Cleanup Program

Development of Oregon Background Metals Concentrations in Soil

Technical Report

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State of Oregon
Department of
Environmental
Quality

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DEQ is a leader in restoring, maintaining and enhancing the quality of Oregon's air, land and water.

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Executive Summary

The Oregon Department of Environmental Quality (DEQ) recently completed a re-evaluation of metals background data in Oregon. This presents regional background metals concentrations and provides supporting documentation on how these concentrations were developed.The background concentrations presented in this report can be used to establish background metals concentrations for cleanup sites.

The values in Table 4 of this report replace previous statewide background values contained in a 2002 DEQ memorandum (DEQ, 2002) subsequently incorporated into Appendix B of DEQ's *Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment* (DEQ, 2007) and into Table 1 of DEQ's *Human Health Risk Assessment Guidance* (DEQ, 2010). Background metals concentrations are provided for 10 physiographic provinces across the state.

Additional information on the use and application of these values is provided in DEQ's Fact Sheet titled *Background Levels of Metals in Soils for Cleanups*

1. Introduction

1.1 Purpose and Organization

The Oregon Department of Environmental Quality (DEQ) recently completed a re-evaluation of metals background data in Oregon. This project generated an Oregon-specific database representing a variety of different regions. This document's focus is to present regional background metals concentrations and provide supporting documentation on how these concentrations were developed.

A DEQ memorandum prepared in 2002 remained in draft form; however, it was commonly utilized by DEQ to help establish background metals concentrations for cleanup sites (DEQ, 2002). This memorandum presented Pacific Northwest regional default background concentrations for metals in soil and sediment. The identified soil background levels were subsequently incorporated into Appendix B of DEQ's 2007 Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment (DEQ, 2007) and into Table 1 of DEQ's 2010 Human Health Risk Assessment Guidance (DEQ, 2010).

The 2002 memorandum was itself based primarily on data obtained from the State of Washington's Department of Ecology, the United States Geological Survey (USGS), and British Columbia's Ministry of Water, Land and Air Protection. Subsequent discussions with DEQ staff indicated that there was an appreciable amount of Oregon-specific data that was not evaluated or included in this original analysis.

While DEQ's 2002 memorandum was widely used, it had the following limitations:

- The memo was based on data and literature existing in 2002. New information and datasets are now available and relevant for incorporation;
- Some data sources were not specific to Oregon, and some areas of the state were underrepresented;
- Background estimates did not account for mineralized areas like mining districts;
- Background estimates were not available for some metals considered important to risk screening;
- All of the "default" background soil values for metals from the memorandum were based on British Columbia 95th percentile or Washington 90th percentile values; and,
- Several Oregon supporting datasets were not included in the evaluation of background metals.

1.2 Funding

Funding to update information related to background metal concentrations was provided by the DEQ's "State Response" Cooperative Agreement with the Environmental Protection Agency (EPA) in 2010 and 2011. GeoEngineers, Inc., (GeoEngineers) under contract to DEQ, completed Phase 1 and Phase 2 work focused on updating DEQ's 2002 memorandum.

1.3 Acknowledgements

This document was authored by the following DEQ Environmental Cleanup Program staff and Contractors:

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Annette Dietz, DEQ Land Quality Division
Paul Seidel, DEQ Northwest Region
Neil Morton, Rob Smith, Stan Miller, of GeoEngineers, Inc.

Additional review was provided by DEQ cleanup program managers and staff.

2. Background Metals Investigation

DEQ began initial data collection efforts in 2002 and DEQ and GeoEngineers completed two phases of work beginning in 2009 to establish background metals concentrations in Oregon.

2.1 Phase 1 Work

In 2010, GeoEngineers completed Phase 1 work focused on updating DEQ's 2002 memorandum. GeoEngineers produced a Background Metals Report and associated database in June 2010 (GeoEngineers, 2010). The reporting included compilation and standardization of the analytical results into a database, including GIS information with accompanying text, summary statistics, figures, and tables (GeoEngineers, 2010).

The 2010 Background Metals Report presented state-wide and regional concentrations for 16 metals: antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. Calculated descriptive summary statistics included minimum and maximum detected concentrations, mean, median, 25^{th}, 75^{th}, 90^{th}, and 95^{th} percentile concentrations, 90 percent upper confidence limits on the arithmetic mean (90% UCL), and box-plots for each metal dataset.

While the summary statistics presented in the 2010 report showed that the soils in Oregon differed enough from the soils of Washington and British Columbia to justify the calculation of state-specific regional background soil metals concentrations, several additional issues were identified and became the focus of Phase 2 work. The issues included:

- Detection frequency of individual metals;
- Potential outliers in the database;
- Elevated analytical detection limits;
- Areal distribution and density of sample locations; particularly the very high sample frequency in southeast Oregon; and,
- The need to update the Portland State University (PSU) and USGS datasets.

2.2 Phase 2 Work

In 2011, GeoEngineers completed the Phase 2 work which included compilation and standardization of analytical results for 5,127 samples into a database and geographic information system (GIS) with accompanying text, summary statistics, figures, and tables (GeoEngineers, 2011). The database and GIS are discussed in Section 2.3 and 2.4.

As part of Phase 2, an evaluation of the data was conducted to address outliers, non-detects, and duplicate samples. Geostatistical analysis was performed including kriging techniques to identify areas that needed additional sampling. In addition, declustering techniques[1] were implemented to reduce the number of samples in some of the areas (e.g. southeast Oregon) and ensure representativeness of the data for use in Oregon.

One of the goals of the Phase 2 work was to identify a representative dataset that could be used to calculate the background concentrations in the State of Oregon. The declustered dataset was identified as the most representative of the state and was then used to calculate descriptive summary statistics including minimum and maximum detected concentrations, mean, median, and 25th, 75th, 90th and 95th percentile concentrations. Figure 1 shows the locations of the declustered background samples. The declustered dataset was subsequently used to develop regional background concentration estimates as outlined in Section 3.

2.3 Database Sources

The 2010 Background Metals Database included analytical data from eight sources, which are briefly described below. The 2010 Background Metals Report (GeoEngineers, 2010) includes a more complete description of each data source.

- PSU Soil Database – Southwest Oregon: PSU obtained more than 400 soil samples in western Oregon to determine background metals concentrations in soil. The 2010 Background Metals Database includes 246 soil samples obtained in southwest Oregon from 118 sample locations in 1994/1995. Rafiqul Alam Khandoker's Master's thesis includes a description of the sampling methodology employed as well as an interpretation of the analytical results (Khandoker, 1997).

- PSU Soil Database – Southwest & Northwest Oregon: DEQ and GeoEngineers submitted 384 PSU soil samples, obtained in southwest and northwest Oregon in 1994/1995, for reanalysis GeoEngineers, 2010). These samples were submitted for analysis of eight metals (antimony, arsenic, beryllium, cadmium, lead, selenium, silver, and thallium) that were either not detected in 1994/1995 or had a low detection frequency.

- Mine Scarred Lands Pilot Project – Clear Creek and Ochoco Creek Basins: DEQ conducted soil, sediment, and surface water sampling in these two basins in 2006 to help establish a frame work for watershed-based assessments of mining districts in Oregon (DEQ, 2006a and 2006b). 84 soil samples from these two basins were incorporated into the 2010 Background Metals Database.

[1] Clustered sampling often results during environmental site investigations when localized areas are over-sampled due to project-specific sampling objectives resulting in differential sampling densities when differing datasets are combined. A nearest-neighbor method for spatial declustering was used to generate a spatially unbiased dataset across the State of Oregon.

- Oregon Department of Geology and Mineral Industries (DOGAMI) – Western Ochoco National Forest: DOGAMI conducted a stream-sediment sampling program in the western part of the Ochoco National Forest in 1982 (Ferns and Brooks, 1983). The purpose of the program was to evaluate the use of geochemical sampling in helping to identify potential mineral-resource areas. The 2010 Background Metals Database includes 299 stream-sediment samples from this program.

- DOGAMI – Geoanalytical Information Layer for Oregon (GILO), Release 1: GILO is a spatial database of DOGAMI's geochemical (whole rock and trace elements) and geochronological data (Ferns and McConnell, 2005). The 2005 database contains geochemical information for 1,141 samples obtained during regional geologic mapping projects in central and eastern Oregon. 1,073 samples from this dataset were included in the 2010 Background Metals Database.

- USGS – Geochemical Datasets: The USGS has a number of geochemical datasets available on-line. The 2010 Background Metals Database includes (1) geochemistry of soils in the United States from the PLUTO database (USGS 2001) and 2) a version of the National Geochemical Survey database specific to Oregon (Smith 2007). The 2010 Background Metals Database includes 3,257 USGS soil and stream sediment samples.

