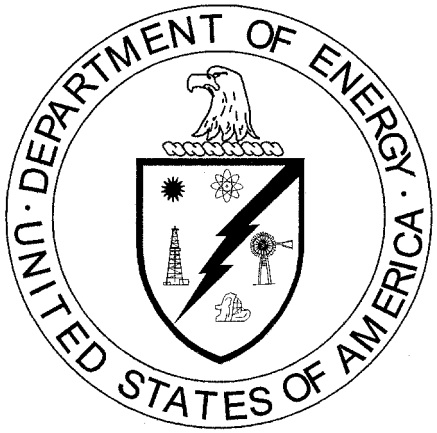
DOE/OR/01-2105&D1

Soil Background Supplemental Data Set for the East Tennessee Technology Park, Oak Ridge, Tennessee



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Soil Background Supplemental Data Set for the East Tennessee Technology Park, Oak Ridge, Tennessee

Date Issued—September 2003

Prepared for the
U.S. Department of Energy
Office of Environmental Management

BECHTEL JACOBS COMPANY LLC
managing the
Environmental Management Activities at the
East Tennessee Technology Park
Y-12 National Security Complex Oak Ridge National Laboratory
Paducah Gaseous Diffusion Plant Portsmouth Gaseous Diffusion Plant
under contract DE-AC05-98OR22700
for the
U.S. DEPARTMENT OF ENERGY

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ACRONYMS

BSCP	Background Soil Characterization Project
COC	constituent of concern
D&D	decontamination and decommissioning
EPA	U.S. Environmental Protection Agency
ETTP	East Tennessee Technology Park
OREIS	Oak Ridge Environmental Information System
UCL	upper confidence level
UTL	upper tolerance limit

1.0 INTRODUCTION

With the recent issuance of the Record of Decision for Interim Remediation of Contaminated Soil, Material, and Buried Waste in Zone 1, East Tennessee Technology Park, Oak Ridge, Tennessee, the need for site representative background soils data has been identified as a key component for future actions. Remedial actions have been identified for five contaminant sites in Zone 1, and nine additional sites have been identified as suspect areas for future remedial actions. Clean-up goals have been established for Zone 1 soils in the record of decision. The constituents of concern (COCs) include several naturally occurring inorganic elements (e.g., arsenic, beryllium, and mercury). There is a possibility that additional naturally occurring inorganic elements (metals) will be identified at elevated levels as additional characterization and confirmatory sampling is performed in Zone 1. In order to perform the necessary risk evaluations, screening of site characterization data against natural background levels is required to differentiate the chemical intakes that are the result of U.S. Department of Energy operations from those that are due to natural background sources. Background soil data are also needed by other projects that are currently active at the East Tennessee Technology Park (ETTP). Comparative data for decontamination and decommissioning (D&D) operations and for Zone 2 soil screening are needed for COC contaminant concentration screening and site evaluation.

2.0 REVIEW OF HISTORICAL ETTP BACKGROUND DATA

Previously, the ETTP Remedial Action Project used reference (background) levels for screening inorganic element data derived from the Background Soil Characterization Project (BSCP) report (DOE/OR/01-1175). The 95 percent upper tolerance limit (UTL) was calculated for each chemical using the data representing selected formations and soil horizons. The characterization data were then screened against the corresponding 95 percent UTL reference levels to determine if there was a contaminant impact to the area being evaluated. However, concerns regarding these reference levels were raised by the regulatory agencies. Concerns that have been expressed include the lack of samples associated with the Rome Formation and the representativeness of the Knox samples collected under the BSCP to the ETTP site.

Following U.S. Environmental Protection Agency (EPA) guidance as described in the document *Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites* (EPA 540-01-003), ETTP Remedial Action Project staff reviewed the data presented in the BSCP report (DOE/OR/01-1175/V1) issued December 1993. Other soil sample data from areas east of the ETTP site along the southwestern flank of McKinney Ridge and other areas that could possibly be used as representative of soil background conditions were also reviewed. The following were the conclusions of the ETTP Remedial Action Project technical staff with regard to the adequacy of available data for use in background comparisons.

- The BSCP sampling methodology, site selection procedures, collection procedures, laboratory analytical methods, detection levels, and suite of analytes provide data of known and acceptable quality for use in determining background concentrations of naturally occurring inorganic and radiological constituents.

