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Naturally Occurring Background Levels of Arsenic in the Soils of Southwestern Oregon

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by

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Abstract

This study examines the natural background concentrations of arsenic in the soils of southwest Oregon, using new samples in addition to data collected from previous theses (Khandoker, 1997 and Douglas, 1999). The original 213 samples were run by ICPAES with a reporting limit of 20 ppm, and only three samples had detected values. The original samples were tested again (2013) at a detection limit of 0.20 ppm by ICP-MS, as were 42 new samples (2013), to better ascertain the natural levels of arsenic in undisturbed soils. The aim is to add to the existing DEQ data set, which has been used to establish new regulatory levels based on natural levels in the environment that are both safer and more economically viable than the former risk-based remediation levels (DEQ, 2013).

The maximum and mean concentrations, respectively, for each province (with high formation map unit) are 85.4 and 21.99 ppm for South Willamette Valley (Tfee), 45.4 and 5.42 ppm for the Klamath Mountains (Jub), 11.9 and 2.76 ppm for the Cascade Range (Tbaa), 10.6 and 5.15 ppm for the Coast Range (Ty), 2.32 and 1.29 ppm for the Basin and Range (Qba) and 1.5 and 1.20 ppm for the High Lava Plains (Tmv).

In addition, the distribution and variance of arsenic in the A and B soil horizons is assessed in this study; one of 18 new sites sampled for this study (distinguished with the HH prefix), site HH11, was randomly chosen for this purpose. Site HH11 is an Inceptisol soil above volcanic rock (KJdv map unit) located at 275 meters elevation in Douglas County within the Klamath province. Five samples were taken from the A and from the B

horizons at site HH11. The mean and standard deviation, respectively, was 3.74 ± 0.44 for the A horizon and 4.53 ± 0.39 for the B horizon. The consistency and low deviation within each horizon indicate that a single sample within a horizon is a good representative of that horizon and supports the field methodology used in this study of taking only one sample in the A horizon and one sample in the B horizon. The Wilcoxon Rank-Sum test (p-value: 0.76) determined that A and B horizons for the 119 sites that had data for both the A and B horizons were not statistically different. However, 47 sites (39.5%) are higher in arsenic in the A horizon while 63 sites (52.9%) are higher in the B horizon, with 9 sites (7.6%) having no value detected. This is strong support for sampling in both the A and B horizons to ensure a sample is collected from the horizon with the highest arsenic value, and critical for an accurate assessment of the maximum levels for naturally occurring arsenic in soils.

Lastly, this study statistically examines six potentially important environmental predictors of naturally occurring arsenic in southwestern Oregon: site elevation, geomorphic province, mapped rock type and age, and sample soil order and color (redness). A Classification and Regression Tree Model (CART) determined soil order, elevation and rock type to be of significant importance in determining arsenic concentrations in the natural environment. According to the regression tree, arsenic concentrations are greater within Alfisol and Ultisol/Alfisol and Vertisol soil orders, at lower elevations below 1,207 meters, and within soils from sedimentary, mixed volcanic/sedimentary and unconsolidated rock types.

The relationship between environmental factors and high levels of arsenic is complex and research is ongoing. However, soil order is likely to be a significant factor for predicting levels of arsenic since soil order is defined by its horizon development. Negatively charged arsenic ions adsorb to positively charged minerals, commonly iron, aluminum and magnesium oxides and clay. Any soils with a zone of mineral accumulation (B horizon) — such as Alfisol, Ultisol and Vertisol soils have — are likely to attract, retain and concentrate arsenic in the soil.

The relationship between elevation and rock type to arsenic level is less clear. Arsenic values could be higher in lower elevations because weather and gravity have transported arsenic-bearing sediments to lower topography where it accumulates, or a result of more chemical processes in the more temperate climates at lower elevation, or is correlated with other factors such as depositional regime of the rock. Rock type as a predictive factor also requires more research; the degree of arsenic enrichment in rock and arsenic released through physical and chemical weathering are likely to have a high degree of local variability than will ultimately not allow definitive association of high arsenic levels by rock type.

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Dr. Scott Burns, your encouragement and confidence has made the process of creating this Master's thesis much more enjoyable than I imagined it could be. Also, I learned a lot from you! David Anderson from DEQ and Neil Morton from GeoEngineers, Inc. were both invaluable resources for questions I had regarding the DEQ data set. I thank Kassandra Lindsey and Aubrey Frimoth for being my post-surgery arms and legs with their physical contributions (digging many holes) and can-do attitude in the field. Classmates Traci Parker and Kimberly Yazzie joined me in playing with my data for a class project, helped troubleshoot appropriate analyses for the data and traded ideas for what the results may imply.

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CHAPTER I: INTRODUCTION

Some elements that are natural to the environment can lead to significant, even fatal health effects and so must be managed to ensure human health and safety. In Oregon a major element of concern is arsenic (As). Exposure and poisoning from this naturally occurring metalloid can occur from drinking water, inhaling dust, or ingesting foods grown in high-arsenic soils or irrigated with high-arsenic waters. Anthropogenic sources also contribute to elevated arsenic by introducing products with arsenic content, such as some pesticides and treated lumber. The Environmental Protection Agency has classified inorganic arsenic as a human carcinogen. Inorganic arsenic poisoning has also been linked to various cancers, skin lesions, and decreased function in the cardiovascular, neurological and respiratory systems (U.S. Department of Health, 2007).

Originally, the Department of Environmental Quality (DEQ) set remediation standards to one part per million (ppm) of arsenic, but Khandoker (1997) found natural values can be higher in Oregon. For northwest Oregon, Ricker (2013) showed many samples from undisturbed soils were higher in arsenic than one ppm. Khandoker's southwest Oregon samples were originally tested for arsenic with a minimum reporting limit of 20 ppm. In this study, his arsenic samples were re-tested at a detection limit of <0.20 ppm to investigate the arsenic in soil to assess naturally occurring levels of arsenic in southwest Oregon. Soil nomenclature and a background of arsenic in soils is introduced in Chapter III.

1.1 PURPOSE AND SCOPE

The regulatory authority for setting standards and assuring compliance for environmental quality at the state level is the Department of Environmental Quality (DEQ). The maximum exposure levels for metal and metalloid elements, chosen by DEQ, have historically been established using risk-based concentrations (RBC's) using data not specific to Oregon, where risk from exposure is defined as the product of a chemical's toxicity and the degree of exposure to it (DEQ, 2003). The difference between the scenarios for exposure is the frequency of the exposure expected in a given year (DEQ, 2003).

Risk-based concentrations for arsenic in soils in Oregon were based on duration of exposure and ranged from 0.4 to 1.7 ppm for residential and occupational environments (Table 1). Studies in northwest Oregon (Ricker, 2013) have shown most natural soil samples are above that number. To move away from RBC's and refine clean-up standards, an understanding of natural background levels of arsenic and other elements in soils is needed. Regional background elemental concentrations data will aid the design of standards that are more reasonable and therefore economically sustainable for cleanup. To accomplish this, the DEQ has compiled data from Portland State University, the United States Geological Survey, the National Geochemical Database, the Umatilla Chemical Depot and samples and analysis from GeoEngineers. The DEQ has recently completed the re-evaluation of background data for elements of concern in Oregon, and released a report (DEQ, 2013) with the project phase information and values based on background concentration data to replace the previous values. Concentrations were grouped by physiographic province (Figure 1), and new standards dictate that metals require remediation when exceeding the regional 95% upper tolerance limit of the default background concentrations (Table 1).

The objective of this study is to determine the range of naturally occurring arsenic in southwest Oregon soils. The data in this thesis will add to the dataset that supports the evaluation of background levels of arsenic for Oregon. In addition, environmental factors were assessed to see if there are more readily measurable environmental parameters. A potential relationship may justify more research to determine if an environmental source may be used as a "red flag" indicator of potentially high soil arsenic content. Factors being assessed are rock type and age, soil order, soil color, elevation, and geomorphic region.

Table 1. Historic and new maximum limits of arsenic established by DEQ (2012, 2013).

	Risk-Based Concentration Method (DEQ, 2012)				
Maximum Exposure Scenario	Residential	Urban Residential	Occupational	Construction Worker	Excavation Worker
soil (ppm)	0.4	1.0	1.7	13.0	370.0

	Regional 95% Upper Prediction Limit (UPL) Default Background Concentrations within Southwest Oregon (DEQ, 2013)					
Physiographic Province	Basin and Range	Cascade Range	Coast Range	High Lava Plains	Klamath Mountains	South Willamette Valley
soil (ppm)	12.0	19.0	12.0	7.2	12.0	18.0

1.2 STUDY AREA

The study area is from the Pacific Ocean on the west to the city of Bend on the east, the Oregon-California border on the south up to the city of Eugene on the north. The bounds of this study area were chosen to be consistent with a study by Khandoker (1997), since soil samples from Khandoker's study were retested for arsenic for use in this study. The primary physiographic provinces in the study area (Figure 1) are the Klamath Mountains, the Coast Range and the Cascade Range (Orr and Orr, 2012). This study also includes the southernmost portion of Willamette Valley and a few sites within the westernmost portions of the High Lava Plains and Basin and Range provinces. The varied physiography within southwest Oregon is a result of tectonic accretion and deformation, volcanism and Quaternary glaciation. Detailed unit descriptions (Walker and MacLeod, 1991) are in Appendix B.

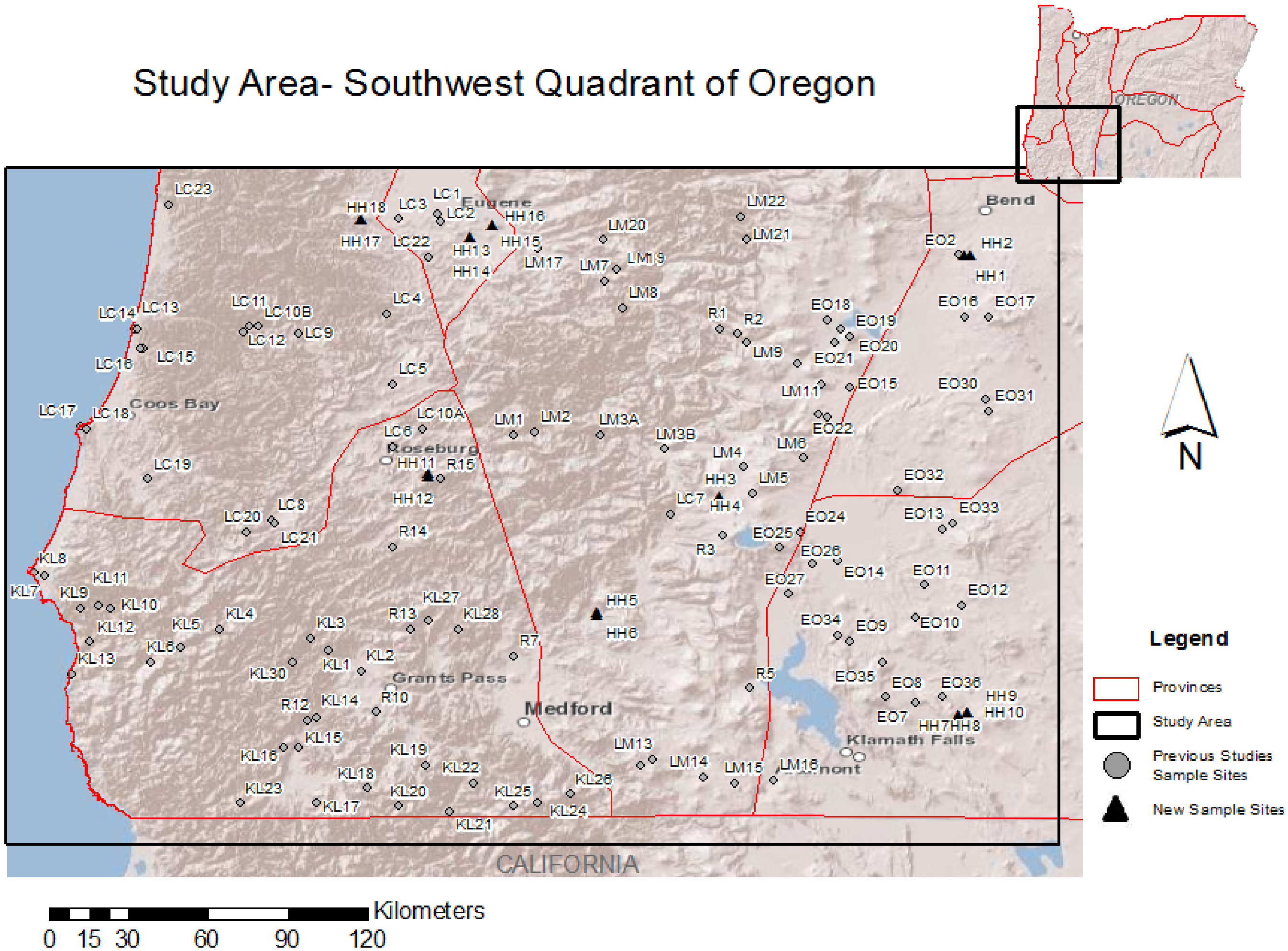

Figure 1. Physiographic provinces (Orr and Orr, 2012) within Southwest Oregon study area with sample locations. Physiographic provinces from lower left corner, clockwise, are the Klamath Mountains, Coast Range, South Willamette Valley, Cascade Range, High Lava Plains and Basin and Range. Province lines are from DEQ (2013).

