UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

# Analytical results and sample locality map of whiteleaf manzanita, digger pine, soil, and water samples, Redding CUSMAP sheet biogeochemical study, Tehama County, California

By
G. R. Meadows, S. Dudka, L. L. Jackson,
L. P. Gough, and P. H. Briggs[1]

Open-File Report 88-595

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

[1]DFC, Box 25046, MS 973, Denver, CO 80225

1988

## CONTENTS



## ILLUSTRATIONS



## TABLES



## APPENDICES

# INTRODUCTION

In this report we present the analytical results of plant, soil, and water samples collected as part of the U.S. Geological Survey's CUSMAP (Contiguous U.S. Mineral Assessment Program) project for the Redding, California 1° x 3° sheet. These samples were collected as one of several multidisciplinary studies being conducted in the region. This report serves as a mechanism for the release of the analytical data. Interpretative analysis may be found elsewhere (Gough and others, 1986; Meadows and others, 1987; Gough and others, 1989).

## Purpose of Study

The study was initiated to examine areal element concentration trends in plant material and soils in a highly serpentinized ultramafic chromite-rich area. The primary purpose was to examine the processes that define any observed areal trends. A better understanding of the mechanisms of element uptake by plants growing in ultramafic areas with associated chromite deposits is necessary if biogeochemical methods of prospecting for chromite are to be effective. An increase in our knowledge of the biogeochemistry of Cr and related elements is applicable not only to exploration efforts but also to environmental and toxicological concerns of Cr (particularly as Cr(VI)) phyto- and zoo-toxicity.

## Description of the Study Area

### Location

The study area is located in the southeast corner of the Redding 1° x 3° sheet, Tehama County, northern California, in the southeast-quarter of section 16, T.25N., R.7W (Raglin Ridge, California, 1:24,000 quadrangle, fig. 1). It encompasses an area of slightly less than 0.25 $km^2$ and is located in rugged, highly serpentinized-ultramafic terrain south of the North Fork of Elder Creek.

### Geology

The study area is located at the northern tip of a northward-trending, tabular peridotite body of the coast range ophiolite suite (Strand, 1962; Irwin, 1964). It occurs in an area of complex geology, near the junction of three major geologic provinces, the Klamath Mountains, the Coast Range, and the Great Valley (Irwin, 1966). Blake and others (1982) associate the study area with the Pre-Cenozoic rocks of the Great Valley.

An interpretation of the tectonic history of the peridotite given by Blake and others (1982) suggests that the peridotite and associated sedimentary rocks were obducted onto a late Jurassic Age volcanic arc, sometime between Late Jurassic and Early Cretaceous. This ophiolite sequence, and the overlying

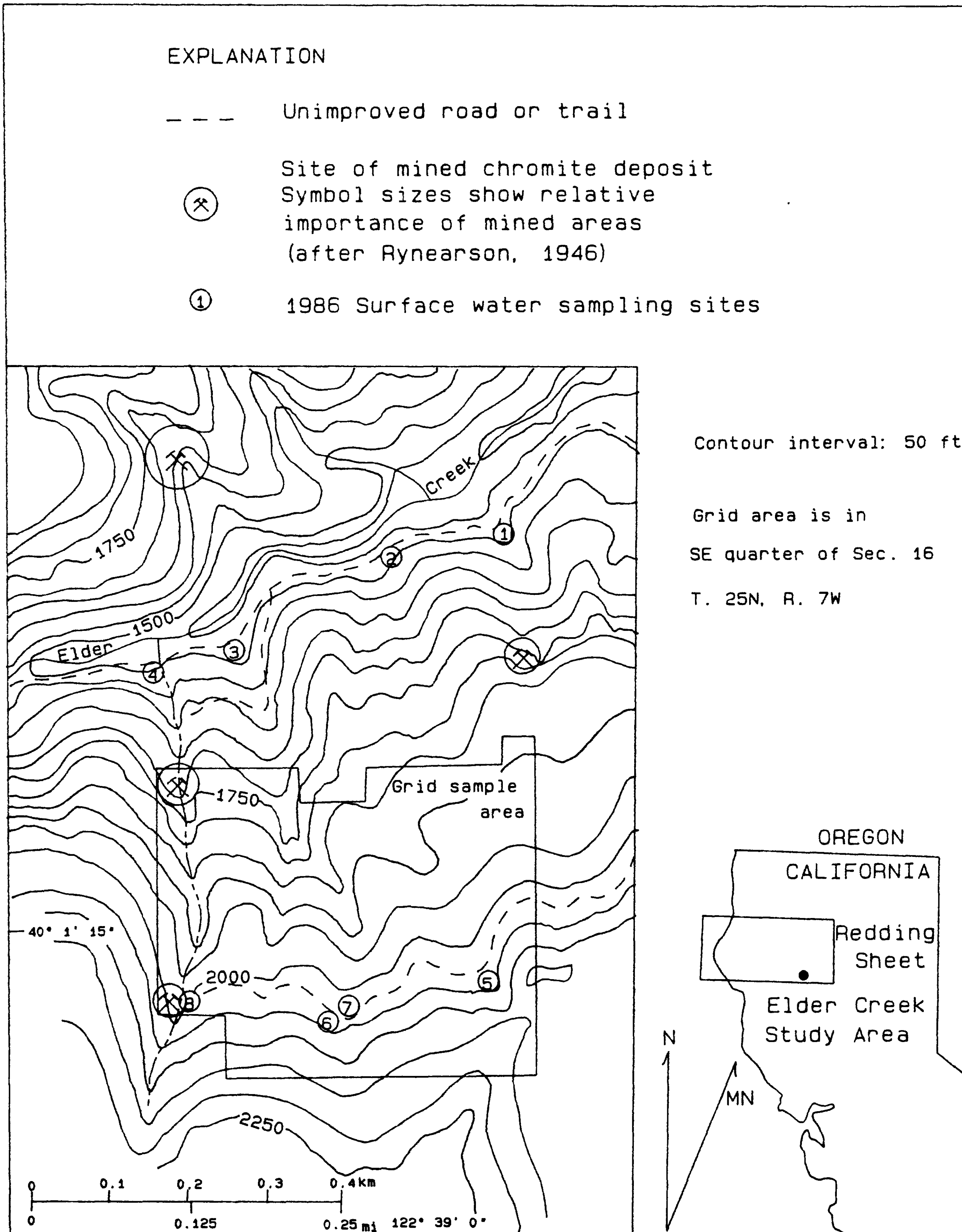


FIGURE 1. Map of the Elder Creek ultramafic study area showing topography, past mining sites, and location within the Redding CUSMAP sheet.

sedimentary rocks have been identified as the Elder Creek terrane (Blake and others, 1984). The chromite deposits within the peridotite have been classified as alpine-type podiform deposits (Wells and others, 1965; Thayer, 1966; Page and Johnson, 1977). Shearing and serpentinization appear to have been the dominant geologic forces within the area.

**Physiography and Vegetation**

The vegetation of the Elder Creek study area has been described as serpentine chaparral (Kruckeberg, 1984). The ecology of serpentine areas is complex and is characterized by (1) soils which are imbalanced in macronutrients (i.e., very high in Fe and with very small Ca/Mg ratios) and have low levels of N and P, (2) soils that contain unusually high (often toxic) levels of Cr, Ni, and sometimes Co, (3) sparsely vegetated areas, (4) open tree and shrub canopies and high surface soil temperatures, and (5) unstable soils usually low in surface soil moisture (Walker, 1954).

The study area is dominated by the presence of whiteleaf manzanita (Archtostaphlos viscida Parry). In general, the manzanita shrubs are smaller and more crowded in the low bench region (northeast) and larger and more widely spaced in the high bench region (southwest). Digger pine trees (Pinus sabiniana Dougl.) are scattered about, but most common on the small ridge crests, particularly in the steep ridge and gully region on the western side of the study area.

## METHODS OF STUDY

### Study Design

In June, 1984, a grid of approximately 400 m x 500 m was laid out over an area of known chromite mineralization (fig. 2). The study area was defined by 120 possible sampling sites with centers that were separated by 44 m.

### Sampling Procedures

**Gridded study, manzanita and pine**

At each site, plant material collected included stems and leaves (current-year's growth, usually the terminal 5 to 8 cm) of the shrub whiteleaf manzanita (A. viscida) and two-year-old needles (needles from the second whorl) of digger pine (P. sabiniana). Each sample consisted of about 20 g of material collected from around the perimeter of a single individual plant located as close as possible to the measured grid point. All manzanita samples were collected at about 1.5 m above the ground using stainless steel shears. Pine needles were stripped by hand from the lowest accessible branches; usually these were 3 to 5 m above ground and had to be obtained using extension pruning shears.

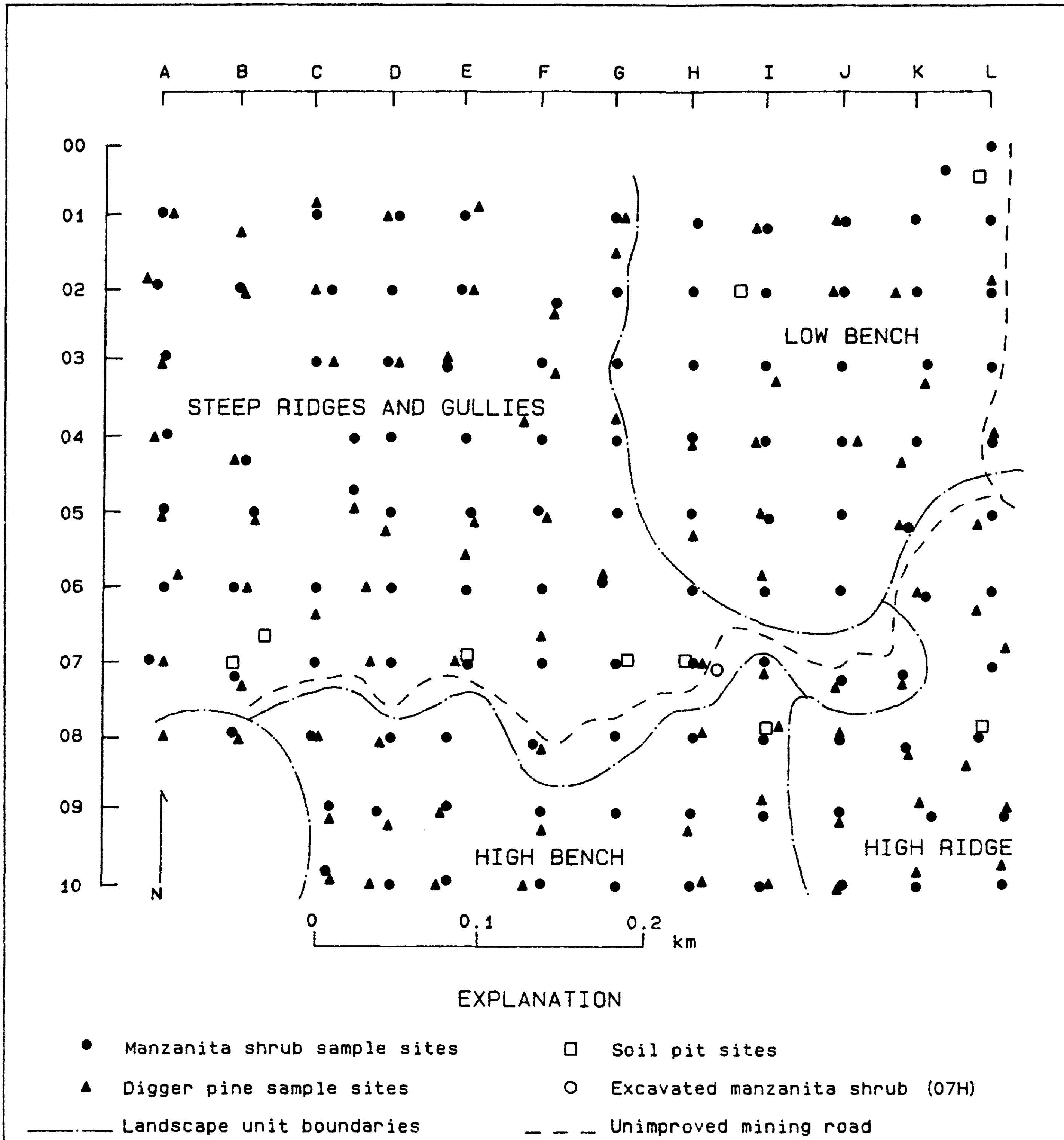


FIGURE 2. Detailed map of plant and soil sampling sites.

Manzanita was found at 112 and digger pine at 91 of the 116 accessible sampling sites. Ten percent of the sites for each species were chosen randomly for replication and ten percent for duplicate sample analysis. At each replicated site a shrub (or tree) that was adjacent to the original sample was chosen forsampling. Duplicate analyses were performed on sample splits obtained after grinding of the dry material in the laboratory.

Plant samples were stored in Hubco cloth bags. In the laboratory the samples were dried in a forced-air oven at about 38°C for 24 hours. Samples were then ground in a Wiley mill to pass a 1.3 mm screen. Duplicate samples of the ground plant material were obtained using a Jones splitter.

**Excavated manzanita shrub**

In August, 1985, we excavated a single manzanita shrub located at the crest of an old road cut near site 07H (fig. 2). Major roots were traced laterally along the road cut for about seven meters and vertically about two meters. Samples taken included: (1) root cortex and stele (epidermis was peeled and removed) at 1 m intervals away from the basal manzanita burl, (2) basal burl (sap wood), (3) main stem 1 m above burl (sap wood), (4) primary branches off main stem (outer bark was peeled and removed), (5) secondary branches off primary branches, (6) leaves. The purpose of these collections was to evaluate the relative concentrations of elements among parts of the plant and to assess the possible partitioning of absorbed elements between root and shoot tissue.

**Soils from excavated pits**

In August, 1985, eight pits (fig. 2) were excavated through the highly weathered soil and rock profile at sites judged to be different biogeochemically as determined by the evaluation of manzanita and digger pine chemistry. The purpose of the soil collections was to examine soil chemical and physical parameters which would help in defining trace metal mobility in ultramafic terrains.

The pits were located adjacent to the manzanita shrub (or shrubs) that was sampled as part of the gridded biogeochemical study. Pits were excavated to a depth of about 100 cm and samples were collected at five depths: 0-5 cm (surface litter having been scraped away), 10, 20, 40, and 80 cm. At each depth, paired samples, separated by about 20 cm, were first sieved through a 1 cm screen and then placed in 1 L polyethylene acid-washed bottles. The bottles were sealed to prevent moisture loss. Rocks for chemical analysis and thin section examination were also collected.

About 50 g of bulk material were removed from the plastic bottles and pH and moisture percentage were measured. The presence of Cr(VI) was also determined; mineralogical determinations using x-ray diffraction were conducted for selected samples. About 100 g of soil were ground to pass a 100-mesh sieve for additional analyses. Each sample was analyzed for total and inorganic C (organic C was calculated as the difference between the two measured C values). Samples were also analyzed by sintering with sodium peroxide, dissolving the sinter cake in nitric acid, and determining major and trace element concentrations by inductively coupled plasma optical emission spectrometry.

**Surface water collections**

The study area is cut by several north-south gullies, all of which drain into Elder Creek (fig. 2). Surface water is present in these gullies for only a relatively short time during the wet season each spring.

In late March, 1986, we collected water samples from four different gullies, at both the top of the slope containing the field area, and at the bottom of the slope, before the streams drained into Elder Creek (fig. 1). The samples were placed in acid-rinsed, 500 ml polyethylene bottles. The samples were capped and refrigerated. Measurements were made of pH, conductivity, and for the presence of hexavalent Cr using a colorimetric test.

Table 1 lists the analytical methods used in this study. Procedural details are given in the references that are listed in Table 1.

## ROCK ANALYSIS STORAGE SYSTEM

Upon completion of all analytical work, the analytical results were entered into a computer-based file called Rock Analysis Storage System (RASS). This data base contains both descriptive geological information and analytical data. Any or all of this information may be retrieved and converted to a binary form (STATPAC) for computerized statistical analysis or publication (VanTrump and Miesch, 1977).

## USE OF THE DATA

This report provides a timely release of analytical results in a tabular format and is not meant to be interpretive. These data have been interpreted by Gough and others (1986), Meadows and others (1987), and Gough and others (1989).

## REFERENCES CITED


Blake, M. C., Jr., Howell, D. C., and Jones, D. L., 1982, Preliminary tectono-stratigraphic terrane map of California, scale 1:750,000: U.S. Geological Survey Open-file Report 82-593.

_____, Harwood, D. S., Helley, E. J., Irwin, W. P., Jayko, A. S., and Jones, D. L., 1984, Preliminary geologic map of the Red Bluff 100,000 quadrangle, California: U.S. Geological Survey Open-file Report 84-105.

Bartlett, R. and James B., 1979, Behavior of chromium in soils. III. Oxidation: Journal of Environmental Quality, v. 8, p. 31-35.

Church, S.E., Mosier, E. L., and Motooka, J. M., 1987, Mineralogical basis for the interpretation of multi-element (ICP-AES), oxalic acid, and aqua regia partial digestions of stream sediments for reconnaissance exploration geochemistry: Journal of Exploration Research, v. 29, p. 207-233.

Gough, L. P., Meadows, G. R., and Jackson, L. L., 1986, Uptake of chromium by vegetation and its mobilization in ultramafic soils, California [abs.]: Soil Science Society of America, Agronomy Abstracts, v. 78, p. 168.

_____, Meadows, G. R., Jackson, L. L., and Dudka, S., 1989, The biogeochemistry of a highly serpentinized ultramafic chromite-rich area, Tehama County, California: U.S. Geological Bulletin (in press).

Harms, T. F., 1976, Analysis of plants and plant ashes by methods other than emission spectroscopy, in Miesch, A. T., Geochemical survey of Missouri, methods of sampling, laboratory analysis, and statistical reduction of data: U.S. Geological Survey Professional Paper 954-A, p. 17-18.

Irwin, W. P., 1964, Late Mesozoic orogenies in the ultramafic belts of northwestern California and southwestern Oregon: U.S. Geological Survey Professional Paper 501-C, p. C1-C9.

_____, 1966, Geology of the Klamath Mountains Province, in Geology of Northern California: California Division of Mines and Geology, Bulletin 190, p. 19-62.

Jackson, L. L., Brown, F. W., and Neil, S. T., 1987, Major and minor elements requiring individual determinations, classical whole rock analysis, and rapid rock analysis, in Baedecker, P. A., ed., Geochemical methods of analysis: U.S. Geological Survey Bulletin 1770, p. G1-G23.

Kruckeberg, A. R., 1984, California serpentines, flora, vegetation, geology, soils, and management problems: University of California Press, Berkeley, 180 p.

Lichte, F. E., Golightly, D. W., and Lamothe, P. J., 1988, Inductively coupled plasma-atomic emission spectrometry, in Baedecker, P. A., ed., Geochemical methods of analysis: U.S. Geological Survey Bulletin 1770, p. B1-B10.

Meadows, G. A., Jackson, L. L., and Gough, L. P., 1987, Pulse polarographic determination of naturally occurring Cr(VI) in soils and waters [abs.]: 29th Rocky Mountain Conference Program, Rocky Mountain Section Society for Applied Spectroscopy, Aug. 2-6, 1987, p. 32.