- US Department of Agriculture (USDA) – National Resource Conservation Service (NRCS): The USDA – NRCS Soil Geochemistry Spatial Dataset contains data collectively produced by the National Cooperative Soil Survey (NCSS) Program (USDA-NRCS, 2009a and 2009b). The Soil Geochemistry Spatial Dataset includes two major sets of geochemistry data: 1) the NCSS Characterization Database (aka, Current Geochemistry Project) and 2) the Holmgren Dataset. The 2010 Background Metals Database includes 348 soil samples from the USDA-NRCS dataset.

- Kingsley Firing Range Annex: Shaw Environmental, Inc. obtained 18 background surface soil samples in 2007 (Shaw, 2008). These samples were submitted for chemical analysis of aluminum, antimony, arsenic, barium, copper, iron, lead, manganese, mercury, molybdenum, nickel, and zinc. The background samples were obtained at locations assumed not to be impacted by site activities and within approximately 1/2–mile of the Site.

The 2010 Background Metals Report identified two data gaps associated with the sources of soils background metals data. The 2010 Background Metals Database did not include (1) sample coordinates for the PSU soil samples obtained in northwest Oregon and did not include the 1994/1995 soil sample results for these samples and (2) the most up-to-date and comprehensive USGS geochemical dataset. One of the purposes of the Phase 2 work was to address these data gaps, as follows:

1. The 1994/1995 PSU data for northwest Oregon, and the associated sample coordinates, were incorporated into the Background Metals Database. The 1994/1995 PSU dataset for northwest Oregon contains analytical data for 8 metals (Antimony, Arsenic, Beryllium, Cadmium, Lead, Selenium, Silver, and Thallum) that were reanalyzed in 2010 using analytical methods with lower detection limits. The 1994/1995 PSU data for these eight metals are maintained in the Background Metals Database. However, because the 2010 detection limits are lower, the 2010 data and not the 1994/1995 data for these eight metals are used in the statistical analyses described in this report.

2. The latest available metals data from the USGS (National Geochemical Database) were incorporated into the Background Metals Database. The USGS data replaced older, less reliable data that generally

were based on analytical methods with higher detection limits. Specifically, the National Geochemical Database replaced two USGS datasets that were included in the June 2010 Oregon Background Metals Database (USGS: Pluto Database and USGS: NURE Database). In cases where the National Geochemical Database included multiple results for individual soil and sediment samples, results associated with analytical methods identified by USGS as having the highest analytical quality (http://tin.er.usgs.gov/geochem/method.php) were used in the statistical analyses described in this report. However, results from all available methods are included in the Background Metals Database. Multiple results are included in the National Geochemical Database because many samples were originally analyzed in the late 1970s/early 1980s using methods with inadequate detection limits. A subset of these samples was reanalyzed in later years using better analytical methods, achieving lower detection limits.

3. Background data from the Umatilla Chemical Depot (UMCD). The UMCD background dataset was sent to GeoEngineers by David Anderson (DEQ) on February 18, 2011 (Dames & Moore, 1992; Quanterra, 1998).

4. 30 additional soil samples at 15 target sampling areas collected by GeoEngineers in May 2011as part of the Phase 2 investigation. These 30 soil samples were obtained in areas within Oregon that had the greatest uncertainty associated with estimating the background value of selected metals as identified by the geostatistical and kriging analysis (GeoEngineers, 2011).

2.4 Database Development

As part of Phase 1 and Phase 2 work, GeoEngineers helped establish, standardize, and populate the Background Metals Database; specific tasks included performing the following activities:

- Converted sample locations into a common projection (geographic) and horizontal datum (WGS84) for the State of Oregon;

- Converted sample results to common units of milligrams per kilogram (mg/kg);

- Assigned each sample location to a physiographic province (see Section 2.5 below);

- Evaluated the database for overlapping samples (i.e., identify samples that are in multiple datasets);

- Flagged as non-reportable those results that were not used in the statistical evaluations;

- Selected only those analytical results from soil samples obtained between the ground surface and a depth of 3 feet in the operational database. Samples with no depth information were assumed to have been obtained between the ground surface and a depth of 3 feet; and,

- Reviewed the background dataset for each metal to identify if any non-detect (ND) values that exceeded the maximum detected concentration for those metals were included. As noted in the Background Metals Report (GeoEngineers, 2010), ND values greater than the maximum detected concentration were removed from further statistical evaluation. However, after replacing older USGS datasets with the USGS National Geochemical Database there are no longer any ND values that exceed the maximum detected concentration for the 16 background metals.

The final database consists of over 229,376 analytical results from 5,127 locationsand was developed on, and is currently stored in, Microsoft Access and ESRI ArcGIS platforms. DEQ's tables were developed from a declustered dataset of 18,456 analytical results from 1,799 locations. DEQ is evaluating options for how this database might be accessed by users in the future. Due to the size of the database, it is currently only available by request from DEQ.

2.5 Physiographic Province Development

The data were initially broken into nine physiographic provinces as defined in the Geology of Oregon (Orr et. al., 1992). The nine "regional" provinces identified in Oregon include the Coast Range, Basin and Range, Cascades, Willamette Valley, High Lava Plains, Owyhee Uplands, Blue Mountains, Klamath Mountains and Deschutes Columbia Plateau physiographic provinces (Figure 2).

The Willamette Valley province was further divided into two provinces called the South Willamette Valley and Portland Basin. The Portland Basin was identified as those northern portions of the Willamette Valley province that included Clackamas, Columbia, Multnomah, and Washington counties. In addition, some samples located in the Chehalem/Sherwood region were included in the South Willamette Valley province. The sample location points used for calculation of background concentrations in each province are shown in Figure 1. All regional data and summary statistics presented in this report are partitioned according to these boundaries.

3. Oregon Background Metals Concentrations

The background metals database was evaluated using EPA's ProUCL software (Version 4.1.00, 2009) and the R Software (Version 2.15.1, 2012) to develop Oregon background metals concentrations for the regional provinces around the state.

3.1 Statewide Data Summary

Summary statistics for the statewide declustered dataset of the 16 background metals are presented in Table 1 and include the detection frequency, range of non-detect data, range of detected concentrations, mean, standard deviation, and method used to calculate the mean and standard deviation.

3.2 Regional Data Summary

Summary statistics for the region-specific declustered dataset of the 16 background metals are presented in Table 2 and include the number of detects, number of non-detects, detection frequency, minimum detected concentration, maximum detected concentration, mean, standard deviation, and method used to calculate the mean and standard deviation.

Various statistical values calculated for the region-specific declustered dataset of the 16 background metals are presented in Table 3. These include the 90th and 95th percentile values, 90 percent upper tolerance limit (90% UTL), 90 percent upper prediction limit (90% UPL), 95% UPL and the the method used to calculate the percentiles (standard or nonparametric) for the 16 background metals.

4. Use and Application

This document's focus is to present regional background metals concentrations and provide information on how these concentrations were developed. The default background concentrations selected for use are the 95% UPL values in Table 3. The upper prediction limit was selected in consideration of the U.S. EPA recommendation to select this statistic for use in performing sample-specific comparisons to the estimated background threshold value and in consideration of its definition as a statistic that is expected to be exceeded only rarely by individual samples. A simplified table showing only these default background concentrations for each physiographic province is provided as Table 4. The boundaries of the physiographic provinces are shown in Figure 2. Additional information on the use and application of these values is provided in DEQ's Fact Sheet titled *Background Levels of Metals in Soils for Cleanups* .

