0.6	0.2	6.7	13.3	13	<0.29	23.8	16900	582	11.2	13.5	<0.1	<0.2	0.16	20.5	63
MBSI-15-02	<0.1	16900	4.5	122	0.4	<0.1	4.7	13.7	14	<0.29	29.4	15500	167	12.3	9.2	<0.1	<0.2	0.13	21.6	58
MBSI-16-01	<0.1	15000	17.1	533	0.7	0.2	5.5	18.1	18	<0.29	118	18000	389	13.3	20	0.3	0.5	0.24	23.8	71
MBSI-16-02	0.1	15200	8.4	228	0.6	0.2	5.8	20.3	20	<0.29	127	14800	249	15.4	12	0.1	0.5	0.17	29.1	61
MBSI-17-01	<0.2	12600	6.9	282	0.5	0.3	9.1	26.6	27	<0.29	22.9	18400	400	30.6	9.4	0.1	0.5	0.18	35.4	59
MBSI-17-02	<0.1	7790	6.3	91	0.3	0.2	4.8	13.8	14	<0.29	15.4	11700	327	13.2	6.2	0.1	0.3	0.12	22.3	43

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Fine Fraction (<250 µm) Concentrations (mg/kg)																		
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-18-01	<0.3	16500	26.1	213	0.6	0.8	4.9	39.3	39	<0.29	37	15300	602	20.1	14	0.4	0.5	0.45	24	88
MBSI-18-02	<0.3	8850	9.6	127	0.3	0.3	1.5	22.1	22	<0.29	17.1	8220	213	7.9	9	0.1	0.6	0.17	15.3	34
MBSI-19-01	<0.1	21300	10.9	188	0.9	0.2	8.8	22	22	<0.29	31.9	21100	353	23.4	12.7	0.2	0.8	0.31	55.8	69
MBSI-19-02	0.1	14600	6.9	147	0.6	0.3	7.8	16.5	16	<0.29	36.7	17000	447	16.8	10.4	0.1	0.3	0.25	32.7	70
MBSI-20-01	<0.2	16200	14.6	524	0.6	0.2	8.2	46.1	46	<0.29	67.2	20300	406	25.3	13.8	0.2	0.5	0.19	48.2	60
MBSI-20-02	<0.2	9490	4.6	147	0.3	0.2	6.3	15.5	16	<0.29	19.6	12000	350	10.6	6.9	<0.1	0.4	0.13	24.7	57
MBSI-21-01	0.1	12400	16.6	273	0.6	0.1	3.5	21.1	21	<0.29	69.7	21000	80	15.1	13.6	<0.1	1.3	0.28	41.3	83
MBSI-21-02	0.2	17400	11.6	312	0.8	0.1	3.5	26.9	27	<0.29	46.3	23900	61	15.2	19.1	<0.1	0.7	0.36	49.2	84
MBSI-22-01	0.1	20700	7.3	224	0.8	0.4	5.7	23.6	24	<0.29	31.1	18300	425	16.5	11	0.1	0.3	0.27	31.5	54
MBSI-22-03	0.1	21000	7.2	230	0.8	0.4	4.7	24	24	<0.29	28.8	18400	413	16.7	14	0.1	0.3	0.26	31.1	51
MBSI-22-02	<0.1	14900	8.8	148	0.6	0.2	4.8	18.2	18	<0.29	23.2	16600	307	13.3	16	<0.1	0.7	0.24	38.1	62
MBSI-23-01	<0.1	16900	8.5	129	0.8	0.2	7.6	19.1	19	<0.29	32.7	18800	523	14.3	21	0.1	0.3	0.19	25	55
MBSI-23-02	<0.1	19800	10.8	168	0.8	0.3	7.6	21.4	21	<0.29	31.8	18100	335	16.5	15	<0.1	0.4	0.23	38.5	62
MBSI-24-01	0.3	9500	2.8	229	0.7	0.1	18.2	160	160	<0.29	82.6	29900	409	114	7.1	<0.1	<0.2	0.18	99	67
MBSI-24-02	0.2	14600	8.5	172	0.6	0.2	8	33.6	34	<0.29	37.9	19100	309	27.5	10.7	0.1	0.4	0.22	41.3	62