- The set of samples identified in the BSCP report as the Chickamagua-K-25 sample set is representative of background soil conditions for the majority of the ETTP site. The Chickamauga Supergroup geologic section underlies the central and western portions of Zone

2, and also underlies three of the four areas of Zone 1: Duct Island, Powerhouse, Peninsula, and the K-1007-P Pond subwatersheds.

- The BSCP concluded that "Soils from the Rome Formation do not appear with regularity at contaminated sites on the ORR and, for that reason, are not addressed in this project." This assessment is not accurate for the ETTP site. The eastern portion of ETTP Zone 2 is underlain by Rome Formation. Remedial actions will probably be conducted at Release Sites that are located in soils derived from the Rome Formation, including but not limited to K-1070-C/D, K-1414, K-1401, and K-1420. No samples were collected in soils associated with the Rome Formation under the BSCP. Samples collected for Footprint Reduction investigations and other site characterization activities do not conform to the appropriate background sampling protocols, sample intervals, or suite of analytes.

- The BSCP collected samples in areas where residual soils were derived from the Copper Ridge and Chepultepec Formations (Lower Knox Group). At the ETTP site, there are several potential contaminant release sites that are located in areas where the Upper Knox formations are in subcrop and residual soils are present. The background data obtained by the BSCP in Bear Creek Valley for the Knox Group Formations are not representative of the Upper Knox Group residual soils present at the ETTP site area.

3.0 RECOMMENDATIONS TO MODIFY THE ETTP BACKGROUND SOIL CHARACTERIZATION REPORT

The following recommendations were made to the ETTP Remedial Action Core Team in February of 2003. The Core Team members, after due consideration, agreed to the recommendations as stated.

- Collect and analyze samples from residual soil areas that overlie the Rome Formation and the Upper Knox Group Formations. Locations of the background soil locations are shown on Figure 1. Soil samples will be collected from twelve individual locations within the Rome Formation and twelve locations within the Upper Knox Group formations. Proposed background soil sample locations are indicated on Figure 1. Samples for background characterization of the Rome Formation will be collected from the Pine Ridge area south of ETTP, and samples for background characterization of the Upper Knox Group will be collected from the northern flank of McKinney Ridge.
- Follow the site selections, sample collection, and analytical data evaluation procedures as defined in the BSCP report (DOE/OR/01-1175/V1).
- Do not collect samples from the A soil horizon (the data provided by the BSCP report indicates that the A soil horizon is consistently lower in naturally occurring inorganic constituents and the A horizon is generally not present in areas where site operations were conducted). Samples will only be collected from the B soil horizon from approximately 12-24 inches below the ground surface. Based on results of the BSCP, the maximum sample depth for B horizon soils is anticipated to be approximately 2 ft (60 cm).
- Collect samples for radiological and inorganic element (metals) analyses only; do not collect samples for anthropogenic volatile organic compound, herbicide, pesticide, polychlorinated biphenyl, or semi-volatile organic compound analyses (data presented in the BSCP report indicates that there is no significant anthropogenic background condition from these compounds in the area).

- Collect discrete soil samples at each of the 24 locations to be analyzed by alpha spectroscopy for U-234, U-235, and U-238.
- Prepare four composite samples for both the Rome Formation and Upper Knox Group formations by combining three individual samples, determined randomly, from each unit. Submit the composite samples for laboratory analysis as stated above. (Sample designations and composites are presented in Table 1).
- Analyze each of 8 composite samples for Cation Exchange Capacity, inorganic elements, natural nutrient compounds (sulfate, nitrate, phosphate), and naturally occurring radioactive elements.

Table 1. Proposed samples for soil background characterization at ETTP

Characterization Unit	Sample Location Designation	Composite Sample[a]/OREIS[b] ID
Upper Knox Group	OK01, OK02, OK03, OK04, OK05, OK06, OK 07, OK08, OK09, OK10, OK11, OK12	OK02, OK05, OK12 /OKBKG01 OK06, OK08, OK10/ OKBKG02 OK01, OK07, OK09/ OKBKG03 OK03, OK04, OK11/ OKBKG04
Rome Formation	CR01, CR02, CR03, CR04, CR05, CR06, CR07, CR08, CR09, CR10, CR11, CR12	CR02, CR05, CR08/CRBKG01 CR01, CR09, CR11/ CRBKG02 CR03, CR06, CR07/ CRBKG03 CR04, CR10, CR12/ CRBKG04