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Figures

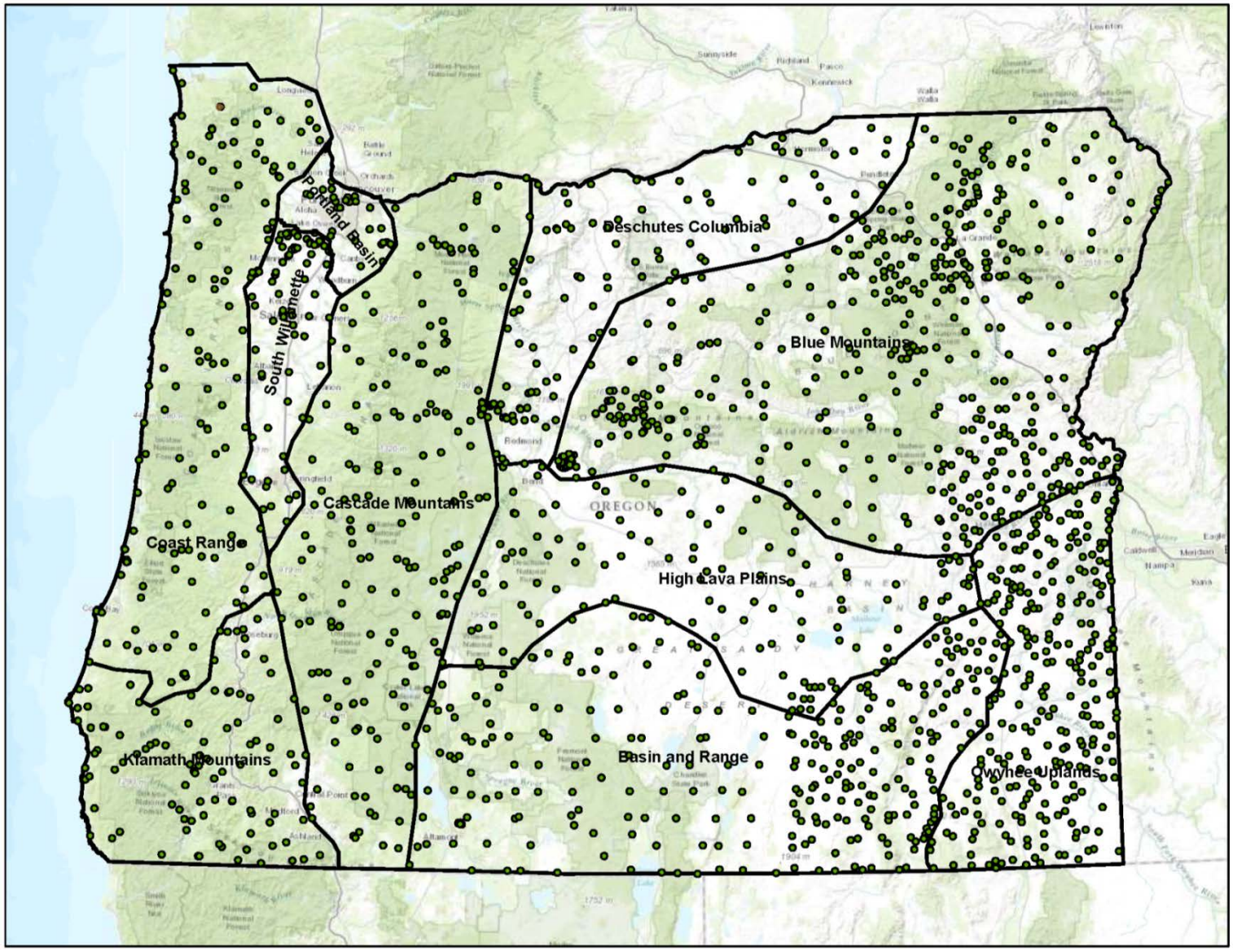

Figure 1. Background Metals Sample Locations (Declustered Dataset)

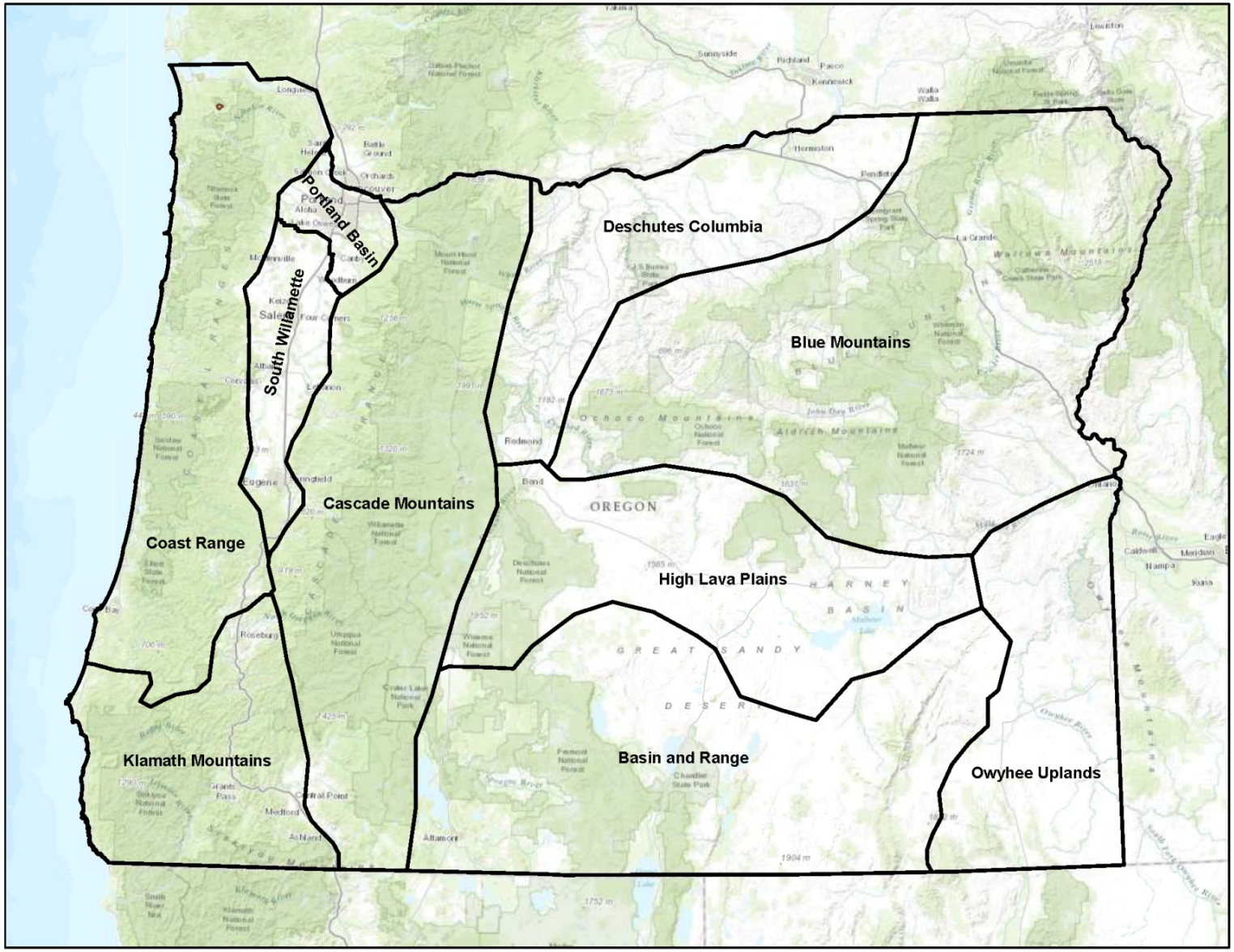

Figure 2. Physiographic Provinces of Oregon

Tables

Table 1
State-Wide Background Metals Summary Statistics
Declustered Dataset
State of Oregon

Metal	Detection Frequency		Non-Detect Range (Min - Max)	Detect Range (Min - Max)	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg							
Antimony	145/234	62%	0.0155 - 0.6	0.0204 - 1.917	0.225	0.290	Kaplan-Meier
Arsenic	1,047/1,288	81%	0.6 - 10	0.228 - 73.4	4.977	5.612	Kaplan-Meier
Barium	1,330/1,330	100%	--	10.5 - 1,855	508.70	233.60	Standard
Beryllium	1,106/1,290	86%	0.203 - 1	0.031 - 6	1.341	0.721	Kaplan-Meier
Cadmium	224/1,243	18%	0.102 - 2	0.0263 - 4.7	0.297	0.319	Kaplan-Meier
Chromium	1,331/1,331	100%	--	0.878 - 1,520	76.920	111.20	Standard
Copper	1,329/1,332	100%	2	2 - 308	38.080	29.920	Kaplan-Meier
Lead	1,282/1,328	97%	4 - 10	1 - 135	13.080	10.620	Kaplan-Meier
Manganese	1,292/1,292	100%	--	22.5 - 5,914	1015.0	557.50	Standard
Mercury	738/1,210	61%	0.02 - 0.04	0.0069 - 12.23	0.062	0.394	Kaplan-Meier
Nickel	1,320/1,322	100%	4	1 - 2,850	45.10	105.60	Kaplan-Meier
Selenium	374/1,180	32%	0.2 - 4.1	0.0613 - 5.045	0.239	0.348	Kaplan-Meier
Silver	83/1,221	7%	0.02 - 2	0.02 - 4	0.114	0.293	Kaplan-Meier
Thallium	114/208	55%	0.0568 - 4.224	0.0705 - 5.581	1.264	1.853	Kaplan-Meier
Vanadium	1,322/1,322	100%	--	4 - 486	150.30	82.320	Standard
Zinc	1,325/1,325	100%	--	11.5 - 730	93.470	41.160	Standard

Notes:
Data generated with ProUCL(Version 4.1.00), R (Version 2.15.1);