CHAPTER II: BACKGROUND

2.1 PHYSIOGRAPHIC PROVINCES OF OREGON

Of Oregon’s ten physiographic provinces (Orr and Orr, 2012), six lie within the bounds of the southwest quadrant of Oregon. The Klamath Mountains dominate the study area while parts of the Coast Range, Cascade Range, Willamette Valley, Basin and Range and High Lava Plains stretch into it (Figure 1). Southwest Oregon was covered by ocean until about 150 Ma (Orr and Orr, 2006). The diverse geography we see today in southwest Oregon — with half of all Oregon geophysical provinces present in the southwest quadrant — illustrates the dynamic earth processes that formed them.

2.2 GEOLOGIC HISTORY OF SOUTHWEST OREGON

The Klamath Mountains are formed of accreted ocean crust from the Farallon and later Juan de Fuca plates, and volcanic island chains active in the Mesozoic era (Orr and Orr, 2012). Collision with the North American plate folded and thrust slabs of this material beneath each other, stacking successive terranes like shingles with the oldest terrane (~210 Ma) inland to the east. Various igneous plutons intruded all belts of the Klamath Mountains from 174-136 Ma, which bound the terranes together. Paleomagnetic data from these plutonic intrusions indicate the clockwise rotation of terranes was active during off-shore Jurassic deposition, prior to collision with North America and was mostly completed by about 100 Ma in the early Cretaceous Period (Orr and Orr, 2012).

About 140 Ma, uplift of the Klamath Mountains began (Orr and Orr, 2012). Uplift and an ocean transgressive period continued into the Cenozoic. The Willamette Valley subsided in the late Cenozoic into a northward- dipping marine trough, collecting Klamath debris and sand, mud and silts consistent with marine deposition. The ocean receded, and Willamette Valley held lakes, meandering streams and swamp lands.

The Cenozoic era was dominated by volcanism and sedimentation (Orr and Orr, 2012). Eocene to Oligocene volcanism was brought on by the collision of the Farallon and North American plates. From 35-17 Ma plate subduction and rising plumes resulted in a volcanic arc that produced lavas and ash that created the Western Cascade Range, which is composed of andesites, basaltic andesites and dacites. Plate collision also created a north-south crustal fold that rotated and uplifted marine sediments and Klamath erosional debris and Tertiary ocean-bottom basalts to become the Coast Range. East-West crustal extension of the Basin and Range in the Miocene resulted in basaltic to rhyolitic flow of lavas across the Basin and Range and High Lava Plains (17- 10 Ma), an elevated desert plateau. Crustal failure also resulted in northwest-trending faults for hundreds of miles, active until 7-8 Ma.

From the late Miocene to Holocene (10,000 BP), basaltic and basaltic-andesite lavas from stratovolcanoes and shield volcanoes formed the High Cascade peaks. Less than 2 Ma to 12,000 BP, glacial and interglacial periods resulted in massive geomorphic change in all provinces. Marine terracing occurred along the Oregon coast in the Coast Range and Klamath Mountains, and lahars flowed down High Cascade Mountain sides. Catastrophic flooding covered older bedrock with alluvial fans and gravel terraces and deposited thick silts in the Willamette Valley (Orr and Orr, 2012).

Klamath Mountains

The Klamath Mountains province is bordered by the Pacific Ocean on the west, the Western Cascades to the east, and extends 402 km (250 miles) south from the Coast Range into northwest California. Overall, the summits in this region are of uniform relief. Mount Ashland is the highest point in the Oregon Klamath Mountains at 2,295 m (7,530 feet). From Port Orford, coastal terrain is rocky headlands south to Ophir, then 18- to 24-m (59- to 79-feet) wide sandy beaches to Gold Beach at the mouth of the Rogue River. Cliffs dominate the remaining coastline into California, with occasional thin strips of coastal terraces. The Klamath, Rogue and Chetco rivers drain the province into the Pacific Ocean.

Early Paleozoic to Mesozoic ocean crust and volcanic island arcs accreted through collision and subduction under the North American plate. Successive slab collisions in late Mesozoic resulted in an east-dipping imbrication of terranes, bounded by thrust-faults, with the oldest terrane inland and progressively younger terranes westward to the Pacific Ocean (Figure 2). These terranes were delineated and further divided into subterranes and formations. Descriptions of the Klamath Mountain formations are summarized from Walker and MacLeod (1991) in Appendix A and listed in Table 2. Descriptions of the terranes in the text also list spatially concurrent formations or map units.

The western Paleozoic and Triassic belt was accreted in the mid- to late-Jurassic and rotated to its current position in the late Mesozoic to early Cenozoic. This 322 km long and 80 km (200 by 50 miles) wide belt is divided into four terranes, two of which are in Oregon. The Rattlesnake Creek Terrane (Js, Ju, Jub, Jv, Kc, KJg, mc, Qal, Qt, TRPv, TRPzm) is described as an ophiolitic mélange overlain by ocean arc rocks (Jm, Js and Jv). The Western Hayfork volcanic arc terrane (Jm, Ju, Kc, KJg, Qal, Qf, Qt, TRPv, TRPzs) covered Rattlesnake Creek by the middle Jurassic and was then intruded by plutons (Orr and Orr, 2012).

Jurassic May Creek Terrane (mc) and Condrey Mountain Terrane (cm) are backarc basin remnants that were thrust beneath the Rattlesnake Creek and Western Hayfork terranes. May Creek Terrane is comprised of ophiolites metamorphosed to amphibolites. The Condrey Mountain Terrane is late-Jurassic schist that was then uplifted in the Miocene into a dome structure; the Condrey Mountain dome is believed to be the result of lateral pressure between the Juan de Fuca and North America plates (Orr and Orr, 2012).

The Western Klamath Terrane is composed of ophiolites, island arc volcanic rocks and deep ocean basin sediments (Orr and Orr, 2006) accreted in the late-Jurassic. The Western Klamath Terrane is to the west of the Western Paleozoic and Triassic belt, separated by the Orleans Fault. It runs 322 km (200 miles) along the western edge of the Oregon and California Klamath Mountains. From east to west, the Western Klamath Terrane includes the Smith River, Rogue Valley, Briggs Creek, Dry Butte and Elk subterranes (Figure 2).

The Smith River Subterrane (Js, Jss, JTRgd, Ju, Jub, Kc, KJg, Qal, Qf, Qt) consists of ophiolite, overlain by a thick layer of deep-water shales and turbidite sandstone known as the Galice Formation. The Josephine Ophiolite (160 Ma) developed in a back-arc basin between the Rogue-Chetco volcanic arc and the mainland. It is famous for being one of the world's largest and most complete ophiolite sequences and for its rich economic mineral content, yielding gold, silver, copper, nickel and chromite. Galice Formation sediment sources include both accreted terrain and volcanic arc materials (Orr and Orr, 2012).

Northwest of the Smith River Subterrane are the Rogue Valley (Js, JTRgd, Ju, Jub, Jv, KJg, Qal), Briggs Creek (bc, Jv) and Dry Butte (JTRgd, Ju, Jv, Qls) subterranes.

Table 2. Description of geologic units sampled within Klamath Mountain Province. Unit description summarized from Walker and MacLeod (1991) and province boundary defined by DEQ (2013). Detailed descriptions are found in Appendix B.

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
bc	**amphibolite, quartzite, schist, chert**	Amphibolite of Briggs Creek: amphibolite, micaceous quartzite, quartz schist and recrystallized manganifererous chert
cm	**schist**/ chert	Condrey Mountain Schist: a variety of schistose rocks; rare metachert and metagabbro
cs	**pelitic schist**/ meta-basalt	Colebrook Schist: metamorphosed sedimentary rocks; subordinate metamorphosed submarine pillow lavas and basaltic pyroclastics
Jm	**melange: volcanic, metamorphic and sedimentary rocks**	melange: complex mix of basaltic rocks, serpentinite, chert, argillite, conglomerate, silty sandstone and marble lenses
Jop	**melange: greywacke, mudstone, siltstone, shale**/ various metamorphic rocks	Otter Point Fm./Melange(?): highly sheared greywacke, mudstone, siltstone, shale; lenses of greenstone limestone, chert, blueschist and serpentine
Js	**sedimentary rocks, tuff**/ metamorphic rocks	mudstone, shale, siltstone, graywacke, andesitic to dacitic tuff; minor limestone, phyllite, slate
Jss	**shale, mudstone, sandstone**/ pebble conglomerate	sedimentary rocks with local lenses of pebble conglomerate
JTrgd	**granite, diorite**	felsic to intermediate granitoids: muscovite granodiorite, hornblende gabro, tonalite and quartz diorite
Ju	**harzburgite, dunite**/ serpentinite, gabbro	ultramafic and related rocks of ophiolite sequence
Jub	**basalt, breccia**/ shale, siltstone, mudstone	basaltic volcanic and sedimentary rocks: basalt flows, breccia, agglomerate, pillow basalt and breccia; lesser shale, chert siltstone and mudstone of ophiolitic complexes

(table continues on next page)

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
Jv	**andesite, basalt to rhyolite flows**/ tuff, tuffaceous sedimentary rocks	volcanic rocks: lava flows, flow breccia and agglomerate dominantly andesite; flow rocks basaltic to rhyolitic; interlayered tuff and tuffaceous sedimentary rocks
Kc	**sandstone, conglomerate**	fossiliferous clastic sedimentary rocks
KJds	**sandstone, conglomerate, graywacke**/ chert	sedimentary rocks related to Dothan Formation; chert lenses
KJdv	**basalt**	volcanic rocks related to Dothan Formation: basaltic pillow lavas, volcanic breccia and silicified basalt lava flows
KJg	**tonalite, quartz diorite**/ other granitoid rocks	granitic rocks
KJgu	**gabbro/** pyroxenite, pyroxene, peridotite, dunite, serpentinite	gabbro and ultramafic rocks associated with granitic plutons: hornblende gabbro, gabbro and olivine gabbro; includes pyroxenite, hornblende pyroxene; minor peridotite, dunite, serpentinite
KJm	**conglomerate, sandstone, siltstone, limestone**	Myrtle Group; locally fossiliferous
Ks	**graywacke, conglomerate, shale**	marine graywacke and subgraywacke; conglomerate composed of volcanic, metavolcanic, metasedimentary and plutonic rocks
mc	**amphibolite, schist, gneiss, quartzite**	May Creek Schist
Qt	**terrace**/ alluvium	terrace, pediment and lag gravels: unconsolidated gravel, cobbles and boulders intermixed with clay, silt and sand
Tmss	**sandstone, siltstone, mudstone**	shallow marine sedimentary rocks; contains foraminifera
Tn	**conglomerate, sandstone, siltstone, mudstone**	nonmarine sedimentary rocks with abundant biotite and muscovite
TrPv	**intermediate metavolcanic rock**/ andesite, tuff, basalt	meta-andesite, meta-basalt, spilite, keratophyre, volcanic breccia; andesite flows, breccia, agglomerate, tuff, basalt flows and dacitic tuffs of Applegate Group
TrPzm	**melange: metasedimentary and metavolcanic rocks**	Melange of Dutchmans Peak: heterogeneous mix metamorphosed to upper greenschist, serpentinite, gabbro and metagabbro
TrPzs	**shale, mudstone, sandstone, graywacke, conglomerate, tuff, chert, marble**/ argillite, chert, phyllite, quartzite, limestone, marble	Applegate Group: partially metamorphosed, poorly bedded sedimentary rocks; impure limestone and marble
Tsr	**basalt**/ siltstone, sandstone, tuff, conglomerate	Siletz River Volcanics and related rocks: visicular pillow flows, tuff-breccias, massive lava flows and sills of tholeiitic and alkali basalt; upper part of sequence contains interbeds of basaltic sedimentary rocks

The Rogue Valley Terrane was deposited at the same time as the Galice Formation; it is eight km (5 miles) wide and composed of undersea volcanic flows and ash. The Galice Formation has been locally altered to slate which interfingers with the Rogue Formation volcanics. Briggs Creek Terrane is coarse-grained metamorphic rock, which includes chert, quartzite and folded and altered garnet amphibolites; this is the basement rock for the Rogue Valley volcanic arc. The late-Jurassic, Dry Butte Subterrane is an igneous batholith, thrust beneath Briggs Creek. The Briggs Creek and Dry Butte subterranes are currently considered mid- to late-Jurassic components of the Rogue Valley Arc (Orr and Orr, 2012).

The Elk Subterrane (cs, Js, JTRgd, Ju, Ks, Qt, Tmsc) is composed of sandy turbidites, shales and andesitic lavas. Although this terrane is over 32 km (20 miles) north of the main Western Klamath Terrane, it is placed in the Western Klamath belt due to the thick sequences of Galice Formation submarine slides found within it. The Elk Subterrane is believed to be tectonically displaced 160 km (100 miles) northward from California by faulting (Orr and Orr, 2012).