MBSI-25-01	0.1	18600	6.3	308	0.8	0.7	5.2	16.7	17	<0.29	34.3	16300	682	12.2	21	<0.1	0.2	0.26	24.4	83
MBSI-25-03	0.1	20900	6.4	304	0.9	0.7	4.7	18.8	19	<0.29	49	17000	643	12.4	20	0.1	0.3	0.3	26.5	87
MBSI-25-02	<0.1	15800	8.9	168	0.7	0.3	5.8	30.8	31	<0.29	70	18100	525	21.7	12	<0.1	0.3	0.23	31.1	58
MBSI-26-01	<0.1	18800	8.7	166	0.6	0.4	5.3	20.7	21	<0.29	24.5	15100	372	15	15	<0.1	0.4	0.23	29.1	58
MBSI-26-03	<0.1	18500	8.7	165	0.6	0.4	4.7	19.9	20	<0.29	23.3	15100	372	14.3	15	<0.1	0.5	0.22	28.7	56
MBSI-26-02	0.1	15600	9.5	205	0.6	0.3	5.6	21	21	<0.29	36.5	17300	331	19.4	12.7	<0.1	0.5	0.26	40.3	82
MBSI-27-01	<0.5	11000	10	268	0.5	0.2	4.8	17	17	<0.29	28.4	15400	273	10.1	15	0.2	0.5	0.15	24.6	39
MBSI-27-02	<0.5	12700	9.3	434	0.6	0.3	6.3	18.3	18	<0.29	43.5	16800	402	17.8	27	0.1	0.6	0.23	26.4	50
MBSI-28-01	<0.3	17600	33.9	349	0.6	0.3	8.1	39	39	<0.29	70.2	19200	1280	22.8	30	0.5	0.2	0.62	23.5	74
MBSI-28-02	<0.3	12900	36	283	0.8	0.6	4.8	24.4	24	<0.29	49.9	20300	891	13	33	0.4	<0.2	0.23	33.9	107
MBSI-29-01	<0.1	9190	5.7	125	0.5	0.1	5.1	14.5	14	<0.29	64.5	11600	227	9.5	7	<0.1	0.3	0.11	15.1	53
MBSI-29-02	<0.1	5980	3.8	54	0.4	0.1	4.8	10.2	10	<0.29	20	7260	218	7.9	7	<0.1	0.2	0.09	16	30
MBSI-30-01	0.3	24000	80.2	305	1.1	1	4	66.8	67	<0.29	138	16800	1440	29.4	30	0.7	0.3	0.33	24.4	116
MBSI-30-02	<0.3	19700	116	237	0.6	1	8.6	35	35	<0.29	91.4	23000	676	19.3	21	0.4	0.2	0.22	45.2	109
MBSI-30-03	<0.3	20800	115	241	0.6	1	9.4	50.8	51	<0.29	100	24400	676	24.7	21	0.4	0.2	0.24	50.1	112
MBSI-31-01	0.2	22600	12.7	264	0.8	0.4	5.3	19.8	20	<0.29	68.1	16900	326	15.8	15	<0.1	0.4	0.22	31.1	68
MBSI-31-02	0.1	29000	10.2	230	1	0.3	7.1	32.4	32	<0.29	32.9	22200	340	23.2	12	<0.1	0.5	0.3	61.2	74
MBSI-31-03	0.1	28700	10.3	230	1	0.3	7.4	32.9	33	<0.29	31.9	22400	344	23.9	14.8	0.2	0.5	0.3	60.3	76
MBSI-32-01	0.2	16500	8.2	107	0.8	0.4	5.2	25.5	26	<0.29	251	15100	358	17.4	32	0.2	0.4	0.25	25.3	105
MBSI-32-02	0.1	18500	8	171	0.8	0.2	6	24.4	24	<0.29	143	19000	404	15.6	15	0.1	0.4	0.25	33.9	86
MBSI-33-01	<0.1	11800	5.4	176	0.6	0.2	7.7	22.9	23	<0.29	21.3	15600	349	15.7	14	<0.1	0.3	0.17	26.2	59
MBSI-33-02	<0.5	18100	9.1	304	0.6	0.2	5.2	22.2	22	<0.29	27.3	16300	183	12.8	13	0.1	0.3	0.21	35.3	51