Table 2
Regional Background Metals Summary Statistics
Declustered Dataset
State of Oregon
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Basin and Range								
Antimony	19	24	44%	0.020	1.20	0.265	0.352	Kaplan-Meier
Arsenic	125	80	61%	0.588	43.0	3.990	5.033	Kaplan-Meier
Barium	204	0	100%	61.0	1200.0	561.0	179.20	Standard
Beryllium	161	46	78%	0.301	3.0	1.252	0.677	Kaplan-Meier
Cadmium	15	193	7%	0.047	4.0	0.259	0.335	Kaplan-Meier
Chromium	203	0	100%	3.50	290.0	53.540	34.230	Standard
Copper	202	0	100%	8.0	190.0	45.610	31.20	Standard
Lead	197	5	98%	1.580	68.0	14.660	8.499	Kaplan-Meier
Manganese	207	0	100%	211.0	5497.0	946.90	467.60	Standard
Mercury	90	113	44%	0.009	1.30	0.055	0.135	Kaplan-Meier
Nickel	201	0	100%	5.0	227.0	30.750	21.380	Standard
Selenium	24	150	14%	0.061	1.90	0.120	0.176	Kaplan-Meier
Silver	6	198	3%	0.059	4.0	0.101	0.305	Kaplan-Meier
Thallium	9	8	53%	0.071	0.291	0.112	0.056	Kaplan-Meier
Vanadium	200	0	100%	19.50	420.0	145.80	71.480	Standard
Zinc	203	0	100%	24.0	187.0	83.980	24.70	Standard

Table 2
Regional Background Metals Summary Statistics
Declustered Dataset
State of Oregon
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Blue Mountains								
Antimony	1	2	33%	0.143	0.143	0.143	N/A	Standard
Arsenic	208	39	84%	0.615	32.20	4.576	5.550	Kaplan-Meier
Barium	266	0	100%	34.0	1115.0	600.10	194.90	Standard
Beryllium	188	51	79%	0.031	4.0	1.315	0.785	Kaplan-Meier
Cadmium	7	231	3%	0.047	4.0	0.121	0.345	Kaplan-Meier
Chromium	259	0	100%	0.878	927.0	76.640	94.660	Standard
Copper	265	0	100%	3.0	195.50	41.410	33.670	Standard
Lead	250	17	94%	1.470	28.0	9.786	4.664	Kaplan-Meier
Manganese	244	0	100%	125.0	4797.0	1051.0	514.10	Standard
Mercury	142	105	57%	0.010	12.230	0.097	0.806	Kaplan-Meier
Nickel	264	0	100%	1.0	442.0	38.60	42.990	Standard
Selenium	78	174	31%	0.078	5.0	0.210	0.433	Kaplan-Meier
Silver	15	230	6%	0.020	3.0	0.162	0.387	Kaplan-Meier
Thallium	1	2	33%	0.149	0.149	0.149	N/A	N/A
Vanadium	259	0	100%	17.0	486.0	199.90	103.50	Standard
Zinc	266	0	100%	21.0	350.0	105.0	39.130	Standard

Table 2
Regional Background Metals Summary Statistics
Declustered Dataset
State of Oregon
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Cascade Range								
Antimony	20	31	39%	0.027	1.707	0.158	0.301	Kaplan-Meier
Arsenic	175	5	97%	0.228	73.40	5.445	7.943	Kaplan-Meier
Barium	187	0	100%	15.50	1855.0	338.10	203.50	Standard
Beryllium	153	27	85%	0.222	3.0	1.048	0.629	Kaplan-Meier
Cadmium	51	104	33%	0.048	0.969	0.261	0.169	Kaplan-Meier
Chromium	187	0	100%	3.50	394.0	66.690	63.510	Standard
Copper	188	0	100%	7.50	308.0	37.650	30.110	Standard
Lead	181	7	96%	1.0	94.550	13.390	12.490	Kaplan-Meier
Manganese	180	0	100%	48.750	4571.0	1126.0	595.0	Standard
Mercury	148	17	90%	0.020	1.230	0.068	0.101	Kaplan-Meier
Nickel	185	2	99%	2.420	243.0	44.910	39.240	Kaplan-Meier
Selenium	54	116	32%	0.095	1.20	0.215	0.184	Kaplan-Meier
Silver	13	130	9%	0.054	0.262	0.092	0.044	Kaplan-Meier
Thallium	18	33	35%	0.082	4.384	0.593	1.331	Kaplan-Meier
Vanadium	187	0	100%	15.0	400.0	145.50	78.580	Standard
Zinc	188	0	100%	17.0	477.0	98.650	48.720	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Coast Range								
Antimony	25	7	78%	0.046	1.170	0.208	0.199	Kaplan-Meier
Arsenic	136	0	100%	0.573	16.40	5.571	3.356	Standard
Barium	140	0	100%	10.50	990.0	458.50	270.20	Standard
Beryllium	129	11	92%	0.361	4.0	1.540	0.740	Kaplan-Meier
Cadmium	36	85	30%	0.026	0.701	0.264	0.169	Kaplan-Meier
Chromium	140	0	100%	5.50	473.0	83.810	81.870	Standard
Copper	137	3	98%	2.0	202.40	36.760	40.460	Kaplan-Meier
Lead	137	3	98%	1.333	104.50	14.340	11.570	Kaplan-Meier
Manganese	133	0	100%	22.50	5115.0	914.70	648.10	Standard
Mercury	105	20	84%	0.015	0.310	0.045	0.040	Kaplan-Meier
Nickel	139	0	100%	4.0	249.0	43.230	45.680	Standard
Selenium	85	53	62%	0.153	5.045	0.457	0.616	Kaplan-Meier
Silver	14	118	11%	0.093	0.866	0.151	0.154	Kaplan-Meier
Thallium	22	10	69%	0.114	5.244	1.914	2.052	Kaplan-Meier
Vanadium	140	0	100%	6.0	329.70	122.80	72.470	Standard
Zinc	140	0	100%	11.50	413.0	88.150	47.070	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Deschutes - Columbia Plateau								
Antimony	16	5	76%	0.093	1.917	0.403	0.480	Kaplan-Meier
Arsenic	95	0	100%	0.553	15.10	3.763	2.026	Standard
Barium	108	0	100%	103.70	967.90	498.70	168.40	Standard
Beryllium	96	0	100%	0.257	2.0	1.578	0.640	Standard
Cadmium	15	81	16%	0.128	0.587	0.243	0.094	Kaplan-Meier
Chromium	115	0	100%	3.0	306.0	49.520	50.180	Standard
Copper	115	0	100%	2.0	94.0	25.530	15.60	Standard
Lead	112	0	100%	1.0	30.0	11.050	4.922	Standard
Manganese	96	0	100%	282.50	2830.0	776.80	321.40	Standard
Mercury	31	50	38%	0.007	0.090	0.016	0.015	Kaplan-Meier
Nickel	113	0	100%	1.0	167.0	29.060	26.680	Standard
Selenium	17	79	18%	0.099	0.880	0.187	0.165	Kaplan-Meier
Silver	13	83	14%	0.099	4.0	0.163	0.395	Kaplan-Meier
Thallium	13	8	62%	0.186	4.209	1.617	1.681	Kaplan-Meier
Vanadium	116	0	100%	4.0	370.0	146.0	73.810	Standard
Zinc	108	0	100%	43.70	150.0	86.060	21.090	Standard