Page, N. J. and Johnson, M. G., 1977, Chromite resources of the podiform chromite deposits and exploration for concealed chromite deposits in the Medford-Coos Bay quadrangles, southwestern Oregon: U.S. Geological Survey Open-file Report 77-656, 14 p.

Peech, M., 1965, Hydrogen-ion activity, in Methods of soil analysis, Part 2, Agronomy 9: American Society of Agronomy, Madison, p. 922-923.

Rynearson, G. A., 1946, Chromite deposits of the North Elder Creek area, Tehama County, California: U.S. Geological Survey Bulletin 945-G, p. 191-210.

Starkey, H. C., Blackmon, P. D., and Hauff, P. L., 1984, The routine mineralogical analysis of clay-bearing samples: U.S. Geological Survey Bulletin 1563.

Strand, R. G., 1962, Geologic map of California, Redding sheet: California Division of Mines and Geology, Sacramento, California, fourth printing, 1978, 1:250,000, 1 sheet plus index.

Thayer, T. P., 1966, Chromite, in Mineral resources of California: California Division of Mines and Geology, Bulletin 191, p. 120-126.

VanTrump, George, Jr., and Miesch, A. T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geoscience, v. 3, p. 475-488.

Walker, R. B., 1954, The ecology of serpentine soils II. Factors affecting plant growth on serpentine soils: Ecology, v. 35, p. 259-266.

Wells, F. G., and Hawkes, H. E., 1965, Geological investigations of chromite in California, Part I, Klamath Mountains: California Division of Mines and Geology, Bulletin 134, Chapter 3, p. 130-191.

TABLE 1. Analytical methodology and references for the analyses of sampled plant material and soils.
[A, soil pit geochemical; B, plant grid biogeochemical; C, excavated shrub biogeochemical; D, intermittent stream chemical]

| Variable | Method | Study | Reference |
|---|---|---|---|
| Concentrations of total B, Ba, Ca, Co, Cr, Cu, Fe, Mg, Mn, Ni, Pb, Sc, Ti, V, Y, Zn, and Zr | ICP[1] on dry soils sintered with sodium peroxide | A | Lichte and others, 1988 |
| Concentrations of total Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Nb, Ni, P, Pb, Sr, Ti, V, Y, and Zn | ICP[1] on aqua regia-digested plant ash | B | Church and others, 1987 |
| Concentrations of total Ca, Cu, Cr, Fe, Mg, Mn, and Ni | Atomic absorption spectrometry on acid-digested ash of manzanita plant roots, trunk, stems, and leaves | C | Harms, 1976 |
| Percent total C, organic C, and carbonate C | Combustion-infrared photometry, difference, and coulometric titration, respectively, on dry soil | A | Jackson and others, 1988 |
| Soil moisture | Gravimetric | A | Loss of weight after 24 hrs. at 105°C |
| Ash yield | Gravimetric on dry plant material | B | Ashed at 500°C |
| Plant ash and soil mineralogy | Powder x-ray diffraction | A,B | Starkey and others, 1984 |
| pH | Glass electrode, 1:1 water:soil (<2 mm fraction) slurry, and stream water | A,D | Peech, 1965 |
| Cr(VI) presence in water and field soils | Qualitative colorimetric test with s-diphenyl carbazide | A,D | Modified from Bartlett and James, 1979 |

[1] Inductively coupled argon plasma optical emission spectrometry.

## EXPLANATION OF APPENDICES

**APPENDIX I.** Element concentrations (dry weight basis) in whiteleaf manzanita stem and leaves.

Tables giving the sample identification, location, and chemical composition of whiteleaf manzanita (Arctostaphlos viscida) stems and leaves, Elder Creek study area, Tehama County, California. The sample identifications are keyed as follows: first position (M)--manzanita tissue; second and third positions (00-10)--site location on x-axis of study grid; fourth position (A-L)--site location on y-axis of study grid; fifth position (1 or 2)--site replicated sample; sixth position (1 or 2)--analytical duplicated sample. Values preceded by an "<" indicate that the actual concentration is "less than" the value given; variable "<" values result from the conversion of the concentrations from an ash weight basis (reported by the analyst) to a dry weight basis (reported in this table). Concentration values are significant to two places.

**APPENDIX II.** Element concentrations (dry weight basis) in digger pine needles.

Tables giving the sample identification, location, and chemical composition of digger pine (Pinus sabiniana) needles, Elder Creek study area, Tehama County, California. The sample identifications are keyed as follows: first position (D)--digger pine tissue; second and third positions (00-10)--site location on x-axis of study grid; fourth position (A-L)--site location on y-axis of study grid; fifth position (1 or 2)--site replicated sample; sixth position (1 or 2)--analytical duplicated sample. Values preceded by an "<" indicate that the actual concentration is "less than" the value given; variable "<" values result from the conversion of the concentrations from an ash weight basis (reported by the analyst) to a dry weight basis (reported in this table). Concentration values are significant to two places.

**APPENDIX III.** Element concentrations (ash weight basis) in tissues of an excavated manzanita shrub.

Element concentrations are presented on ash weight basis in order to compare different tissues of an excavated whiteleaf manzanita (Arctostaphios viscida) shrub.

**APPENDIX IV.** Element concentrations in soils from excavated pits.

Cr(VI) qualitatively identified as to presence (1) or absence (0) by visual colorimetric test. The following elements were below the determination limit (ppm in parentheses) for all samples: Ag(8), As(0.8), Be(4), Bi(40), Cd(8), Ce(20), Ga(20), Ho(20), La(8), Li(8), Mo(8), Pb(20), Ta(200), Th(20), U(400), and Yb(4)

**APPENDIX V.** Element concentrations in stream water samples.

Sample location is identified in Figure 1. Cr(VI) qualitatively identified as to presence (POS) or absence (NEG) by visual colorimetric test.

**APPENDIX I.** Element concentrations (dry weight basis) in whiteleaf manzanita stem and leaves.

| Sample ID. | X-Coor. | Y-Coor. | Ash % | Al ppm | As ppm | Ba ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 M00K11 | 11.2 | 9.7 | 4.0 | 19.5 | < 0.3 | 7.6 | 1.0 | 0.07 | < 0.3 | 0.3 | 4.8 |
| 2 M00L11 | 11.8 | 10.0 | 3.4 | 17.5 | < 0.3 | 7.2 | 0.6 | < 0.03 | < 0.3 | 0.7 | 4.8 |
| 3 M01A11 | -0.2 | 9.0 | 3.8 | 18.1 | < 0.3 | 9.5 | 1.1 | 0.06 | < 0.3 | 0.8 | 4.5 |
| 4 M01C11 | 2.0 | 9.0 | 4.1 | 14.5 | < 0.7 | 5.4 | 0.7 | 0.05 | < 0.3 | 2.9 | 5.4 |
| 5 M01C12 | 2.0 | 9.0 | 4.1 | 14.3 | 1.8 | 6.1 | 0.5 | 0.06 | < 0.3 | 2.6 | 4.9 |
| 6 M01D11 | 3.1 | 9.0 | 3.4 | 25.0 | < 0.3 | 7.1 | 0.7 | < 0.03 | < 0.3 | 4.7 | 4.7 |
| 7 M01E11 | 4.2 | 9.0 | 2.7 | 20.8 | < 0.2 | 6.9 | 0.5 | < 0.02 | < 0.2 | 0.7 | 2.7 |
| 8 M01G11 | 6.4 | 9.0 | 3.3 | 28.4 | < 0.3 | 10.4 | 0.6 | < 0.03 | < 0.3 | 0.8 | 5.2 |
| 9 M01H11 | 7.5 | 8.9 | 3.7 | 23.8 | 2.1 | 9.2 | 0.3 | 0.05 | < 0.3 | 1.3 | 4.8 |
| 10 M01I11 | 8.6 | 8.8 | 3.6 | 17.8 | < 0.3 | 11.8 | 0.8 | < 0.03 | < 0.3 | 0.9 | 4.3 |
| 11 M01J11 | 9.6 | 9.0 | 4.2 | 20.3 | < 0.3 | 9.3 | 1.0 | 0.07 | < 0.3 | 1.2 | 5.5 |
| 12 M01K11 | 10.7 | 9.0 | 3.3 | 15.3 | 1.4 | 4.9 | 0.3 | 0.03 | < 0.3 | 0.4 | 5.5 |
| 13 M01L11 | 11.8 | 9.0 | 4.3 | 23.2 | < 0.3 | 10.3 | 1.0 | < 0.03 | < 0.3 | 0.7 | 5.2 |
| 14 M02A11 | -0.3 | 8.1 | 4.4 | 22.0 | < 0.4 | 15.0 | 0.9 | < 0.04 | < 0.4 | 2.6 | 4.4 |
| 15 M02A12 | -0.3 | 8.1 | 4.2 | 23.7 | < 0.3 | 17.4 | 1.0 | < 0.03 | < 0.3 | 2.5 | 3.4 |
| 16 M02B11 | 0.9 | 8.0 | 2.9 | 20.3 | < 0.2 | 12.0 | 0.6 | < 0.02 | < 0.2 | 2.4 | 6.6 |
| 17 M02C11 | 2.2 | 8.0 | 3.7 | 26.7 | < 0.3 | 15.4 | 0.9 | 0.03 | < 0.3 | 2.2 | 4.0 |
| 18 M02C12 | 2.2 | 8.0 | 3.7 | 23.8 | < 0.3 | 13.0 | 0.7 | 0.04 | < 0.3 | 2.1 | 4.5 |
| 19 M02E11 | 4.2 | 8.0 | 3.4 | 18.9 | < 0.3 | 7.8 | 0.5 | < 0.03 | < 0.3 | 1.8 | 3.0 |
| 20 M02F11 | 5.4 | 7.9 | 2.5 | 17.8 | < 0.2 | 6.6 | 0.5 | 0.03 | < 0.2 | 2.5 | 1.4 |
| 21 M02G11 | 6.4 | 8.0 | 3.8 | 13.5 | < 0.3 | 17.3 | 0.8 | 0.04 | < 0.3 | 0.5 | 4.5 |
| 22 M02H11 | 7.5 | 8.0 | 4.2 | 18.1 | 1.6 | 18.5 | 0.4 | < 0.03 | < 0.3 | 2.4 | 7.6 |
| 23 M02I11 | 8.6 | 8.0 | 3.3 | 19.4 | < 0.3 | 8.0 | 0.5 | 0.03 | < 0.3 | 0.7 | 6.4 |
| 24 M02J11 | 9.6 | 8.0 | 3.5 | 18.1 | < 0.3 | 6.0 | 0.8 | 0.04 | < 0.3 | 0.7 | 5.3 |
| 25 M02K11 | 10.7 | 8.0 | 3.6 | 17.5 | < 0.3 | 12.0 | 0.8 | < 0.03 | < 0.3 | 0.7 | 4.4 |
| 26 M02K12 | 10.7 | 8.0 | 3.6 | 16.9 | < 0.3 | 7.9 | 0.8 | 0.05 | < 0.3 | 0.8 | 4.3 |
| 27 M02L11 | 11.8 | 8.0 | 4.3 | 21.3 | < 0.3 | 9.8 | 1.1 | 0.08 | < 0.3 | 0.5 | 4.2 |
| 28 M03A11 | -0.2 | 7.0 | 4.4 | 20.9 | < 0.4 | 18.2 | 1.2 | 0.05 | < 0.4 | 2.4 | 3.6 |
| 29 M03C11 | 2.0 | 7.0 | 3.1 | 26.4 | < 0.3 | 14.8 | 0.7 | < 0.03 | < 0.3 | 0.7 | 3.5 |
| 30 M03D11 | 3.1 | 7.0 | 3.8 | 13.4 | < 0.3 | 14.6 | 1.0 | < 0.03 | < 0.3 | 1.9 | 3.2 |
| 31 M03E11 | 4.0 | 7.0 | 4.1 | 24.4 | 1.5 | 8.1 | 0.5 | 0.04 | < 0.3 | 3.0 | 4.1 |
| 32 M03E12 | 4.0 | 7.0 | 4.0 | 22.2 | < 0.3 | 8.9 | 1.0 | < 0.03 | < 0.3 | 2.9 | 2.5 |
| 33 M03F11 | 5.3 | 7.0 | 3.5 | 15.6 | 1.3 | 5.9 | 0.4 | 0.03 | < 0.3 | 3.5 | 3.4 |
| 34 M03G11 | 6.4 | 7.0 | 3.1 | 18.1 | < 0.2 | 10.4 | 0.6 | 0.03 | < 0.2 | 1.3 | 4.3 |
| 35 M03H11 | 7.5 | 7.0 | 3.7 | 17.2 | < 0.3 | 7.0 | 0.8 | 0.03 | < 0.3 | 2.3 | 6.2 |
| 36 M03H21 | 7.5 | 7.0 | 3.9 | 21.6 | < 1.0 | 6.2 | 0.5 | < 0.03 | < 0.3 | 1.9 | 4.6 |
| 37 M03I11 | 8.6 | 7.0 | 4.6 | 27.6 | < 0.4 | 10.1 | 1.1 | 0.04 | < 0.4 | 0.4 | 5.5 |
| 38 M03I21 | 8.6 | 7.0 | 5.1 | 27.2 | < 0.4 | 12.9 | 1.2 | 0.04 | < 0.4 | 0.5 | 5.1 |
| 39 M03J11 | 9.7 | 7.0 | 4.3 | 25.3 | < 0.3 | 12.0 | 0.9 | 0.05 | < 0.3 | 0.4 | 6.4 |
| 40 M03K11 | 10.9 | 7.0 | 4.5 | 67.8 | < 0.4 | 14.9 | 1.2 | 0.07 | < 0.4 | 1.7 | 5.0 |
| 41 M03L11 | 11.8 | 7.0 | 4.5 | 18.4 | < 0.4 | 25.1 | 1.1 | 0.17 | < 0.4 | 0.3 | 7.2 |
| 42 M04A11 | -0.2 | 6.0 | 3.8 | 12.6 | < 0.3 | 8.4 | 0.8 | < 0.03 | < 0.3 | 0.9 | 5.4 |
| 43 M04B11 | 1.0 | 5.7 | 3.6 | 11.5 | < 0.3 | 8.3 | 0.8 | 0.04 | < 0.3 | 3.1 | 4.7 |
| 44 M04C11 | 2.5 | 6.0 | 3.2 | 13.6 | < 0.3 | 11.7 | 0.6 | 0.03 | < 0.3 | 1.0 | 4.5 |
| 45 M04D11 | 3.1 | 6.0 | 2.7 | 19.8 | < 0.2 | 5.1 | 0.5 | < 0.02 | < 0.2 | 1.3 | 3.5 |
| 46 M04E11 | 4.2 | 6.0 | 2.5 | 15.8 | < 0.2 | 3.5 | 0.6 | < 0.02 | < 0.2 | 2.0 | 3.8 |
| 47 M04F11 | 5.3 | 6.0 | 2.8 | 17.7 | < 0.2 | 2.5 | 0.5 | < 0.02 | < 0.2 | 2.0 | 1.7 |
| 48 M04F12 | 5.3 | 6.0 | 2.7 | 17.7 | < 0.2 | 2.6 | 0.5 | 0.02 | < 0.2 | 2.0 | 1.3 |
| 49 M04G11 | 6.4 | 6.0 | 3.3 | 14.6 | < 0.3 | 9.0 | 0.7 | < 0.03 | < 0.3 | 1.2 | 3.3 |
| 50 M04H11 | 7.5 | 6.0 | 3.4 | 18.6 | < 0.3 | 14.1 | 0.8 | < 0.03 | < 0.3 | 0.7 | 6.5 |
| 51 M04I11 | 8.6 | 6.0 | 4.2 | 15.5 | < 0.3 | 22.6 | 0.9 | 0.05 | < 0.3 | 1.6 | 5.4 |
| 52 M04J11 | 9.7 | 6.0 | 4.7 | 24.0 | < 0.4 | 17.4 | 1.1 | 0.05 | < 0.4 | 1.0 | 4.3 |
| 53 M04K11 | 10.7 | 6.0 | 4.2 | 20.7 | 2.0 | 8.4 | 0.4 | 0.06 | < 0.3 | 0.9 | 5.9 |
| 54 M04L11 | 11.8 | 6.0 | 3.9 | 20.1 | < 0.3 | 17.4 | 0.8 | < 0.03 | < 0.3 | 1.1 | 4.6 |
| 55 M04L12 | 11.8 | 6.0 | 3.7 | 22.0 | < 0.3 | 13.8 | 0.8 | 0.04 | < 0.3 | 1.2 | 5.2 |

Appendix I. Whiteleaf manzanita cont.