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Fine Fraction (<250 µm) Concentrations (mg/kg)																		
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-34-01	<0.2	13100	6.1	198	0.5	0.4	7.3	26.6	27	<0.29	29.5	16800	917	20.4	8.9	0.1	0.6	0.21	32.2	71
MBSI-34-02	<0.1	11800	6.3	115	0.4	0.3	6.1	21.9	22	<0.29	20.3	15200	405	16.9	7.6	<0.1	0.6	0.19	35.6	55
MBSI-34-03	<0.2	12100	6.4	118	0.5	0.3	6.4	21.8	22	<0.29	32.2	15900	418	17.7	7.8	0.1	0.6	0.19	35.7	59
MBSI-35-01	0.3	20600	13.7	325	0.8	0.5	14	18.7	19	<0.29	45.1	28500	1180	27.4	45	0.2	<0.2	0.31	28.2	194
MBSI-35-02	0.1	24500	6.9	236	1	0.2	9	24.4	24	<0.29	36.2	23200	806	15.8	17	0.2	0.2	0.43	30.8	83
MBSI-35-03	<0.3	22800	6.8	220	0.9	0.2	9.5	20.3	20	<0.29	39.4	22400	767	14.4	20	0.2	<0.2	0.42	29.2	78
MBSI-36-01	0.2	18500	13	204	0.9	0.4	8.7	20.9	21	<0.29	33.8	20000	522	20.7	14.9	0.3	0.6	0.26	39.6	93
MBSI-36-02	0.2	19500	12.6	204	1.1	0.7	9.4	29.2	29	<0.29	34	21000	585	29.9	18.9	0.2	0.7	0.33	44.8	83
MBSI-37-01	<0.2	12100	7.3	194	0.5	0.3	6.4	31.7	32	<0.29	28.7	17100	622	20.9	10.6	0.1	0.6	0.18	25.6	69
MBSI-37-02	<0.1	13700	6.2	150	0.5	0.2	8.7	24.9	25	<0.29	29.9	19000	563	21.4	8.5	<0.1	0.4	0.14	32.3	65
MBSI-38-01	0.1	17000	5.8	237	0.8	1	6.8	18.9	19	<0.29	42.2	21200	418	19	12	<0.1	0.4	0.23	31.3	109
MBSI-38-02	<0.1	14800	5.2	211	0.5	0.5	4.9	17.2	17	<0.29	42.9	15200	599	11.3	10.2	<0.1	0.6	0.2	26.2	82
MBSI-39-01	<0.1	17000	8.1	762	0.7	0.3	6.6	24.5	24	<0.29	186	26900	798	21.3	12	0.1	0.8	0.28	29.5	83
MBSI-39-02	<0.1	9520	5.7	73	0.5	0.1	3	15	15	<0.29	56.4	12400	261	10.9	10	<0.1	0.2	0.1	16.9	43
MBSI-40-01	0.1	38400	6.1	161	0.5	0.4	9.8	34.3	34	<0.29	533	18300	490	44	16	<0.1	0.3	0.15	30.9	153
MBSI-40-02	0.1	25900	7.2	231	0.9	0.3	8.6	35.4	35	<0.29	37.4	23100	455	26.5	25	0.1	0.3	0.24	41.2	63
MBSI-41-01	<0.5	11700	8.7	89	0.6	0.2	5.6	17.3	17	<0.29	43.3	18400	427	14.1	13	0.2	0.4	0.2	22.8	50
MBSI-41-02	<0.5	16400	8.8	110	0.7	0.3	7.2	20	20	<0.29	45.4	18100	466	16.4	19	0.2	0.5	0.25	29.6	61