[a] Composite sample combinations determined using random number generating function in Excel

[b] Oak Ridge Environmental Information System

4.0 SAMPLING AND ANALYSIS

MDM Corporation, the ETTP field sampling subcontractor, collected background soil samples on April 2 and 3, 2003 from the 24 locations as defined on the sample location map (Fig. 1.) Locations were adjusted slightly in the field to move away from surface obstructions (e.g., tree roots, rocks etc). Location coordinates were obtained using a hand held global positioning system unit, and are accurate to within three meters. Coordinate data were linked to the sample data in the Project Environmental Measurement System (PEMS) data management system. Samples were collected using stainless steel hand augers from depths of 1-2 feet subsurface. A typical collection site in the Rome (CR04) is shown in Image 1 and a typical Knox soil site (OK 02) is shown in Image 2.

Sampling followed established procedures and quality assurance/quality control requirements. Samples were shipped to the Portsmouth USEC Laboratory for analysis on March 03, 2003. Cation exchange capacity determinations were performed at the Lionsville Laboratory in Exton, Pennsylvania. All of the analytical results were subsequently validated and verified. Data were loaded into the OREIS database in June 2003.

5.0 SAMPLE RESULTS

Soil sample analytical results are presented in Table 2. Data for the Chickamauga data set that were collected by the BSCP (DOE 1993) are also provided for completeness. Results from the metals analyses show consistent concentrations as related to soil derived from a formation.

Image 1

Image 2

For example, arsenic concentrations reported for soils associated with the Rome Formation are consistently much lower than arsenic concentrations in the Chickamauga- and Knox-derived residual soils. Four inorganic constituents (cadmium, cyanide, silver, and thallium) were not detected in background soil. Antimony was not detected in the 1993 data set; however, improved laboratory methods did detect antimony in the 2003 samples. Lithium, silicon and strontium results were not reported for the 2003 series samples. Americium-241, cesium-137 and strontium-90 were not detected in background soil. Several of the inorganic constituents such as aluminum, arsenic, and iron exhibit natural concentrations that are higher than what is common in the southeastern United States soils (EPA Region 4). These higher concentrations are due to the fact that the soils are residual insoluble residue derived from thick sections of interbedded carbonate and aluminu-silicate clastic rocks. These soils characteristically have higher levels of insoluble metals due to the manner in which the soils form. The soluble fraction of the rock units are removed by chemical erosion over geologic time leaving the insoluble fraction behind. This process tends to concentrate certain constituents of the original rock mass in the remaining soil fraction.

A statistical evaluation of the sample results was performed as required by EPA guidance as described in *Guidance for Comparing Background and Chemical concentrations in Soil for*

CERCLA Sites (EPA 540-R-01-003). Once the analytical data had been 100 percent validated and verified, a series of statistical tests were performed on the data set for each analyte. The Kolmogorov-Smirnoff and Anderson-Darling tests were performed to determine if the data set for each analyte had a normal distribution. If the data set had a normal distribution, the 95 percent Upper Confidence Level (UCL) was calculated. For data sets that did not have normal distribution, a non-parametric tolerance interval (95 percentile) was calculated. The statistical evaluations of the data, test results, and calculated values are shown in Table 3. A summary of the ETTP soil background concentrations for inorganic constituents and radioisotopes is presented in Table 4.

6.0 USE OF THE ETTP BACKGROUND DATA SET

The background soil data presented in Table 4 have been developed according to EPA guidance and in cooperation with and approval of the ETTP Remedial Action Core Team. The data presented in this report will be issued for use as a supplemental document to the BSCP report (DOE/OR/01-1175). The data presented in Table 4 will be used to perform background screening of existing data and will be used to perform background screening of newly acquired soil data during additional characterization activities in Zone 1 and Zone 2 of the ETTP site. Data analyses will include comparison of COC concentrations in soil samples collected in each investigation area with associated COC background levels (UCLs or 95^{th} percentile). Hypothesis testing and the Wilcoxon rank sum statistical tests will be used for these comparisons. Concentration differences that are sufficiently large will warrant further investigations.