| Sample ID. | X-Coor. | Y-Coor. | Ash % | Al ppm | As ppm | Ba ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 56 M05A11 | -0.2 | 5.0 | 4.0 | 14.7 | < 0.3 | 12.3 | 1.0 | 0.07 | < 0.3 | 0.7 | 5.2 |
| 57 M05B11 | 1.0 | 5.0 | 4.0 | 16.6 | < 0.3 | 12.3 | 0.8 | < 0.03 | < 0.3 | 2.6 | 4.0 |
| 58 M05C11 | 2.5 | 5.2 | 2.0 | 40.4 | < 0.3 | 2.2 | 0.2 | < 0.02 | < 0.2 | 2.8 | 4.0 |
| 59 M05D11 | 3.1 | 5.0 | 2.3 | 12.4 | 1.0 | 2.5 | 0.2 | 0.02 | < 0.2 | 1.0 | 4.1 |
| 60 M05D21 | 3.1 | 5.0 | 2.5 | 10.1 | < 0.5 | 1.1 | 0.2 | < 0.02 | < 0.2 | 1.5 | 4.8 |
| 61 M05E11 | 4.2 | 5.0 | 2.1 | 25.4 | < 0.5 | 1.3 | 0.2 | < 0.02 | < 0.2 | 2.0 | 4.5 |
| 62 M05F11 | 5.3 | 5.0 | 3.6 | 17.2 | < 0.3 | 5.7 | 0.7 | < 0.03 | < 0.3 | 0.8 | 5.0 |
| 63 M05G11 | 6.4 | 5.0 | 3.7 | 19.1 | < 0.3 | 11.2 | 0.7 | 0.03 | < 0.3 | 2.9 | 4.1 |
| 64 M05H11 | 7.5 | 5.0 | 4.0 | 23.8 | < 0.3 | 9.3. | 1.1 | 0.04 | < 0.3 | 2.4 | 4.0 |
| 65 M05H21 | 7.5 | 5.0 | 4.5 | 19.7 | < 0.4 | 7.2 | 1.0 | 0.05 | < 0.4 | 1.2 | 4.1 |
| 66 M05I11 | 8.6 | 4.9 | 4.2 | 15.5 | < 0.3 | 7.1 | 0.8 | 0.04 | < 0.3 | 2.7 | 8.8 |
| 67 M05J11 | 9.6 | 5.0 | 3.4 | 16.5 | < 0.3 | 7.4 | 0.5 | < 0.03 | < 0.3 | 0.9 | 3.2 |
| 68 M05K11 | 10.7 | 4.8 | 5.6 | 26.5 | < 0.7 | 11.8 | 1.1 | 0.1 | < 0.5 | 0.7 | 6.2 |
| 69 M05L11 | 11.8 | 5.0 | 3.6 | 21.8 | < 0.3 | 8.0 | 0.7 | < 0.03 | < 0.3 | 0.5 | 4.4 |
| 70 M06A11 | -0.2 | 4.0 | 4.4 | 18.3 | 1.7 | 10.9 | 0.6 | 0.07 | < 0.4 | 0.2 | 3.8 |
| 71 M06A12 | -0.2 | 4.0 | 4.5 | 16.5 | < 0.4 | 12.0 | 1.1 | 0.05 | < 0.4 | < 0.2 | 4.9 |
| 72 M06B11 | 0.9 | 4.0 | 3.2 | 15.0 | < 0.3 | 4.5 | 0.6 | < 0.03 | < 0.3 | 6.1 | 2.0 |
| 73 M06B21 | 0.9 | 4.0 | 3.5 | 14.9 | < 0.3 | 4.5 | 0.6 | < 0.03 | < 0.3 | 7.3 | 3.5 |
| 74 M06C11 | 2.0 | 4.0 | 3.8 | 20.7 | < 0.3 | 5.3 | 0.9 | 0.04 | < 0.3 | 7.5 | 4.1 |
| 75 M06D11 | 3.1 | 4.0 | 3.8 | 14.9 | < 0.9 | 12.6 | 0.5 | < 0.03 | < 0.3 | 1.3 | 6.5 |
| 76 M06E21 | 4.2 | 4.0 | 4.1 | 21.1 | < 0.3 | 4.5 | 0.7 | < 0.03 | < 0.3 | 3.0 | 3.1 |
| 77 M06F11 | 5.3 | 4.0 | 2.5 | 24.1 | < 0.2 | 1.6 | 0.7 | 0.03 | < 0.2 | 3.1 | 2.5 |
| 78 M06G11 | 6.2 | 4.0 | 3.5 | 14.4 | < 0.3 | 6.3 | 0.7 | < 0.03 | < 0.3 | 1.1 | 2.1 |
| 79 M06H11 | 7.5 | 4.0 | 3.0 | 24.5 | < 0.2 | 10.6 | 0.5 | < 0.02 | < 0.2 | 0.8 | 5.4 |
| 80 M06I11 | 8.6 | 4.0 | 3.6 | 15.0 | < 0.3 | 17.4 | 0.6 | < 0.03 | < 0.3 | 1.4 | 5.0 |
| 81 M06I12 | 8.6 | 4.0 | 3.6 | 15.1 | < 0.3 | 14.8 | 0.6 | < 0.03 | < 0.3 | 1.3 | 5.0 |
| 82 M06J11 | 9.6 | 4.0 | 3.4 | 16.9 | < 0.3 | 8.8 | 0.8 | < 0.03 | < 0.3 | 2.3 | 7.1 |
| 83 M06K11 | 10.8 | 3.9 | 3.4 | 28.7 | < 0.3 | 16.4 | 0.5 | < 0.03 | < 0.3 | 0.7 | 3.4 |
| 84 M06L11 | 11.8 | 4.0 | 4.8 | 22.2 | < 0.4 | 13.5 | 1.1 | 0.1 | < 0.4 | 2.7 | 7.7 |
| 85 M07A11 | -0.4 | 3.0 | 4.9 | 42.0 | < 0.4 | 21.5 | 1.3 | 0.1 | < 0.4 | 3.7 | 5.9 |
| 86 M07A21 | -0.4 | 3.0 | 4.0 | 44.0 | < 0.3 | 16.8 | 1.0 | 0.04 | < 0.3 | 3.0 | 4.0 |
| 87 M07B11 | 0.9 | 2.9 | 4.6 | 17.9 | < 0.4 | 16.5 | 1.1 | 0.06 | < 0.4 | 3.8 | 4.4 |
| 88 M07C11 | 2.0 | 3.0 | 4.8 | 20.6 | 1.8 | 11.0 | 0.7 | 0.09 | < 0.4 | 1.4 | 2.7 |
| 89 M07D11 | 3.1 | 3.0 | 3.9 | 11.2 | < 0.7 | 5.8 | 0.6 | 0.03 | < 0.3 | 1.4 | 7.7 |
| 90 M07D21 | 3.1 | 3.0 | 3.9 | 12.0 | < 0.7 | 5.4 | 0.6 | < 0.03 | < 0.3 | 1.2 | 5.0 |
| 91 M07E11 | 4.2 | 2.9 | 4.1 | 15.1 | < 0.3 | 15.1 | 0.9 | < 0.03 | < 0.3 | 0.8 | 3.9 |
| 92 M07F11 | 5.3 | 3.0 | 3.8 | 27.2 | < 0.3 | 11.3 | 0.4 | < 0.03 | < 0.3 | 1.7 | 3.8 |
| 93 M07G11 | 6.4 | 3.0 | 3.6 | 18.0 | < 0.3 | 5.4 | 0.8 | < 0.03 | < 0.3 | 1.0 | 1.7 |
| 94 M07H11 | 7.5 | 3.0 | 3.3 | 35.9 | < 0.3 | 13.4 | 0.8 | < 0.03 | < 0.3 | 4.2 | 3.9 |
| 95 M07I11 | 8.6 | 3.0 | 3.6 | 17.5 | < 0.3 | 12.4 | 0.6 | 0.03 | < 0.3 | 0.9 | 8.4 |
| 96 M07J11 | 9.7 | 2.8 | 3.6 | 43.0 | < 0.3 | 15.0 | 0.6 | < 0.03 | < 0.3 | 2.4 | 6.4 |
| 97 M07J21 | 9.7 | 2.8 | 3.5 | 30.6 | < 0.3 | 13.9 | 0.6 | < 0.03 | < 0.3 | 3.0 | 4.9 |
| 98 M07K11 | 10.6 | 2.9 | 4.1 | 27.9 | < 0.3 | 2.6 | 1.1 | 0.06 | < 0.3 | 2.8 | 2.5 |
| 99 M07L11 | 11.8 | 3.0 | 4.5 | 17.0 | < 0.4 | 17.4 | 0.9 | < 0.04 | < 0.4 | 3.3 | 4.9 |
| 100 M07L12 | 11.8 | 3.0 | 4.4 | 19.9 | < 0.4 | 19.0 | 1.0 | < 0.04 | < 0.4 | 3.8 | 5.8 |
| 101 M08B11 | 0.9 | 2.0 | 5.6 | 22.8 | 2.6 | 15.0 | 0.8 | 0.11 | < 0.4 | 6.1 | 4.2 |
| 102 M08C11 | 1.9 | 2.0 | 2.4 | 43.9 | < 0.2 | 3.7 | 0.4 | < 0.02 | < 0.2 | 1.2 | 3.7 |
| 103 M08D11 | 3.1 | 2.0 | 4.1 | 20.6 | < 0.3 | 16.1 | 0.9 | 0.05 | < 0.3 | 0.6 | 4.9 |
| 104 M08D12 | 3.1 | 2.0 | 4.1 | 21.4 | < 0.3 | 12.8 | 0.7 | 0.04 | < 0.3 | 0.7 | 4.5 |
| 105 M08E11 | 3.9 | 2.0 | 3.0 | 14.0 | < 0.2 | 12.8 | 0.6 | 0.03 | < 0.2 | 2.4 | 4.2 |
| 106 M08F11 | 5.2 | 1.9 | 3.3 | 12.1 | < 0.3 | 6.9 | 0.8 | 0.05 | < 0.3 | 0.7 | 3.9 |
| 107 M08G11 | 6.4 | 2.0 | 3.4 | 19.2 | < 0.3 | 6.2 | 0.8 | 0.04 | < 0.3 | 0.9 | 2.7 |
| 108 M08H11 | 7.5 | 2.0 | 4.3 | 19.3 | < 0.3 | 21.0 | 1.1 | 0.05 | < 0.3 | 2.3 | 4.2 |
| 109 M08H21 | 7.5 | 2.0 | 4.4 | 25.5 | < 0.4 | 29.0 | 0.9 | 0.04 | < 0.4 | 2.5 | 4.4 |
| 110 M08I11 | 8.6 | 2.0 | 5.8 | 21.0 | < 0.5 | 14.6 | 1.6 | 0.08 | < 0.5 | 3.3 | 6.4 |

Appendix I. Whiteleaf manzanita cont.

| Sample ID. | X-Coor. | Y-Coor. | Ash % | Al ppm | As ppm | Ba ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 M08J11 | 9.6 | 2.0 | 3.7 | 14.5 | < 0.3 | 16.7 | 0.7 | 0.03 | < 0.3 | 2.4 | 4.1 |
| 112 M08K11 | 10.6 | 1.9 | 3.2 | 17.8 | < 0.7 | 3.6 | 0.3 | < 0.03 | < 0.3 | 2.6 | 2.7 |
| 113 M08L11 | 11.7 | 2.0 | 3.9 | 24.4 | 1.5 | 7.1 | 0.3 | < 0.03 | < 0.3 | 1.5 | 4.7 |
| 114 M09C11 | 2.2 | 1.1 | 4.2 | 21.4 | < 0.3 | 12.2 | 1.1 | 0.03 | < 0.3 | 3.7 | 4.0 |
| 115 M09D11 | 2.9 | 1.0 | 3.1 | 11.9 | < 0.1 | 3.5 | 0.5 | 0.02 | < 0.1 | 0.9 | 1.6 |
| 116 M09E11 | 3.9 | 1.0 | 3.4 | 20.8 | < 0.6 | 7.7 | 0.5 | 0.04 | < 0.3 | 0.5 | 2.9 |
| 117 M09E21 | 3.9 | 1.1 | 3.6 | 27.4 | 1.9 | 14.0 | 0.3 | 0.08 | < 0.3 | 0.9 | 5.0 |
| 118 M09F11 | 5.3 | 1.0 | 3.5 | 14.7 | < 0.3 | 9.5 | 0.7 | < 0.03 | < 0.3 | 2.2 | 3.9 |
| 119 M09G11 | 6.3 | 1.0 | 3.7 | 20.1 | 1.5 | 12.4 | 0.4 | 0.03 | < 0.3 | 3.2 | 2.5 |
| 120 M09H11 | 7.4 | 1.0 | 3.1 | 15.8 | < 0.3 | 11.2 | 0.7 | < 0.02 | < 0.3 | 3.4 | 5.9 |
| 121 M09H21 | 7.4 | 1.0 | 3.1 | 19.5 | < 1.0 | 12.3 | 0.3 | < 0.03 | < 0.3 | 3.8 | 7.2 |
| 122 M09I11 | 8.6 | 1.1 | 3.1 | 16.9 | < 0.3 | 4.7 | 0.6 | 0.04 | < 0.3 | 1.1 | 6.6 |
| 123 M09J11 | 9.6 | 1.0 | 3.4 | 14.5 | < 0.3 | 10.7 | 0.6 | < 0.03 | < 0.3 | 1.5 | 4.5 |
| 124 M09K11 | 10.9 | 1.0 | 2.9 | 35.0 | < 0.2 | 4.1 | 0.4 | < 0.02 | < 0.2 | 2.0 | 3.8 |
| 125 M09L11 | 12.0 | 1.0 | 3.3 | 20.2 | < 0.3 | 11.4 | 0.8 | 0.05 | < 0.3 | 1.3 | 3.6 |
| 126 M10C11 | 2.1 | 0.2 | 3.2 | 15.8 | < 0.9 | 13.9 | 0.4 | < 0.03 | < 0.3 | 3.2 | 9.0 |
| 127 M10D11 | 3.1 | 0.0 | 4.3 | 30.0 | < 0.3 | 30.4 | 1.2 | 0.05 | < 0.3 | 1.9 | 6.4 |
| 128 M10E11 | 3.9 | 0.1 | 3.5 | 17.3 | < 0.3 | 6.3 | 1.0 | 0.1 | < 0.3 | 1.0 | 3.5 |
| 129 M10E12 | 3.8 | 0.1 | 3.7 | 17.2 | < 0.3 | 5.9 | 0.8 | 0.06 | < 0.3 | 1.1 | 3.7 |
| 130 M10F11 | 5.2 | 0.0 | 4.3 | 26.5 | < 0.4 | 11.1 | 0.8 | 0.04 | < 0.3 | 1.2 | 3.3 |
| 131 M10G11 | 6.3 | 0.0 | 3.4 | 22.1 | < 0.3 | 7.5 | 1.0 | < 0.03 | < 0.3 | 2.7 | 2.9 |
| 132 M10H11 | 7.4 | 0.0 | 3.0 | 30.4 | < 0.2 | 2.8 | 0.5 | < 0.02 | < 0.2 | 1.9 | 4.6 |
| 133 M10I11 | 8.5 | 0.0 | 4.7 | 25.5 | < 0.4 | 11.8 | 1.2 | 0.06 | < 0.4 | 1.1 | 3.7 |
| 134 M10J11 | 9.6 | 0.0 | 4.5 | 24.1 | < 0.4 | 10.3 | 1.1 | 0.05 | < 0.4 | 0.6 | 3.2 |
| 135 M10K11 | 10.7 | 0.0 | 3.6 | 32.0 | 1.2 | 4.7 | 0.3 | 0.09 | < 0.3 | 1.7 | 9.1 |
| 136 M10K21 | 10.7 | 0.0 | 3.6 | 25.3 | < 0.3 | 5.7 | 0.6 | < 0.03 | < 0.3 | 1.2 | 6.8 |
| 137 M10L11 | 11.9 | 0.0 | 3.4 | 16.8 | < 0.9 | 9.4 | 0.3 | < 0.03 | < 0.3 | 0.8 | 2.3 |

Appendix I. Whiteleaf manzanita cont.

| Sample ID. | Fe ppm | Mg % | Mn ppm | Nb ppm | Ni ppm | P % | Pb ppm | Sr ppm | Ti ppm | V ppm | Y ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 M00K11 | 28 | 0.3 | 17 | 0.2 | 6.8 | 0.1 | < 0.3 | 22 | 1.3 | < 0.02 | 0.01 | 28 |
| 2 M00L11 | 22 | 0.4 | 69 | 0.2 | 8.6 | 0.1 | < 0.3 | 25 | 1.6 | < 0.02 | < 0.01 | 31 |
| 3 M01A11 | 27 | 0.3 | 37 | 0.2 | 2.3 | 0.1 | < 0.3 | 13 | 1.2 | < 0.02 | 0.01 | 42 |
| 4 M01C11 | 22 | 0.2 | 28 | < 0.2 | 2.7 | 0.1 | < 0.3 | 8 | 0.8 | < 0.02 | < 0.01 | 24 |
| 5 M01C12 | 17 | 0.2 | 25 | 0.2 | 2.5 | 0.1 | < 0.3 | 7 | 0.8 | < 0.02 | 0.01 | 23 |
| 6 M01D11 | 32 | 0.4 | 47 | 0.3 | 1.9 | 0.1 | < 0.3 | 6 | 1.6 | 0.02 | < 0.01 | 26 |
| 7 M01E11 | 27 | 0.4 | 101 | 0.3 | 0.9 | 0.1 | < 0.2 | 10 | 1.5 | < 0.02 | < 0.01 | 20 |
| 8 M01G11 | 33 | 0.5 | 16 | 0.4 | 4.6 | 0.1 | < 0.3 | 12 | 2.0 | 0.04 | 0.01 | 36 |
| 9 M01H11 | 29 | 0.3 | 48 | 0.2 | 5.5 | 0.1 | < 0.3 | 14 | 1.3 | 0.03 | 0.02 | 31 |
| 10 M01I11 | 24 | 0.3 | 13 | 0.2 | 5.0 | 0.1 | < 0.3 | 14 | 1.7 | < 0.02 | < 0.01 | 31 |
| 11 M01J11 | 23 | 0.2 | 131 | < 0.2 | 9.7 | 0.1 | < 0.3 | 18 | 1.7 | < 0.03 | < 0.01 | 40 |
| 12 M01K11 | 25 | 0.3 | 20 | 0.2 | 5.5 | 0.1 | < 0.3 | 9 | 0.9 | < 0.02 | 0.01 | 31 |
| 13 M01L11 | 26 | 0.4 | 47 | 0.2 | 11.2 | 0.1 | < 0.3 | 34 | 1.7 | < 0.03 | < 0.01 | 31 |
| 14 M02A11 | 33 | 0.6 | 70 | 0.5 | 1.7 | 0.1 | < 0.4 | 26 | 1.4 | < 0.03 | < 0.01 | 29 |
| 15 M02A12 | 31 | 0.6 | 68 | 0.5 | 1.8 | 0.1 | < 0.3 | 28 | 1.6 | 0.03 | 0.01 | 31 |
| 16 M02B11 | 34 | 0.3 | 13 | 0.2 | 0.9 | 0.1 | < 0.2 | 5 | 1.4 | < 0.02 | < 0.01 | 26 |
| 17 M02C11 | 33 | 0.3 | 13 | 0.2 | 2.1 | 0.1 | < 0.3 | 10 | 1.7 | < 0.02 | < 0.01 | 30 |
| 18 M02C12 | 33 | 0.3 | 13 | 0.2 | 1.9 | 0.1 | < 0.3 | 10 | 1.5 | < 0.02 | < 0.01 | 26 |
| 19 M02E11 | 33 | 0.4 | 21 | 0.3 | 0.7 | 0.1 | < 0.3 | 9 | 1.1 | < 0.02 | < 0.01 | 21 |
| 20 M02F11 | 30 | 0.3 | 10 | 0.2 | 0.9 | 0.1 | < 0.2 | 19 | 1.0 | < 0.02 | < 0.01 | 14 |
| 21 M02G11 | 22 | 0.3 | 41 | < 0.2 | 7.1 | 0.1 | < 0.3 | 9 | 0.8 | < 0.02 | < 0.01 | 26 |
| 22 M02H11 | 26 | 0.6 | 80 | 0.4 | 3.2 | 0.1 | < 0.3 | 14 | 0.9 | < 0.03 | 0.01 | 50 |
| 23 M02I11 | 24 | 0.4 | 63 | 0.3 | 10.7 | 0.1 | < 0.3 | 22 | 2.5 | < 0.02 | 0.01 | 40 |
| 24 M02J11 | 27 | 0.2 | 21 | < 0.1 | 4.6 | 0.1 | < 0.3 | 30 | 1.1 | < 0.02 | 0.01 | 21 |
| 25 M02K11 | 18 | 0.4 | 35 | 0.2 | 9.1 | 0.1 | < 0.3 | 19 | 1.0 | < 0.02 | 0.01 | 33 |
| 26 M02K12 | 19 | 0.4 | 33 | 0.3 | 9.7 | 0.1 | < 0.3 | 17 | 1.3 | < 0.02 | 0.02 | 36 |
| 27 M02L11 | 26 | 0.3 | 24 | 0.2 | 6.0 | 0.1 | < 0.3 | 29 | 2.0 | < 0.03 | 0.02 | 42 |
| 28 M03A11 | 26 | 0.5 | 49 | 0.4 | 1.5 | 0.1 | < 0.4 | 33 | 1.5 | < 0.03 | 0.01 | 37 |
| 29 M03C11 | 31 | 0.4 | 18 | 0.2 | 1.0 | 0.1 | < 0.3 | 14 | 1.7 | 0.02 | < 0.01 | 26 |
| 30 M03D11 | 18 | 0.4 | 31 | 0.3 | 1.3 | 0.1 | < 0.3 | 10 | 0.8 | < 0.02 | < 0.01 | 28 |
| 31 M03E11 | 38 | 0.3 | 30 | 0.3 | 1.5 | 0.1 | < 0.3 | 10 | 1.7 | < 0.02 | 0.01 | 22 |
| 32 M03E12 | 37 | 0.3 | 30 | 0.2 | 1.5 | 0.1 | < 0.3 | 11 | 1.7 | < 0.02 | < 0.01 | 22 |
| 33 M03F11 | 35 | 0.5 | 33 | 0.5 | 1.4 | 0.1 | < 0.3 | 13 | 0.8 | 0.03 | 0.01 | 21 |
| 34 M03G11 | 24 | 0.3 | 40 | 0.3 | 2.7 | 0.1 | < 0.2 | 17 | 1.2 | < 0.02 | < 0.01 | 43 |
| 35 M03H11 | 22 | 0.4 | 34 | 0.3 | 5.5 | 0.1 | < 0.3 | 23 | 1.3 | < 0.02 | < 0.01 | 40 |
| 36 M03H21 | 28 | 0.4 | 42 | 0.3 | 5.0 | 0.1 | < 0.3 | 20 | 1.2 | < 0.02 | 0.02 | 39 |
| 37 M03I11 | 31 | 0.3 | 28 | < 0.2 | 6.4 | 0.1 | < 0.4 | 27 | 2.4 | < 0.03 | 0.01 | 34 |
| 38 M03I21 | 30 | 0.4 | 32 | 0.2 | 8.7 | 0.1 | < 0.4 | 36 | 2.5 | < 0.03 | 0.01 | 40 |
| 39 M03J11 | 28 | 0.5 | 38 | 0.4 | 12.8 | 0.1 | < 0.3 | 23 | 1.3 | < 0.03 | 0.01 | 27 |
| 40 M03K11 | 31 | 0.3 | 33 | 0.2 | 2.5 | 0.1 | < 0.4 | 31 | 1.9 | < 0.03 | 0.01 | 42 |
| 41 M03L11 | 22 | 0.5 | 36 | 0.4 | 9.4 | 0.1 | < 0.4 | 21 | 1.5 | < 0.03 | 0.02 | 37 |
| 42 M04A11 | 18 | 0.4 | 25 | 0.2 | 6.1 | 0.1 | < 0.3 | 10 | 0.8 | < 0.02 | < 0.01 | 46 |
| 43 M04B11 | 24 | 0.3 | 29 | 0.2 | 1.0 | 0.1 | < 0.3 | 5 | 0.8 | < 0.02 | < 0.01 | 27 |
| 44 M04C11 | 21 | 0.2 | 27 | < 0.1 | 2.3 | 0.1 | < 0.3 | 19 | 1.1 | < 0.02 | < 0.01 | 25 |
| 45 M04D11 | 25 | 0.3 | 23 | 0.2 | 0.8 | 0.1 | < 0.2 | 14 | 1.1 | < 0.02 | < 0.01 | 17 |
| 46 M04E11 | 25 | 0.4 | 17 | 0.3 | 0.9 | 0.1 | < 0.2 | 6 | 1.1 | < 0.01 | < 0.01 | 28 |
| 47 M04F11 | 28 | 0.4 | 12 | 0.3 | 0.5 | 0.1 | < 0.2 | 6 | 1.1 | < 0.02 | < 0.01 | 25 |
| 48 M04F12 | 25 | 0.4 | 12 | 0.3 | 0.6 | 0.1 | < 0.2 | 6 | 0.9 | < 0.02 | < 0.01 | 27 |
| 49 M04G11 | 27 | 0.4 | 15 | 0.3 | 2.4 | 0.1 | < 0.3 | 25 | 0.9 | < 0.02 | < 0.01 | 33 |
| 50 M04H11 | 24 | 0.5 | 89 | 0.3 | 7.2 | 0.1 | < 0.3 | 16 | 1.1 | < 0.02 | < 0.01 | 29 |
| 51 M04I11 | 23 | 0.4 | 33 | 0.2 | 2.9 | 0.1 | < 0.3 | 10 | 1.1 | < 0.03 | 0.01 | 31 |
| 52 M04J11 | 30 | 0.3 | 85 | < 0.2 | 3.7 | 0.1 | < 0.4 | 22 | 1.3 | < 0.03 | 0.01 | 36 |
| 53 M04K11 | 30 | 0.2 | 33 | 0.2 | 2.9 | 0.1 | < 0.3 | 24 | 1.1 | < 0.03 | 0.02 | 28 |
| 54 M04L11 | 30 | 0.3 | 22 | 0.2 | 5.4 | 0.1 | < 0.3 | 13 | 1.2 | < 0.02 | < 0.01 | 33 |
| 55 M04L12 | 31 | 0.3 | 22 | 0.2 | 6.0 | 0.1 | < 0.3 | 13 | 1.9 | < 0.02 | < 0.01 | 37 |