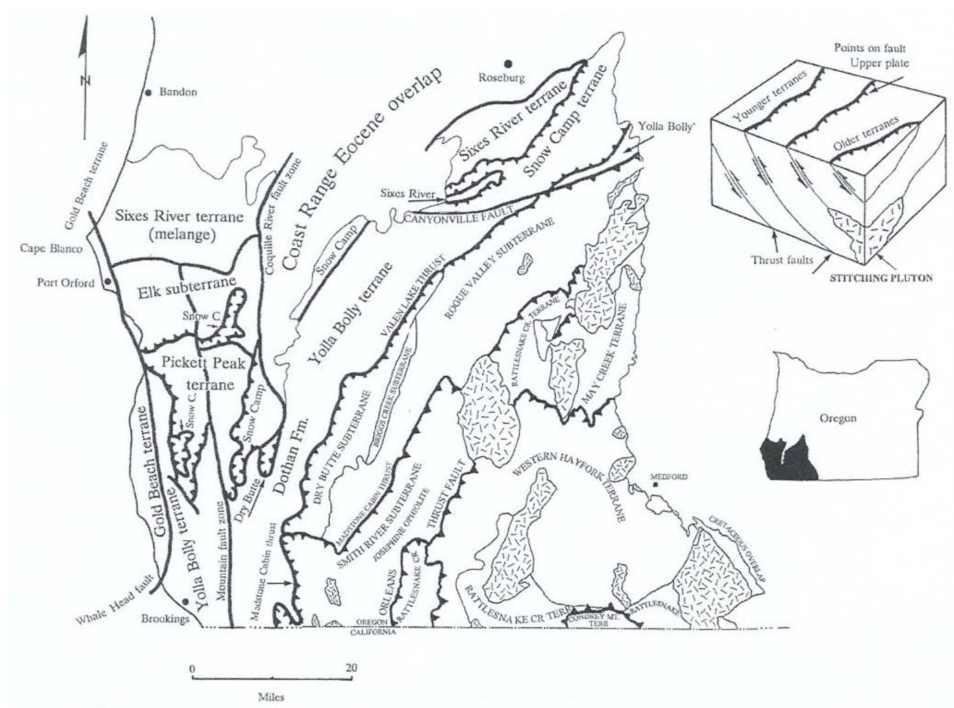

Figure 2. The Klamath Mountain province is comprised of east-dipping terranes, imbricated by subduction and thrust faults. The oldest terrane is to the east with progressively younger terranes to the west (Orr and Orr, 2012).

The southwest Oregon terranes (Figure 2) are the Snow Camp (Jc, Ju, Jv, KJds, KJg, KJm, Qal, Qls, Qt, Tfe, Tut), Pickett Peak (Ju, KJds, KJm), Yolla Bolly (cs, Jc, JTRgd, Ju, Jv, KJds, KJdv, Qls, Tia, Tmsc), Gold Beach (Jop, Ju, KJds, Qal, Tcs) and the Sixes River (cs, Ju, KJds Qt, Tmsc, Tmsm, Tt) terranes and are located on the southwest Oregon Coast and were displaced from the Western Klamath Terrane and transported from the south by early Cretaceous thrust faulting. Formations within the Snow Camp Terrane include the Coast Range ophiolite, late Jurassic Mule Mountain Volcanics, the Jurassic Riddle Formation and the Cretaceous Days Creek conglomerates, silts and sands.

The Oregon section of the Pickett Peak Terrane is made of blueschist; deep sea tuffs, cherts and pillow lavas were metamorphosed in the early Cretaceous into Colebrooke Schist. Late Jurassic to early Cretaceous Yolla Bolly Terrane is composed of forearc basin sands, muds and deep-water cherts. These sediments, known as the Dothan Formation, were transported by turbidity currents from continental and volcanic arc sources (Orr and Orr, 2012).

Gold Beach Terrane includes the late Jurassic Otter Point Formation, and late Cretaceous Cape Sebastian and Hunters Cove formations. The deep-water Otter Point Formation was part of an accretionary wedge at a subduction zone. Cape Sebastian Sandstone and Hunters Cove siltstone include turbidite-deposited deeper sands and shales as remnants from past storms. Sixes River Terrane includes Jurassic and Cretaceous mudstones, sandstones and conglomerates with blueschist and eclogite outsized clasts, as well as limestones, deep-water shales and pillow lavas.

The Klamath terranes were accreted, subject to faulting and clockwise rotation and intruded by plutons. According to paleomagnetic data, rotation occurred from late-

Triassic to early-Jurassic and continued into the early Cretaceous. The late Cretaceous brought a transgressing seaway that inundated most of Oregon. Cretaceous to Cenozoic uplift of the Klamath Mountains pushed the shoreline north and provided sedimentation to the surrounding basin. Fluctuating sea levels resulted in raised marine terraces, some of which are still intact along the southwest Oregon coast. See Appendix A, Figure A.1 for stratigraphy of this province (Orr and Orr, 2012).

Coast Range

The Coast Range extends south from the Columbia River to the Middle Fork of the Coquille River on the northern side of the Klamath Mountains, and west from the Willamette Valley into the Pacific Ocean (Figure 1). The heavy marine influence has extensively eroded the west slopes of the Cascade Range, and heavy precipitation has produced an intricate drainage system and dense forests. Coastal terrain includes abrupt headlands, sea stacks, marine terraces, bays, estuaries, small beaches, sand dunes and spits. Drainage within the province is provided by moderately-sized rivers (Orr and Orr, 2012).

The geologic history of the province includes submarine volcanism, subsidence, uplift and sedimentation (Orr and Orr, 2012). Oblique plate subduction of the Juan de Fuca plate under North America resulted in Eocene to Pleistocene clockwise rotation, faulting and uplift of the Coast Range. However, only the southern part of this province is included in the study area, with the north border of the study area extending from Eugene, Oregon to approximately Florence, Oregon at the coast. Descriptions of the

Coast Range formations within the study area are summarized from Walker and MacLeod (1991) in Table 3.

Table 3. Description of geologic units sampled within the Coast Range. Unit description summarized from Walker and MacLeod (1991) and province boundary defined by DEQ (2013). Detailed descriptions are found in Appendix B.

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
Qal	**sand, gravel, silt**/ talus, slope wash	alluvial deposits; locally, thin peat beds and high in organic material
Qd	**sand**	dune sand; mostly feldspar and quartz minerals
Qls	**landslide: basalt, andesite, tuff**/ slope wash, colluvium	landslide and debris flow deposits are unstratified mixtures of fragments of adjacent bedrock; largest slides and flow occur where thick sections of basalt and andesite flows overlie clayey tuffaceous rocks
Qt	**terrace**/ alluvium	terrace, pediment and lag gravels: unconsolidated gravel, cobbles and boulders intermixed with clay, silt and sand
Ti	**gabbro**/ granitoid	mafic intrusions: sheets, sills and dikes of granohpyric ferrogabbro
Tmsm	**sandstone, siltstone, mudstone**/ conglomerate	**Roseburg Formation:** marine sedimentary rocks with minor conglomerate; contains foraminifera
Tmss	**sandstone, siltstone, mudstone**	shallow marine sedimentary rocks; contains foraminifera
Tpb	**basalt**/ basaltic andesite, dacite	lava flows and breccia of porphyritic basalt, minor basaltic andesite and rare dacite
Tsr	**basalt**/ siltstone, sandstone, tuff, conglomerate	Siletz River Volcanics and related rocks: visicular pillow flows, tuff-breccias, massive lava flows and sills of tholeiitic and alkali basalt; upper part of sequence contains interbeds of basaltic sedimentary rocks
Tss	**mudstone, siltstone, sandstone**/ tuff	tuffaceous marine sedimentary rocks; contains calcareous concretions and foraminiferal assemblage
Tt	**sandstone, siltstone**/ dacite tuff	**Tyee Formation:** rhythmically-bedded marine sandstone and micaceous carbonaceous siltstone; minor interbeds of dacite tuff; foraminifera
Ty	**siltstone, sandstone**/ basalt, lapilli tuff	**Yamhill Formation** and related rocks: marine siltstone; thin interbeds of arkosic, glauconitic and basaltic SS; locally interlayered basalt lava flows and lapilli tuff; foraminiferal assemblages

The oldest Coast Range rocks in the south part of the range are Eocene pillow basalts and breccias, named the Roseburg Volcanics. These ocean-bottom flows were produced in the Siletzia Terrane, which was a Paleocene-Eocene coastal marine basin. The 644-kilometer-long (400 mile) Siletzia platform subsided into a forearc basin in the middle Eocene; deposition from deep-sea fans and deltas and subsequent uplift closed the seaway by late Miocene. This deposition covered Roseburg Volcanics with fluvial and marine deposits: the Lookingglass (Tmsc), Flournoy (Tmss) and Tyee (Tt) Formations. Slope deposits during sea transgression created the Lookingglass Formation. The

Flournoy Formation includes conglomerates, pebbly sandstones and siltstones deposited during the seaway retreat. The Tyee Formation, overlying the Flournoy, is composed of huge submarine fans from river-transported Klamath Mountain sediments. In the middle to late Eocene, inland streams provided sediments to the Elkton, Bateman and Coaledo formations (Tss). These sediments from the Western Cascade Range and northern Klamath Mountains settled in the forearc basin at Coos Bay. The Elkton Formation is mudstone, which coarsens up through the Bateman submarine fan to the Coaledo's coarse delta sandstones. Ash and pyroclastics from the early Western Cascade eruptions provided sediment for the bathyal Bastendorff Shales (Tsd) and overlying marine embayment Tunnel Point Sandstones (Orr and Orr, 2012).

Oligocene marine sedimentation was limited to the central and north coast. Late Oligocene to mid-Miocene included regional uplift that shifted the shoreline near to its present-day location. The Western Cascades eruptions continued to deposit ash into the ocean. The Miocene Tarheel Formation is fossiliferous sandstone and is overlain by the sandstone of both the mid-Miocene Floras Lake Formation and late Miocene Empire Formation. The Empire Formation (Tm, not sampled) is an estuary deposit of silts and fine sands full of mollusks and marine vertebrate fossils. The Roseburg Formation (Tmsm) is composed of deep-sea turbidite mudstone and shales (Orr and Orr, 2012).

Erosion predominated in the Pliocene before Pleistocene glaciations widened coastal plains and rapidly down-cut estuaries and stream valleys. About 11,000 years ago, the climate reversed, and ocean levels rose and submerged the coastline. The Port Orford and Elk River Formations at Cape Blanco and the Coquille Formation at Bandon, Oregon are shallow-water terrace deposits dominated with mollusks. See Appendix A, Figure A.2 for stratigraphy of this province.

Cascade Range

The Cascade Mountains extend north-south 966 km (600 miles) from British Columbia, through the entirety of Oregon (Figure 1). The Oregon Cascade Range is divided into the Western Cascades and the High Cascades. In contrast to the older, eroded Western Cascades (518 to 1,768 m), the younger High Cascades are near double the elevation at greater than 3,353 meters (Orr and Orr, 2012).

The major rivers in the Cascades drain west. Near the study area, the McKenzie River drains into the Willamette River just north of Eugene. Within the study area, the Middle Fork Willamette River also joins the Willamette River system. The Umpqua River drains 180 km (112 miles) from the Western Cascades, through Roseburg and the Coast Range to the Pacific Ocean at Reedsport. East-draining rivers are much smaller, averaging 48 to 56 km (30 to 35 miles) in length.

During the Eocene, a volcanic arc formed along the Pacific Ocean from the subduction of the Farallon Plate. From Eocene to Miocene (40 to 7.5 Ma), thick deposits of volcanic debris, intrusives and marine sediments built the Western Cascades. Volcanic activity prior to 17 Ma produced andesites, basaltic andesites and dacites, after which production lessened and transitioned to lava and ash. Tectonic tilting and folding ceased deposition about 5 Ma, and volcanic activity moved eastward. Basaltic and basaltic andesite lava and ash from the late-Miocene to Holocene stratovolcanoes and shield volcanoes of the High Cascades obscured much of the Western Cascades and were active as recently as a few thousand years before present. Significant volcanic peaks within the study area include the Crater Lake stratovolcano, and the Mt. Bachelor, Mt. Thielsen and Mt. McLoughlin volcanoes (Orr and Orr, 2012).

The geology of the Cascade Range formations within the study area is summarized from Walker and MacLeod (1991) in Table 4. The Western Cascades shared the same depositional regimes as the Coast Range, and therefore include some of the same significant formations (Appendix A, Figure A.3) within the study area. The Umpqua and Lookingglass Formation (Tmsc) siltstone, sandstone and conglomerate present in the Coast Range as siltstone, sandstone and mudstone extends into the Western Cascades. The Roseburg Formation (Tmsm) is partly a shelf and slope facies, and Eugene and Fisher (Tfe, Tfee) Formations are marine and nearshore sands and tuffs, all present across provinces.

Volcanic activity produced the basaltic and andesitic rock Elk Lake and Nohorn Creek (Tbaa). Little Butte, Mehama, Breitenbush and Molalla Formations (Tv) are composed of flows and tuffs. The Sardine Formation (Trb) is described as having andesitic, basaltic andesite and dacitic lavas. In the High Cascades, Mount Mazama eruption resulted in rhyodacitic to andesitic ash-flow deposits (Qma), and more recently the Newberry and South Sister volcanoes (Qrd) produced rhyolite and dacite flow breccia. See Appendix A, Figure A.3 for stratigraphy of this province.