Hold Page for Figure 1

Table 2 ETTP Background Concentration (mg/kg) of Inorganic Constituents (metals) in Soil

Analyte	Chickamagua Samples								Knox Samples								Rome Samples							
	OCBK01		OCBK02		OCBK03		OCBK04		OKBKG01		OKBKG02		OKBKG03		OKBKG04		CRBKG01		CRBKG02		CRBKG03		CRBKG04	
Aluminum	32900		40300		35900		30800		10000		11000		8800		9800		15000		11000		15000		15000	
Antimony	0.45	U	0.43	U	0.43	U	0.44	U	1.00		1.20		0.58	B	1.50		1.2		0.92	B	0.78	B	1.2	
Arsenic	7		11.1		7.6		5.1		11.0		15.0		6.9		9.7		1.1		1		0.77		1.5	
Barium	87.4		133		74.6		73.7		85.0		83.0		23.0		100.0		61.0		49.0		71.0		81.0	
Beryllium	2.2		1.9		0.93		1.1		0.60		0.39		0.24		0.45		0.67		0.69		0.77		0.73	
Cadmium	0.22	U	0.22	U	0.22	U	0.22	U	0.02	U	0.04	U	0.02	U	0.02	U	0.037	U	0.019	U	0.037	U	0.038	U
Calcium	2400		1530		396		1390		580		210		97		450		180		80		310		250	
Chromium	31.1	J	39	J	48.5		23.3	J	16.0		19.0		12.0		17.0		33		23		23		28	
Cobalt	36.6		10.8		7.5		8.7		17.0		42.0		4.8		21.0		7.2		9.1		6.5		6.4	
Copper	23		15		18.2		16.4		6.0		15.0		5.2		3.9		6.9		8.6		5.9		13	
Cyanide	1.1	U	1.1	U	1	U	1	U	0.61	U	0.61	U	0.62	U	0.62	U	0.59	U	0.6	U	0.59	U	0.61	U
Iron	58200		56600		58600		47800		17000		24000		16000		21000		29000		20000		28000		27000	
Lead	27.1		15.5		12.8		14.3		28.0		45.0		11.0		20.0		5.6		6.3		5		6.4	
Lithium	32.1		42.3		26.1		31.8		NV		NV		NV		NV		NV		NV		NV		NV	
Magnesium	2140		2880		1610		2850		400		370		360		460		3100		2200		3300		2400	
Manganese	496	J	612	J	206	J	186	J	2200		2100		210		1800		78		380		94		120	
Mercury	0.11		0.17		0.11		0.1	U	0.09	B	0.09	B	0.12		0.10	B	0.019	B	0.02	B	0.021	B	0.017	B
Nickel	28.4		22		18.4		19.2		11.0		12.0		11.0		7.9		17		14		17		13	
Potassium	3880		4660		2620		4710		340		380		450		300		2300		1400		2400		2200	
Selenium	0.6		1		0.92	U	0.66	J	1.40		1.30		0.81		1.40		0.67	U	0.54	B	0.66	U	1	B
Silicon	913		802		710	J	748		NV		NV		NV		NV		NV		NV		NV		NV	
Silver	0.9	U	0.87	U	0.87	U	0.88	U	0.06	U	0.08	B	0.06	U	0.06	U	0.059	U	0.06	U	0.058	U	0.06	U
Sodium	461		497		401		466		19	B	19	B	18	B	20	B	52	B	32	B	45	B	42	B
Strontium	6.8		63.1		5.6	J	17.9		NV		NV		NV		NV		NV		NV		NV		NV	
Sulfate	334		169		59		107		21		41		55		18		18		16		16		17	
Thallium	0.67	U	0.65	U	0.64	U	0.66	U	0.41	U	0.41	U	0.21	U	0.42	U	0.4	U	0.2	U	0.4	U	0.41	U
Vanadium	51.6	J	55.3	J	74.4	J	36.3	J	29.0		41.0		31.0		35.0		30		23		25		34	
Zinc	72.6	J	89.7	J	68.6	J	56.8	J	22.0		54.0		16.0		14.0		28		23		26		28	

Result Qualifiers

U = non detect

J = The analyte is present at the approximate concentration based on the judgement of the lab technician

B = the reported value is below the method detection limit but above the detection limit

NV = No Value measured or reported

Table 2 (cont) Background Concentration (pCi/g) of Radioisotopic Constituents in Soil