Appendix I. Whiteleaf manzanita cont.

| Sample ID. | Fe ppm | Mg % | Mn ppm | Nb ppm | Ni ppm | P % | Pb ppm | Sr ppm | Ti ppm | V ppm | Y ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 56 M05A11 | 22 | 0.4 | 123 | 0.3 | 3.4 | 0.1 | < 0.3 | 17 | 1.0 | < 0.02 | < 0.01 | 32 |
| 57 M05B11 | 28 | 0.5 | 16 | 0.4 | 2.7 | 0.1 | < 0.3 | 4 | 1.2 | < 0.02 | < 0.01 | 44 |
| 58 M05C11 | 53 | 0.3 | 17 | 0.2 | 1.1 | 0.1 | < 0.2 | 3 | 2.6 | 0.08 | < 0.01 | 17 |
| 59 M05D11 | 21 | 0.2 | 23 | 0.2 | 1.4 | 0.1 | < 0.2 | 6 | 0.7 | < 0.01 | < 0.01 | 19 |
| 60 M05D21 | 22 | 0.3 | 17 | 0.2 | 1.2 | 0.1 | < 0.2 | 6 | 0.7 | < 0.02 | < 0.01 | 16 |
| 61 M05E11 | 38 | 0.3 | 28 | 0.2 | 0.6 | 0.1 | < 0.2 | 7 | 1.4 | 0.03 | < 0.01 | 17 |
| 62 M05F11 | 27 | 0.3 | 19 | 0.2 | 2.4 | 0.1 | < 0.3 | 11 | 1.2 | < 0.02 | < 0.01 | 32 |
| 63 M05G11 | 33 | 0.3 | 49 | 0.2 | 1.9 | 0.1 | < 0.3 | 15 | 1.2 | < 0.02 | < 0.01 | 28 |
| 64 M05H11 | 27 | 0.3 | 34 | < 0.2 | 5.3 | 0.1 | < 0.3 | 16 | 1.5 | < 0.02 | < 0.01 | 40 |
| 65 M05H21 | 27 | 0.3 | 32 | 0.2 | 5.8 | 0.1 | < 0.4 | 13 | 1.4 | < 0.03 | 0.01 | 38 |
| 66 M05I11 | 26 | 0.3 | 23 | 0.2 | 4.6 | 0.1 | < 0.3 | 29 | 1.0 | < 0.03 | < 0.01 | 29 |
| 67 M05J11 | 26 | 0.3 | 40 | 0.1 | 4.4 | 0.1 | < 0.3 | 18 | 2.0 | < 0.02 | < 0.01 | 37 |
| 68 M05K11 | 36 | 0.2 | 29 | < 0.2 | 2.3 | 0.2 | < 0.5 | 18 | 1.7 | < 0.03 | 0.02 | 33 |
| 69 M05L11 | 27 | 0.4 | 31 | 0.3 | 3.2 | 0.1 | < 0.3 | 18 | 2.0 | < 0.02 | < 0.01 | 33 |
| 70 M06A11 | 20 | 0.2 | 14 | 0.2 | 3.4 | 0.1 | < 0.4 | 10 | 1.1 | < 0.03 | 0.02 | 32 |
| 71 M06A12 | 22 | 0.3 | 15 | < 0.2 | 3.5 | 0.1 | < 0.4 | 12 | 1.1 | < 0.03 | < 0.01 | 34 |
| 72 M06B11 | 27 | 0.3 | 14 | 0.2 | 0.8 | 0.2 | < 0.3 | 4 | 1.2 | < 0.02 | < 0.01 | 15 |
| 73 M06B21 | 26 | 0.3 | 16 | 0.2 | 1.0 | 0.1 | < 0.3 | 4 | 0.9 | < 0.02 | < 0.01 | 16 |
| 74 M06C11 | 29 | 0.5 | 30 | 0.4 | 1.4 | 0.1 | < 0.3 | 11 | 1.5 | < 0.02 | 0.01 | 41 |
| 75 M06D11 | 27 | 0.3 | 17 | 0.2 | 6.1 | 0.1 | < 0.3 | 11 | 0.8 | < 0.02 | < 0.01 | 36 |
| 76 M06E21 | 27 | 0.5 | 35 | 0.3 | 0.8 | 0.1 | < 0.3 | 18 | 1.5 | < 0.02 | < 0.01 | 28 |
| 77 M06F11 | 33 | 0.4 | 28 | 0.3 | 1.1 | 0.1 | < 0.2 | 8 | 1.2 | 0.02 | < 0.01 | 43 |
| 78 M06G11 | 22 | 0.4 | 25 | 0.2 | 0.6 | 0.1 | < 0.3 | 10 | 0.9 | < 0.02 | < 0.01 | 23 |
| 79 M06H11 | 29 | 0.3 | 23 | 0.2 | 2.9 | 0.1 | < 0.2 | 8 | 1.6 | < 0.02 | < 0.01 | 28 |
| 80 M06I11 | 23 | 0.5 | 25 | 0.3 | 4.6 | 0.1 | < 0.3 | 16 | 1.0 | < 0.02 | 0.01 | 31 |
| 81 M06I12 | 22 | 0.4 | 24 | 0.3 | 4.3 | 0.1 | < 0.3 | 15 | 0.9 | < 0.02 | < 0.01 | 31 |
| 82 M06J11 | 23 | 0.5 | 20 | 0.4 | 0.9 | 0.1 | < 0.3 | 8 | 1.2 | < 0.02 | 0.01 | 24 |
| 83 M06K11 | 41 | 0.3 | 16 | 0.2 | 1.6 | 0.1 | < 0.3 | 11 | 2.7 | < 0.02 | < 0.01 | 27 |
| 84 M06L11 | 30 | 0.4 | 96 | 0.3 | 6.3 | 0.1 | < 0.4 | 16 | 1.2 | < 0.03 | 0.01 | 31 |
| 85 M07A11 | 45 | 0.3 | 59 | 0.2 | 3.7 | 0.1 | < 0.4 | 21 | 3.0 | 0.06 | 0.01 | 47 |
| 86 M07A21 | 44 | 0.2 | 52 | < 0.2 | 2.8 | 0.1 | < 0.3 | 19 | 3.0 | < 0.02 | < 0.01 | 31 |
| 87 M07B11 | 24 | 0.4 | 11 | 0.3 | 2.4 | 0.1 | < 0.4 | 8 | 1.4 | < 0.03 | 0.01 | 27 |
| 88 M07C11 | 20 | 0.3 | 39 | 0.2 | 4.2 | 0.1 | < 0.4 | 20 | 1.1 | < 0.03 | 0.02 | 33 |
| 89 M07D11 | 19 | 0.3 | 18 | 0.2 | 3.1 | 0.1 | < 0.3 | 26 | 0.6 | < 0.02 | < 0.01 | 32 |
| 90 M07D21 | 18 | 0.3 | 19 | 0.2 | 4.3 | 0.1 | < 0.3 | 28 | 0.6 | < 0.02 | < 0.01 | 31 |
| 91 M07E11 | 23 | 0.3 | 22 | 0.2 | 2.2 | 0.1 | < 0.3 | 16 | 0.9 | < 0.02 | < 0.01 | 40 |
| 92 M07F11 | 36 | 0.3 | 28 | 0.2 | 1.6 | 0.1 | < 0.3 | 6 | 1.6 | < 0.02 | < 0.01 | 26 |
| 93 M07G11 | 24 | 0.6 | 24 | 0.4 | 0.8 | 0.1 | < 0.3 | 9 | 1.2 | < 0.02 | < 0.01 | 30 |
| 94 M07H11 | 46 | 0.4 | 42 | 0.3 | 1.4 | 0.1 | < 0.3 | 18 | 2.0 | 0.04 | < 0.01 | 25 |
| 95 M07I11 | 23 | 0.2 | 28 | < 0.2 | 5.8 | 0.1 | < 0.3 | 13 | 1.1 | < 0.02 | < 0.01 | 29 |
| 96 M07J11 | 61 | 0.3 | 47 | 0.2 | 2.6 | 0.1 | < 0.3 | 16 | 2.7 | 0.06 | 0.01 | 31 |
| 97 M07J21 | 52 | 0.3 | 52 | 0.2 | 2.8 | 0.1 | < 0.3 | 16 | 2.3 | 0.02 | < 0.01 | 28 |
| 98 M07K11 | 38 | 0.5 | 22 | 0.4 | 1.2 | 0.1 | < 0.3 | 16 | 1.7 | < 0.02 | 0.02 | 23 |
| 99 M07L11 | 28 | 0.4 | 49 | 0.3 | 2.5 | 0.1 | < 0.4 | 19 | 0.9 | < 0.03 | < 0.01 | 35 |
| 100 M07L12 | 33 | 0.5 | 57 | 0.3 | 2.9 | 0.1 | < 0.4 | 21 | 1.4 | < 0.03 | < 0.01 | 39 |
| 101 M08B11 | 26 | 0.3 | 38 | 0.3 | 1.9 | 0.1 | < 0.4 | 19 | 1.1 | < 0.03 | 0.04 | 24 |
| 102 M08C11 | 44 | 0.4 | 34 | 0.3 | 7.1 | 0.1 | < 0.2 | 5 | 3.2 | 0.08 | 0.01 | 32 |
| 103 M08D11 | 28 | 0.2 | 26 | < 0.2 | 3.1 | 0.1 | < 0.3 | 17 | 1.4 | < 0.02 | < 0.01 | 32 |
| 104 M08D12 | 30 | 0.2 | 26 | < 0.2 | 3.0 | 0.1 | < 0.3 | 16 | 1.4 | < 0.02 | < 0.01 | 32 |
| 105 M08E11 | 19 | 0.4 | 21 | 0.3 | 1.3 | 0.1 | < 0.2 | 15 | 1.0 | < 0.02 | < 0.01 | 28 |
| 106 M08F11 | 21 | 0.2 | 16 | 0.1 | 2.9 | 0.1 | < 0.3 | 10 | 0.9 | < 0.02 | < 0.01 | 31 |
| 107 M08G11 | 27 | 0.3 | 16 | 0.2 | 1.0 | 0.1 | < 0.3 | 11 | 1.3 | < 0.02 | < 0.01 | 25 |
| 108 M08H11 | 22 | 0.5 | 19 | 0.4 | 1.9 | 0.1 | < 0.3 | 13 | 1.4 | < 0.03 | 0.01 | 33 |
| 109 M08H21 | 31 | 0.5 | 25 | 0.4 | 2.2 | 0.1 | < 0.4 | 16 | 1.4 | < 0.03 | 0.01 | 37 |
| 110 M08I11 | 25 | 0.4 | 70 | 0.3 | 7.6 | 0.1 | < 0.5 | 20 | 1.3 | < 0.04 | 0.02 | 46 |

Appendix I. Whiteleaf manzanita cont.

| Sample ID. | Fe ppm | Mg % | Mn ppm | Nb ppm | Ni ppm | P % | Pb ppm | Sr ppm | Ti ppm | V ppm | Y ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 111 M08J11 | 20 | 0.5 | 31 | 0.4 | 1.9 | 0.1 | < 0.3 | 20 | 0.9 | < 0.02 | 0.01 | 29 |
| 112 M08K11 | 31 | 0.4 | 13 | 0.3 | 1.4 | 0.1 | < 0.3 | 18 | 1.1 | < 0.02 | < 0.01 | 23 |
| 113 M08L11 | 59 | 0.4 | 26 | 0.4 | 4.7 | 0.1 | < 0.3 | 15 | 1.4 | 0.04 | 0.01 | 31 |
| 114 M09C11 | 24 | 0.4 | 17 | 0.2 | 2.1 | 0.1 | < 0.3 | 18 | 1.3 | < 0.03 | < 0.01 | 39 |
| 115 M09D11 | 13 | 0.1 | 35 | < 0.1 | 1.6 | 0.1 | < 0.1 | 4 | 0.9 | < 0.01 | < 0.01 | 27 |
| 116 M09E11 | 31 | 0.3 | 40 | 0.2 | 1.5 | 0.1 | < 0.3 | 13 | 1.3 | < 0.02 | < 0.01 | 26 |
| 117 M09E21 | 35 | 0.3 | 33 | 0.2 | 2.0 | 0.1 | < 0.3 | 13 | 1.6 | 0.04 | 0.01 | 28 |
| 118 M09F11 | 21 | 0.3 | 42 | 0.2 | 2.0 | 0.1 | < 0.3 | 11 | 0.9 | < 0.02 | < 0.01 | 33 |
| 119 M09G11 | 31 | 0.4 | 55 | 0.3 | 1.0 | 0.1 | < 0.3 | 13 | 1.1 | < 0.02 | 0.01 | 31 |
| 120 M09H11 | 26 | 0.4 | 62 | 0.3 | 2.8 | 0.1 | < 0.3 | 11 | 1.0 | < 0.02 | < 0.01 | 31 |
| 121 M09H21 | 28 | 0.5 | 97 | 0.4 | 2.5 | 0.1 | < 0.3 | 12 | 1.1 | < 0.02 | < 0.01 | 28 |
| 122 M09I11 | 28 | 0.3 | 34 | 0.2 | 4.1 | 0.1 | < 0.3 | 9 | 1.7 | < 0.02 | 0.01 | 31 |
| 123 M09J11 | 21 | 0.4 | 30 | 0.3 | 1.8 | 0.1 | < 0.3 | 29 | 0.8 | < 0.02 | 0.01 | 31 |
| 124 M09K11 | 55 | 0.4 | 25 | 0.3 | 1.4 | 0.1 | 0.4 | 17 | 2.2 | 0.06 | < 0.01 | 21 |
| 125 M09L11 | 33 | 0.3 | 11 | 0.2 | 2.0 | 0.1 | < 0.3 | 16 | 1.7 | 0.03 | 0.02 | 39 |
| 126 M10C11 | 24 | 0.5 | 8 | 0.4 | 3.5 | 0.1 | < 0.3 | 11 | 0.9 | < 0.02 | < 0.01 | 26 |
| 127 M10D11 | 51 | 0.3 | 68 | 0.2 | 3.6 | 0.1 | < 0.3 | 15 | 2.0 | < 0.03 | < 0.01 | 30 |
| 128 M10E11 | 23 | 0.1 | 10 | < 0.1 | 3.9 | 0.1 | < 0.3 | 13 | 1.3 | < 0.02 | 0.01 | 35 |
| 129 M10E12 | 27 | 0.2 | 10 | < 0.2 | 3.7 | 0.1 | < 0.3 | 14 | 1.1 | < 0.02 | < 0.01 | 33 |
| 130 M10F11 | 30 | 0.4 | 14 | 0.3 | 4.7 | 0.1 | < 0.3 | 25 | 1.5 | < 0.03 | 0.01 | 35 |
| 131 M10G11 | 33 | 0.3 | 75 | 0.2 | 1.8 | 0.1 | < 0.3 | 18 | 1.6 | < 0.02 | < 0.01 | 37 |
| 132 M10H11 | 40 | 0.4 | 46 | 0.2 | 1.6 | 0.1 | < 0.2 | 8 | 2.1 | 0.03 | < 0.01 | 43 |
| 133 M10I11 | 30 | 0.4 | 46 | 0.3 | 3.7 | 0.1 | < 0.4 | 34 | 1.7 | < 0.03 | 0.02 | 31 |
| 134 M10J11 | 31 | 0.3 | 20 | 0.2 | 2.8 | 0.1 | < 0.4 | 21 | 2.0 | < 0.03 | < 0.01 | 36 |
| 135 M10K11 | 44 | 0.4 | 16 | 0.3 | 2.2 | 0.1 | 0.4 | 19 | 2.1 | 0.03 | 0.01 | 28 |
| 136 M10K21 | 33 | 0.3 | 13 | 0.2 | 2.5 | 0.1 | < 0.3 | 22 | 2.3 | < 0.02 | < 0.01 | 30 |
| 137 M10L11 | 31 | 0.4 | 47 | 0.3 | 2.5 | 0.1 | < 0.3 | 13 | 1.0 | < 0.02 | < 0.01 | 31 |