MBSI-42-01	0.1	31500	13	166	1.1	0.2	10.9	39	39	<0.29	58.6	31800	267	32.1	22	0.2	1	0.31	95.4	100
MBSI-42-02	<0.1	9740	9.5	136	0.5	<0.1	3.5	15.7	16	<0.29	15.2	13200	112	11.5	15	<0.1	0.6	0.16	33.9	52
MBSI-43-01	<0.3	21500	9.6	412	1.2	0.4	6.8	35.4	35	<0.29	63	21100	567	20.8	23	0.4	0.2	0.2	20.5	88
MBSI-43-02	0.2	20000	12	157	1	0.5	6.1	24.8	25	<0.29	59.8	17900	491	14.9	30	0.2	0.3	0.31	29.8	72
MBSI-44-01	0.2	15700	9.7	126	0.7	0.3	4.9	21.6	22	<0.29	52.6	17600	415	12.1	25	0.2	0.4	0.21	34.1	64
MBSI-44-02	<0.1	18500	8.1	129	0.7	0.3	5.1	22.4	22	<0.29	29.8	16000	336	13.2	24	0.2	0.4	0.21	25.7	56
MBSI-45-01	0.1	14200	9	227	0.6	0.2	5.8	18.9	19	<0.29	114	16800	404	14.1	13	0.1	0.5	0.18	24.7	64
MBSI-45-02	<0.1	14000	6.4	129	0.6	0.3	5.6	19.3	19	<0.29	115	17200	387	14.3	13	0.1	0.4	0.19	25.1	64
MBSI-45-03	<0.1	13200	6.1	135	0.6	0.2	5.4	18.3	18	<0.29	44.4	17000	378	13.8	12	<0.1	0.4	0.17	23.5	50
MBSI-46-01	<0.3	10800	14.9	246	0.7	0.3	6.5	22.7	23	<0.29	54.8	14900	338	13.1	20	0.8	0.2	0.32	25.4	72
MBSI-46-02	<0.3	19500	21.9	398	1.1	0.5	6.4	25.2	25	<0.29	52.5	19100	694	17.2	19	0.3	<0.2	0.55	30.6	106
MBSI-47-01	<0.1	21600	8.1	255	1	0.3	6.1	17.3	17	<0.29	40.9	17700	712	10	21	0.2	0.3	0.36	26.2	61
MBSI-47-02	<0.1	26300	9.4	104	1.6	0.2	8.8	32.9	33	<0.29	36.1	25100	581	19.9	28	0.1	0.4	0.27	30.5	53
MBSI-48-01	<0.5	16800	9.6	171	0.6	0.3	7.4	21.4	21	<0.29	36.2	18400	417	18.8	13	0.1	0.4	0.25	35.6	72
MBSI-48-02	<0.5	24600	8.4	207	0.9	0.3	7.6	27	27	<0.29	55.8	20600	371	21.5	20	0.3	0.4	0.32	47.7	74
MBSI-49-01	0.2	27500	7.7	231	1	0.3	8.7	35	35	<0.29	173	24600	717	21	23	0.2	0.3	0.27	47.8	92
MBSI-49-02	0.2	24300	8.9	191	1.3	0.3	9.4	34.8	35	<0.29	307	22900	796	20.9	33	0.2	0.3	0.31	28.5	135
MBSI-50-01	<0.5	18600	5.9	531	0.7	0.2	9.7	27.9	28	<0.29	55.2	20300	980	23.1	16	0.1	0.3	0.23	30.3	61
MBSI-50-03	0.1	19200	5.6	504	0.8	0.2	9.3	27.1	27	<0.29	53.5	20000	852	22.1	15.2	0.2	0.3	0.23	30	61