	Chickamagua Samples								Knox Samples								Rome Samples							
	OCBK01		OCBK02		OCBK03		OCBK04		OKBKG01		OKBKG02		OKBKG03		OKBKG04		CRBKG01		CRBKG02		CRBKG03		CRBKG04	
Americium-241	0.071	U	0.091	U	0.087	U	89.700	U	0.287	U	-0.198	U	-0.293	U	0.049	U	-0.238	U	0.000	U	-0.028	U	-0.503	U
Cesium-137	0.025	U	0.031	U	0.031	U	0.024	U	-0.067	U	-0.040	U	0.058	U	0.155	U	0.079	U	0.165	U	0.055	U	0.032	U
Potassium-40	24.800	=	26.100	=	17.400	=	23.800	=	NV		NV		NV		NV		NV		NV		NV		NV	
Radium-226	0.915	=	0.940	=	1.050	=	0.902	=	0.414		1.190		0.329		0.540		0.389		0.134	U	0.485		0.476	
Strontium-90	NV		NV		NV		NV		0.174	U	0.092	U	0.065	U	0.027	U	-0.074	U	0.027	U	0.015	U	0.028	U
Thorium-228	1.590	J	1.460	J	1.520	J	1.550	J	0.662		1.100		0.915		0.524		1.330		1.160		1.590		1.030	
Thorium-230	1.130	J	NV		1.060	J	1.090	J	0.972		1.160		0.876		0.736		0.901		0.932		0.936		0.886	
Thorium-232	1.740	J	2.770	J	1.460	J	1.380	J	0.605		1.010		0.777		0.561		1.390		0.983		1.610		1.020	
Cation Exchange Capacity			NV		NV		NV		17		8.5		20.3		6.7		13.6		8.6		21.1		12.5	

U = non detect

J = The analyte is present at the approximate concentration based on the judgement of the lab technician

Radioisotopic results are reported in pCi/g

Cation Exchange Capacity in units of milequivelents /100grams of soil

Table 2 (cont) Uranium-238 data

Uranium-238 (pCi/g)											
Rome Formation Samples				**Knox Group Samples**				**Chickamauga Formation Samples**			
Location ID	Result		Rad Error	Location ID	Result		Rad Error	Location ID	Result		Rad Error
CR01	0.826		0.10	OK01	1.3		0.13	ORR 118,122,124	1.15	J	0.194
CR02	1.000		0.11	OK02	0.8		0.10	ORR 119,123,127	1.38	J	0.257
CR03	0.825		0.11	OK03	0.652		0.09	ORR 119,123,127	1.31	=	0.399
CR04	0.831		0.10	OK04	0.964		0.11	ORR 120,126,129	1.29	J	0.256
CR05	0.669		0.09	OK05	0.858		0.11	ORR 120,126,129	1.69	=	0.454
CR06	1.270		0.14	OK06	1.12		0.18	ORR 121,125,128	1.22	J	0.228
CR07	1.020		0.11	OK07	0.695		0.10	ORR 121,125,128	1.22	=	0.351
CR08	1.020		0.15	OK08	1.43		0.15				
CR09	0.728		0.10	OK09	0.915		0.11				
CR10	0.950		0.12	OK10	1.15		0.13				
CR11	0.988		0.12	OK11	0.927		0.12				
CR12	0.739		0.10	OK12	1.17		0.14				
Mean	**Min**	**Max**	**Stndev**	**Mean**	**Min**	**Max**	**Stndev**	**Mean**	**Min**	**Max**	**Stndev**
0.9055	0.669	1.27	0.17	0.998	0.652	1.430	0.239	1.32	1.150	1.69	0.18