APPENDIX II. Element concentrations (dry weight basis) for digger pine needles.

| Sample ID. | X-Coor. | Y-Coor. | Ash % | Al ppm | As ppm | Ba ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 D00K11 | 11.1 | 9.9 | 2.6 | 131 | < 0.2 | 1.6 | 0.4 | < 0.02 | < 0.2 | 0.6 | 5.1 |
| 2 D01A11 | -0.4 | 9.0 | 2.2 | 94 | < 0.2 | 0.9 | 0.4 | 0.02 | < 0.2 | 1.1 | 5.6 |
| 3 D01B11 | 0.9 | 8.8 | 2.8 | 50 | < 0.2 | 0.5 | 0.5 | < 0.02 | < 0.2 | 2.1 | 5.0 |
| 4 D01C11 | 2.0 | 9.1 | 3.0 | 60 | < 0.7 | 0.8 | 0.3 | < 0.02 | < 0.2 | 0.6 | 2.4 |
| 5 D01C12 | 2.0 | 9.1 | 3.0 | 63 | < 0.6 | 0.8 | 0.3 | < 0.02 | < 0.2 | 0.6 | 2.7 |
| 6 D01D11 | 2.9 | 9.0 | 1.9 | 61 | < 0.3 | 0.7 | 0.2 | 0.02 | < 0.2 | 0.8 | 5.0 |
| 7 D01E11 | 4.3 | 9.1 | 2.0 | 63 | < 0.2 | 0.5 | 0.2 | < 0.02 | < 0.2 | 1.2 | 5.0 |
| 8 D01G11 | 6.5 | 9.0 | 1.9 | 111 | < 0.2 | 0.9 | 0.2 | < 0.02 | < 0.2 | 0.8 | 6.0 |
| 9 D01I11 | 8.4 | 8.8 | 2.4 | 60 | < 0.2 | 0.8 | 0.3 | < 0.02 | < 0.2 | 0.6 | 4.3 |
| 10 D01J11 | 9.5 | 9.0 | 2.1 | 50 | < 0.2 | 1.0 | 0.4 | < 0.02 | < 0.2 | 0.6 | 3.8 |
| 11 D02A11 | -0.4 | 8.2 | 2.5 | 55 | < 0.2 | 0.8 | 0.5 | 0.02 | 0.4 | 0.6 | 5.0 |
| 12 D02A12 | -0.4 | 8.2 | 2.4 | 54 | < 0.2 | 0.7 | 0.4 | 0.02 | < 0.2 | 0.5 | 4.4 |
| 13 D02B11 | 1.0 | 7.9 | 2.8 | 120 | < 0.2 | 1.1 | 0.6 | 0.03 | < 0.2 | 2.4 | 4.8 |
| 14 D02C11 | 2.0 | 8.0 | 3.3 | 128 | < 0.4 | 1.4 | 0.4 | < 0.02 | < 0.2 | 2.0 | 3.3 |
| 15 D02C12 | 2.0 | 8.0 | 3.3 | 108 | < 0.8 | 1.0 | 0.3 | < 0.02 | < 0.2 | 1.6 | 2.3 |
| 16 D02E11 | 4.3 | 8.0 | 1.7 | 87 | < 0.1 | 0.8 | 0.2 | < 0.02 | < 0.2 | 1.5 | 5.4 |
| 17 D02F11 | 5.4 | 7.7 | 1.8 | 75 | < 0.5 | 0.6 | 0.1 | < 0.02 | < 0.2 | 2.5 | 4.5 |
| 18 D02G11 | 6.4 | 8.4 | 1.8 | 171 | < 0.1 | 1.7 | 0.2 | < 0.02 | 0.2 | 1.7 | 5.5 |
| 19 D02J11 | 9.5 | 8.0 | 2.6 | 66 | < 0.2 | 1.2 | 0.4 | < 0.02 | < 0.2 | 1.1 | 3.2 |
| 20 D02K11 | 10.5 | 8.0 | 2.6 | 119 | < 0.3 | 1.9 | 0.3 | < 0.02 | < 0.2 | 1.0 | 3.2 |
| 21 D02K12 | 10.5 | 8.0 | 2.7 | 115 | < 0.4 | 2.0 | 0.3 | < 0.02 | < 0.2 | 0.9 | 3.0 |
| 22 D02L11 | 11.8 | 8.2 | 2.4 | 88 | < 0.3 | 1.1 | 0.2 | < 0.02 | < 0.2 | 0.6 | 4.8 |
| 23 D03A11 | -0.4 | 6.9 | 1.6 | 66 | < 0.1 | 0.6 | 0.2 | < 0.02 | < 0.2 | 0.8 | 4.7 |
| 24 D03C11 | 2.2 | 7.0 | 2.3 | 133 | < 0.3 | 1.2 | 0.2 | < 0.02 | < 0.2 | 1.2 | 4.1 |
| 25 D03D11 | 3.2 | 7.0 | 2.3 | 48 | < 0.2 | 0.6 | 0.3 | < 0.02 | < 0.2 | 1.1 | 4.3 |
| 26 D03E11 | 4.0 | 7.1 | 1.7 | 22 | < 0.2 | 0.3 | 0.2 | < 0.02 | < 0.2 | 1.0 | 3.5 |
| 27 D03E12 | 4.0 | 7.1 | 1.6 | 20 | < 0.2 | 0.3 | 0.2 | < 0.02 | < 0.2 | 0.9 | 3.1 |
| 28 D03F11 | 5.4 | 6.9 | 2.2 | 93 | < 0.2 | 1.1 | 0.3 | < 0.02 | < 0.2 | 4.8 | 6.7 |
| 29 D03I11 | 8.7 | 6.8 | 2.4 | 119 | < 0.2 | 1.2 | 0.3 | < 0.02 | 0.3 | 0.7 | 6.8 |
| 30 D03I21 | 8.7 | 6.8 | 2.4 | 73 | < 0.5 | 0.8 | 0.2 | < 0.02 | 0.3 | 0.5 | 4.4 |
| 31 D03K11 | 10.8 | 6.8 | 2.9 | 162 | < 0.2 | 1.9 | 0.6 | 0.03 | < 0.2 | 1.8 | 5.0 |
| 32 D04A11 | -0.4 | 6.0 | 2.5 | 63 | 0.9 | 0.7 | 0.2 | < 0.02 | 0.2 | 0.7 | 3.3 |
| 33 D04B11 | 0.8 | 5.8 | 2.5 | 62 | < 0.2 | 0.6 | 0.6 | < 0.02 | < 0.2 | 1.4 | 6.9 |
| 34 D04F11 | 5.0 | 6.1 | 2.3 | 62 | < 0.2 | 0.6 | 0.2 | < 0.02 | < 0.2 | 1.0 | 3.0 |
| 35 D04F12 | 5.0 | 6.1 | 2.3 | 59 | < 0.4 | 0.6 | 0.2 | < 0.02 | < 0.2 | 1.0 | 3.3 |
| 36 D04G11 | 6.4 | 6.3 | 2.4 | 98 | < 0.2 | 1.1 | 0.3 | < 0.02 | 0.2 | 0.8 | 7.4 |
| 37 D04H11 | 7.5 | 5.8 | 2.1 | 99 | < 0.2 | 0.8 | 0.3 | < 0.02 | < 0.2 | 0.8 | 4.9 |
| 38 D04I11 | 8.5 | 6.0 | 2.2 | 28 | < 0.2 | 0.7 | 0.3 | 0.02 | 0.3 | 0.7 | 6.7 |
| 39 D04J11 | 9.8 | 6.0 | 2.5 | 94 | < 0.2 | 1.3 | 0.4 | < 0.02 | < 0.2 | 0.7 | 2.7 |
| 40 D04K11 | 10.5 | 5.8 | 2.4 | 31 | < 0.3 | 1.1 | 0.3 | 0.02 | < 0.2 | 0.6 | 2.6 |
| 41 D04L11 | 11.8 | 6.2 | 2.0 | 67 | < 0.2 | 0.9 | 0.3 | 0.02 | 0.3 | 1.0 | 3.4 |
| 42 D04L12 | 11.8 | 6.1 | 2.0 | 67 | < 0.2 | 0.9 | 0.3 | < 0.02 | 0.2 | 0.8 | 3.6 |
| 43 D05A11 | -0.4 | 4.9 | 2.2 | 75 | < 0.2 | 1.0 | 0.3 | < 0.02 | < 0.2 | 0.7 | 3.5 |
| 44 D05B11 | 1.1 | 4.9 | 2.5 | 53 | < 0.2 | 0.6 | 0.6 | 0.03 | < 0.2 | 1.6 | 9.1 |
| 45 D05C11 | 2.5 | 5.1 | 2.4 | 90 | < 0.7 | 0.8 | 0.2 | < 0.02 | < 0.2 | 1.3 | 2.9 |
| 46 D05D11 | 3.0 | 4.8 | 2.4 | 82 | < 0.3 | 0.7 | 0.3 | < 0.02 | < 0.2 | 1.1 | 5.3 |
| 47 D05D21 | 3.0 | 4.8 | 2.2 | 85 | < 0.2 | 0.9 | 0.3 | < 0.02 | < 0.2 | 1.3 | 4.4 |
| 48 D05E11 | 4.3 | 4.8 | 1.8 | 130 | < 0.2 | 1.0 | 0.1 | < 0.02 | < 0.2 | 1.4 | 6.9 |
| 49 D05F11 | 5.4 | 4.8 | 2.2 | 48 | < 0.5 | 0.5 | 0.2 | < 0.02 | < 0.2 | 1.2 | 3.2 |
| 50 D05H11 | 7.5 | 4.7 | 2.5 | 104 | < 0.2 | 1.4 | 0.4 | 0.02 | 0.5 | 1.1 | 5.7 |
| 51 D05H21 | 7.5 | 4.7 | 2.5 | 99 | < 0.4 | 1.3 | 0.3 | 0.02 | 0.4 | 0.9 | 3.3 |
| 52 D05I11 | 8.5 | 5.0 | 2.0 | 73 | < 0.2 | 1.2 | 0.3 | 0.02 | < 0.2 | 1.1 | 2.6 |
| 53 D05K11 | 10.6 | 4.8 | 2.6 | 121 | < 0.3 | 1.1 | 0.3 | < 0.02 | < 0.2 | 1.0 | 3.7 |
| 54 D05L11 | 11.7 | 4.9 | 2.2 | 147 | < 0.2 | 1.3 | 0.2 | < 0.02 | < 0.2 | 0.8 | 4.7 |
| 55 D06A11 | -0.4 | 4.1 | 3.0 | 101 | < 0.2 | 0.9 | 0.5 | 0.04 | 0.3 | 0.6 | 4.1 |
| 56 D06A12 | -0.4 | 4.1 | 2.9 | 96 | < 0.2 | 0.8 | 0.5 | 0.03 | < 0.2 | 0.5 | 4.1 |

Appendix II. Digger pine cont.

| Sample ID. | X-Coor. | Y-Coor. | Ash % | Al ppm | As ppm | Ba ppm | Ca % | Cd ppm | Co ppm | Cr ppm | Cu ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 D06B11 | 1.0 | 3.9 | 3.4 | 82 | < 0.3 | 0.7 | 0.9 | 0.03 | < 0.2 | 8.5 | 3.2 |
| 58 D06B21 | 1.0 | 3.9 | 3.3 | 72 | < 0.3 | 0.6 | 0.8 | 0.03 | < 0.2 | 6.6 | 3.6 |
| 59 D06C11 | 2.0 | 3.7 | 2.6 | 65 | < 0.3 | 0.8 | 0.4 | 0.07 | < 0.2 | 2.5 | 3.9 |
| 60 D06D11 | 2.7 | 4.0 | 2.2 | 122 | < 0.3 | 1.2 | 0.2 | < 0.02 | < 0.2 | 0.8 | 3.9 |
| 61 D06E11 | 4.2 | 4.3 | 1.6 | 85 | < 0.1 | 0.8 | 0.2 | < 0.02 | 0.2 | 2.5 | 3.8 |
| 62 D06E21 | 4.2 | 4.3 | 1.7 | 108 | < 0.1 | 1.0 | 0.2 | < 0.02 | < 0.2 | 2.9 | 3.7 |
| 63 D06G11 | 6.2 | 4.1 | 2.3 | 59 | < 0.4 | 0.6 | 0.2 | 0.05 | < 0.2 | 1.6 | 2.8 |
| 64 D06I11 | 8.5 | 4.1 | 2.2 | 58 | < 0.2 | 1.0 | 0.4 | 0.02 | 0.3 | 2.1 | 3.4 |
| 65 D06I12 | 8.5 | 4.1 | 2.2 | 56 | < 0.2 | 0.7 | 0.3 | < 0.02 | 0.3 | 1.5 | 2.5 |
| 66 D06K11 | 10.7 | 4.0 | 3.1 | 129 | < 0.2 | 1.7 | 0.8 | < 0.02 | < 0.2 | 1.8 | 4.9 |
| 67 D06L11 | 11.7 | 3.8 | 2.5 | 129 | < 0.2 | 1.4 | 0.4 | < 0.02 | < 0.2 | 0.8 | 6.7 |
| 68 D07A11 | -0.4 | 3.0 | 1.7 | 134 | < 0.2 | 1.4 | 0.1 | < 0.01 | 0.3 | 2.4 | 4.7 |
| 69 D07A21 | -0.4 | 3.0 | 2.1 | 131 | < 0.3 | 1.3 | 0.2 | < 0.02 | 0.6 | 1.8 | 5.4 |
| 70 D07B11 | 1.0 | 2.7 | 2.6 | 68 | < 0.2 | 0.7 | 0.4 | < 0.02 | < 0.2 | 1.4 | 3.9 |
| 71 D07D11 | 2.9 | 3.0 | 2.9 | 130 | < 0.2 | 1.0 | 0.3 | < 0.02 | < 0.2 | 1.1 | 8.6 |
| 72 D07D21 | 2.9 | 3.0 | 2.6 | 108 | < 0.6 | 1.0 | 0.2 | < 0.02 | < 0.2 | 1.2 | 3.8 |
| 73 D07E11 | 4.0 | 3.0 | 1.6 | 34 | < 0.2 | 0.3 | 0.1 | < 0.01 | < 0.2 | 0.4 | 4.4 |
| 74 D07F11 | 5.3 | 3.3 | 2.0 | 26 | < 0.2 | 0.4 | 0.3 | 0.02 | < 0.2 | 1.3 | 3.8 |
| 75 D07H11 | 7.6 | 3.0 | 2.2 | 72 | < 0.5 | 0.9 | 0.2 | < 0.02 | < 0.2 | 1.5 | 3.1 |
| 76 D07I11 | 8.6 | 2.8 | 2.7 | 113 | < 0.6 | 1.2 | 0.2 | < 0.02 | < 0.2 | 0.7 | 3.5 |
| 77 D07J11 | 9.6 | 2.8 | 2.5 | 79 | < 0.2 | 0.9 | 0.4 | < 0.02 | < 0.2 | 1.6 | 3.5 |
| 78 D07K11 | 10.6 | 2.8 | 2.1 | 67 | < 0.4 | 0.7 | 0.2 | < 0.02 | < 0.2 | 1.9 | 4.6 |
| 79 D07L11 | 12.1 | 3.2 | 2.2 | 83 | < 0.4 | 0.8 | 0.3 | < 0.02 | 0.2 | 1.0 | 3.5 |
| 80 D07L12 | 12.1 | 3.2 | 2.2 | 87 | < 0.2 | 0.8 | 0.3 | < 0.02 | < 0.2 | 1.0 | 3.3 |
| 81 D08A11 | -0.4 | 2.0 | 1.7 | 48 | < 0.1 | 0.5 | 0.3 | < 0.02 | < 0.2 | 1.3 | 5.6 |
| 82 D08B11 | 0.9 | 2.0 | 2.9 | 46 | < 0.2 | 0.4 | 0.6 | < 0.02 | < 0.2 | 1.1 | 3.7 |
| 83 D08C11 | 2.0 | 2.0 | 2.5 | 52 | < 0.2 | 0.9 | 0.4 | < 0.02 | < 0.2 | 0.6 | 6.5 |
| 84 D08D11 | 3.0 | 1.9 | 2.9 | 61 | < 0.6 | 0.6 | 0.2 | < 0.02 | < 0.2 | 0.9 | 4.1 |
| 85 D08D12 | 2.9 | 1.9 | 3.0 | 57 | < 0.7 | 0.5 | 0.2 | < 0.02 | < 0.2 | 0.9 | 4.2 |
| 86 D08F11 | 5.3 | 1.8 | 1.9 | 54 | < 0.2 | 0.5 | 0.2 | < 0.01 | < 0.2 | 0.5 | 4.7 |
| 87 D08H11 | 7.6 | 2.0 | 2.6 | 34 | < 0.6 | 0.5 | 0.2 | < 0.02 | < 0.2 | 0.8 | 1.9 |
| 88 D08I11 | 8.8 | 2.1 | 2.3 | 64 | < 0.2 | 1.3 | 0.5 | 0.03 | 0.5 | 1.1 | 5.8 |
| 89 D08J11 | 9.6 | 2.1 | 2.8 | 58 | < 0.2 | 1.3 | 0.6 | 0.03 | < 0.2 | 0.8 | 5.2 |
| 90 D08K11 | 10.6 | 1.8 | 2.5 | 70 | < 0.4 | 0.7 | 0.2 | < 0.02 | < 0.2 | 2.5 | 4.5 |
| 91 D08L11 | 11.5 | 1.7 | 2.6 | 161 | < 0.2 | 1.6 | 0.3 | < 0.02 | < 0.2 | 3.8 | 4.6 |
| 92 D09C11 | 2.2 | 0.9 | 3.5 | 99 | < 0.7 | 1.3 | 0.5 | < 0.02 | < 0.2 | 1.0 | 3.9 |
| 93 D09D11 | 3.1 | 0.8 | 2.2 | 29 | < 0.2 | 0.6 | 0.4 | 0.03 | 0.2 | 0.7 | 4.0 |
| 94 D09E11 | 3.8 | 0.9 | 2.3 | 60 | < 0.2 | 0.6 | 0.4 | < 0.02 | < 0.2 | 0.7 | 3.9 |
| 95 D09E21 | 3.8 | 0.9 | 2.2 | 43 | < 0.2 | 0.5 | 0.3 | 0.02 | < 0.2 | 0.7 | 4.5 |
| 96 D09F11 | 5.2 | 0.8 | 1.5 | 34 | < 0.1 | 0.4 | 0.1 | < 0.02 | < 0.2 | 0.5 | 4.1 |
| 97 D09H11 | 7.4 | 0.8 | 1.9 | 85 | < 0.3 | 0.9 | 0.1 | < 0.02 | < 0.2 | 0.8 | 4.7 |
| 98 D09H21 | 7.4 | 0.8 | 2.0 | 90 | < 0.3 | 0.8 | 0.1 | < 0.02 | < 0.2 | 0.9 | 4.5 |
| 99 D09I11 | 8.6 | 1.0 | 1.9 | 48 | < 0.2 | 0.6 | 0.2 | < 0.02 | < 0.2 | 0.8 | 4.9 |
| 100 D09J11 | 9.6 | 0.9 | 3.0 | 60 | < 0.8 | 0.6 | 0.3 | < 0.02 | < 0.2 | 2.3 | 4.2 |
| 101 D09K11 | 10.8 | 1.2 | 2.2 | 144 | < 0.3 | 1.3 | 0.2 | < 0.02 | < 0.2 | 3.7 | 2.4 |
| 102 D09L11 | 12.1 | 1.1 | 1.9 | 52 | < 0.2 | 0.5 | 0.2 | < 0.02 | < 0.2 | 1.9 | 2.1 |
| 103 D10C11 | 2.2 | 0.1 | 2.7 | 88 | < 0.3 | 0.8 | 0.4 | < 0.02 | < 0.2 | 1.3 | 5.6 |
| 104 D10D11 | 2.8 | -0.1 | 2.7 | 60 | < 0.3 | 0.8 | 0.4 | < 0.02 | < 0.2 | 0.7 | 5.2 |
| 105 D10E11 | 3.7 | -0.1 | 2.0 | 78 | < 0.2 | 0.7 | 0.1 | < 0.02 | < 0.2 | 0.4 | 3.3 |
| 106 D10E12 | 3.7 | -0.1 | 2.0 | 80 | < 0.3 | 0.7 | 0.1 | < 0.02 | < 0.2 | 0.4 | 3.1 |
| 107 D10F11 | 5.1 | -0.1 | 2.3 | 48 | < 0.2 | 0.8 | 0.4 | 0.03 | < 0.2 | 0.8 | 4.8 |
| 108 D10H11 | 7.6 | -0.1 | 2.5 | 87 | < 0.4 | 1.0 | 0.2 | < 0.02 | < 0.2 | 1.8 | 3.0 |
| 109 D10I11 | 8.7 | -0.1 | 2.8 | 97 | < 0.2 | 1.4 | 0.5 | 0.02 | < 0.2 | 0.7 | 3.4 |
| 110 D10J11 | 9.5 | -0.1 | 1.9 | 85 | < 0.4 | 0.8 | 0.1 | < 0.02 | < 0.2 | 1.6 | 5.8 |
| 111 D10K11 | 10.7 | 0.2 | 2.3 | 103 | < 0.3 | 1.1 | 0.2 | < 0.02 | < 0.2 | 5.0 | 4.1 |
| 112 D10L11 | 11.9 | 0.3 | 1.8 | 42 | < 0.3 | 0.5 | 0.2 | < 0.02 | < 0.2 | 1.1 | 3.9 |