Table 2
Regional Background Metals Summary Statistics
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State of Oregon
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
High Lava Plains								
Antimony	8	3	73%	0.109	0.393	0.172	0.093	Kaplan-Meier
Arsenic	95	10	90%	0.671	14.0	3.50	2.242	Kaplan-Meier
Barium	107	0	100%	45.0	1110.0	528.50	172.20	Standard
Beryllium	98	5	95%	0.205	3.0	1.553	0.632	Kaplan-Meier
Cadmium	12	91	12%	0.053	2.50	0.310	0.279	Kaplan-Meier
Chromium	105	0	100%	5.0	379.0	57.860	44.880	Standard
Copper	103	0	100%	11.0	95.0	33.150	14.190	Standard
Lead	103	0	100%	1.870	135.0	12.640	13.560	Standard
Manganese	104	0	100%	192.50	1910.0	873.60	307.80	Standard
Mercury	49	56	47%	0.020	0.167	0.029	0.019	Kaplan-Meier
Nickel	104	0	100%	6.0	149.0	34.070	20.0	Standard
Selenium	21	91	19%	0.070	1.90	0.184	0.216	Kaplan-Meier
Silver	5	99	5%	0.075	3.50	0.126	0.334	Kaplan-Meier
Thallium	2	9	18%	0.172	0.228	0.178	0.018	Kaplan-Meier
Vanadium	104	0	100%	26.0	275.0	123.20	53.850	Standard
Zinc	104	0	100%	24.20	214.0	92.060	29.510	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Klamath Mountains								
Antimony	19	13	59%	0.111	0.895	0.216	0.215	Kaplan-Meier
Arsenic	94	5	95%	0.273	29.50	4.983	4.501	Kaplan-Meier
Barium	99	0	100%	14.60	1030.0	344.50	206.30	Standard
Beryllium	56	43	57%	0.063	2.0	0.622	0.465	Kaplan-Meier
Cadmium	28	70	29%	0.050	1.10	0.214	0.180	Kaplan-Meier
Chromium	99	0	100%	4.0	1520.0	236.10	296.10	Standard
Copper	99	0	100%	4.0	170.50	45.970	30.330	Standard
Lead	88	11	89%	1.360	130.0	10.920	14.760	Kaplan-Meier
Manganese	99	0	100%	45.0	3614.0	1183.0	688.40	Standard
Mercury	91	8	92%	0.020	0.280	0.080	0.052	Kaplan-Meier
Nickel	98	0	100%	5.0	2850.0	170.50	347.20	Standard
Selenium	45	46	49%	0.175	2.293	0.329	0.281	Kaplan-Meier
Silver	6	85	7%	0.104	0.265	0.112	0.029	Kaplan-Meier
Thallium	14	18	44%	0.107	0.566	0.148	0.091	Kaplan-Meier
Vanadium	99	0	100%	12.0	391.50	146.80	74.820	Standard
Zinc	99	0	100%	12.0	249.0	84.960	35.0	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Owyhee Uplands								
Antimony	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	27	102	21%	4.50	66.0	7.315	6.120	Kaplan-Meier
Barium	124	0	100%	120.0	1300.0	764.0	153.0	Standard
Beryllium	131	0	100%	1.0	6.0	1.824	0.601	Standard
Cadmium	1	129	1%	4.0	4.0	4.0	N/A	N/A
Chromium	124	0	100%	19.0	230.0	62.810	33.020	Standard
Copper	121	0	100%	12.0	69.0	33.170	9.740	Standard
Lead	118	1	99%	4.0	88.0	15.630	8.634	Kaplan-Meier
Manganese	126	0	100%	449.70	1599.0	847.10	187.60	Standard
Mercury	28	97	22%	0.020	4.60	0.064	0.409	Kaplan-Meier
Nickel	117	0	100%	9.0	130.0	24.540	14.720	Standard
Selenium	13	51	20%	0.20	1.40	0.231	0.154	Kaplan-Meier
Silver	3	126	2%	2.0	3.0	2.016	0.124	Kaplan-Meier
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	123	0	100%	34.0	270.0	116.0	36.730	Standard
Zinc	118	0	100%	47.0	730.0	86.830	61.90	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
South Willamette Valley								
Antimony	16	4	80%	0.108	0.123	0.212	0.098	Kaplan-Meier
Arsenic	62	0	100%	1.905	58.940	9.481	8.097	Standard
Barium	65	0	100%	71.550	768.0	413.20	201.10	Standard
Beryllium	63	1	98%	0.284	3.0	1.462	0.668	Kaplan-Meier
Cadmium	38	24	61%	0.065	4.70	0.478	0.659	Kaplan-Meier
Chromium	69	0	100%	8.30	256.0	49.450	36.620	Standard
Copper	69	0	100%	5.0	194.40	40.160	38.940	Standard
Lead	66	2	97%	1.918	60.70	13.950	8.383	Kaplan-Meier
Manganese	73	0	100%	309.80	5914.0	1619.0	899.70	Standard
Mercury	45	6	88%	0.015	0.130	0.037	0.020	Kaplan-Meier
Nickel	69	0	100%	4.950	82.0	25.340	14.540	Standard
Selenium	26	27	49%	0.089	0.882	0.277	0.236	Kaplan-Meier
Silver	2	45	4%	0.101	0.710	0.126	0.122	Kaplan-Meier
Thallium	15	5	75%	0.108	4.224	2.086	2.026	Kaplan-Meier
Vanadium	64	0	100%	39.0	438.90	187.70	91.030	Standard
Zinc	69	0	100%	25.50	238.30	106.10	44.520	Standard

Table 2
Regional Background Metals Summary Statistics
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Metal	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
All concentrations in mg/kg								
Portland Basin								
Antimony	21	0	100%	0.135	0.576	0.290	0.104	Standard
Arsenic	30	0	100%	2.40	9.495	4.447	1.847	Standard
Barium	30	0	100%	127.90	813.0	319.70	194.70	Standard
Beryllium	30	0	100%	0.386	2.0	1.013	0.541	Standard
Cadmium	21	9	70%	0.146	0.825	0.387	0.139	Kaplan-Meier
Chromium	30	0	100%	20.350	84.150	38.940	16.60	Standard
Copper	30	0	100%	11.60	60.240	24.190	9.919	Standard
Lead	30	0	100%	6.963	100.0	27.190	20.220	Standard
Manganese	30	0	100%	321.70	1979.0	1026.0	419.50	Standard
Mercury	9	0	100%	0.020	0.230	0.073	0.063	Standard
Nickel	30	0	100%	13.40	49.0	23.410	8.711	Standard
Selenium	11	19	37%	0.20	1.154	0.331	0.220	Kaplan-Meier
Silver	6	24	20%	0.106	2.169	0.179	0.370	Kaplan-Meier
Thallium	20	1	95%	4.199	5.581	4.449	0.40	Kaplan-Meier
Vanadium	30	0	100%	42.0	213.20	109.0	43.60	Standard
Zinc	30	0	100%	51.60	189.0	104.90	32.960	Standard

Notes:
Data generated with ProUCL, Version 4.1.00
N/A - Not Available

Table 3
Regional Background Calculations for Metals
Declustered Dataset
State of Oregon
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Basin and Range								
Antimony	0.715	0.843	Nonparametric KM(z)	0.819	0.728	90% UTL 90% Coverage;90% KM UPL (t)	**0.863**	95% KM UPL (t)
Arsenic	10.440	12.270	Nonparametric KM(z)	11.080	10.480	90% UTL 90% Coverage;90% KM UPL (t)	**12.330**	95% KM UPL (t)
Barium	740.0	783.0	Nonparametric	750.0	740.0	90% UTL 90% Coverage;90% UPL	**787.80**	95% UPL
Beryllium	2.120	2.366	Nonparametric KM(z)	2.205	2.125	90% UTL 90% Coverage;90% KM UPL (t)	**2.374**	95% KM UPL (t)
Cadmium	0.688	0.809	Nonparametric KM(z)	0.730	0.690	90% UTL 90% Coverage;90% KM UPL (t)	**0.813**	95% KM UPL (t)
Chromium	88.60	100.0	Nonparametric	96.0	89.60	90% UTL 90% Coverage;90% UPL	**100.0**	95% UPL
Copper	75.90	100.0	Nonparametric	87.0	80.90	90% UTL 90% Coverage;90% UPL	**108.50**	95% UPL
Lead	25.550	28.640	Nonparametric KM(z)	26.640	25.620	90% UTL 90% Coverage;90% KM UPL (t)	**28.740**	95% KM UPL (t)
Manganese	1304.0	1582.0	Nonparametric	1400.0	1312.0	90% UTL 90% Coverage;90% UPL	**1613.0**	95% UPL
Mercury	0.228	0.277	Nonparametric KM(z)	0.245	0.229	90% UTL 90% Coverage;90% KM UPL (t)	**0.279**	95% KM UPL (t)
Nickel	53.0	65.0	Nonparametric	54.0	53.0	90% UTL 90% Coverage;90% UPL	**65.90**	95% UPL
Selenium	0.346	0.410	Nonparametric KM(z)	0.370	0.347	90% UTL 90% Coverage;90% KM UPL (t)	**0.412**	95% KM UPL (t)
Silver	0.280	0.412	Nonparametric KM(z)	0.531	0.494	90% UTL 90% Coverage;90% KM UPL (t)	**0.417**	95% KM UPL (t)
Thallium	0.173	0.202	Nonparametric KM(z)	0.214	0.189	90% UTL 90% Coverage;90% KM UPL (t)	**0.215**	95% KM UPL (t)
Vanadium	240.0	270.0	Nonparametric	256.0	240.0	90% UTL 90% Coverage;90% UPL	**270.0**	95% UPL
Zinc	110.0	130.0	Nonparametric	120.0	110.0	90% UTL 90% Coverage;90% UPL	**130.0**	95% UPL