Table 4. Description of geologic units sampled within the Cascade Range Province. Unit description summarized from Walker and MacLeod (1991) and province boundary defined by DEQ (2013). Detailed descriptions are found in Appendix B.

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
Qa	**andesite, basaltic andesite**/ dacite, basalt	andesite phenocrysts are principally pyroxene, olivine, plagioclase, few hornblende
Qal	**sand, gravel, silt**/ talus, slope wash	alluvial deposits; locally, thin peat beds and high in organic material
Qba	**basaltic andesite, basalt**	flows and flow breccia; basaltic andesite of plagioclase, olivine, pyroxene phenocrysts and olivine basalt
Qg	**boulder gravel, sand, rock flour**	glacial deposits in ground terminal and lateral moraines
Qgf	**boulder gravel, sand, rock flour**	partly sorted glaciofluvial deposits in ground terminal and lateral moraines
Qls	**landslide: basalt, andesite, tuff**/ slope wash, colluvium	landslide and debris flow deposits are unstratified mixtures of fragments of adjacent bedrock; largest slides and flow occur where thick sections of basalt and andesite flows overlie clayey tuffaceous rocks
Qma	**rhyodacitic to andesitic ash-flow**	Mount Mazama ash-flow deposits
Qmp	**rhyodacite pumice**	Mount Mazama primary and reworked air-fall pumice deposits
Qrd	**rhyolite, dacite**	domes and related aphric and porphyritic flows and flow breccia on Newberry and South Sister volcanoes
Qs	**clay, silt sand, gravel**/ mudflow, fluvial deposits, peat	unconsolidated to semi-consolidated lacustrine and fluvial sedimentary rocks
Qta	**andesite, basaltic andesite**	flows and flow breccia; plagioclase, olivine, clinopyroxene, and lesser hypersthene and hornblende phenocrysts
QTba	**basalt, basaltic andesite**	flows, flow breccia and pyroclastic deposits; bytownite and labradorite, olivine, calcic augite and hypersthene phenocrysts
QTmv	**basalt, basaltic andesite, andesite**/ pyroclastic rocks	mafic vent complexes: plugs, dikes, breccia, cinders and agglutinate
QTp	**basalt, andesite**	basaltic and andesitic ejecta: scoriaceous cinders, bombs and agglutinate
Tbaa	**basalt, andesite**	lava flows and flow breccia of hypersthene and olivine andesite, basaltic andesite with plagioclase and pyroxene phenocrysts, and basalt
Tfc	**basaltic andesite, andesite**/ dacite	undifferentiated flows and clastic rocks: lava flows, flow breccia, mudflows and volcanic conglomerates
Thi	**diorite, quartz diorite**/ gabbro, biotite quartz monzonite, granodiorite	hypabyssal intrusive rocks
Tmsc	**conglomerate, sandstone, siltstone, mudstone**	marine sedimentary rocks; foraminifera
Trb	**basaltic andesite, olivine basalt**	ridge-capping basalt and basaltic andesite flows and flow breccia
Tsv	**rhyolite, dacite**	silicic vent complexes
Tu	**complexly interstratified epiclastic and**	undifferentiated tuffs, tuffaceous sedimentary rocks, and basalt:
Tub	**basalt, basaltic andesite**	basaltic lava flows and breccia
Tus	**sedimentary and volcanic rocks**/ tuff	basaltic to dacitic sedimentary and volcaniclastic rocks: lapilli tuff,
Tut	**ash-flow tuff**	welded to unwelded vitric tuff; glass locally altered to clay, zeolites and secondary silica minerals
Qyb	**basalt, basaltic andesite**	youngest basalt and basaltic andesite: flows and associated breccia on slopes of Newberry Volcano

Willamette Valley

The Willamette Valley province is a synclinal valley bounded by the Cascade Mountains on the east and the Coast Range on the west, with up to 64 km (40 miles) between the borders. The province is tapered at both ends, with Cottage Grove, Oregon at its southern point, and the Columbia River 130 miles to the north. The basin is a north-dipping syncline, with 122 meters (400 feet) of elevation at Eugene decreasing to near sea level at Portland. The Willamette River meanders north through alluvial plain from near Eugene to the Columbia River. Topography in the southern portion of the valley is fairly flat. This province supports 70 percent of Oregon's population and a diverse agriculture (Orr and Orr, 2012).

Table 5. Description of geologic units sampled within the South Willamette Valley. Unit description summarized from Walker and MacLeod (1991) and province boundary defined by DEQ (2013). Detailed descriptions are found in Appendix B.

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
Qs	**clay, silt sand, gravel**/ mudflow, fluvial deposits, peat	unconsolidated to semi-consolidated lacustrine and fluvial sedimentary rocks
Qt	**terrace/ alluvium**	terrace, pediment and lag gravels: unconsolidated gravel, cobbles and boulders intermixed with clay, silt and sand
Tfe	**sandstone, siltstone/ lapilli tuff, breccia, ash**	**Fisher and Eugene Formations** and correlative rocks; marine arkosic and micaceous sandstone and siltstone
Tfeb	**basalt**	basaltic rocks, **Fisher Formation**(?)
Tfee	**marine sandstone**/ tuffaceous SS, siltstone; pebbly conglomerate	**Marine Eugene Formation**

The environments and sediments of the Willamette Valley are the result of the same geologic influences as the Coast Range. The Siletzia Volcanic Island Terrane collided and accreted with the North America plate, subsided into a forearc basin in the middle Eocene and was buried by marine sediments through the Oligocene. Siletzia volcanics are the basement rock for both the Coast Range and Willamette Valley.

The Willamette Valley subsided into a trough concurrent with the late Cenozoic uplift and tilting of the Coast Range; uplift, tilting and increased sedimentation led to the northward retreat of the ocean. Pleistocene melt-waters increased sediment transport and filled the valley with alluvial sediments. The Missoula Floods then covered the basin with thick silts from 18,000 to about 15,000 calendar years ago (Allen et al., 2009).

Descriptions of the South Willamette Valley formations within the study area are summarized from Walker and MacLeod (1991) in Table 5. The formations in the Willamette Valley province within the southwest Oregon study area are the Eugene Formation (Tfe, Tfee), Lacomb and Leffler Gravels (Qt), and the Rowland Formation (Qs) with overlying Holocene alluvium. The Eugene Formation consists of thick, shallow marine and non-marine sandstones and siltstones deposited during the late Eocene to Oligocene. In the mid- to late-Pliocene, glacio-fluvial sediments from the Cascades and Coast Range created the Lacomb and Leffler (2.5 to 0.5 Ma) gravels. The Rowland Formation (formerly Linn Formation) is composed of thick, glacial outwash gravel fans that invaded from the Cascades (420 ka) after further subsidence and river downcutting in the valley (Orr and Orr, 2012). See Appendix A, Figure A.4 for stratigraphy of this province.

Basin and Range

The Oregon Basin and Range is made of alternating north-south trending mountains and wide valleys, and it extends from the Cascade Mountains on the west to the Owyhee Uplands in the east. The north and south borders are the High Lava Plains and California, respectively. Overall, the elevation average is 1,219 m (3,999 ft.), with the highest elevations east of the study area at Steens Mountain (2,947 m; 9,669 ft.) and

Warner Peak (2,458 m; 8,064 ft.). All drainage is small and toward the interior, except the 31,080 km^2 (12,000 square miles) Klamath River watershed, which reaches the Pacific Ocean from Klamath Lake through northern California (Orr and Orr, 2012).

Regional uplift and crustal extension with consequent faulting and volcanism has resulted in horst and graben physiography by Miocene north-west strike-slip faults and Quaternary north-northeast normal faults. North American plate movement over a mantle plume produced flood basalts at Steens Mountain (17 Ma) and rhyolitic eruptions that prograded across the Oregon Basin and Range and High Lava Plains (Orr and Orr, 2012). Pleistocene cooling increased precipitation and introduced pluvial lakes in the valley lowlands. Descriptions of the Basin and Range formations within the study area are summarized from Walker and MacLeod (1991) in Table 6. The eastern border of the southwest Oregon study area is approximately 233 km (145 miles) west of Steens Mountain.

Significant stratigraphy in the west part of this province includes the Gearhart Mountain Volcanics (Tvm), the Yamsay Mountain Volcanics (Tob, Trh), and the Yonna Formation (Ts) (Appendix A, Figure A.5). Gearhart Mountain is a mid- to late-Miocene andesitic volcano. The Yamsay Mountain shield cone produced basalt, then rhyolitic lavas in the Pliocene (4.7 Ma), emitting a small amount of basalt at the end of its cycle. The Yonna Formation is lacustrine-deposited Pliocene ash and debris (Orr and Orr, 2012).

Both Tertiary and Quaternary deposition were dominated by volcanics, pyroclastics and sediments of basaltic and andesitic composition. Tertiary and Quaternary geologic units sampled within the Basin and Range Province descriptions are summarized in Table 6. For the full description, see Appendix B. See Appendix A, Figure A.5 for stratigraphy of this province.

Table 6. Description of geologic units sampled within the Basin and Range Province. Unit description summarized from Walker and MacLeod (1991) and province boundary defined by DEQ (2013). Detailed descriptions are found in Appendix B.

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
Qba	**basaltic andesite, basalt**	flows and flow breccia; basaltic andesite of plagioclase, olivine, pyroxene phenocrysts and olivine basalt is part of the volcanic sequence of the High Cascade Range
Qf	**alluvial fan, slope wash, colluvium, talus**/ silt, basalt fragments	fanglomerate
Qma	**rhyodacitic to andesitic ash-flow**	Mount Mazama ash-flow deposits
QTb	**olivine basalt/** palagonite tuff, breccia	basalt grades laterally through tuff and breccia into sedimentary rocks
QTs	**sandstone, siltstone/** ashy and palagonitic sedimentary rocks, palagonitized basaltic debris, pebble conglomerate	semiconsolidated lacustrine and fluvial sedimentary rocks, mostly tuffaceous SS and siltstone
QTvm	**basalt, andesite/** pyroclastic rocks	mafic vent deposits: agglomerate, breccia, scoria, cinder, ash, restricted flows and small basaltic intrusions
Tb	**basalt**/ andesite, tuff, tuffaceous sedimentary rocks	basalt flows, flow breccia and basaltic peperite; minor andesite flows; tuffaceous interbeds
Tob	**olivine basalt**/ andesite	basalt grades laterally through palagonite breccia and tuff into tuffaceous sedimentary rocks (Ts)
Tp	**basalt, andesite**	basaltic and andesitic ejecta: scoriaceous cinders, bombs and agglutinate
Tps	**pyroclastic**/ some lacustrine sedimentary rock interbeds	subaqueous pyroclastic rocks of basaltic cinder cones: bombs, breccia and mafic to intermediate tuff
Trh	**rhyolite, dacite**/ andesite, andesite breccia	ash-flow tuff, lava flows, pumice-lapilli tuff, coarse pumicite, blow breccia and rhyolitic to dacitic domal complexes
Ts	**various sedimentary rocks**/ tuff	tuffaceous sedimentary rocks and tuff: tuffaceous SS, siltstone, mudstone, claystone, pumicite, diatomite, vitric ash, palagonitic tuff and tuff breccia, fluvial SS and conglomerate
Tvm	**basalt, andesite**/ pyroclastic rocks	mafic and intermediate vent deposits: agglomerate, breccia, scoria, cinder, flow and inrusive masses forming lava cones and shields
Tvs	**rhyolite, rhyodacite, dacite**	silicic vent rocks: near-vent flows, flow breccia, obsidian, perlite, pumice

High Lava Plains

The High Lava Plains province is an elevated desert plateau bordering five other provinces (Figure 1), extending 241 km (150 miles) to the east from central Oregon, and with about 80 km (50 miles) between the northern and southern border. Only the southwestern portion of the High Lava Plains is within the study area, with the Cascade Range bordering to the west, and the Basin and Range to the south (Orr and Orr, 2012).

Topography is mostly level, with an average elevation of 1.6 km (1 mile) above sea level. Highest elevation is 2,434 m (7,984 feet) at Paulina Peak, located only about five km (three miles) east of the study area. Low rounded domes and steep, flat-topped ridges provide moderate relief between Paulina Peak and the Harney Basin on the east end of the province. Streams are seasonal, with water provided by modest precipitation and snowmelt from nearby mountains.

Descriptions of the High Lava Plains formations within the study area are summarized from Walker and MacLeod (1991) in

Table 7. The High Lava Plains deposition is dominated by Tertiary and Quaternary bimodal lava flows. From the Harney Basin, eruptions progressed northwest to the Newberry Crater (Appendix A, Figure A.6); the oldest eruptions at Duck Creek Butte in Harney Basin are dated at over 10 million years, while the Newberry flows (Qyb) are as recent at 1,300 years ago. Within the study area, the oldest units sampled range from 4 to 10 Ma and include the Devine Canyon and Prater Creek (Tmv) ash-flow tuffs, overlain by Rattlesnake Tuff (Tat). Younger stratigraphy is predominantly basalt and basaltic andesite flows dated less than 6,800 year old (^{14}C), found on the flanks of the Newberry Volcano and to the northwest in the Bend, Oregon area. See Appendix A, Figure A.6 for stratigraphy of this province (Orr and Orr, 2012).