| Sample ID. | Fe ppm | Mg % | Mn ppm | Nb ppm | Ni ppm | P % | Pb ppm | Sr ppm | Ti ppm | V ppm | Y ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 D00K11 | 154 | 0.3 | 108 | 0.16 | 5.9 | 0.1 | 0.9 | 5.4 | 7.7 | 0.3 | < 0.1 | 23 |
| 2 D01A11 | 108 | 0.2 | 63 | 0.11 | 2.7 | 0.1 | 0.7 | 3.6 | 5.2 | 0.2 | < 0.1 | 12 |
| 3 D01B11 | 76 | 0.3 | 13 | 0.16 | 0.7 | 0.2 | 0.3 | 2.2 | 2.2 | 0.1 | < 0.1 | 5 |
| 4 D01C11 | 87 | 0.3 | 147 | < 0.12 | 6.9 | 0.2 | < 0.2 | 1.4 | 2.3 | 0.1 | < 0.1 | 51 |
| 5 D01C12 | 90 | 0.3 | 153 | < 0.12 | 7.2 | 0.2 | < 0.2 | 1.4 | 2.3 | 0.1 | < 0.1 | 54 |
| 6 D01D11 | 71 | 0.2 | 71 | 0.08 | 1.7 | 0.1 | 0.6 | 1.1 | 4.3 | 0.1 | < 0.1 | 17 |
| 7 D01E11 | 95 | 0.3 | 59 | 0.22 | 1.4 | 0.1 | 0.4 | 2.2 | 3.2 | 0.1 | < 0.1 | 19 |
| 8 D01G11 | 136 | 0.3 | 71 | 0.11 | 3.8 | 0.2 | 0.7 | 3.3 | 6.1 | 0.2 | < 0.1 | 25 |
| 9 D01I11 | 84 | 0.2 | 108 | 0.13 | 7.7 | 0.1 | 0.4 | 5.3 | 2.9 | 0.1 | < 0.1 | 18 |
| 10 D01J11 | 42 | 0.2 | 107 | 0.10 | 10.5 | 0.2 | 0.3 | 4.4 | 2.3 | 0.1 | < 0.1 | 20 |
| 11 D02A11 | 42 | 0.2 | 104 | < 0.10 | 4.5 | 0.2 | 0.3 | 4.2 | 1.5 | 0.1 | < 0.1 | 40 |
| 12 D02A12 | 44 | 0.1 | 102 | < 0.10 | 3.9 | 0.1 | < 0.2 | 3.7 | 2.1 | 0.1 | < 0.1 | 34 |
| 13 D02B11 | 137 | 0.3 | 8 | 0.17 | 1.0 | 0.2 | 0.5 | 3.9 | 6.2 | 0.2 | < 0.1 | 6 |
| 14 D02C11 | 167 | 0.4 | 154 | 0.24 | 3.6 | 0.1 | 0.6 | 2.7 | 5.6 | 0.3 | < 0.1 | 28 |
| 15 D02C12 | 138 | 0.3 | 128 | 0.18 | 3.1 | 0.1 | 0.3 | 2.4 | 5.3 | 0.2 | < 0.1 | 22 |
| 16 D02E11 | 108 | 0.2 | 59 | 0.12 | 1.1 | 0.2 | 0.7 | 1.2 | 4.5 | 0.2 | < 0.1 | 20 |
| 17 D02F11 | 121 | 0.2 | 41 | < 0.07 | 2.3 | 0.1 | 0.5 | 0.6 | 4.8 | 0.2 | < 0.1 | 16 |
| 18 D02G11 | 176 | 0.3 | 94 | 0.16 | 4.8 | 0.2 | 1.1 | 2.9 | 10.3 | 0.3 | < 0.1 | 15 |
| 19 D02J11 | 90 | 0.3 | 156 | 0.13 | 7.7 | 0.1 | 0.7 | 6.9 | 3.7 | 0.1 | < 0.1 | 20 |
| 20 D02K11 | 137 | 0.3 | 132 | 0.16 | 13.7 | 0.1 | 1.1 | 8.5 | 6.1 | 0.3 | < 0.1 | 20 |
| 21 D02K12 | 137 | 0.3 | 129 | 0.17 | 13.4 | 0.1 | 1.2 | 7.8 | 5.6 | 0.3 | < 0.1 | 19 |
| 22 D02L11 | 121 | 0.3 | 121 | 0.11 | 7.1 | 0.2 | 0.5 | 2.2 | 4.3 | 0.2 | < 0.1 | 14 |
| 23 D03A11 | 65 | 0.2 | 51 | 0.07 | 2.2 | 0.1 | 0.3 | 1.7 | 2.8 | 0.1 | < 0.1 | 19 |
| 24 D03C11 | 154 | 0.3 | 81 | 0.17 | 3.0 | 0.1 | 0.5 | 2.1 | 7.1 | 0.3 | < 0.1 | 25 |
| 25 D03D11 | 68 | 0.3 | 89 | 0.17 | 3.2 | 0.1 | 0.5 | 2.0 | 2.3 | 0.1 | < 0.1 | 18 |
| 26 D03E11 | 38 | 0.2 | 17 | 0.14 | 2.3 | 0.1 | 0.4 | 1.1 | 1.3 | 0.1 | < 0.1 | 13 |
| 27 D03E12 | 38 | 0.2 | 16 | 0.12 | 2.3 | 0.1 | 0.3 | 1.0 | 1.2 | 0.0 | < 0.1 | 13 |
| 28 D03F11 | 108 | 0.3 | 39 | 0.17 | 2.0 | 0.1 | 0.7 | 3.5 | 6.7 | 0.2 | < 0.1 | 21 |
| 29 D03I11 | 157 | 0.4 | 148 | 0.20 | 8.0 | 0.2 | 0.9 | 4.1 | 7.7 | 0.3 | < 0.1 | 23 |
| 30 D03I21 | 107 | 0.3 | 110 | 0.16 | 6.3 | 0.1 | 0.7 | 2.9 | 4.2 | 0.2 | < 0.1 | 19 |
| 31 D03K11 | 182 | 0.2 | 147 | < 0.12 | 3.5 | 0.2 | 0.9 | 9.1 | 7.9 | 0.3 | < 0.1 | 22 |
| 32 D04A11 | 101 | 0.2 | 123 | < 0.10 | 8.1 | 0.1 | < 0.2 | 1.4 | 3.0 | 0.2 | < 0.1 | 13 |
| 33 D04B11 | 77 | 0.3 | 64 | 0.11 | 1.7 | 0.2 | < 0.2 | 3.0 | 4.2 | 0.1 | < 0.1 | 20 |
| 34 D04F11 | 94 | 0.2 | 69 | 0.10 | 3.5 | 0.1 | < 0.2 | 2.1 | 3.0 | 0.1 | < 0.1 | 25 |
| 35 D04F12 | 94 | 0.2 | 70 | 0.10 | 3.5 | 0.1 | 0.2 | 2.2 | 2.6 | 0.1 | < 0.1 | 26 |
| 36 D04G11 | 158 | 0.3 | 108 | 0.16 | 4.6 | 0.1 | 1.0 | 3.1 | 4.8 | 0.2 | < 0.1 | 26 |
| 37 D04H11 | 138 | 0.3 | 62 | 0.15 | 5.6 | 0.2 | 0.7 | 3.5 | 4.9 | 0.2 | < 0.1 | 13 |
| 38 D04I11 | 22 | 0.2 | 63 | 0.11 | 8.2 | 0.1 | 0.4 | 3.7 | 0.8 | 0.0 | < 0.1 | 30 |
| 39 D04J11 | 74 | 0.2 | 104 | < 0.10 | 5.5 | 0.1 | 0.4 | 3.5 | 3.2 | 0.2 | < 0.1 | 10 |
| 40 D04K11 | 34 | 0.1 | 94 | < 0.10 | 5.5 | 0.1 | 0.2 | 3.4 | 1.4 | 0.0 | < 0.1 | 16 |
| 41 D04L11 | 109 | 0.2 | 139 | 0.10 | 10.5 | 0.1 | 0.7 | 4.0 | 4.0 | 0.2 | < 0.1 | 26 |
| 42 D04L12 | 113 | 0.2 | 147 | 0.09 | 10.3 | 0.1 | 0.7 | 3.8 | 4.4 | 0.2 | < 0.1 | 26 |
| 43 D05A11 | 79 | 0.2 | 130 | 0.10 | 4.6 | 0.2 | 0.6 | 1.8 | 3.5 | 0.2 | < 0.1 | 24 |
| 44 D05B11 | 58 | 0.2 | 25 | 0.10 | 1.3 | 0.1 | < 0.2 | 3.0 | 3.3 | 0.1 | < 0.1 | 17 |
| 45 D05C11 | 119 | 0.3 | 48 | 0.13 | 4.1 | 0.1 | 0.2 | 1.6 | 4.1 | 0.2 | < 0.1 | 10 |
| 46 D05D11 | 122 | 0.2 | 118 | 0.10 | 7.7 | 0.2 | 0.8 | 2.4 | 4.1 | 0.2 | < 0.1 | 38 |
| 47 D05D21 | 81 | 0.2 | 76 | 0.10 | 6.3 | 0.1 | 0.5 | 2.2 | 2.8 | 0.2 | < 0.1 | 33 |
| 48 D05E11 | 136 | 0.3 | 49 | 0.13 | 2.1 | 0.1 | 0.7 | 0.9 | 8.6 | 0.3 | < 0.1 | 30 |
| 49 D05F11 | 93 | 0.3 | 45 | 0.20 | 3.2 | 0.1 | 0.8 | 1.0 | 2.4 | 0.1 | < 0.1 | 19 |
| 50 D05H11 | 114 | 0.2 | 171 | 0.10 | 8.4 | 0.1 | 1.1 | 3.7 | 6.5 | 0.2 | < 0.1 | 15 |
| 51 D05H21 | 89 | 0.2 | 145 | < 0.10 | 8.9 | 0.1 | 0.7 | 3.3 | 5.1 | 0.2 | < 0.1 | 18 |
| 52 D05I11 | 67 | 0.1 | 71 | < 0.08 | 5.9 | 0.1 | 0.4 | 5.1 | 3.2 | 0.1 | < 0.1 | 16 |
| 53 D05K11 | 139 | 0.2 | 152 | < 0.10 | 6.8 | 0.2 | 0.6 | 2.3 | 7.9 | 0.3 | < 0.1 | 18 |
| 54 D05L11 | 171 | 0.2 | 60 | 0.12 | 3.8 | 0.1 | 1.1 | 3.8 | 7.1 | 0.3 | < 0.1 | 19 |
| 55 D06A11 | 89 | 0.1 | 181 | < 0.12 | 5.0 | 0.2 | 0.8 | 7.7 | 3.9 | 0.2 | < 0.1 | 33 |
| 56 D06A12 | 52 | 0.1 | 116 | < 0.12 | 4.9 | 0.1 | 0.6 | 7.5 | 2.1 | 0.1 | < 0.1 | 29 |