Table 3
Regional Background Calculations for Metals
Declustered Dataset
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Blue Mountains								
Antimony	N/A	N/A	Not enough Samples	N/A	N/A	Not enough Samples	**N/A**	Not enough Samples
Arsenic	11.690	13.70	Nonparametric KM(z)	12.320	11.720	90% UTL 90% Coverage;90% KM UPL (t)	**13.760**	95% KM UPL (t)
Barium	864.50	938.40	Nonparametric	900.0	870.0	90% UTL 90% Coverage;90% UPL	**945.30**	95% UPL
Beryllium	2.321	2.606	Nonparametric KM(z)	2.412	2.326	90% UTL 90% Coverage;90% KM UPL (t)	**2.614**	95% KM UPL (t)
Cadmium	0.563	0.689	Nonparametric KM(z)	0.603	0.565	90% UTL 90% Coverage;90% KM UPL (t)	**0.692**	95% KM UPL (t)
Chromium	140.0	183.70	Nonparametric	160.0	140.0	90% UTL 90% Coverage;90% UPL	**190.0**	95% UPL
Copper	88.20	119.60	Nonparametric	104.50	90.60	90% UTL 90% Coverage;90% UPL	**122.80**	95% UPL
Lead	15.760	17.460	Nonparametric KM(z)	16.280	15.790	90% UTL 90% Coverage;90% KM UPL (t)	**20.590**	95% KM UPL (t)
Manganese	1510.0	1732.0	Nonparametric	1590.0	1535.0	90% UTL 90% Coverage;90% UPL	**1780.0**	95% UPL
Mercury	1.130	1.423	Nonparametric KM(z)	1.222	1.135	90% UTL 90% Coverage;90% UPL	**1.430**	95% KM UPL (t)
Nickel	64.750	91.850	Nonparametric	75.50	65.750	90% UTL 90% Coverage;90% UPL	**92.0**	95% UPL
Selenium	0.765	0.922	Nonparametric KM(z)	0.814	0.767	90% UTL 90% Coverage;90% KM UPL (t)	**0.926**	95% KM UPL (t)
Silver	0.657	0.798	Nonparametric KM(z)	0.702	0.660	90% UTL 90% Coverage;90% KM UPL (t)	**0.508**	95% KM UPL (t)
Thallium	2.299	2.782	Nonparametric KM(z)	2.655	2.338	90% UTL 90% Coverage;90% KM UPL (t)	**N/A**	Not enough Samples
Vanadium	358.0	396.10	Nonparametric	378.0	358.0	90% UTL 90% Coverage;90% UPL	**397.0**	95% UPL
Zinc	146.30	155.30	Nonparametric	150.0	146.70	90% UTL 90% Coverage;90% UPL	**156.0**	95% UPL

Table 3
Regional Background Calculations for Metals
Declustered Dataset
State of Oregon
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Cascade Range								
Antimony	0.544	0.654	Nonparametric KM(z)	0.625	0.533	90% UTL 90% Coverage;90% KM UPL (t)	**0.668**	95% KM UPL (t)
Arsenic	15.620	18.510	Nonparametric KM(z)	16.70	15.690	90% UTL 90% Coverage;90% KM UPL (t)	**18.610**	95% KM UPL (t)
Barium	558.60	627.80	Nonparametric	590.0	564.40	90% UTL 90% Coverage;90% UPL	**632.0**	95% UPL
Beryllium	1.854	2.083	Nonparametric KM(z)	1.939	1.859	90% UTL 90% Coverage;90% KM UPL (t)	**2.091**	95% KM UPL (t)
Cadmium	0.478	0.540	Nonparametric KM(z)	0.503	0.480	90% UTL 90% Coverage;90% KM UPL (t)	**0.543**	95% KM UPL (t)
Chromium	127.60	191.40	Nonparametric	141.0	130.0	90% UTL 90% Coverage;90% UPL	**204.0**	95% UPL
Copper	59.30	69.950	Nonparametric	63.0	60.050	90% UTL 90% Coverage;90% UPL	**73.250**	95% UPL
Lead	29.40	33.940	Nonparametric KM(z)	31.050	29.50	90% UTL 90% Coverage;90% KM UPL (t)	**34.090**	95% KM UPL (t)
Manganese	1724.0	1965.0	Nonparametric	1800.0	1756.0	90% UTL 90% Coverage;90% UPL	**2111.0**	95% UPL
Mercury	0.198	0.235	Nonparametric KM(z)	0.212	0.199	90% UTL 90% Coverage;90% KM UPL (t)	**0.236**	95% KM UPL (t)
Nickel	95.210	109.50	Nonparametric KM(z)	100.40	95.520	90% UTL 90% Coverage;90% UPL	**110.0**	95% KM UPL (t)
Selenium	0.451	0.517	Nonparametric KM(z)	0.476	0.452	90% UTL 90% Coverage;90% KM UPL (t)	**0.520**	95% KM UPL (t)
Silver	0.148	0.164	Nonparametric KM(z)	0.155	0.149	90% UTL 90% Coverage;90% KM UPL (t)	**0.165**	95% KM UPL (t)
Thallium	2.299	2.782	Nonparametric KM(z)	2.655	2.338	90% UTL 90% Coverage;90% KM UPL (t)	**2.845**	95% KM UPL (t)
Vanadium	235.0	276.0	Nonparametric	251.50	236.0	90% UTL 90% Coverage;90% UPL	**280.20**	95% UPL
Zinc	144.30	166.60	Nonparametric	151.0	145.10	90% UTL 90% Coverage;90% UPL	**170.40**	95% UPL