Table 3-2. Background Soil Sample Analytical Results

Sample ID	Fine Fraction (<250 µm) Concentrations (mg/kg)																		
	Ag	Al	As	Ba	Be	Cd	Co	Cr	Cr(III)	Cr(VI)	Cu	Fe	Mn	Ni	Pb	Sb	Se	Tl	V	Zn
MBSI-50-02	<0.5	18300	7.1	795	0.7	0.2	9.1	30.1	30	<0.29	60.7	21700	512	24.1	18	0.2	0.3	0.19	37.6	59
MBSI-51-01	0.4	22800	43.3	210	0.8	0.9	7.7	13.8	14	<0.29	77.3	19200	640	6.5	23.2	0.3	<0.2	0.25	44.6	132
MBSI-51-02	0.5	20900	21.8	178	0.9	0.9	9	22.4	22	<0.29	60.5	19000	581	15.8	38.6	0.6	0.3	0.36	41.7	112
MBSI-52-01	<0.1	18400	8.5	218	0.9	0.3	5.9	26	26	<0.29	195	17800	431	18.1	17	<0.1	0.7	0.26	28.9	92
MBSI-52-02	<0.1	12600	6.5	150	0.7	0.2	5.1	16.6	17	<0.29	58.9	15500	335	14.5	17	0.1	0.5	0.18	23.5	58
MBSI-53-01	0.1	23900	11.2	211	0.9	0.2	7.2	27.3	27	<0.29	165	22000	264	18.8	23	0.2	0.5	0.31	47.7	95
MBSI-53-02	0.1	22100	9.3	140	0.8	0.4	5.7	26.9	27	<0.29	54.9	18100	425	15.7	27	0.1	0.3	0.28	33.7	73
MBSI-53-03	0.1	21600	9.5	139	0.9	0.4	6.2	25.5	26	<0.29	69.7	18000	433	16	24	0.1	0.4	0.29	32.4	75
MBSI-54-01	<0.3	26000	3.1	276	0.5	<0.1	4.1	15.7	16	<0.29	21.5	18400	732	17.1	22	<0.1	<0.2	0.3	19.8	110
MBSI-54-02	<0.1	12200	8	89	0.6	<0.1	5.1	22.5	22	<0.29	23	17000	225	15	9	<0.1	<0.2	0.13	22.6	32
MBSI-55-01	<0.2	19900	16.4	303	0.9	0.3	7.7	29.5	30	<0.29	34	22100	351	26.5	15.8	0.2	0.7	0.34	58.8	93
MBSI-55-02	<0.1	19000	8.6	171	0.6	0.1	6.8	22.9	23	<0.29	18.1	17600	322	17.7	9.8	0.1	0.3	0.17	32.7	54
MBSI-56-01	<0.5	15600	2.6	252	0.4	0.1	5	11.7	12	<0.29	35.5	14000	834	11.2	14	0.1	<0.2	0.22	18.9	52
MBSI-56-02	<0.5	17900	3.2	249	0.4	0.2	6.8	14.1	14	<0.29	52.1	19000	475	19.5	11	<0.1	<0.2	0.34	15.6	129

NOTES: (1) Shaded pairs of samples indicate sample/field duplicate pairs.

(2) Results are presented on the figures in Appendix C.

(3) Fine fraction (<250 µm) samples analyzed as the portion of sample passing No. 60 sieve; dry sieving of samples was conducted in the laboratory.

Table 4-1. Background Sample Summary Statistics

Parameter[1]	Fraction[2]	#ND[3]	%ND[4]	Median	Mean[5]	Minimum	Maximum
Aluminum	Bulk	0	0%	15000	15500	4150	33700
	Fine	0	0%	16900	17300	5200	38400
Antimony	Bulk	23	21%	0.2	0.2	<0.1	1.2
	Fine	35	31%	0.1	0.2	<0.1	0.8
Arsenic	Bulk	0	0%	8.4	11.4	1.5	81.9
	Fine	0	0%	8.5	11.5	2.6	116
Barium	Bulk	0	0%	171.5	195	32	575
	Fine	0	0%	204	225	48	795
Beryllium	Bulk	0	0%	0.7	0.7	0.1	1.4
	Fine	0	0%	0.7	0.7	0.2	1.6
Cadmium	Bulk	15	13%	0.25	0.3	<0.1	1.1
	Fine	10	9%	0.3	0.3	<0.1	1.6
Chromium	Bulk	0	0%	18.1	19.6	3.2	130
	Fine	0	0%	22.1	24.7	8.5	160
Chromium (III)	Bulk	1	1%	18	19.5	<5	130
	Fine	0	0%	22	24.7	8	160
Chromium (VI)	Bulk	98	88%	<0.29	0.33	<0.29	1.2
	Fine	112	100%	<0.29	0.29	<0.29	<0.29
Cobalt	Bulk	0	0%	6.9	7.3	2.1	16.4
	Fine	0	0%	6.3	6.6	1.5	18.2
Copper	Bulk	0	0%	15.8	17.6	3.8	70.7
	Fine	0	0%	44.0	65.0	15.2	533
Iron	Bulk	0	0%	17650	18200	6430	59200
	Fine	0	0%	18100	18000	7230	31800
Lead	Bulk	0	0%	14.5	15.3	3	36.9
	Fine	0	0%	15	16.9	6.2	45
Manganese	Bulk	0	0%	425	508	74	2920
	Fine	0	0%	412	477	61	1560
Mercury	Bulk	111	99%	<0.05	0.05	<0.05	0.068
Nickel	Bulk	0	0%	14.7	16.6	1.6	81.5
	Fine	0	0%	16.6	18.1	5.8	114
Selenium	Bulk	24	21%	0.4	0.4	0.2	1.6
	Fine	17	15%	0.4	0.4	0.2	1.3
Silver	Bulk	83	74%	<0.1	0.2	<0.1	0.5
	Fine	68	61%	<0.2	0.2	<0.1	0.6