| Sample ID. | Fe ppm | Mg % | Mn ppm | Nb ppm | Ni ppm | P % | Pb ppm | Sr ppm | Ti ppm | V ppm | Y ppm | Zn ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 D06B11 | 92 | 0.3 | 44 | 0.19 | 1.7 | 0.2 | 0.4 | 4.4 | 3.7 | 0.1 | < 0.1 | 29 |
| 58 D06B21 | 75 | 0.3 | 39 | 0.18 | 1.6 | 0.2 | < 0.2 | 3.6 | 4.6 | 0.1 | < 0.1 | 31 |
| 59 D06C11 | 80 | 0.3 | 59 | 0.19 | 3.4 | 0.1 | 0.5 | 3.9 | 3.1 | 0.1 | < 0.1 | 15 |
| 60 D06D11 | 155 | 0.4 | 72 | 0.22 | 3.9 | 0.1 | 1.5 | 1.1 | 6.5 | 0.3 | < 0.1 | 20 |
| 61 D06E11 | 113 | 0.3 | 41 | 0.16 | 3.8 | 0.1 | 0.9 | 1.1 | 5.3 | 0.2 | < 0.1 | 20 |
| 62 D06E21 | 123 | 0.2 | 34 | 0.09 | 3.0 | 0.1 | 0.6 | 1.1 | 6.6 | 0.2 | < 0.1 | 15 |
| 63 D06G11 | 87 | 0.3 | 73 | 0.18 | 2.8 | 0.1 | 0.4 | 2.1 | 2.8 | 0.1 | < 0.1 | 22 |
| 64 D06I11 | 78 | 0.3 | 186 | 0.16 | 14.8 | 0.1 | 1.1 | 3.4 | 2.9 | 0.2 | < 0.1 | 22 |
| 65 D06I12 | 76 | 0.2 | 193 | 0.12 | 6.7 | 0.1 | 0.7 | 3.1 | 2.5 | 0.1 | < 0.1 | 20 |
| 66 D06K11 | 159 | 0.5 | 125 | 0.23 | 4.9 | 0.3 | 0.9 | 14.7 | 6.1 | 0.2 | < 0.1 | 30 |
| 67 D06L11 | 151 | 0.2 | 124 | < 0.10 | 7.2 | 0.1 | 0.8 | 5.0 | 7.7 | 0.3 | < 0.1 | 12 |
| 68 D07A11 | 144 | 0.2 | 80 | < 0.07 | 5.2 | 0.1 | 1.3 | 0.9 | 9.6 | 0.3 | < 0.1 | 17 |
| 69 D07A21 | 148 | 0.2 | 106 | 0.13 | 6.2 | 0.1 | 1.3 | 1.3 | 7.5 | 0.3 | < 0.1 | 29 |
| 70 D07B11 | 78 | 0.3 | 29 | 0.16 | 2.0 | 0.2 | 0.4 | 2.4 | 3.1 | 0.1 | < 0.1 | 16 |
| 71 D07D11 | 158 | 0.3 | 127 | < 0.12 | 5.2 | 0.2 | < 0.2 | 2.6 | 6.3 | 0.2 | < 0.1 | 27 |
| 72 D07D21 | 146 | 0.3 | 92 | 0.18 | 4.4 | 0.1 | 0.6 | 1.5 | 4.9 | 0.3 | < 0.1 | 17 |
| 73 D07E11 | 67 | 0.2 | 38 | 0.08 | 2.5 | 0.1 | 0.3 | 0.7 | 2.3 | 0.1 | < 0.1 | 21 |
| 74 D07F11 | 44 | 0.2 | 64 | 0.11 | 2.4 | 0.2 | 0.3 | 1.2 | 1.4 | 0.1 | < 0.1 | 22 |
| 75 D07H11 | 94 | 0.3 | 85 | 0.10 | 2.7 | 0.1 | 0.5 | 2.9 | 2.9 | 0.2 | < 0.1 | 27 |
| 76 D07I11 | 137 | 0.2 | 105 | < 0.11 | 10.5 | 0.1 | 0.7 | 2.0 | 6.7 | 0.3 | < 0.1 | 23 |
| 77 D07J11 | 99 | 0.2 | 77 | < 0.10 | 3.0 | 0.1 | 0.5 | 4.0 | 5.0 | 0.2 | < 0.1 | 16 |
| 78 D07K11 | 112 | 0.3 | 42 | 0.12 | 5.4 | 0.1 | 0.6 | 1.5 | 4.4 | 0.2 | < 0.1 | 19 |
| 79 D07L11 | 111 | 0.2 | 92 | 0.12 | 4.4 | 0.1 | 0.6 | 2.8 | 4.8 | 0.2 | < 0.1 | 13 |
| 80 D07L12 | 120 | 0.2 | 100 | 0.09 | 4.4 | 0.1 | 0.5 | 2.8 | 5.2 | 0.2 | < 0.1 | 13 |
| 81 D08A11 | 80 | 0.1 | 83 | < 0.07 | 3.2 | 0.1 | 0.3 | 1.9 | 2.6 | 0.1 | < 0.1 | 36 |
| 82 D08B11 | 69 | 0.4 | 75 | 0.18 | 2.9 | 0.2 | < 0.2 | 3.2 | 2.9 | 0.1 | < 0.1 | 27 |
| 83 D08C11 | 27 | 0.3 | 104 | 0.10 | 8.9 | 0.2 | 0.3 | 3.0 | 1.2 | 0.0 | < 0.1 | 27 |
| 84 D08D11 | 79 | 0.4 | 70 | 0.17 | 7.0 | 0.1 | 0.3 | 1.3 | 2.9 | 0.1 | < 0.1 | 12 |
| 85 D08D12 | 82 | 0.4 | 69 | 0.23 | 7.3 | 0.1 | 0.4 | 1.2 | 2.8 | 0.1 | < 0.1 | 13 |
| 86 D08F11 | 74 | 0.2 | 48 | 0.08 | 3.2 | 0.1 | 0.5 | 1.1 | 2.6 | 0.1 | < 0.1 | 16 |
| 87 D08H11 | 55 | 0.3 | 42 | < 0.11 | 2.9 | 0.1 | < 0.2 | 1.2 | 1.5 | 0.1 | < 0.1 | 22 |
| 88 D08I11 | 37 | 0.2 | 209 | 0.11 | 12.7 | 0.2 | 0.9 | 3.7 | 1.5 | 0.1 | < 0.1 | 28 |
| 89 D08J11 | 50 | 0.2 | 99 | < 0.11 | 7.2 | 0.1 | 0.3 | 6.9 | 2.8 | 0.1 | < 0.1 | 19 |
| 90 D08K11 | 93 | 0.4 | 53 | 0.19 | 3.8 | 0.1 | 0.7 | 3.3 | 4.0 | 0.1 | < 0.1 | 20 |
| 91 D08L11 | 225 | 0.4 | 64 | 0.19 | 5.4 | 0.1 | 2.2 | 2.8 | 7.9 | 0.4 | < 0.1 | 41 |
| 92 D09C11 | 138 | 0.3 | 142 | 0.18 | 7.1 | 0.1 | 0.3 | 4.3 | 3.9 | 0.2 | < 0.1 | 33 |
| 93 D09D11 | 16 | 0.2 | 46 | 0.12 | 4.6 | 0.1 | 0.3 | 2.2 | 0.7 | 0.0 | < 0.1 | 33 |
| 94 D09E11 | 95 | 0.2 | 155 | 0.11 | 6.3 | 0.2 | 0.6 | 1.7 | 3.3 | 0.1 | < 0.1 | 26 |
| 95 D09E21 | 56 | 0.2 | 110 | < 0.09 | 5.6 | 0.1 | 0.3 | 2.0 | 2.2 | 0.1 | < 0.1 | 21 |
| 96 D09F11 | 58 | 0.2 | 53 | 0.08 | 5.1 | 0.2 | 0.5 | 0.8 | 2.0 | 0.1 | < 0.1 | 19 |
| 97 D09H11 | 171 | 0.2 | 34 | < 0.08 | 4.0 | 0.1 | 1.0 | 0.7 | 5.1 | 0.2 | < 0.1 | 11 |
| 98 D09H21 | 171 | 0.2 | 43 | < 0.08 | 3.3 | 0.1 | 0.3 | 0.7 | 5.7 | 0.2 | < 0.1 | 13 |
| 99 D09I11 | 46 | 0.2 | 44 | 0.09 | 6.7 | 0.1 | 0.2 | 2.1 | 1.1 | 0.1 | < 0.1 | 21 |
| 100 D09J11 | 90 | 0.3 | 111 | 0.18 | 5.4 | 0.1 | 0.3 | 2.1 | 2.6 | 0.1 | < 0.1 | 19 |
| 101 D09K11 | 177 | 0.3 | 70 | 0.17 | 2.1 | 0.1 | 1.8 | 3.3 | 9.2 | 0.4 | < 0.1 | 26 |
| 102 D09L11 | 89 | 0.3 | 43 | 0.16 | 3.7 | 0.1 | 0.7 | 1.6 | 3.1 | 0.1 | < 0.1 | 33 |
| 103 D10C11 | 112 | 0.3 | 128 | 0.11 | 5.9 | 0.1 | < 0.2 | 2.3 | 4.0 | 0.2 | < 0.1 | 35 |
| 104 D10D11 | 82 | 0.3 | 133 | 0.14 | 7.1 | 0.1 | 0.3 | 2.2 | 3.0 | 0.1 | < 0.1 | 54 |
| 105 D10E11 | 104 | 0.2 | 53 | 0.09 | 5.1 | 0.1 | 0.7 | 1.0 | 4.5 | 0.2 | < 0.1 | 17 |
| 106 D10E12 | 108 | 0.2 | 51 | 0.12 | 5.1 | 0.1 | 0.8 | 1.0 | 5.1 | 0.2 | < 0.1 | 17 |
| 107 D10F11 | 41 | 0.1 | 115 | < 0.09 | 9.4 | 0.1 | 0.7 | 2.5 | 1.7 | 0.1 | < 0.1 | 37 |
| 108 D10H11 | 119 | 0.4 | 52 | 0.16 | 3.5 | 0.1 | 0.9 | 2.5 | 4.7 | 0.2 | < 0.1 | 18 |
| 109 D10I11 | 116 | 0.3 | 102 | 0.13 | 7.4 | 0.2 | 0.7 | 5.1 | 6.0 | 0.2 | < 0.1 | 31 |
| 110 D10J11 | 120 | 0.2 | 43 | 0.13 | 2.5 | 0.1 | 0.8 | 0.9 | 4.5 | 0.2 | < 0.1 | 14 |
| 111 D10K11 | 135 | 0.3 | 32 | 0.12 | 2.3 | 0.1 | 1.8 | 2.5 | 5.5 | 0.3 | < 0.1 | 22 |
| 112 D10L11 | 72 | 0.2 | 57 | 0.12 | 3.3 | 0.1 | 0.7 | 1.8 | 2.8 | 0.1 | < 0.1 | 15 |

**APPENDIX III.** Element Concentrations (ash weight basis) in tissue of an excavated whiteleaf manzanita shrub.

| Sample Description | Distance from basal burl (m) | Ash yield (%) | Ca % | Mg % | Cr ppm | Ni ppm | Mn ppm | Fe % |
|---|---|---|---|---|---|---|---|---|
| Secondary root | -8.0 | 0.53 | 12.0 | 10.5 | 110 | 560 | 900 | 1.20 |
| Secondary root | -6.0 | 0.56 | 16.5 | 9.9 | 20 | 250 | 790 | 0.60 |
| Primary root | -3.0 | 0.66 | 20.0 | 6.0 | 30 | 260 | 700 | 0.40 |
| Primary root | -1.0 | 0.88 | 19.0 | 3.7 | 40 | 260 | 940 | 0.35 |
| Basal burl | 0.0 | 0.36 | 25.0 | 5.4 | 60 | 400 | 1000 | 0.95 |
| Primary stem | 1.0 | 0.40 | 26.0 | 5.5 | 20 | 170 | 1700 | 0.30 |
| Secondary stem | 3.0 | 0.57 | 25.0 | 4.2 | 20 | 150 | 3250 | 0.20 |
| Stems and leaves | 4.0 | 0.90 | 16.5 | 6.5 | 20 | 200 | 12000 | 0.10 |

Appendix IV. Element concentrations in soils from excavated pits.

| Field # | TOTAL C% | ORGNC C% | CRBNT C% | Al% | Ca% | Fe% | K% | Mg% | P% | Ti% | Mn PPM | Ba PPM | Co PPM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00L05A | 1.23 | 1.23 | 0.01 | 0.71 | 0.30 | 8.3 | 0.2 | 17 | 0.02 | 0.03 | 1200 | 28 | 210 |
| 00L05AX | 1.45 | 1.45 | 0.01 | 0.73 | 0.34 | 9.3 | 0.2 | 17 | 0.02 | 0.03 | 1400 | 34 | 220 |
| 00L05B | 1.08 | 1.08 | 0.01 | 0.81 | 0.36 | 8.7 | 0.2 | 18 | 0.02 | 0.03 | 1200 | 30 | 200 |
| 00L20A | 1.55 | 1.55 | 0.01 | 0.69 | 0.19 | 11 | 0.2 | 13 | 0.02 | 0.02 | 1000 | 13 | 210 |
| 00L20B | 1.62 | 1.62 | 0.01 | 1.3 | 0.24 | 12 | 0.2 | 14 | 0.02 | 0.04 | 1500 | 18 | 240 |
| 07B05A | 0.36 | 0.34 | 0.02 | 0.62 | 0.43 | 5.5 | 0.2 | 17 | 0.02 | 0.04 | 640 | 16 | 110 |
| 07B05B | 0.21 | 0.19 | 0.02 | 1.1 | 0.67 | 5.7 | 0.2 | 19 | 0.02 | 0.08 | 790 | 13 | 110 |
| 07B10A | 0.39 | 0.37 | 0.02 | 1.4 | 0.78 | 6.5 | 0.2 | 17 | 0.02 | 0.13 | 940 | 33 | 110 |
| 07B10B | 0.35 | 0.33 | 0.02 | 1.7 | 1.1 | 7.0 | 0.2 | 15 | 0.02 | 0.16 | 870 | 32 | 130 |
| 07B20A | 0.36 | 0.35 | 0.01 | 1.6 | 0.87 | 6.5 | 0.2 | 17 | 0.02 | 0.13 | 990 | 42 | 120 |
| 07B20B | 0.38 | 0.36 | 0.02 | 1.8 | 1.1 | 6.5 | 0.2 | 16 | 0.02 | 0.17 | 1000 | 46 | 120 |
| 07B40A | 0.34 | 0.32 | 0.02 | 1.3 | 0.72 | 6.4 | 0.2 | 18 | 0.02 | 0.11 | 1000 | 28 | 130 |
| 07B40B | 0.35 | 0.33 | 0.02 | 0.63 | 0.35 | 3.3 | 0.2 | 8 | 0.02 | 0.05 | 420 | 10 | 65 |
| 07B40BX | 0.34 | 0.34 | 0.01 | 1.3 | 0.66 | 6.8 | 0.2 | 18 | 0.02 | 0.10 | 980 | 30 | 130 |
| 07B80A | 0.28 | 0.26 | 0.02 | 1.2 | 0.81 | 6.1 | 0.2 | 18 | 0.02 | 0.09 | 900 | 25 | 120 |
| 07B80B | 0.36 | 0.34 | 0.02 | 1.2 | 0.75 | 6.4 | 0.2 | 18 | 0.02 | 0.11 | 980 | 26 | 130 |
| 07C05A | 1.38 | 1.38 | 0.01 | 0.58 | 0.35 | 6.8 | 0.2 | 16 | 0.02 | 0.02 | 860 | 16 | 140 |
| 07C05B | 1.84 | 1.83 | 0.01 | 0.71 | 0.39 | 7.3 | 0.2 | 15 | 0.02 | 0.03 | 970 | 26 | 160 |
| 07C10A | 0.53 | 0.53 | 0.01 | 0.36 | 0.29 | 5.9 | 0.2 | 17 | 0.02 | 0.02 | 580 | 6 | 120 |
| 07C10B | 0.87 | 0.87 | 0.01 | 0.71 | 0.32 | 7.1 | 0.2 | 15 | 0.02 | 0.03 | 790 | 15 | 150 |
| 07C10BX | 0.87 | 0.87 | 0.01 | 0.71 | 0.27 | 7.3 | 0.2 | 15 | 0.02 | 0.03 | 760 | 16 | 140 |
| 07C20A | 0.34 | 0.34 | 0.01 | 0.21 | 0.15 | 4.8 | 0.2 | 19 | 0.02 | 0.02 | 680 | 7 | 110 |
| 07C20B | 0.40 | 0.40 | 0.01 | 0.34 | 0.18 | 5.5 | 0.2 | 16 | 0.02 | 0.02 | 570 | 6 | 120 |
| 07C40A | 0.20 | 0.20 | 0.01 | 0.19 | 0.15 | 5.0 | 0.2 | 18 | 0.02 | 0.02 | 540 | < 4 | 110 |
| 07C40B | 0.33 | 0.33 | 0.01 | 0.23 | 0.12 | 4.7 | 0.2 | 20 | 0.02 | 0.02 | 590 | 6 | 100 |
| 07C80A | 0.33 | 0.33 | 0.01 | 0.36 | 0.24 | 4.8 | 0.2 | 18 | 0.02 | 0.02 | 540 | 4 | 110 |
| 07C80B | 0.27 | 0.27 | 0.01 | 0.33 | 0.16 | 4.9 | 0.2 | 17 | 0.02 | 0.02 | 630 | 4 | 120 |
| 07E05A | 1.73 | 1.73 | 0.01 | 0.29 | 0.33 | 6.3 | 0.2 | 19 | 0.02 | 0.02 | 940 | 17 | 130 |
| 07E05B | 2.64 | 2.64 | 0.01 | 0.31 | 0.32 | 6.5 | 0.2 | 19 | 0.02 | 0.02 | 1000 | 19 | 140 |
| 07E10A | 0.94 | 0.94 | 0.01 | 0.28 | 0.32 | 7.5 | 0.2 | 19 | 0.02 | 0.02 | 1000 | 13 | 150 |
| 07E10B | 1.13 | 1.13 | 0.01 | 0.29 | 0.20 | 8.4 | 0.2 | 17 | 0.02 | 0.02 | 1200 | 7 | 170 |
| 07E20A | 0.71 | 0.71 | 0.01 | 0.26 | 0.17 | 7.8 | 0.2 | 15 | 0.02 | 0.02 | 970 | 5 | 150 |
| 07E20B | 0.78 | 0.78 | 0.01 | 0.26 | 0.17 | 8.2 | 0.2 | 17 | 0.02 | 0.02 | 1100 | 5 | 160 |
| 07E40A | 0.34 | 0.34 | 0.01 | 0.45 | 0.40 | 14 | 0.2 | 29 | 0.02 | 0.02 | 1500 | < 4 | 260 |
| 07E40B | 0.18 | 0.18 | 0.01 | 0.19 | 0.14 | 5.7 | 0.2 | 20 | 0.02 | 0.02 | 790 | 5 | 110 |
| 07E40BX | 0.16 | 0.16 | 0.01 | 0.16 | 0.13 | 5.5 | 0.2 | 20 | 0.02 | 0.02 | 770 | < 4 | 100 |
| 07E80A | 0.24 | 0.24 | 0.01 | 0.14 | 0.12 | 6.8 | 0.2 | 16 | 0.02 | 0.02 | 780 | < 4 | 140 |
| 07E80AX | 0.18 | 0.18 | 0.01 | 0.12 | 0.11 | 6.3 | 0.2 | 19 | 0.02 | 0.02 | 850 | < 4 | 130 |
| 07E80B | 0.32 | 0.32 | 0.01 | 0.16 | 0.13 | 6.8 | 0.2 | 19 | 0.02 | 0.02 | 950 | < 4 | 150 |
| 07G05A | 3.02 | 3.00 | 0.02 | 0.28 | 0.37 | 5.4 | 0.2 | 19 | 0.02 | 0.02 | 810 | 22 | 110 |
| 07G05B | 2.83 | 2.82 | 0.01 | 0.35 | 0.36 | 6.1 | 0.2 | 16 | 0.02 | 0.02 | 740 | 22 | 120 |
| 07G05BX | 2.64 | 2.63 | 0.01 | 0.33 | 0.33 | 6.1 | 0.2 | 16 | 0.02 | 0.02 | 750 | 20 | 120 |
| 07G10A | 1.91 | 1.88 | 0.03 | 0.29 | 0.30 | 6.3 | 0.2 | 17 | 0.02 | 0.02 | 790 | 12 | 130 |
| 07G10B | 1.51 | 1.50 | 0.01 | 0.25 | 0.25 | 5.7 | 0.2 | 20 | 0.02 | 0.02 | 860 | 18 | 120 |
| 07G20A | 0.82 | 0.82 | 0.01 | 0.26 | 0.23 | 6.1 | 0.2 | 20 | 0.02 | 0.02 | 940 | 14 | 130 |
| 07G20B | 0.63 | 0.63 | 0.01 | 0.31 | 0.20 | 5.8 | 0.2 | 20 | 0.02 | 0.02 | 840 | 12 | 120 |
| 07G20BX | 0.69 | 0.68 | 0.01 | 0.30 | 0.20 | 6.2 | 0.2 | 17 | 0.02 | 0.02 | 740 | 12 | 130 |
| 07G40A | 0.41 | 0.41 | 0.01 | 0.28 | 0.28 | 5.8 | 0.2 | 17 | 0.02 | 0.02 | 640 | < 4 | 120 |
| 07G40B | 0.39 | 0.39 | 0.01 | 0.25 | 0.27 | 5.8 | 0.2 | 18 | 0.02 | 0.02 | 650 | 5 | 120 |
| 07G80A | 0.37 | 0.37 | 0.01 | 0.24 | 0.22 | 4.7 | 0.2 | 20 | 0.02 | 0.02 | 550 | 5 | 90 |
| 07G80B | 0.21 | 0.19 | 0.02 | 0.18 | 0.20 | 5.0 | 0.2 | 21 | 0.02 | 0.02 | 650 | 5 | 100 |
| 07G80BX | 0.27 | 0.25 | 0.02 | 0.21 | 0.22 | 4.9 | 0.2 | 17 | 0.02 | 0.02 | 530 | < 4 | 100 |

Appendix IV. Soils (continued).