Table 3
Regional Background Calculations for Metals
Declustered Dataset
State of Oregon
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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Coast Range								
Antimony	0.464	0.536	Nonparametric KM(z)	0.533	0.473	90% UTL 90% Coverage;90% KM UPL (t)	**0.551**	95% KM UPL (t)
Arsenic	10.260	11.670	Nonparametric	11.0	10.330	90% UTL 90% Coverage;90% UPL	**12.190**	95% UPL
Barium	804.20	834.50	Nonparametric	811.0	805.80	90% UTL 90% DEQCoverage;90% UPL	**842.60**	95% UPL
Beryllium	2.488	2.757	Nonparametric KM(z)	2.603	2.496	90% UTL 90% Coverage;90% KM UPL (t)	**2.770**	95% KM UPL (t)
Cadmium	0.480	0.541	Nonparametric KM(z)	0.508	0.482	90% UTL 90% Coverage;90% KM UPL (t)	**0.544**	95% KM UPL (t)
Chromium	159.80	222.10	Nonparametric	202.0	172.40	90% UTL 90% Coverage;90% UPL	**241.0**	95% UPL
Copper	88.610	103.30	Nonparametric KM(z)	94.870	89.050	90% UTL 90% Coverage;90% KM UPL (t)	**104.0**	95% KM UPL (t)
Lead	29.170	33.370	Nonparametric KM(z)	30.960	29.290	90% UTL 90% Coverage;90% KM UPL (t)	**33.570**	95% KM UPL (t)
Manganese	1547.0	2046.0	Nonparametric	1750.0	1574.0	90% UTL 90% Coverage;90% UPL	**2138.0**	95% UPL
Mercury	0.096	0.111	Nonparametric KM(z)	0.103	0.097	90% UTL 90% Coverage;90% KM UPL (t)	**0.112**	95% KM UPL (t)
Nickel	96.50	141.70	Nonparametric	102.0	96.50	90% UTL 90% Coverage;90% UPL	**157.0**	95% UPL
Selenium	1.246	1.470	Nonparametric KM(z)	1.342	1.253	90% UTL 90% Coverage;90% KM UPL (t)	**1.481**	95% KM UPL (t)
Silver	0.348	0.404	Nonparametric KM(z)	0.373	0.350	90% UTL 90% Coverage;90% KM UPL (t)	**0.407**	95% KM UPL (t)
Thallium	4.544	5.290	Nonparametric KM(z)	5.261	4.643	90% UTL 90% Coverage;90% KM UPL (t)	**5.448**	95% KM UPL (t)
Vanadium	239.0	254.70	Nonparametric	251.0	239.0	90% UTL 90% Coverage;90% UPL	**255.10**	95% UPL
Zinc	127.60	134.20	Nonparametric	130.0	128.0	90% UTL 90% Coverage;90% UPL	**137.80**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Deschutes - Columbia Plateau								
Antimony	1.018	1.193	Nonparametric KM(z)	1.243	1.054	90% UTL 90% Coverage;90% KM UPL (t)	**1.250**	95% KM UPL (t)
Arsenic	5.540	6.129	Nonparametric	5.80	5.608	90% UTL 90% Coverage;90% UPL	**6.824**	95% UPL
Barium	657.80	694.0	Nonparametric	668.0	662.50	90% UTL 90% Coverage;90% UPL	**704.60**	95% UPL
Beryllium	2.363	2.593	Nonparametric KM(z)	2.0	2.0	90% UTL 90% Coverage;90% UPL	**2.608**	95% KM UPL (t)
Cadmium	0.364	0.398	Nonparametric KM(z)	0.381	0.365	90% UTL 90% Coverage;90% KM UPL (t)	**0.40**	95% KM UPL (t)
Chromium	81.40	142.90	Nonparametric	99.0	82.80	90% UTL 90% Coverage;90% UPL	**169.80**	95% UPL
Copper	50.360	58.30	Nonparametric	56.0	51.160	90% UTL 90% Coverage;90% UPL	**29.40**	95% UPL
Lead	15.0	17.450	Nonparametric	16.0	15.350	90% UTL 90% Coverage;90% UPL	**18.350**	95% UPL
Manganese	1032.0	1291.0	Nonparametric	1140.0	1058.0	90% UTL 90% Coverage;90% UPL	**1323.0**	95% UPL
Mercury	0.035	0.040	Nonparametric KM(z)	0.038	0.035	90% UTL 90% Coverage;90% KM UPL (t)	**0.040**	95% KM UPL (t)
Nickel	45.70	83.70	Nonparametric	62.0	55.0	90% UTL 90% Coverage;90% UPL	**78.440**	95% UPL
Selenium	0.398	0.458	Nonparametric KM(z)	0.429	0.40	90% UTL 90% Coverage;90% KM UPL (t)	**0.462**	95% KM UPL (t)
Silver	0.668	0.811	Nonparametric KM(z)	0.743	0.674	90% UTL 90% Coverage;90% KM UPL (t)	**0.821**	95% KM UPL (t)
Thallium	3.771	4.381	Nonparametric KM(z)	4.558	3.897	90% UTL 90% Coverage;90% KM UPL (t)	**4.584**	95% KM UPL (t)
Vanadium	240.30	284.0	Nonparametric	262.0	241.70	90% UTL 90% Coverage;90% UPL	**299.30**	95% UPL
Zinc	112.30	124.30	Nonparametric	120.0	113.20	90% UTL 90% Coverage;90% UPL	**127.20**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
High Lava Plains								
Antimony	0.291	0.325	Nonparametric KM(z)	0.359	0.305	90% UTL 90% Coverage;90% KM UPL (t)	**0.348**	95% KM UPL (t)
Arsenic	6.373	7.188	Nonparametric KM(z)	6.777	6.405	90% UTL 90% Coverage;90% KM UPL (t)	**7.238**	95% KM UPL (t)
Barium	671.10	778.20	Nonparametric	712.0	687.20	90% UTL 90% Coverage;90% UPL	**790.20**	95% UPL
Beryllium	2.363	2.593	Nonparametric KM(z)	2.479	2.373	90% UTL 90% Coverage;90% KM UPL (t)	**2.608**	95% KM UPL (t)
Cadmium	0.667	0.769	Nonparametric KM(z)	0.718	0.671	90% UTL 90% Coverage;90% KM UPL (t)	**0.775**	95% KM UPL (t)
Chromium	93.40	117.20	Nonparametric	102.0	96.20	90% UTL 90% Coverage;90% UPL	**141.70**	95% UPL
Copper	47.0	57.150	Nonparametric	51.0	48.20	90% UTL 90% Coverage;90% UPL	**62.30**	95% UPL
Lead	15.0	18.80	Nonparametric	16.0	15.60	90% UTL 90% Coverage;90% UPL	**21.40**	95% UPL
Manganese	1284.0	1429.0	Nonparametric	1399.0	1310.0	90% UTL 90% Coverage;90% UPL	**1482.0**	95% UPL
Mercury	0.053	0.060	Nonparametric KM(z)	0.056	0.053	90% UTL 90% Coverage;90% KM UPL (t)	**0.060**	95% KM UPL (t)
Nickel	53.250	70.650	Nonparametric	56.0	54.50	90% UTL 90% Coverage;90% UPL	**75.380**	95% UPL
Selenium	0.461	0.540	Nonparametric KM(z)	0.499	0.464	90% UTL 90% Coverage;90% KM UPL (t)	**0.544**	95% KM UPL (t)
Silver	0.553	0.675	Nonparametric KM(z)	0.614	0.558	90% UTL 90% Coverage;90% KM UPL (t)	**0.682**	95% KM UPL (t)
Thallium	0.201	0.207	Nonparametric KM(z)	0.214	0.203	90% UTL 90% Coverage;90% KM UPL (t)	**0.212**	95% KM UPL (t)
Vanadium	201.60	219.60	Nonparametric	215.0	208.50	90% UTL 90% Coverage;90% UPL	**223.80**	95% UPL
Zinc	121.90	136.90	Nonparametric	129.0	122.0	90% UTL 90% Coverage;90% UPL	**139.30**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Klamath Mountains								
Antimony	0.492	0.570	Nonparametric KM(z)	0.567	0.502	90% UTL 90% Coverage;90% KM UPL (t)	**0.587**	95% KM UPL (t)
Arsenic	10.750	12.390	Nonparametric KM(z)	11.590	10.820	90% UTL 90% Coverage;90% KM UPL (t)	**12.490**	95% KM UPL (t)
Barium	568.80	630.20	Nonparametric	607.0	572.0	90% UTL 90% Coverage;90% UPL	**632.0**	95% UPL
Beryllium	1.217	1.386	Nonparametric KM(z)	1.304	1.224	90% UTL 90% Coverage;90% KM UPL (t)	**1.397**	95% KM UPL (t)
Cadmium	0.445	0.510	Nonparametric KM(z)	0.479	0.448	90% UTL 90% Coverage;90% KM UPL (t)	**0.515**	95% KM UPL (t)
Chromium	624.20	762.60	Nonparametric	668.0	625.0	90% UTL 90% Coverage;90% UPL	**894.0**	95% UPL
Copper	77.0	100.90	Nonparametric	89.50	79.0	90% UTL 90% Coverage;90% UPL	**108.50**	95% UPL
Lead	29.840	35.20	Nonparametric KM(z)	32.590	30.060	90% UTL 90% Coverage;90% KM UPL (t)	**35.560**	95% KM UPL (t)
Manganese	1830.0	2948.0	Nonparametric	2113.0	1870.0	90% UTL 90% Coverage;90% UPL	**2957.0**	95% UPL
Mercury	0.146	0.165	Nonparametric KM(z)	0.156	0.147	90% UTL 90% Coverage;90% KM UPL (t)	**0.166**	95% KM UPL (t)
Nickel	343.0	472.60	Nonparametric	396.0	360.60	90% UTL 90% Coverage;90% UPL	**634.40**	95% UPL
Selenium	0.689	0.791	Nonparametric KM(z)	0.744	0.694	90% UTL 90% Coverage;90% KM UPL (t)	**0.799**	95% KM UPL (t)
Silver	0.148	0.159	Nonparametric KM(z)	0.154	0.149	90% UTL 90% Coverage;90% KM UPL (t)	**0.159**	95% KM UPL (t)
Thallium	0.264	0.298	Nonparametric	0.296	0.269	90% UTL 90% Coverage;90% KM UPL (t)	**0.305**	95% KM UPL (t)
Vanadium	237.20	277.0	Nonparametric	253.0	238.0	90% UTL 90% Coverage;90% UPL	**286.0**	95% UPL
Zinc	120.0	135.90	Nonparametric	122.0	120.0	90% UTL 90% Coverage;90% UPL	**139.0**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Owyhee Uplands								
Antimony	N/A	N/A	No Data	N/A	N/A	No Data	**N/A**	No Data
Arsenic	15.160	17.380	Nonparametric KM(z)	16.150	15.230	90% UTL 90% Coverage;90% KM UPL (t)	**17.490**	95% KM UPL (t)
Barium	907.0	950.0	Nonparametric	930.0	915.0	90% UTL 90% Coverage;90% UPL	**965.0**	95% UPL
Beryllium	2.0	2.0	Nonparametric	2.0	2.0	90% UTL 90% Coverage;90% UPL	**2.0**	95% UPL
Cadmium	N/A	N/A	Not enough Samples	N/A	N/A	Not enough Samples	**N/A**	Not enough Samples
Chromium	91.10	117.70	Nonparametric	104.0	94.50	90% UTL 90% Coverage;90% UPL	**119.80**	95% UPL
Copper	45.0	50.0	Nonparametric	48.0	45.80	90% UTL 90% Coverage;90% UPL	**50.0**	95% UPL
Lead	26.70	29.830	Nonparametric KM(z)	28.150	26.80	90% UTL 90% Coverage;90% KM UPL (t)	**30.0**	95% KM UPL (t)
Manganese	1099.0	1199.0	Nonparametric	1099.0	1099.0	90% UTL 90% Coverage;90% UPL	**1199.0**	95% UPL
Mercury	0.588	0.737	Nonparametric KM(z)	0.655	0.593	90% UTL 90% Coverage;90% KM UPL (t)	**0.745**	95% KM UPL (t)
Nickel	33.40	50.40	Nonparametric	41.0	34.60	90% UTL 90% Coverage;90% UPL	**52.60**	95% UPL
Selenium	0.429	0.485	Nonparametric KM(z)	0.465	0.432	90% UTL 90% Coverage;90% KM UPL (t)	**0.490**	95% KM UPL (t)
Silver	2.174	2.219	Nonparametric KM(z)	2.194	2.175	90% UTL 90% Coverage;90% KM UPL (t)	**2.221**	95% KM UPL (t)
Thallium	N/A	N/A	No Data	N/A	N/A	No Data	**N/A**	No Data
Vanadium	160.0	189.0	Nonparametric	170.0	160.0	90% UTL 90% Coverage;90% UPL	**190.0**	95% UPL
Zinc	100.0	120.0	Nonparametric	110.0	100.0	90% UTL 90% Coverage;90% UPL	**120.50**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
South Willamette Valley								
Antimony	0.337	0.372	Nonparametric KM(z)	0.384	0.345	90% UTL 90% Coverage;90% KM UPL (t)	**0.385**	95% KM UPL (t)
Arsenic	16.780	17.50	Nonparametric	17.40	17.180	90% UTL 90% Coverage;90% UPL	**17.650**	95% UPL
Barium	682.40	708.90	Nonparametric	688.50	683.60	90% UTL 90% Coverage;90% UPL	**734.30**	95% UPL
Beryllium	2.319	2.562	Nonparametric KM(z)	2.477	2.335	90% UTL 90% Coverage;90% KM UPL (t)	**2.587**	95% KM UPL (t)
Cadmium	1.323	1.563	Nonparametric KM(z)	1.481	1.339	90% UTL 90% Coverage;90% KM UPL (t)	**1.588**	95% KM UPL (t)
Chromium	82.0	94.60	Nonparametric	91.0	82.0	90% UTL 90% Coverage;90% UPL	**103.30**	95% UPL
Copper	74.20	124.50	Nonparametric	105.0	79.0	90% UTL 90% Coverage;90% UPL	**141.30**	95% UPL
Lead	24.690	27.740	Nonparametric KM(z)	26.60	24.880	90% UTL 90% Coverage;90% KM UPL (t)	**28.030**	95% KM UPL (t)
Manganese	2434.0	2845.0	Nonparametric	2540.0	2439.0	90% UTL 90% Coverage;90% UPL	**2936.0**	95% UPL
Mercury	0.064	0.071	Nonparametric KM(z)	0.069	0.064	90% UTL 90% Coverage;90% KM UPL (t)	**0.072**	95% KM UPL (t)
Nickel	44.60	49.050	Nonparametric	48.890	47.0	90% UTL 90% Coverage;90% UPL	**50.080**	95% UPL
Selenium	0.579	0.665	Nonparametric KM(z)	0.641	0.586	90% UTL 90% Coverage;90% KM UPL (t)	**0.675**	95% KM UPL (t)
Silver	0.282	0.326	Nonparametric KM(z)	0.316	0.286	90% UTL 90% Coverage;90% KM UPL (t)	**0.333**	95% KM UPL (t)
Thallium	4.683	5.419	Nonparametric KM(z)	5.662	4.843	90% UTL 90% Coverage;90% KM UPL (t)	**5.676**	95% KM UPL (t)
Vanadium	323.90	366.0	Nonparametric	368.80	370.80	90% UTL 90% Coverage;90% UPL	**370.80**	95% UPL
Zinc	167.0	187.90	Nonparametric	195.50	200.30	90% UTL 90% Coverage;90% UPL	**200.30**	95% UPL