Table 7. Description of geologic units sampled within High Lava Plains Province. Unit description summarized from Walker and MacLeod (1991) and province boundary defined by DEQ (2013). Detailed descriptions are found in Appendix B.

Geologic Unit	**Primary Rock Types**/ Additional Rock Types	Description of Map Units
Qb	**basalt, andesite**	basalt, basaltic andesite, olivine basalt
QTps	**basalt, andesite**	subaqueous basaltic and andesitic ejecta: scoriaceous cinders, bombs, breccia, minor agglutinate
QTst	**rhyolitic to andesitic tuff**/ mud flows, alluvium	tuffacious sedimentary rocks and tuffs
Qyb	**basalt, basaltic andesite**	youngest basalt and basaltic andesite: flows and associated breccia on slopes of Newberry Volcano
Tat	**rhyolitic to dacitic tuff**/ tuffaceous sedimentary rocks	silicic ash-flow tuff; minor tuffaceous sedimentary rocks
Tmv	**basalt, basaltic andesite, andesite**/ pyroclastic rocks	mafic vent complexes: plugs, dikes, breccia, cinders and agglutinate

2.3 CLIMATE

Oregon is divided into nine climatic zones, six of which are represented in this southwest Oregon study area (Figure 3) (Taylor and Hannan, 1999). Zones were established by the National Climatic Data Center using average precipitation and temperature values from NOAA weather stations (Taylor and Hannan, 1999). The following descriptions of the climatic zones and climate 30-year normal averages (1961-1990) are summarized from Taylor and Hannan (1999).

The Coastal Area (zone 1) is characterized by wet winters, relatively dry summers and mild temperatures throughout the year. Annual precipitation averages 165 to 229 cm (65 to 90 inches) along the coast where elevations are lower, and up to 508 cm (200 inches) in the upper elevations of the west slopes in the Coast Range. Summer temperatures increase only about 8 °C (15 °F) above January temperatures. The study area includes the lower half of zone 1.

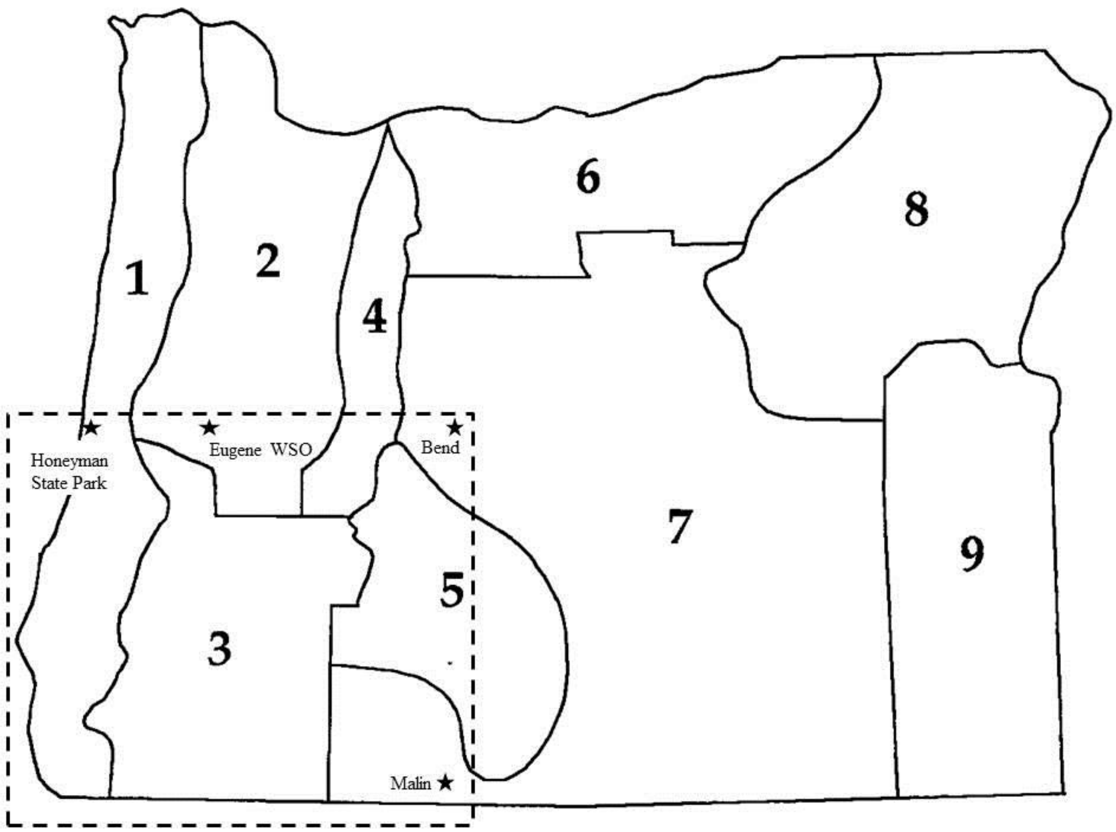

Figure 3. Oregon climate zones (Taylor and Hannan, 1999), with southwest Oregon study area defined within the dashed box. Zones are defined as: Zone 1, the Coastal Area; Zone 2, the Willamette Valley; zone 3, Southwestern Interior; Zone 4, Northern Cascades; Zone 5, the High Plateau; Zone 6, the North Central Area; Zone 7, the South Central Area; Zone 8, the Northeast Area; Zone 9, the Southeast Area. Stations along the study area border are included as a spatial reference.

The Willamette Valley (zone 2) has a mild climate throughout the year with cool, wet winters and warm, dry summers. As with the coastal area, typically half the annual rainfall occurs in the winter months, from December to February. Annual precipitation varies in the valley, with more precipitation at higher elevations. Precipitation in Portland (6.4 m above sea level) averages below 102 cm (40 inches). Average precipitation in Eugene (109 m above sea level) is 117 cm (46 inches) and is greater than 203 cm (80 inches) in the Cascade and Coast Range foothills. Sample sites lie in the southernmost part of this climate zone, near the city of Eugene. The stations local to Eugene are Eugene WSO (110 m, 360 ft.), Noti (137 m, 450 ft.), Cottage Grove (198 m, 650 ft.), Leaburg (207 m, 680 ft.) and Dorena Dam (250 m, 820 ft.). Precipitation averages for these stations are 125-, 154-, 116-, 163-, and 118-cm, respectively (49.25, 60.65, 45.54, 64.11 and 46.65 inches). Mean temperature in zone 2 ranges from about -1 °C to 5 °C (30 °F to 40 °F) during cold months and average from the low 10 °C to low 27 °C (50 °F to 80 °F) in the summer months (Taylor and Hannan, 1999).

All of the Southwestern Interior (zone 3) is included in the study area. The rugged terrain of high mountain ridges and incised river valleys results in precipitation averages from 48 cm (18.85 inches) in the Rogue Valley, to in excess of 305 cm (120 inches) in the Klamath Mountains. Temperature fluctuations in the southwestern interior are large. Mean temperature in zone 3 ranges from -1 ° C (30 °F) to the mid-10s °C (~50 °F) during cold months and average from the low 10 ° C to 32 °C (50 °F to 90 °F) in the summer months (Taylor and Hannan, 1999).

The lower quarter of the Northern Cascades (zone 4) is part of the study area. This zone encompasses high elevations west of the Cascade crest and includes average elevations over 2,743 m (9,000 ft.), extending from 43.5°N latitude to the Columbia River. The northern Cascades receive from 203 cm to over 381 cm (80- to 150-inches) of precipitation (mostly snow), where precipitation increases and temperature decreases with increasing elevation. The Oakridge station (1280 ft.) is the only station listed within the study area, and averages 114.8 cm (45.18 inches) of precipitation annually. The minimum average temperature is -1.3 ° C (29.7 °F), maximum average 28.3 °C (82. 9 °F), and an average temperature range from a few degrees Celsius to 10 °C (high 30s °F to 50s °F) in the winter to about 18 ° C (mid-60's °F) in July (Taylor and Hannan, 1999).

The western half of the High Plateau climatic zone (zone 5) is within the study area. The Plateau has cool temperatures due to its largely high elevations, which average 1,676 m (5,500 ft.). The rain-shadow effect produced by the Cascades is less here than to the north of this zone, because the Cascade crest averages a lower elevation here, and the Plateau elevation is higher, allowing for less of a temperature difference. As a result, there is greater precipitation in zone 5 than the surrounding zone 7, with more than 165 cm (65 inches) in the west at Crater Lake and less than 30.5 cm (12 inches) to the east. The Crater Lake (1975 m, 6480 ft.), Odell Lake (1463 m, 4800 ft.) and Wickiup Dam (1329m, 4360 ft.) stations are within the study area. Mean precipitation is 168-, 85- and 54-cm, respectively (66.28, 33.35 and 21.23 inches). The average temperature ranges from -3 °C (26 °F) to about 2 °C (mid-30s °F) in the winter and about 13 ° C (mid-50s °F) at Crater Lake and about 14 °C to 17 ° C (57 °F to 62 °F) in the summer for Odell Lake and Wickiup Dam (Taylor and Hannan, 1999).

The South Central Area (zone 7) is only partially represented in the study area; only Sisters (969 m, 3180 ft.), Bend (198 m, 650 ft.), Sprague River (1329 m, 4360 ft.), Klamath Falls (1250 m, 4100 ft.) and Malin (1411 m, 4630 ft.) stations are within the study area, which includes the westernmost part of the zone to the left of the "U" created by zone 5. This climate zone is defined by low precipitation. Annual precipitation for the stations listed above is 36-, 30-, 43-, 34- and 34.5-cm, respectively (14.18, 11.70, 16.97, 13.47 and 13.59 inches). The average temperature ranges from -2.6 ° C to about 6 °C (27.4 °F to low 40s °F) in the winter and 16.9 °C to 19.9 °C (62.5 °F to 67.9 °F) in the summer for these stations (Taylor and Hannan, 1999).

2.4 VEGETATION

To obtain the natural distribution of metals in the soil profiles, samples were collected from vegetated locations away from anthropogenic influences. Most sites were heavily forested with species of fir and pine prevailing. In drier climates, Pacific madrone and scrub oak were predominant. Pictures of foliage are included in Appendix C, and vegetation listed by sample site in Appendix E.

CHAPTER III: BACKGROUND WORK ON THE CONCENTRATION OF ARSENIC IN SOILS

3.1 SOILS

3.1.1 SOIL DEFINITION

The definition of soil varies by profession. To an engineer, soil is unconsolidated surficial material (Birkeland, 1999). As disciplines require more details about the soil to study-- for example, its chemistry, mechanical properties or pedogenesis-- the definition becomes more complex. For the purpose of this study, soil is defined as: "a natural body consisting of layers (horizons) of mineral and/or organic constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical, and mineralogical properties and their biological characteristics" (Birkeland, 1999). All soil terms and concepts discussed in this chapter are summarized from Birkeland (1999), unless cited otherwise.

3.1.2 SOIL PROFILES AND HORIZON NOMENCLATURE

The profile of a soil is a two-dimensional vertical arrangement of all the horizons down to the parent material. As soil forms (pedogenesis) and deposition occurs above the parent material, physical and chemical weathering result in horizons within the soil.

The major factors that influence soil formation were defined in a formula by Jenny (1941):

$$\text{Soil} = f\,(cl, o, r, p, t, \ldots).$$

The abbreviations within the parentheses represent the following factors: “cl” for climate, “o” for biota, “r” the topography, “p” the parent material and “t” the time. The ellipsis allows for the addition of unspecified factors that may have local or regional importance to soil formation. All factors despite real world influences on other factors are considered independent variables, where changing a factor will change the soil. By analyzing a single factor and holding the others constant, soil properties may be predicted.

Climate dictates rate of weathering, transport and changes in element species. Organisms recycle nutrients and provide pathways for water, while bacterial decomposition is known to affect the solubility (Banning and Rude, 2010), and therefore transportation of arsenic. Topography influences water flow, water storage and temperature; in the Northern Hemisphere, north-facing slopes, which have thicker A and B horizons, are generally cooler and wetter than south-facing slopes (Birkeland, 1999). Parent material affects the soil type and rate of development. Time is required for soil formation (Jenny, 1941) and allows the other factors to have greater influence on development.

Anthropogenic sources also contribute to elevated arsenic by introducing products with arsenic content, such as some pesticides (organic arsenic), mining and treated lumber, but samples were collected away from these potential human influences. The formation factors are relevant to this thesis only wherein topography, parent material and time were included in the analysis as potential influences on the levels of arsenic in soils.

Soil horizons are termed using capital letters for the master horizons, and lower-case letters to describe characteristics of the sub-horizons. Soil horizon nomenclature and characteristics common to profiles in southwest Oregon are listed in Table 8. The samples for this study were taken only in the A and B master horizons. The A horizon is found at the surface or near the surface beneath the O horizon. The A horizon is defined as having relatively high organic matter mixed with mineral fraction, where the mineral fraction dominates the humified organic matter (Birkeland, 1999). The B horizon is found beneath the A or an E horizon. The B horizon will develop characteristics from the influence of overlying horizons or its parent material; it accumulates clay translated from above horizons and metal compounds such as iron and aluminum, and is typically brown to red in color from iron released from the parent material.