Table 4-1. Background Sample Summary Statistics

Parameter[1]	Fraction[2]	#ND[3]	%ND[4]	Median	Mean[5]	Minimum	Maximum
Thallium	Bulk	0	0%	0.235	0.25	0.07	0.84
	Fine	0	0%	0.23	0.25	0.07	0.62
Vanadium	Bulk	0	0%	29.6	30.9	6.7	92.2
	Fine	0	0%	30.4	32.3	11.9	99
Zinc	Bulk	0	0%	56.5	60.5	16	147
	Fine	0	0%	65	73.1	20	194

NOTES:

(1) Total number of samples (n) for each parameter = 112
For summary statistics calculations, field sample-duplicate pair results were reduced to a single value for each constituent by retaining the higher of the two values.
(2) Fine fraction (<250 µm) samples analyzed as the portion of sample passing No. 60 sieve
(3) #ND = number of reported nondetect results
(4) %ND = percentage of results reported as nondetect
(5) Nondetect values were replaced with the detection limit for calculation of mean.

Table 4-2. Comparison of MBSI Bulk Sample and Western U.S. Mean Concentrations (USGS)[(1)]

Parameter	MBSI Mean (mg/kg)	Western U.S. Mean (mg/kg)
Aluminum	15500	58000
Antimony	0.2	0.47
Arsenic	11.4	5.5
Barium	195	580
Beryllium	0.7	0.68
Cadmium	0.3	not reported
Chromium	19.6	41
Cobalt	7.3	7.1
Copper	17.6	21
Iron	18200	21000
Lead	15.3	17
Manganese	508	380
Mercury	0.05	0.05
Nickel	16.6	15.0
Selenium	0.4	0.23
Silver	0.2	not reported
Thallium	0.25	not reported
Vanadium	30.9	70
Zinc	60.5	55

NOTES: (1) Shacklette, H.T. and J.G. Boerngen, 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. USGS Professional Paper 1270.

Table 4-3. Bulk-Fine Fraction Statistical Comparison

Parameter	Median Concentration (mg/kg)[1]		% Nondetects		Sign Test Statistics			Result
	Bulk	Fine	Bulk	Fine	S Statistic	Z Value	2-sided p-value[3]	
Aluminum	15000	16900	0%	0%	20	-6.71	**<0.0001**	**Fine>Bulk**
Antimony	0.2	0.1	21%	34%	42	3.78	**0.0002**	**Bulk>Fine**
Arsenic	8.4	8.5	0%	0%	58	0.77	0.440	No Difference
Barium	171.5	201	0%	0%	22	-6.20	**<0.0001**	**Fine>Bulk**
Beryllium	0.7	0.7	0%	0%	26	-2.14	**0.032**	**Fine>Bulk**
Cadmium	0.25	0.3	13%	9%	14	-3.30	**0.001**	**Fine>Bulk**
Chromium	18.05	22.05	0%	0%	21	-6.32	**<0.0001**	**Fine>Bulk**
Chromium (III)	18	22	1%	0%	15	-6.70	**<0.0001**	**Fine>Bulk**
Chromium (VI)	<0.29	<0.29	88%	100%	NA[2]	NA	NA	NA
Cobalt	6.9	6.3	0%	0%	71	3.29	**0.001**	**Bulk>Fine**
Copper	15.75	43.4	0%	0%	0	-10.49	**<0.0001**	**Fine>Bulk**
Iron	17650	18100	0%	0%	52	-0.48	0.634	No Difference
Lead	14.5	15	0%	0%	37	-3.42	**0.0006**	**Fine>Bulk**
Manganese	425	407.5	0%	0%	48	-1.42	0.156	No Difference
Mercury	<0.05	NA	99%	NA	NA	NA	NA	NA
Nickel	14.7	16.5	0%	0%	48	-1.42	0.156	No Difference
Selenium	0.4	0.4	22%	15%	18	-0.91	0.360	No Difference
Silver	<0.1	<0.1	73%	61%	NA	NA	NA	NA
Thallium	0.235	0.23	0%	0%	49	-0.39	0.694	No Difference
Vanadium	29.6	30.4	0%	0%	47	-1.61	0.108	No Difference
Zinc	56.5	65	0%	0%	17	-7.09	**<0.0001**	**Fine>Bulk**