Table 3 Statistical Evaluation of ETTP Soil Background Data

								Kolmogorov-Smirnoff		Anderson-Darling			
COC	**Units**	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Variance**	**Test Statistic**	**Critical Value**	**Test Statistic**	**Critical Value**	**95% UCL**	**95th Percentile**
Aluminum	mg/kg	12	8800	40300	19625	11726.98	137522045	.32*	0.242	1.095*	0.679		40300
Antimony	mg/kg	12	0.43	1.5	0.844	0.378	0.143	0.185	0.242	0.543	0.679	1.52	
Arsenic	mg/kg	12	0.77	15	6.481	4.717	22.247	0.188	0.242	0.385	0.679	14.95	
Barium	mg/kg	12	23	133	76.808	26.794	717.943	0.18	0.242	0.389	0.679	124.93	
Beryllium	mg/kg	12	0.24	2.2	0.889	0.592	0.351	.246*	0.242	.896*	0.679		2.2
Calcium	mg/kg	12	80	2400	656.083	727.029	528570.992	.292*	0.242	1.216*	0.679		2400
Chromium	mg/kg	12	12	48.5	26.075	10.468	109.589	0.188	0.242	0.292	0.679	44.88	
Cobalt	mg/kg	12	4.8	42	14	12.412	154.051	.293*	0.242	1.301*	0.679		42
Copper	mg/kg	12	3.9	23	11.425	6.153	37.86	0.186	0.242	0.446	0.679	22.48	
Iron	mg/kg	12	16000	58600	33600	16727.98	279825455	.275*	0.242	.899*	0.679		58600
Lead	mg/kg	12	5	45	16.417	11.969	143.265	0.197	0.242	0.6	0.679	37.91	
Lithium	mg/kg	4	26.1	42.3	33.075	6.741	45.442	0.308	0.371	0.321	1.799	48.94	
Magnesium	mg/kg	12	360	3300	1839.17	1157.438	1339662.88	0.271	0.242	.682*	0.679		3300
Manganese	mg/kg	12	78	2200	706.833	820.756	673641.061	.296*	0.242	1.475*	0.679		2200
Mercury	mg/kg	12	0.017	0.17	0.081	0.05	0.002	0.242	0.242	.771*	0.679		0.17
Nickel	mg/kg	12	7.9	28.4	15.908	5.659	32.024	0.132	0.242	0.28	0.679	26.07	
Potassium	mg/kg	12	300	4710	2136.67	1635.872	2676078.79	0.182	0.242	0.486	0.679	5074.69	
Selenium	mg/kg	12	0.54	1.4	0.913	0.312	0.098	0.199	0.242	0.54	0.679	1.47	
Silicon	mg/kg	4	710	913	793.25	88.308	7798.25	0.211	0.371	0.239	1.799	1001.04	
Sodium	mg/kg	12	18	497	172.667	210.774	44425.879	.383*	0.242	1.832*	0.679		497
Strontium	mg/kg	4	5.6	63.1	23.35	27.072	732.91	0.33	0.371	0.516	1.799	87.05	
Sulfate	mg/kg	12	16	334	72.583	94.591	8947.538	.307*	0.242	1.594*	0.679		334
Vanadium	mg/kg	12	23	74.4	38.8	14.852	220.584	0.234	0.242	0.664	0.679	65.47	
Zinc	mg/kg	12	14	89.7	41.558	25.493	649.901	.286*	0.242	.679*	0.679		89.7
Potassium-40	pCi/g	4	17.4	26.1	23.025	3.866	14.949	0.329	0.371	0.42	1.799	32.12	
Radium-226	pCi/g	12	0.134	1.19	0.647	0.335	0.112	0.209	0.242	0.49	0.679	1.25	
Thorium-228	pCi/g	12	0.524	1.59	1.203	0.367	0.135	0.175	0.242	0.42	0.679	1.86	
Thorium-230	pCi/g	11	0.736	1.16	0.971	0.127	0.016	0.153	0.251	0.284	0.68	1.2	
Thorium-232	pCi/g	12	0.561	1.77	1.192	0.424	0.18	0.171	0.242	0.322	0.679	1.95	
Uranium-238	pCi/g	31	0.652	1.69	1.036	0.253	0.064	0.105	0.157	0.304	0.713	1.47	

*Donates exceedance of test critical value - data set is not normally distributed.

Table 4

ETTP Soil Background Values

Metals	**mg/kg**
Aluminum	40300.00
Antimony	1.52
Arsenic	14.95
Barium	124.93
Beryllium	2.20
Cadmium	0.22U
Calcium	2400.00
Chromium	44.88
Cobalt	42.00
Copper	22.48
Cyanide	0.6U
Iron	58600.00
Lead	37.91
Lithium	48.94
Magnesium	3300.00
Manganese	2200.00
Mercury	0.17
Nickel	26.07
Potassium	5074.69
Selenium	1.47
Silicon	1001.04
Silver	0.6U
Sodium	497.00
Strontium	87.05
Sulfate	334.00
Thallium	0.4U
Vanadium	65.47
Zinc	89.70
Radioisotopes	**pCi/g**
Potassium-40	32.12
Radium-226	1.25
Thorium-228	1.86
Thorium-230	1.20
Thorium-232	1.95
Uranium-238	1.47

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