| Field # | TOTAL C% | ORGNC C% | CRBNT C% | Al% | Ca% | Fe% | K% | Mg% | P% | Ti% | Mn PPM | Ba PPM | Co PPM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07H05A | 2.92 | 2.91 | 0.01 | 0.33 | 0.41 | 6.8 | 0.2 | 16 | 0.02 | 0.02 | 810 | 17 | 140 |
| 07H05AX | 2.81 | 2.81 | 0.01 | 0.32 | 0.39 | 6.7 | 0.2 | 18 | 0.02 | 0.02 | 990 | 23 | 140 |
| 07H05B | 3.31 | 3.29 | 0.02 | 0.37 | 0.45 | 6.7 | 0.2 | 18 | 0.02 | 0.02 | 1000 | 27 | 140 |
| 07H10A | 2.47 | 2.46 | 0.01 | 0.37 | 0.43 | 7.4 | 0.2 | 18 | 0.02 | 0.02 | 1300 | 34 | 170 |
| 07H10B | 1.95 | 1.95 | 0.01 | 0.48 | 0.49 | 8.1 | 0.2 | 18 | 0.02 | 0.02 | 1400 | 36 | 180 |
| 07H20A | 1.56 | 1.56 | 0.01 | 0.57 | 0.53 | 9.5 | 0.2 | 15 | 0.02 | 0.02 | 1200 | 25 | 210 |
| 07H20B | 1.19 | 1.19 | 0.01 | 0.47 | 0.44 | 8.1 | 0.2 | 18 | 0.02 | 0.02 | 1200 | 25 | 180 |
| 07H40A | 0.58 | 0.58 | 0.01 | 0.30 | 1.1 | 7.8 | 0.2 | 19 | 0.02 | 0.02 | 980 | 8 | 150 |
| 07H40AX | 0.53 | 0.53 | 0.01 | 0.33 | 0.93 | 8.1 | 0.2 | 16 | 0.02 | 0.02 | 850 | 6 | 160 |
| 07H40B | 0.53 | 0.53 | 0.01 | 0.28 | 0.43 | 7.3 | 0.2 | 19 | 0.02 | 0.02 | 1100 | 9 | 160 |
| 07H80A | 0.25 | 0.25 | 0.01 | 0.21 | 0.14 | 6.6 | 0.2 | 20 | 0.02 | 0.02 | 960 | 4 | 120 |
| 07H80B | 0.20 | 0.20 | 0.01 | 0.21 | 0.13 | 5.8 | 0.2 | 20 | 0.02 | 0.02 | 820 | < 4 | 120 |
| 08I05A | 3.16 | 3.14 | 0.02 | 2.3 | 1.3 | 11 | 0.2 | 12 | 0.03 | 0.12 | 2500 | 200 | 290 |
| 08I05B | 3.01 | 2.99 | 0.02 | 2.5 | 1.3 | 12 | 0.3 | 12 | 0.03 | 0.14 | 2500 | 210 | 290 |
| 08I10A | 1.22 | 1.22 | 0.01 | 3.1 | 1.2 | 14 | 0.3 | 9 | 0.03 | 0.19 | 1700 | 130 | 270 |
| 08I10B | 1.11 | 1.11 | 0.01 | 2.9 | 1.1 | 13 | 0.3 | 11 | 0.03 | 0.18 | 1900 | 150 | 250 |
| 08I20A | 0.67 | 0.67 | 0.01 | 3.1 | 0.99 | 13 | 0.4 | 10 | 0.03 | 0.18 | 2000 | 160 | 250 |
| 08I20B | 0.57 | 0.57 | 0.01 | 2.9 | 0.96 | 12 | 0.4 | 11 | 0.03 | 0.16 | 2300 | 160 | 280 |
| 08I40A | 0.40 | 0.40 | 0.01 | 4.5 | 1.1 | 13 | 0.4 | 8 | 0.02 | 0.26 | 1300 | 150 | 200 |
| 08I40B | 0.30 | 0.30 | 0.01 | 4.1 | 0.91 | 12 | 0.4 | 10 | 0.03 | 0.24 | 1900 | 180 | 230 |
| 08I80A | 0.30 | 0.30 | 0.01 | 2.1 | 0.42 | 11 | 0.2 | 13 | 0.02 | 0.10 | 1300 | 69 | 220 |
| 08I80B | 0.22 | 0.22 | 0.01 | 1.6 | 0.30 | 10 | 0.3 | 16 | 0.02 | 0.08 | 1600 | 69 | 210 |
| 08L05A | 2.75 | ND | ND | 0.67 | 0.78 | 12 | <0.2 | 13 | < 0.01 | 0.02 | 1500 | 16 | 220 |
| 08L05B | 2.90 | ND | ND | 0.61 | 1.6 | 11 | <0.2 | 14 | < 0.01 | 0.02 | 1400 | 14 | 200 |
| 08L10A | 1.48 | ND | ND | 0.94 | 1.7 | 14 | <0.2 | 9 | < 0.01 | 0.02 | 1500 | 18 | 230 |
| 08L10B | 1.16 | ND | ND | 0.61 | 1.5 | 12 | <0.2 | 13 | < 0.01 | 0.02 | 1400 | 12 | 220 |
| 08L20A | 0.65 | ND | ND | 1.0 | 1.8 | 15 | <0.2 | 8 | < 0.01 | 0.02 | 1600 | 21 | 240 |
| 08L20B | 0.50 | ND | ND | 0.55 | 0.66 | 10 | <0.2 | 14 | < 0.01 | 0.01 | 1300 | 10 | 210 |
| 08L40A | 0.45 | ND | ND | 0.49 | 3.3 | 11 | <0.2 | 13 | < 0.01 | 0.01 | 1100 | 10 | 170 |
| 08L40B | 0.40 | ND | ND | 0.63 | 0.62 | 10 | <0.2 | 15 | < 0.01 | 0.02 | 1400 | 12 | 190 |
| 08L80A | 0.33 | ND | ND | 0.41 | 0.45 | 7.9 | <0.2 | 16 | < 0.01 | 0.01 | 1100 | 10 | 150 |
| 08L80B | 0.29 | ND | ND | 0.35 | 0.30 | 7.3 | <0.2 | 18 | < 0.01 | 0.01 | 1000 | 7 | 130 |

Appendix IV. Soils (continued).

| Field # | Cr PPM | Cu PPM | Nb PPM | Ni PPM | Sc PPM | Sr PPM | V PPM | Y PPM | Zn PPM | Zr PPM | pH | H2O- | Cr(VI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00L05A | 29000 | < 4 | < 20 | 3900 | < 8 | < 8 | 53 | 21 | 60 | 68 | 6.9 | 3.6 | 0 |
| 00L05AX | 26000 | < 4 | < 20 | 4000 | < 8 | < 8 | 49 | 20 | 60 | 25 | 7.0 | 3.8 | 0 |
| 00L05B | 29000 | < 4 | 20 | 3700 | < 8 | < 8 | 64 | 23 | 90 | 88 | 6.8 | 2.8 | 0 |
| 00L20A | 11000 | < 4 | < 20 | 3800 | 9 | < 8 | 28 | < 8 | < 20 | 49 | 7.0 | 13.1 | 0 |
| 00L20B | 53000 | < 4 | < 20 | 4400 | 8 | < 8 | 77 | 38 | 80 | 35 | 7.1 | 12.2 | 0 |
| 07B05A | 9700 | 8 | 20 | 2100 | < 8 | < 8 | 40 | 8 | < 20 | 62 | 7.3 | 3.4 | 0 |
| 07B05B | 23000 | 8 | < 20 | 2300 | 8 | < 8 | 60 | 19 | 30 | 59 | 7.4 | 2.3 | 0 |
| 07B10A | 13000 | 19 | 20 | 2400 | 10 | 12 | 75 | 14 | 50 | 140 | 7.6 | 5.8 | 0 |
| 07B10B | 7400 | 19 | 20 | 2300 | 14 | 18 | 75 | 9 | 20 | 110 | 7.2 | 6.3 | 1 |
| 07B20A | 9400 | 17 | 20 | 2500 | 11 | 13 | 71 | 12 | 40 | 180 | 7.4 | 7.8 | 1 |
| 07B20B | 13000 | 18 | 20 | 2500 | 13 | 16 | 79 | 14 | 30 | 54 | 7.1 | 8.0 | 1 |
| 07B40A | 13000 | 12 | 20 | 2700 | 10 | 14 | 61 | 12 | 30 | 23 | 7.5 | 5.9 | 1 |
| 07B40B | 4200 | 8 | < 20 | 1200 | < 8 | < 8 | 30 | < 8 | < 20 | 14 | 7.4 | 5.0 | 1 |
| 07B40BX | 12000 | 10 | 20 | 2800 | 9 | 11 | 57 | 12 | 30 | 54 | 7.9 | 4.8 | 1 |
| 07B80A | 19000 | 13 | < 20 | 2600 | 10 | 11 | 60 | 16 | 30 | 41 | 8.0 | 4.8 | 1 |
| 07B80B | 17000 | 15 | 20 | 2700 | 10 | 17 | 62 | 15 | 30 | 39 | 7.9 | 4.5 | 1 |
| 07C05A | 4700 | 9 | 20 | 2600 | 9 | < 8 | 33 | < 8 | < 20 | 110 | 6.7 | 4.7 | 0 |
| 07C05B | 4200 | 9 | 20 | 2700 | 10 | < 8 | 36 | < 8 | 20 | 74 | 6.9 | 4.0 | 0 |
| 07C10A | 2800 | < 4 | 20 | 2400 | < 8 | < 8 | 18 | < 8 | < 20 | 27 | 7.4 | 10.1 | 1 |
| 07C10B | 2300 | 17 | 20 | 2700 | 11 | < 8 | 26 | < 8 | < 20 | 24 | 7.4 | 13.7 | 0 |
| 07C10BX | 2600 | 13 | 20 | 2700 | 10 | < 8 | 27 | < 8 | < 20 | 20 | 7.4 | 13.2 | 0 |
| 07C20A | 2700 | 7 | 20 | 2600 | < 8 | < 8 | 11 | < 8 | < 20 | 15 | 6.8 | 11.8 | 1 |
| 07C20B | 2200 | 6 | 20 | 2500 | < 8 | < 8 | 13 | < 8 | < 20 | 43 | 7.3 | 14.4 | 1 |
| 07C40A | 2600 | < 4 | 20 | 2400 | < 8 | < 8 | 11 | < 8 | < 20 | 82 | 7.2 | 12.7 | 1 |
| 07C40B | 1900 | 9 | 30 | 2700 | < 8 | < 8 | 8 | < 8 | 30 | 240 | 7.1 | 13.5 | 1 |
| 07C80A | 2400 | < 4 | 20 | 2400 | < 8 | < 8 | 17 | < 8 | < 20 | 82 | 7.5 | 8.6 | 1 |
| 07C80B | 2500 | < 4 | 20 | 2400 | < 8 | < 8 | 15 | < 8 | < 20 | 52 | 7.7 | 9.4 | 1 |
| 07E05A | 3200 | 11 | 30 | 2700 | < 8 | < 8 | 23 | < 8 | 30 | 110 | 6.9 | 5.2 | 0 |
| 07E05B | 4300 | 5 | 20 | 2700 | 8 | < 8 | 26 | < 8 | 40 | 12 | 6.9 | 4.7 | 0 |
| 07E10A | 3700 | 13 | 20 | 3200 | 10 | < 8 | 25 | < 8 | < 20 | 61 | 6.9 | 8.7 | 0 |
| 07E10B | 3200 | 5 | 20 | 3400 | 10 | < 8 | 24 | < 8 | < 20 | 28 | 7.3 | 12.4 | 0 |
| 07E20A | 2800 | 10 | 20 | 3300 | 11 | < 8 | 26 | < 8 | < 20 | 34 | 7.3 | 13.3 | 1 |
| 07E20B | 3400 | 8 | 20 | 3600 | 9 | < 8 | 23 | < 8 | 20 | 31 | 7.4 | 14.2 | 0 |
| 07E40A | 2600 | 9 | 30 | 5100 | 17 | < 8 | 29 | < 8 | < 20 | 9 | 7.4 | 11.2 | 1 |
| 07E40B | 4100 | 4 | 20 | 2700 | < 8 | < 8 | 20 | < 8 | < 20 | 43 | 6.9 | 9.2 | 0 |
| 07E40BX | 2900 | < 4 | 20 | 2700 | < 8 | < 8 | 16 | < 8 | < 20 | 110 | 7.0 | 7.9 | 0 |
| 07E80A | 1800 | < 4 | 20 | 2700 | < 8 | < 8 | < 8 | < 8 | < 20 | 320 | 7.5 | 11.9 | 0 |
| 07E80AX | 1800 | 5 | 20 | 2800 | < 8 | < 8 | < 8 | < 8 | < 20 | 1000 | 7.2 | 12.1 | 0 |
| 07E80B | 1800 | 6 | 20 | 2900 | < 8 | < 8 | 10 | < 8 | < 20 | 130 | 7.2 | 12.9 | 0 |
| 07G05A | 4100 | 6 | 20 | 2500 | < 8 | < 8 | 19 | < 8 | 30 | 31 | 7.4 | 6.2 | 0 |
| 07G05B | 4000 | 6 | 20 | 2300 | < 8 | < 8 | 22 | < 8 | < 20 | 130 | 7.0 | 5.4 | 0 |
| 07G05BX | 4100 | 8 | 20 | 2300 | < 8 | < 8 | 21 | < 8 | < 20 | 170 | 7.2 | 5.5 | 0 |
| 07G10A | 2900 | < 4 | 20 | 2500 | < 8 | < 8 | 15 | < 8 | < 20 | 140 | 7.5 | 12.4 | 0 |
| 07G10B | 4000 | 14 | 20 | 2700 | < 8 | < 8 | 18 | < 8 | < 20 | 40 | 7.5 | 9.4 | 0 |
| 07G20A | 2600 | 7 | 20 | 2800 | < 8 | < 8 | 14 | < 8 | 20 | 190 | 7.5 | 11.4 | 1 |
| 07G20B | 4900 | < 4 | 30 | 2600 | < 8 | < 8 | 21 | < 8 | 70 | 100 | 7.3 | 10.3 | 1 |
| 07G20BX | 3400 | 8 | 20 | 2500 | < 8 | < 8 | 17 | < 8 | < 20 | 55 | 7.4 | 9.5 | 1 |
| 07G40A | 4300 | 6 | 20 | 2300 | < 8 | < 8 | 19 | < 8 | < 20 | 40 | 7.4 | 10.7 | 1 |
| 07G40B | 4000 | < 4 | 20 | 2300 | < 8 | < 8 | 18 | < 8 | < 20 | 140 | 7.6 | 10.1 | 0 |
| 07G80A | 2000 | < 4 | 20 | 2300 | < 8 | < 8 | 11 | < 8 | < 20 | 220 | 7.6 | 16.9 | 0 |
| 07G80B | 2600 | < 4 | 30 | 2500 | < 8 | < 8 | 11 | < 8 | < 20 | 82 | 7.8 | 12.0 | 0 |
| 07G80BX | 2100 | < 4 | 20 | 2100 | < 8 | < 8 | 11 | < 8 | < 20 | 280 | 7.5 | 11.8 | 0 |

Appendix IV. Soils (continued).

| Field # | Cr PPM | Cu PPM | Nb PPM | Ni PPM | Sc PPM | Sr PPM | V PPM | Y PPM | Zn PPM | Zr PPM | pH | H2O- | Cr(VI) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 07H05A | 3200 | 7 | 20 | 2500 | 8 | < 8 | 23 | < 8 | 20 | 27 | 7.2 | 3.6 | 0 |
| 07H05AX | 4200 | 12 | 20 | 2800 | 8 | < 8 | 25 | < 8 | 30 | 27 | 7.1 | 3.5 | 0 |
| 07H05B | 4500 | 12 | 20 | 2900 | 8 | < 8 | 26 | < 8 | 30 | 43 | 7.2 | 3.9 | 0 |
| 07H10A | 4000 | 13 | 20 | 3300 | 9 | 8 | 27 | < 8 | 30 | 26 | 7.5 | 9.4 | 0 |
| 07H10B | 6000 | 12 | 20 | 3400 | 10 | 9 | 34 | < 8 | 40 | 41 | 7.3 | 8.6 | 0 |
| 07H20A | 5600 | 11 | 20 | 3100 | 12 | < 8 | 38 | < 8 | 20 | 87 | 7.2 | 13.3 | 0 |
| 07H20B | 5500 | 5 | 20 | 3200 | 10 | < 8 | 36 | < 8 | 70 | 54 | 7.3 | 12.2 | 0 |
| 07H40A | 4000 | 10 | 20 | 3100 | 9 | < 8 | 27 | < 8 | < 20 | 32 | 7.1 | 16.3 | 1 |
| 07H40AX | 3100 | < 4 | 20 | 2900 | 10 | < 8 | 27 | < 8 | < 20 | 13 | 7.6 | 17.0 | 1 |
| 07H40B | 3800 | 10 | 20 | 3300 | 9 | < 8 | 23 | < 8 | < 20 | 18 | 7.4 | 17.0 | 1 |
| 07H80A | 3400 | 7 | 20 | 2800 | 9 | < 8 | 22 | < 8 | < 20 | 110 | 7.9 | 11.1 | 1 |
| 07H80B | 2800 | 8 | 20 | 2700 | 8 | < 8 | 20 | < 8 | < 20 | 13 | 7.6 | 11.6 | 1 |
| 08I05A | 14000 | 12 | < 20 | 3700 | 17 | 48 | 100 | 15 | 130 | 45 | 6.7 | 3.9 | 0 |
| 08I05B | 9900 | 18 | < 20 | 3900 | 18 | 51 | 89 | 12 | 120 | 120 | 6.5 | 3.9 | 0 |
| 08I10A | 9000 | 23 | < 20 | 4200 | 21 | 54 | 98 | 11 | 60 | 100 | 6.9 | 11.2 | 0 |
| 08I10B | 8100 | 20 | < 20 | 4500 | 19 | 51 | 91 | 12 | 110 | 68 | 6.8 | 12.1 | 0 |
| 08I20A | 7200 | 27 | < 20 | 4700 | 19 | 55 | 85 | 13 | 90 | 65 | 6.8 | 13.2 | 0 |
| 08I20B | 7900 | 22 | < 20 | 4700 | 19 | 52 | 82 | 12 | 90 | 62 | 6.8 | 14.3 | 0 |
| 08I40A | 6300 | 27 | < 20 | 3800 | 20 | 79 | 100 | 12 | 60 | 83 | 7.0 | 14.9 | 0 |
| 08I40B | 7300 | 26 | < 20 | 4400 | 19 | 72 | 100 | 15 | 110 | 78 | 7.0 | 16.8 | 0 |
| 08I80A | 4800 | 19 | < 20 | 4400 | 16 | 24 | 60 | 8 | 30 | 35 | 7.1 | 18.3 | 0 |
| 08I80B | 4800 | 15 | 20 | 4900 | 13 | 19 | 47 | 8 | 50 | 68 | 6.6 | 17.3 | 0 |
| 08L05A | 6000 | 8 | < 20 | 5000 | 14 | 11 | 40 | < 8 | 28 | 512 | 7.7 | 28.7 | 0 |
| 08L05B | 8100 | 8 | < 20 | 4200 | 12 | 10 | 44 | < 8 | 32 | 437 | 7.5 | 22.7 | 0 |
| 08L10A | 5600 | 10 | < 20 | 4900 | 17 | 10 | 46 | < 8 | 33 | 925 | 7.7 | 36.1 | 0 |
| 08L10B | 5700 | 12 | < 20 | 4500 | 14 | 10 | 39 | < 8 | 23 | 287 | 7.7 | 32.2 | 0 |
| 08L20A | 6600 | 11 | < 20 | 4700 | 17 | 11 | 50 | < 8 | 40 | 1020 | 7.7 | 30.8 | 0 |
| 08L20B | 6600 | 10 | < 20 | 4400 | 15 | 10 | 43 | < 8 | 27 | 294 | 7.8 | 34.2 | 0 |
| 08L40A | 4800 | 9 | < 20 | 4000 | 12 | 9 | 44 | < 8 | 21 | 419 | 7.8 | 35.9 | 0 |
| 08L40B | 5400 | 10 | < 20 | 4500 | 14 | 9 | 43 | < 8 | 28 | 229 | 7.8 | 35.2 | 0 |
| 08L80A | 4400 | 5 | < 20 | 3800 | 11 | 9 | 34 | < 8 | 20 | 237 | 7.9 | 29.9 | 0 |
| 08L80B | 4200 | 6 | < 20 | 3200 | 10 | 9 | 31 | < 8 | 26 | 427 | 7.8 | 26.4 | 0 |

APPENDIX V. Element concentrations in stream water samples.

| Sample Location | pH | Conductivity µS | Cr(VI) | Mg ppm |
|---|---|---|---|---|
| G1 | 9.3 | 470 | NEG | 200 |
| G2 | 8.9 | 500 | POS | 150 |
| G3 | 8.9 | 470 | POS | 150 |
| G4 | 8.6 | 520 | POS | 200 |
| G5 | 9.0 | 280 | POS | 100 |
| G6 | 8.5 | 400 | POS | 150 |
| G7 | 9.3 | 480 | POS | 150 |
| G8 | 8.4 | 520 | POS | 150 |