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Metal	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
All concentrations in mg/kg								
Portland Basin								
Antimony	0.381	0.385	Nonparametric	0.385	0.384	90% UTL 90% Coverage;90% UPL	**0.557**	95% UPL
Arsenic	6.728	8.062	Nonparametric	8.215	7.748	90% UTL 90% Coverage;90% UPL	**8.791**	95% UPL
Barium	704.90	754.70	Nonparametric	774.0	728.10	90% UTL 90% Coverage;90% UPL	**791.60**	95% UPL
Beryllium	2.0	2.0	Nonparametric	2.0	2.0	90% UTL 90% Coverage;90% UPL	**2.0**	95% UPL
Cadmium	0.565	0.616	Nonparametric KM(z)	0.618	0.572	90% UTL 90% Coverage;90% KM UPL (t)	**0.627**	95% KM UPL (t)
Chromium	63.050	66.50	Nonparametric	68.950	63.450	90% UTL 90% Coverage;90% UPL	**75.790**	95% UPL
Copper	31.810	32.990	Nonparametric	33.550	32.250	90% UTL 90% Coverage;90% UPL	**33.750**	95% UPL
Lead	56.220	59.650	Nonparametric	61.930	56.780	90% UTL 90% Coverage;90% UPL	**79.060**	95% UPL
Manganese	1383.0	1504.0	Nonparametric	1584.0	1402.0	90% UTL 90% Coverage;90% UPL	**1762.0**	95% UPL
Mercury	0.174	0.202	Nonparametric	0.230	0.230	90% UTL 90% Coverage;90% UPL	**0.230**	95% UPL
Nickel	34.40	44.430	Nonparametric	46.0	41.60	90% UTL 90% Coverage;90% UPL	**47.350**	95% UPL
Selenium	0.612	0.692	Nonparametric KM(z)	0.695	0.624	90% UTL 90% Coverage;90% KM UPL (t)	**0.710**	95% KM UPL (t)
Silver	0.653	0.788	Nonparametric KM(z)	0.792	0.672	90% UTL 90% Coverage;90% KM UPL (t)	**0.818**	95% KM UPL (t)
Thallium	4.962	5.107	Nonparametric KM(z)	5.149	4.992	90% UTL 90% Coverage;90% KM UPL (t)	**5.156**	95% KM UPL (t)
Vanadium	165.70	173.70	Nonparametric	175.10	171.30	90% UTL 90% Coverage;90% UPL	**178.20**	95% UPL
Zinc	124.10	154.10	Nonparametric	178.0	124.90	90% UTL 90% Coverage;90% UPL	**182.90**	95% UPL

Notes:
Data generated with ProUCL (Version 4.1.00), R (Version 2.15.1)
UTL = Upper threshold limit
UPL = Upper prediction limit
KM = Kaplan-Meier

Table 4
Regional 95% UPL Default Background Concentrations for Metals in Soil
State of Oregon

All concentrations in mg/kg

Metal	Basin and Range	Blue Mountains	Cascade Range	Coast Range	Deschutes - Columbia Plateau	High Lava Plains	Klamath Mountains	Owyhee Uplands	South Willamette Valley	Portland Basin
Antimony	0.86 (a)	N/A (c)	0.67 (a)	0.55 (a)	1.3 (a)	0.35 (a)	0.59 (a)	N/A (d)	0.39 (a)	0.56 (b)
Arsenic	12 (a)	14 (a)	19 (a)	12 (b)	6.8 (b)	7.2 (a)	12 (a)	17 (a)	18 (b)	8.8 (b)
Barium	790 (b)	950 (b)	630 (b)	840 (b)	700 (b)	790 (b)	630 (b)	970 (b)	730 (b)	790 (b)
Beryllium	2.4 (a)	2.6 (a)	2.1 (a)	2.8 (a)	2.6 (a)	2.6 (a)	1.4 (a)	2.0 (b)	2.6 (a)	2.0 (b)
Cadmium	0.81 (a)	0.69 (a)	0.54 (a)	0.54 (a)	0.40 (a)	0.78 (a)	0.52 (a)	N/A (c)	1.6 (a)	0.63 (a)
Chromium	100 (b)	190 (b)	200 (b)	240 (b)	170 (b)	140 (b)	890 (b)	120 (b)	100 (b)	76 (b)
Copper	110 (b)	120 (b)	73 (b)	100 (a)	29 (b)	62 (b)	110 (b)	50 (b)	140 (b)	34 (b)
Lead	29 (a)	21 (a)	34 (a)	34 (a)	18 (b)	21 (b)	36 (a)	30 (a)	28 (a)	79 (b)
Manganese	1600 (b)	1800 (b)	2100 (b)	2100 (b)	1300 (b)	1500 (b)	3000 (b)	1200 (b)	2900 (b)	1800 (b)
Mercury	0.28 (a)	1.4 (a)	0.24 (a)	0.11 (a)	0.040 (a)	0.060 (a)	0.17 (a)	0.75 (a)	0.070 (a)	0.23 (b)
Nickel	66 (b)	92 (b)	110 (a)	160 (b)	78 (b)	75 (b)	630 (b)	53 (b)	50 (b)	47 (b)
Selenium	0.41 (a)	0.93 (a)	0.52 (a)	1.5 (a)	0.46 (a)	0.54 (a)	0.80 (a)	0.49 (a)	0.68 (a)	0.71 (a)
Silver	0.42 (a)	0.51 (a)	0.17 (a)	0.41 (a)	0.82 (a)	0.68 (a)	0.16 (a)	2.2 (a)	0.33 (a)	0.82 (a)
Thallium	0.22 (a)	N/A (c)	2.8 (a)	5.4 (a)	4.6 (a)	0.21 (a)	0.31 (a)	N/A (d)	5.7 (a)	5.2 (a)
Vanadium	270 (b)	400 (b)	280 (b)	260 (b)	300 (b)	220 (b)	290 (b)	190 (b)	370 (b)	180 (b)
Zinc	130 (b)	160 (b)	170 (b)	140 (b)	130 (b)	140 (b)	140 (b)	120 (b)	200 (b)	180 (b)

Notes:
Data generated with ProUCL, Version 4.1.00
UPL = Upper prediction limit
(a) = 95% Kaplan-Meier UPL (t)
(b) = 95% UPL
(c) = Not Enough Samples
(d) = No Data