Both horizons were sampled because Burns et al. (1991) found that sometimes the maximum concentration of a metal is found in the A horizon and in older soils it is found in the B horizon. The purpose of this project was to find the maximum concentration so both horizons were sampled.

3.1.3 FIELD SOIL CHARACTERISTICS AND PROPERTIES

Color, texture, organic matter, structure and soil pH are used as aids in the field to qualitatively determine soil materials and current or previous processes that are or have acted on the soil. Use of a Munsell soil color book allows for consistent soil color comparison using notation for the hue, value and chroma, where hue is the dominant color, value ranges from one (dark) to 8 (light), and chroma is the strength of the spectral color from one (least vivid) to 8 (most vivid). Soil with organic matter will present dark brown to black in color with a low value and chroma, and value will decrease (get darker) as organic matter increases. Leaching of oxides and hydroxides above the B horizon,

Table 8: Soil Horizon Nomenclature (Birkeland, 1999).

Master Horizons	Description
O horizon	Surface accumulations of mainly organic material; may or may not be, or has been, saturated with water.
A horizon	Accumulation of humified organic matter mixed with mineral fraction; mineral fraction dominant. Occurs at the surface or below O horizon in forest soils.
E horizon	Usually underlies O or A horizon. Characterized by less organic matter and/or fewer sesquioxides iron and aluminum compounds) and/or less clay than underlying horizon; light in color.
B horizon	Underlies O, A, or E horizon. Shows little or no evidence of original sediment or rock structure. Subdivided by illuvial accumulations or residual concentrations of materials.
	B horizon subdivisions:
	Bt horizon—Accumulation of silicate clay formed in situ or by clay translocation; greater amount of clay than assumed parent material and/or the overlying horizon.
	Bw horizon—Development of color (redder hue or higher chroma relative to C) or structure, or both, with little or no apparent illuvial accumulation or material.
C horizon	A subsurface horizon, excluding R, like or unlike material from which the soil formed, or is presumed to have formed. Lacks properties of A and B horizons, but includes materials in various stages of weathering.
R horizon	Consolidated bedrock underlying soil.

gibbsite within the B horizon in humid areas, and carbonate or gypsum below the B horizon in arid areas will result in a bleaching effect on the soil. Pedogenic iron will color the soil brown or red. Redoxymorphic conditions will result in mottled (red and gray) soils or gray soils if conditions are fully reduced (gleyed) in poorly drained soils.

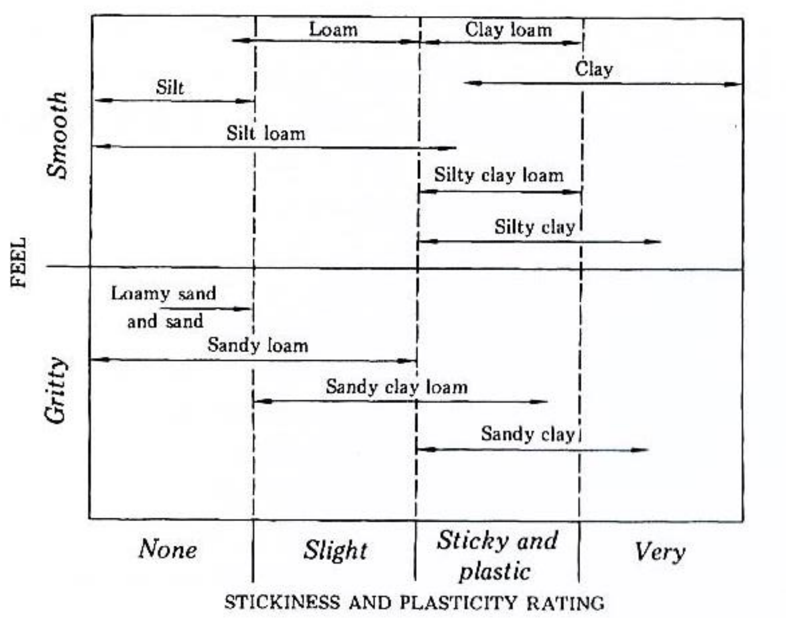

Figure 4: Approximate relations between texture class, grittiness, and wet consistence (Birkeland, 1999).

The texture class is based on the proportion of sand, silt and clay with a particle size less than 2 mm in diameter in the soil. Texture can be determined in the field using Figure 4 and techniques outlined in Appendix 1 of Birkeland (1999). The variation of texture between horizons is a useful tool to interpret the pedogenic and geologic history of the soil. Clay variation with depth can be used to estimate age; the greater the clay content, the older the soil is. Also, soils that are finer in texture will be more chemically active and weather faster (Birkeland, 1999).

Organic matter will be concentrated at the surface. It affects soil structures and reactions, increasing the soil's ability to hold water and the cation-exchange capacity; the increase in chemical reactions results in carbonic acid buildup, a decrease in pH and an increase in weathering.

Structure is classified by the aggregated shape of soil particles. Since horizon formation and subsequent aggregation is a result of the past and active pedogenic processes which then create shapes favorable to the processes, the shapes can be related with particular horizons. A granular structure is indicative of high organic matter, or an A-horizon. B horizons have higher clay content, which is conducive to blocky, prismatic or columnar structures. Platy structures are the result of precipitation and cementation, and will be in an E or K horizon, or labeled as a subhorizon. Structure highly affects water movement and erosion; granular structure has more voids between aggregates, allowing for infiltration of surface water. As porosity decreases due to clay infilling or more compactable structures, the soil's storage capacity will be exceeded and surface runoff will result in erosion. Structure was noted in the field but was not used in the total analysis (Birkeland, 1999).

Soil acidity or alkalinity, measured as pH, influences mineral solubility; dissolution and precipitation is reliant on the proportion of exchangeable ions present in the soil. In acidic soils ($pH<7$), the exchangeable ions of H^+, Al^{3+} and aluminum hydroxides dominate. In alkaline soils (pH>7) the base cations of K^+, Ca^{2+} Mg^{2+} and Na^+ dominate. The pH varies within a soil and should only be used as an estimate of soil weathering and mineral stability (Adriano, 2001).

The pH can also be used to help identify diagnostic soil horizons for soil classification. Base saturation, the percentage of exchangeable base ions (non-hydrogen) that make up the total available cations, is defined to classify soils. However, since base saturation and pH have a positive correlation, and pH is easier to obtain, the pH can be used as a proxy for base saturation for classification. A regional pH-base saturation relationship should be established, but in general 50% base saturation occurs between pH 5 and 6 (Birkeland, 1999). Neither the base saturation nor pH was collected for samples in this study but are discussed as important properties for soil classification.

3.1.4 SOIL CLASSIFICATION

Within the United States, soil is typically classified using the scheme in Keys to Soil Taxonomy (USDA, 2010). Using soil characteristics in the field and laboratory settings, a soil can be grouped into one of eleven soil orders: Entisols, Inceptisols, Aridisols, Mollisols, Alfisols, Spodosols, Andisols, Ultisols, Oxisols, Vertisols and Histosols (USDA, 2010). The soil orders in this study region include Entisols, Inceptisols, Mollisols, Alfisols, Spodosols and Ultisols.

The 11 orders of Soil Taxonomy (USDA, 2010) are generally grouped from least to most developed, where a young soil may begin high in nutrients, then develop and increase in clay, and eventually be leached of nutrients (old soil). However, not all orders are classified by development. The 11 soil orders can be further broken down into 47 suborders and 230 great groups based on more detailed characteristics beyond the scope of this study (Birkeland, 1999).

For the soil orders represented in this study, we focus only on the degree of soil and clay development (Birkeland, 1999). Entisols are young soils with a very mild degree of weathering and slight degree of soil development. Inceptisols are recent soils with mild weathering and a slight degree of soil development. Alfisols consist of mildly acidic clays and have an intermediate degree of weathering and soil development. Ultisols are old, well-developed and leached soils that consist of strongly acid clays with intermediate to strong degree of weathering and soil development. Mollisols are soft, dark, and fertile soils with an intermediate degree of weathering and soil development. Spodosols are commonly found in cool, wet and sandy environments and have an intermediate to strong degree of weathering and soil development. Parent material is bedrock in which soil horizons form from; its physical and chemical composition plays an important role in early soil development.

For analysis, two categories were created that are not technically soil orders. An Alfisols/Ultisols category was assigned to samples where base saturation, the distinguishing characteristic between those two orders, was not determined; physical characteristics between these orders are too similar to make an accurate differentiation without lab testing. This combined Alfisol/Ultisol category shows an intermediate to strong degree of weathering and soil development. The Parent Material category represents sample sites where no soil horizon has developed.

3.2 SOURCES OF NATURALLY OCCURRING ARSENIC

Globally, arsenic concentrations in uncontaminated topsoil (5.1 to 20 cm) can range from 1-100 ppm (McLaren et al., 2006). In the U.S., the range of arsenic in soil and other surficial materials is <0.1–97 ppm, with a mean of 7.2 ppm (USDH, 2007). The range of background arsenic concentrations in soils has been attributed to differences in the soils parent material and its degree of weathering. Typical arsenic concentrations in general rock types were compiled from various sources by Ravenscroft et al. (2009) (Table 9).

Arsenic exists in primary arsenic-bearing minerals which are found in high concentrations in sulfide deposits (Adriano, 2001), or adsorbed onto various mineral phases (Ravenscroft et al., 2009). The common mineral phases — iron, manganese and aluminum oxides — are discussed in the geochemistry section (3.3). Sedimentary rocks have been shown to reach much higher levels of arsenic concentrations than igneous and metamorphic rocks (Table 9). Enrichment of arsenic in rock is attributed to hydrothermal activity in igneous and metamorphic rock; sedimentary rock enrichment is due to pyrite accumulation in swamps for coal and iron hydroxide adsorption in oxic conditions for ironstone (Ravenscroft et al., 2009).

While outside the scope of this study, atmospheric deposition is another source of arsenic accumulation in soils. Despite the large influence of anthropogenic sources on arsenic emissions and subsequent deposition, natural sources of arsenic from volcanic activity and low-temperature volatilization still contribute from 30 to 60% of total global arsenic emissions to the atmosphere (McLaren et al., 2006).

Table 9: Typical arsenic concentrations in rocks and unconsolidated sediments (Ravenscroft et al., 2009).

Lithology (location)	Arsenic (mg/kg or ppm) Mean	Range
Igneous rocks:		
volcanic glass	5.9	2.2 - 12
granite, aplite	1.3	0.2 - 15
andesite, trachyte	2.7	0.5 - 5.8
basalt	2.3	0.18 - 113
gabbro, dolerite	1.5	0.06 – 28
ultrabasic igneous rocks	1.5	0.03 – 16
Metamorphic rocks:		
phyllites, slate	18	0.5 – 143
schist, gneiss	1.1	<0.1 – 19
amphibolite	6.3	0.4 – 45
Sedimentary rocks:		
shale, mudstone	**	3 – 15
sandstone	4.1	0.6 – 120
limestone, dolomite	2.6	0.1 – 20
ironstones	**	1 - 2,900
coal	**	0.3 – 35,000
Unconsolidated sediments:		
alluvial sand (Bangladesh)	2.9	1.0 – 6.2
alluvial mud (Bangladesh	6.5	2.7 – 15
Holocene mud (West Bengal)	7.7	2.8 – 17
Holocene sand (West Bengal)	5.2	0.3 – 16
Pleistocene sand (West Bengal)	1.2	0.1 – 2.3
glacial till (Canada)	**	1.5 – 45
loess (Argentina)	**	5.4 – 18
peat	13	2 – 36

Loess is atypical because of high volcanic ash content.

** is not reported.

3.3 GEOCHEMISTRY: ARSENIC SPECIES AND TRANSPORTATION

The fate and transport of arsenic in soil can be simplified by Figure 5. In this study, we are concerned with arsenic retained in the solid phase of uncontaminated soil. In the near-surface environment in soils, the chemical species of arsenic primarily occurs as As(V) or As(III); corresponding primary arsenic compounds are arsenate (AsO_4^{3-}) and arsenite (AsO_3^{3-}). Retention (adsorption) of arsenic by soils and release (desorption) from soils is influenced by its oxidation state, the surface charge of minerals, the pH of the soil and redox potential. Arsenite is more soluble, mobile and toxic than arsenate, whereas arsenate is generally more readily attracted to and retained by soils and sediments (Adriano, 2001). The negatively charged arsenite and arsenate ions adsorb to positively charged mineral surfaces, most commonly iron, aluminum and magnesium oxides, or to clay due to its high surface area (Ravenscroft et al., 2009). Iron oxides dominate arsenic adsorption, retaining arsenic on the surface of clay particles or as microaggregates (McLaren et al., 2006). The pH affects the charge of oxides; at low pH oxides are positively charged and allow adsorption. In general, as pH increases, adsorption of arsenate will decrease and adsorption of arsenite will increase (Adriano, 2001).