NOTES:

(1) Median values for some parameters differ slightly from those presented in Table 4-1, due to differences in treatment of field duplicates (see Section 4.2).

(2) NA = not analyzed

(3) $p < 0.05$ indicates significant test result

Table 4-4. Background Threshold Values (BTVs) for Inorganics in Montana Surface Soils

Parameter[1]	ProUCL BTV (mg/kg)	Distribution[2]	BTV Method[3]	Comparison Values	
				BGS NBC (mg/kg)[4]	EPA Residential Soil RSL (mg/kg)[5]
Aluminum	**25941**	N	UTL 95/90 N	26335	7700
Antimony	**0.4**	NC	UTL 95/90 KM	NC	3.1
Arsenic	**22.5**	None	UTL 95/90 BS	18.2	0.61
Barium	**429**	LN	UTL 95/90 LN	437	1500
Beryllium	**1.1**	None	UTL 95/90 BS	1.1	16
Cadmium	**0.7**	NC	UTL 95/90 KM	NC	7
Chromium	**41.7**	LN	UTL 95/90 LN	44.6	None
Chromium (III)	**41.7**	LN	UTL 95/90 LN	44.4	12000
Chromium (VI)[6]	**NC**	NC	NC	NC	0.29
Cobalt	**10.0**	N	UTL 95/90 N	9.7	2.3
Copper	**165**	None	UTL 95/90 BS	149	310
Iron	**24400**	None	UTL 95/90 BS	24640	5500
Lead	**29.8**	LN	UTL 95/90 LN	29.7	400
Manganese	**880**	G	UTL 95/90 GWH	929	180
Mercury[7]	**NC**	NC	NC	NC	1
Nickel	**31.4**	LN	UTL 95/90 LN	27.3	150
Selenium	**0.7**	NC	UTL 95/90 KM	NC	39
Silver	**0.3**	NC	UTL 95/90 KM	NC	39
Thallium	**0.41**	LN	UTL 95/90 LN	0.37	0.078
Vanadium	**52.6**	LN	UTL 95/90 LN	54.0	39
Zinc	**118**	LN	UTL 95/90 LN	116	2300

NOTES:

(1) Calculations based on fine fraction (< 250 µm) results for background sample set (n=112).

(2) Distribution tested with ProUCL v5.0 N = normal; LN = lognormal; G = gamma; None = none indicated; NC = not calculated due to nondetects.

(3) UTL 95/90 = Upper Tolerance Limit with 95% confidence/90% coverage. ProUCL v5.0 method selected based on observed distribution. N = normal; LN = lognormal; GWH = gamma Wilson-Hilferty; BS = nonparametric bootstrap; KM = Kaplan-Meier method.