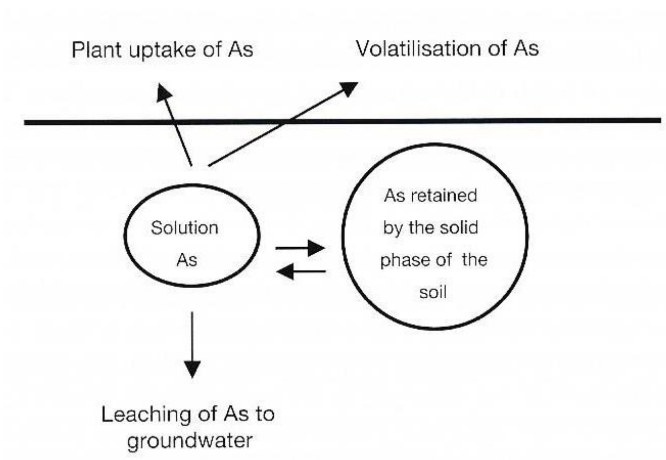

Figure 5: Simplified fate of arsenic in the soil environment (McLaren et al., 2006).

To predict the stability of the arsenic species in different environments, pe-pH diagrams can be used. Redox potential, shown as pe or E_h(mV), is a measure of a species ability to acquire electrons and be reduced. As shown in Figure 6, arsenate is more stable under oxidized conditions, while arsenite is more stable at moderate to low redox potentials below the limits for arsenate (Inskeep et al., 2002).

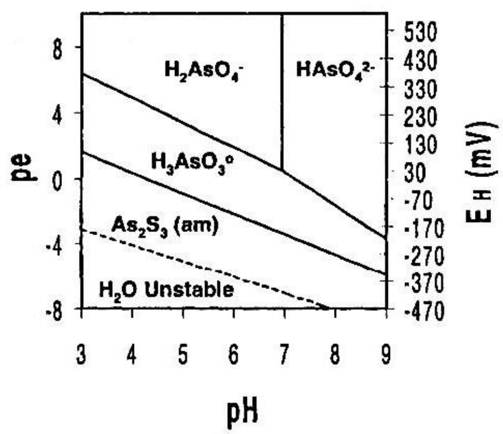

Figure 6: Simplified pe-pH diagram for the As-S-H2O system at 25°C (Inskeep et al., 2002).

3.4 PREVIOUS WORK: ARSENIC IN SOILS IN SOUTHWEST OREGON

Khandoker (1997) sampled 118 sites throughout southwest Oregon in the A and B horizons and found only three samples above the reporting limit of 20 ppm; the B horizon at site R13 had 29.4 ppm, and site KL21 had 36.4 and 46.5 ppm in the A and B horizons, respectively. Locations of these sites are in Figure 1 and characteristics in Appendix E. When retested with the lower detection limit of 0.20 ppm, site R13 was 13.6 ppm, and site KL21 had 32.6 and 26.1 ppm in the A and B horizons, respectively. Both sites are in the Klamath Mountain province. The sample from site R13 is from basaltic volcanic and sedimentary rock unit (Jub) and an Ultisol/Alfisol soil. The samples from site KL21 are from the Condrey Mountain Schist formation (cm) and are Alfisol soils.

DEQ has more recently released a report of the maximum limits permissible by physiographic province (DEQ, 2013). The DEQ analyzed default background concentrations collected by regulatory and educational institutions and consultants; summary statistics and background statistics were used to calculate a regional default background concentration at the 95-percent upper limit (Table 1).

No other current studies were found specific to naturally occurring levels of arsenic in soils in southwest Oregon outside of those related to the Oregon DEQ reports (2013), although there is a study assessing arsenic in groundwater that attributes higher arsenic values to aquifers within specific rock units (Hinkle and Polette, 1999).

CHAPTER IV: METHODOLOGY

4.1 GEOGRAPHIC INFORMATION SYSTEMS

The geologic map of Oregon created by the United States Geological Survey (Walker and MacLeod, 1991) was used as a base map for this study to ensure consistency with arsenic studies done in Oregon previous to this study (Khandoker, 1997; Douglas, 1999). The map was obtained online, and ArcGIS software was used to isolate the lithologic polygons in the southwest Oregon study area. Lithologic units on the map were assumed to be correctly labeled for this analysis. The mapped units were used to ensure good sample coverage in the soils overlying them. In drier climates, such as in eastern Oregon, eolian processes have a much higher influence on arsenic distribution. However, for this study area, it is assumed that soil development is influenced by the weathering of the underlying bedrock.

ArcGIS software was then used to assess the lithologic units (Appendix E: geologic unit) to determine where additional field sampling should be done to maximize sample coverage within the study area. First, the sum of area for each lithologic unit in southwest Oregon was calculated using analysis tools in ArcGIS. The largest units by total area that were not sampled by previous studies (Khandoker, 1997; Douglas, 1999) were selected for sampling: Qyb, Tvm, Thi, Tfeb, Tvs, KJdv, QTa, and Ti. In addition, the previously sampled Tfee unit in Eugene, which had the largest arsenic concentration in Khandoker's study (1997), was selected for resampling. Ultimately, the sum of the area of all lithologic units underlying soil sample sites within the PSU data set represent over 99% of the mapped bedrock in the study area. GIS was also used to determine what formations are within terranes in much of the study area by orthorectifying and digitizing Figure 2, then spatially joining geologic units within the terrane polygons.

4.2 FIELD METHODS

Forty-two samples from soils overlying the nine selected units were acquired July 21-23, 2013. Field sampling was done exactly the same way as was done by Douglas (1999) and Khandoker (1997). Samples from the A and B horizons were collected from uncontaminated, remote and undisturbed soils to avoid anthropogenic influences and obtain the natural distribution of metals in the soil profiles. Once the location was selected, a soil pit was dug with a shovel to reveal the A horizon, and some of the B horizon. A horizons were sampled within the top 4 cm of soil, and B horizons sampled from different locations around the walls of the pit where soil was the most red in color.

To both assess the variability of arsenic within each horizon and validate the consistency of ICP-MS analysis, five samples from the A horizon and five samples from the B horizon were collected for testing. Samples were taken from site HH 11 at different locations around the pit wall within each horizon to test the validity of taking only one sample from the A and B horizons. This one site was chosen randomly for this analysis; additional samples from different pits above this unit, or from other sites, would have added statistical robustness but were not collected because additional sample analysis was cost prohibitive.

The location of each pit was determined by Garmin GPS, using the WGS84 datum with horizontal accuracy of ± 3 meters. Soil properties were recorded using techniques outlined by Birkeland (1999, Appendix 1). Photographs of soil pits and local vegetation at each site were taken (Appendix C). Samples were then placed in a labeled zip-lock bag, and pits filled back in.

4.3 LABORATORY METHODS

In the Portland State University soil lab, the 42 new samples were air dried and soil classifications (USDA, 2010) determined using field notes of soil texture, consistency, and dry Munsell color. Samples were disaggregated using a mortar and pestle, then sieved with a number 10 sieve. Approximately 300 grams were repackaged into labeled zip-lock bags and delivered to Apex Laboratory for testing; however, Apex Laboratories only requires a maximum of 2 grams for ICP-MS analysis.

Soil samples from former studies (Khandoker, 1997; Douglas, 1999) had also been prepared by air drying after the original collection. They were then disaggregated, shaken through a #10 sieve and approximately 300 grams of soil for each sample was bagged for later machine testing. Arsenic concentrations were originally determined by inductively coupled plasma-atomic emission spectrometry (Khandoker, 1997) at a minimum reporting limit of 20 ppm.

For this study, Apex Labs used U.S. Environmental Protection Agency's Method 6020A (EPA, 2007b) for analysis by inductively coupled plasma-mass spectrometry (ICP-MS). Prior to analysis sediments were prepared using acid digestion Method 3051A (EPA, 2007a, which dissolves almost all elements that could become "environmentally available." See Appendix G for partial copies of Apex Labs reports. Samples by work order, quality control sample results, sample preparation information and notes and definitions used in Apex reports are included. Results pages are omitted; these reports are for all samples used for Oregon metals evaluation, only some of which are samples collected by PSU. Results of arsenic for PSU-collected samples are in Appendix D.

All 118 former soil samples (Khandoker, 1997; Douglas, 1999) were re-tested in 2010 by Apex Laboratories in Tigard using ICP-MS with a detection limit of 0.20 ppm, which allows for a more accurate exploration of the true background levels of arsenic in soils of southwest Oregon. Arsenic concentrations of the 42 new samples from July 2013 field work were also tested by Apex Laboratories in October 2013 using the same method and detection limit.

4.4 GROUPINGS FOR STATISTICAL ANALYSES

The statistical analysis started with an examination of the data. Statistical tests used were the Shapiro-Wilk test for normality, Fisher's F-ratio for variance and the Welch t-test for comparison of means between the groups. Wilcoxon Rank-Sum was used for comparison of medians when data was not normally distributed. Horizons were compared to determine if the arsenic in the A horizon (Table 12) should be analyzed separate from the B horizon (Table 13). The detection limit for arsenic is 0.20 ppm. Non-detect samples were assigned a value of 0.001 ppm half the detection limit of the originally reported 0.002 ppm; this method is commonly used for analysis (Helsel, 2006).

A comparison between the samples collected by Portland State University (PSU) students for this study area and a modified DEQ data set was conducted. The samples collected by Douglas (1999) and Khandoker (1997) were first removed from the DEQ data set. The maximum concentration of arsenic measured in samples from each PSU site (136 total sites) was used to compare to the remaining 673 sites from the DEQ data for the provinces in southwest Oregon. Summary statistics and estimates for the two data sets were run using ProUCL Version 4.1.

The maximum arsenic concentrations at each site were then evaluated by their relationship to the following predictors: soil color, soil order, elevation, geomorphic province, and rock age and rock type. The highest value per sample site was used for analysis following the industry standard for determining maximum background levels (Burns et al., 1991). For sites where both the A horizon and B horizon were ND but soil color or order differed, the B horizon was selected for use in analyses. This was done because high arsenic concentrations are often associated with iron oxides and sulfide minerals on clay surfaces (McLaren et al., 2006), which typically concentrate in the B horizon.

To assess a potential relationship with color (or soil development), dry Munsell data were converted to the Buntley-Westin color index (Buntley and Westin, 1965), which indicates the redness of the soil. This color index has assigned values for each hue in the Munsell Color Book and is calculated by multiplying the hue value with chroma. Soil order as recorded by former studies (Khandoker, 1997; Douglas, 1999) was combined with field observations from this study.

Rock analyses in this study include dominant rock type and rock age. The variety of dominant rock types (i.e., sandstone, shale) mapped by the USGS (Walker and MacLeod, 1991) have been simplified to the process that formed them (i.e., sedimentary, metamorphic). The categories were assigned using lithologies described by USGS (Walker and MacLeod, 1991) and the Oregon Department of Geology and Mineral Industries, or DOGAMI (McClaughry et al., 2010). Where mixed lithology did not clearly indicate a primary rock type, assignment was dictated by the parameters listed in Table 10. Descriptions for rocks that included verbiage such as “minor interbeds” and “locally includes” were not considered a primary rock type. For category assignments and lithologic descriptions of each unit, see Appendix B. The reclassification includes the following categories: Metamorphic, Plutonic, Volcanic, Sedimentary, mixed Volcanic/Sedimentary and Unconsolidated sediments (Table 10). Elevation from USGS metadata (Walker and MacLeod, 1991) was converted from feet to meters.

To analyze rock age, the minimum and maximum ages according to the rock unit description (Walker and MacLeod, 1991) were averaged. This was done to provide a single number for relative comparison while taking the duration of deposition into account. For example, a Cretaceous rock unit (65.5 Ma to 145.5 Ma) has a value of 105.5, and a Mesozoic and Paleozoic rock unit (65.5 Ma to 542 Ma) a value of 303.75. A Paleozoic rock unit (251 Ma to 542 Ma) has a value of 396.5. This assigns rocks of similar age but longer duration of deposition a higher value, while maintaining a higher ranking for older deposition. Rock unit ages and ranking are included in Appendix F.

Table 10. Description of rock type categories; mixed lithologies were discerned following these descriptors within the unit descriptions by Walker and MacLeod (1991).

M	Metamorphic: primary rocks are metamorphic, or mixed lithologies are described as mélange, highly sheared or altered.
P	Igneous Plutonic: primary rocks are granite, diorite.
V	Igneous Volcanic: primary rocks are basalt, andesite.
S	Sedimentary: primary rocks are sandstone, siltstone, mudstone, limestone.
VS	Mixed Volcanic and Sedimentary: primary rocks are described as volcanic and sedimentary, tuffaceous sedimentary, undifferentiated or undivided volcanic and sedimentary, or as having one lithology (volcanic or sedimentary) as part of the sequence.
U	Unconsolidated sediments of any lithology not falling under "VS."

Statistical analyses were done to test the validity of the splits in the regression tree using the Shapiro-Wilk Test for normality, Fisher's F- ratio for variance, and the Wilcoxon Rank-Sum Test to compare the center of data between the two groups defined by the split. A regression forest was then done to check the predictions of the regression tree, since forests have been shown to produce better predictions than a single tree (Shih, 2011).