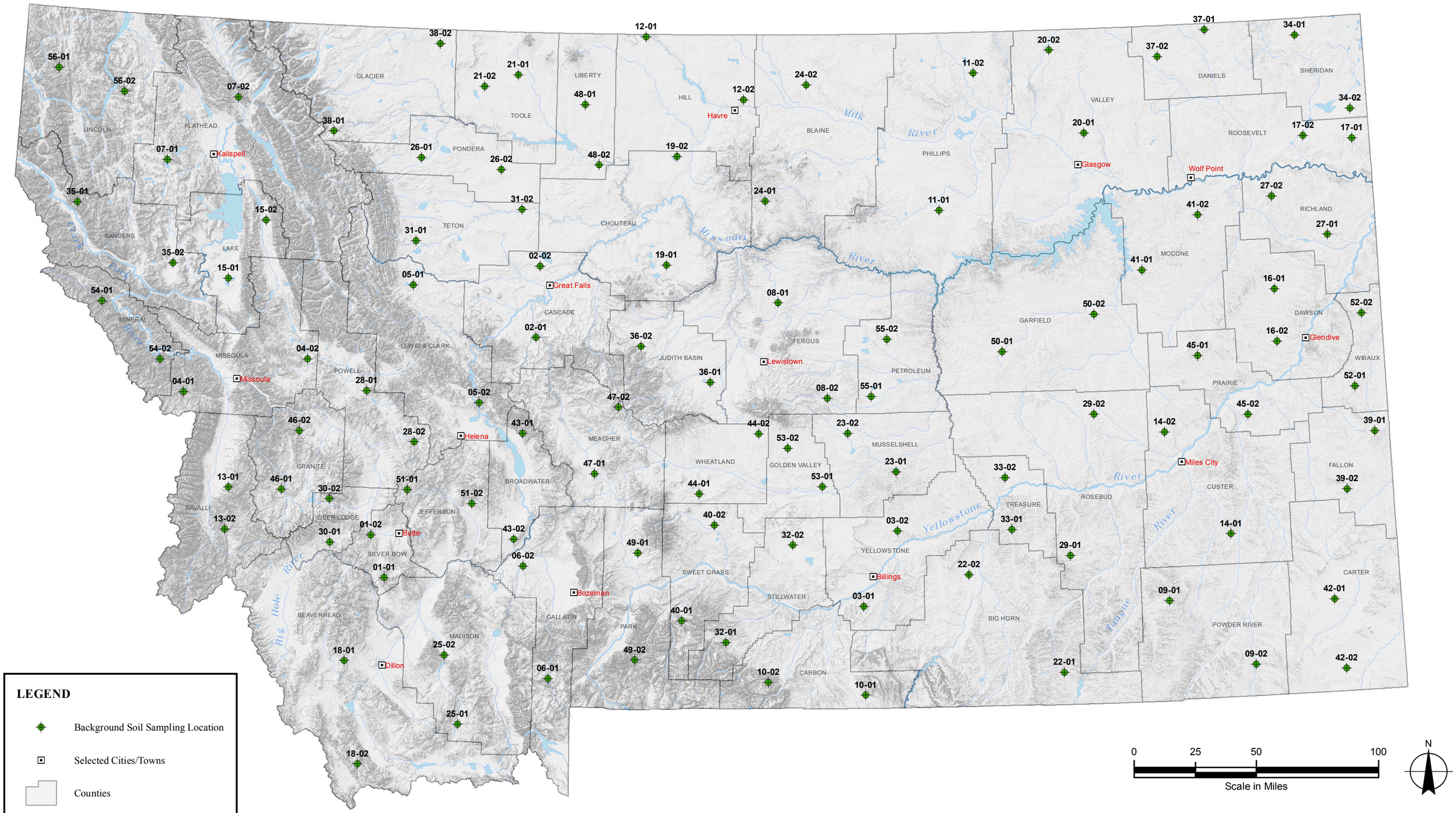
(4) BGS NBC = British Geological Survey Natural Background Concentration method (modified to show upper 95% confidence/90th percentile).

(5) Regional Screening Level for residential soil direct contact. May 2013 values based on target hazard quotient (THQ) of 0.1.

(6) All Cr (VI) values in fine fraction samples were reported as <0.29 mg/kg.

(7) Mercury was analyzed on bulk samples only; all values were <0.05 mg/kg with the exception of one detectable concentration reported at 0.068 mg/kg.

FIGURES



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BACKGROUND CONCENTRATIONS OF INORGANIC CONSTITUENTS IN MONTANA SURFACE SOILS

SOIL SAMPLING LOCATIONS

FIGURE

2-1