CHAPTER V: RESULTS

5.1 ARSENIC CONCENTRATIONS IN SOUTHWEST OREGON

A total of 255 samples from 136 sites were collected by PSU and used in this study; 123 samples are from the top of the A horizon (Table 12) and 132 samples were taken from within the B horizon (Table 13). The highest arsenic concentrations measured in samples from the A and B horizons, respectively, are 63.2 ppm and 85.4 ppm. These maximum values are both from the Eugene Formation, a marine sedimentary deposit exposed along the eastern margin of the Willamette Valley from Creswell on the south to north of the study area in Scio, Oregon (McLaughry et al., 2010). Of the 255 samples, arsenic was not detected (ND) in 20 (7.8%) of the samples tested at a minimum detection limit of 0.20 ppm; of the ND samples, 11 were from the A horizon and 9 from the B horizon.

Maximum concentrations of arsenic for the 136 PSU-collected sites were mapped using ArcGIS and classed using Jenks natural breaks (Figure 7). The Jenks method clusters data to minimize the average deviation from the mean within each class and maximize the deviation from the means of other classes. The Jenks class with the lowest arsenic concentrations (0.00 to 2.82 ppm) includes 60.3% of the maximum arsenic concentrations, 8.1% of which have no arsenic detected. The second class includes 24.3% of the data. The third, fourth and fifth arsenic classes constitute 13.2%, 1.5% and 0.7% of the data, respectively.

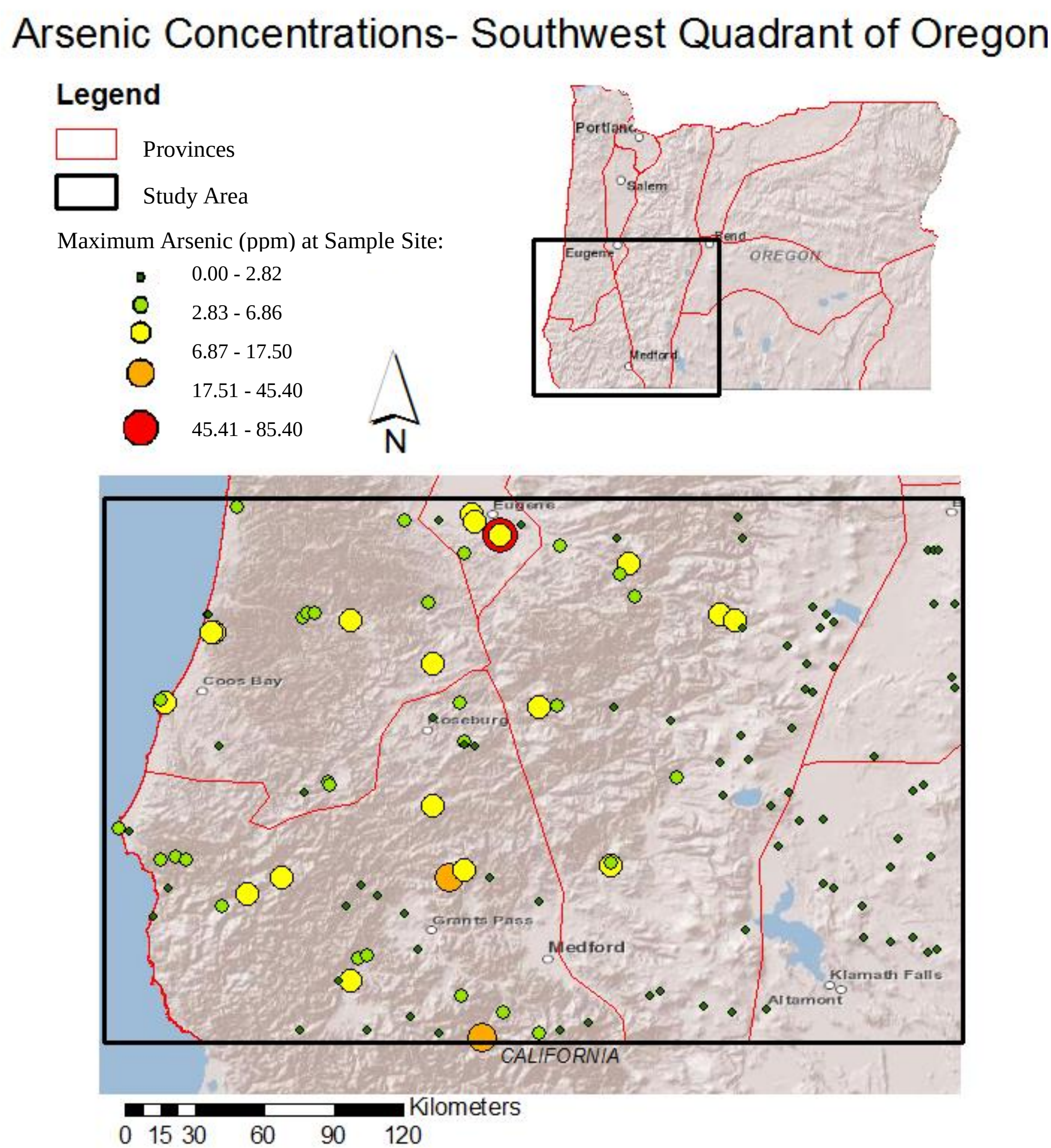

Figure 7. Maximum arsenic concentrations of 136 PSU-collected sites are classed using Jenks natural breaks. Province lines are from DEQ (2013).

5.2 DISTRIBUTION OF ARSENIC IN A AND B SOIL HORIZONS

To test whether the concentration of arsenic was greater in the A or B horizon, the two groups were compared using the results in Table 12 and Table 13. Of 136 sites, 119 sites had samples for both the A and the B horizon; 17 sites were omitted for not having a representative sample in the adjacent horizon. The Shapiro-Wilk normality test (Ellison and Gotelli, 2013) concluded that arsenic levels in both A and B horizons deviated from normality (p-values both <2.2e-16). Fisher's F-ratio (Ellison and Gotelli, 2013) was used to interpret variation. The F-ratio (0.5436) indicates the variance among arsenic samples in the A and B horizon groups is small relative to the variation within the groups A and B (Figure 8).

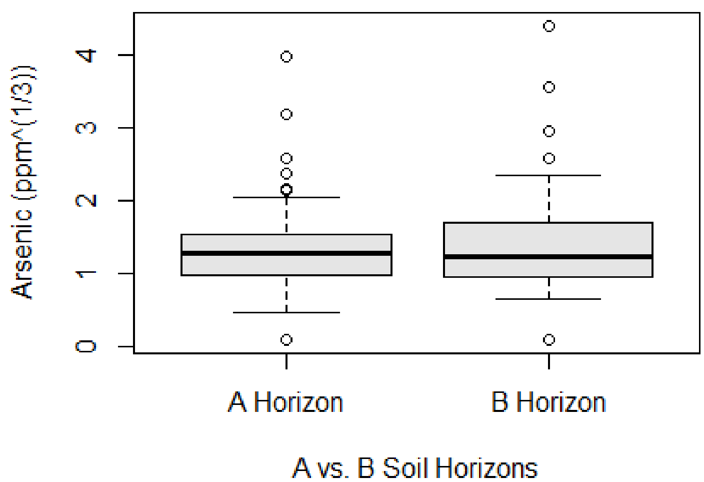

Figure 8. Cube root transformed variance of arsenic within the A and the B horizons for the 119 sites that had samples for both the A and B horizons.

Since the groups deviate from normality, the Wilcoxon rank sum test (Ellison and Gotelli, 2013) was used to compare the median between groups. The center of data for each horizon does not differ significantly (p-value: 0.7567) at a 95% confidence level. The W value (W: 6915.5) is large, so results are less likely to have occurred by chance. Although 47 sites (39.5%) are higher in arsenic in the A horizon while 63 sites (52.9%)

are higher in the B horizon, with 9 sites (7.6%) having no value detected, the A and B horizons are not statistically different (Table 11).

Table 11: Comparison on A and B horizon indicates center of data between horizons is not significantly different.

Data Type: **A vs. B horizon**	**Statistical Test**	**Test Result**	**p-value (α=0.05)**
Raw Arsenic Values	Shapiro -Wilk	W = 0.4099	<2.2e-16 (A horizon)
		W = 0.3696	<2.2e-16 (B horizon)
	F-test	F = 0.5436	0.001044
	Wilcoxon Rank Sum	W = 6915.5	0.7567

Site HH11 was randomly chosen to compare arsenic between A and B horizons and to assess variation within a horizon. Site HH11 is an Inceptisol soil above volcanic rock (KJdv map unit) located at 275 meters elevation in Douglas County within the Klamath province. Five samples were taken from the A and from the B horizons at site HH11. The Shapiro-Wilk normality test concluded that arsenic levels in both A and B horizons have a normal deviation with p-values 0.8981 and 0.8596 for A and B horizons, respectively. Fisher's F-ratio was used to interpret variation. The F-ratio (1.2997) indicates the variance between arsenic samples in the A and B horizon groups is larger relative to the variation within the groups A and B (Figure 9). Since the groups are normally distributed, the Welch Two-Sample t-test was used to compare the median between groups. The test results (Table 14) indicate that with 95% confidence there is a significant difference between the center of data for each horizon subset (p-value: 0.01699).

Table 12. Arsenic concentrations for samples collected in the A horizon, in order of increasing concentration.

Arsenic in A Horizon (ppm)							
Sample	As	Sample	As	Sample	As	Sample	As
HH01	0.001	LM11	0.957	LC04	2.1	HH11.2	3.95
HH02	0.001	LM22	0.965	LM12	2.1	LC12	4.27
HH03	0.001	KL02	0.995	EO27	2.15	HH17	4.28
HH04	0.001	R15	1	KL18	2.22	HH11.1	4.38
HH07	0.001	LM21	1.03	LC17	2.28	HH18	4.54
HH08	0.001	EO33	1.07	LM16	2.32	LC10A	4.58
HH09	0.001	EO22	1.12	KL13	2.36	HH05	4.88
HH10	0.001	EO34	1.15	LM15	2.38	KL19	4.88
HH12	0.001	EO24	1.22	LC13	2.52	LC08	4.96
HH15	0.001	KL24	1.22	KL03	2.57	LC11	4.96
HH16	0.001	LC14	1.25	LM20	2.57	LM02	5.04
KL28	0.1085	LM05	1.26	LC20	2.58	KL08	5.11
LC06	0.301	KL26	1.3	KL11	2.59	KL15	5.14
LM10	0.371	EO16	1.31	LC23	2.66	KL05	5.26
KL23	0.438	EO02	1.36	KL14	2.67	LM01	6.35
EO26	0.483	KL17	1.43	KL12	2.82	LC15	6.44
LM09	0.608	KL20	1.44	KL25	2.88	LC18	6.95
EO01	0.666	EO07	1.46	LM07	2.99	HH06	7.29
EO21	0.687	EO17	1.47	LC21	3.09	LC09	7.36
EO18	0.718	KL01	1.49	LM17	3.13	KL27	7.48
EO20	0.724	EO32	1.5	KL10	3.19	R01	7.94
KL30	0.761	EO08	1.57	HH11.3	3.24	KL04	7.97
EO30	0.762	EO36	1.57	LC22	3.29	LC05	8.74
KL07	0.765	KL22	1.57	KL06	3.43	R14	10
EO15	0.776	EO35	1.62	R02	3.47	LC02	10.1
LC19	0.799	LM14	1.63	HH11.4	3.48	HH13	13.5
EO31	0.821	KL16	1.7	KL09	3.5	R13	13.6
EO23	0.845	R03	1.72	LC07	3.64	LC01	17.2
EO14	0.869	LM13	1.81	HH11.5	3.65	KL21	32.6
EO25	0.892	LM03A	1.92	LM08	3.71	HH14	63.2
LM06	0.914	LC03	2.08	LC16	3.73		

The values for site HH11 in the A horizon were 4.38, 3.95, 3.24, 3.65 and 3.48 with a mean of 3.74 and standard deviation of ±0.44. Values in the B horizon were 4.99, 4.83, 4.51, 4.29 and 4.04 with a mean of 4.53 and standard deviation of ±0.39. Variation within each Site 11 horizon is low (Figure 9); variation is 0.1949 for the A horizon and 0.1499 for the B horizon. Standard deviation for Site 11 A and B horizons is 0.4414 and

0.3872, respectively. Although this should be verified with more pits, the consistency and low deviation within each horizon support that a single sample within a horizon is a good representative of that horizon. This supports the field methodology used in this study of taking only one sample in the A horizon and one sample in the B horizon.

Table 13. Arsenic concentrations for samples collected in the B horizon, in order of increasing concentration.

Arsenic in B Horizon (ppm)							
Sample	As	Sample	As	Sample	As	Sample	As
HH03	0.001	EO18	0.923	LM09	1.79	HH11.2	4.83
HH04	0.001	EO12	0.941	LM12	1.86	LC04	4.9
HH07	0.001	EO17	0.965	KL17	1.9	LC12	4.98
HH08	0.001	LM11	0.977	LM03B	1.96	HH11.3	4.99
HH09	0.001	LM06	1	LM20	2.02	KL08	5.04
HH10	0.001	LM10	1	R07	2.02	KL10	5.28
HH12	0.001	EO16	1.01	LM13	2.03	KL11	5.38
HH15	0.001	EO14	1.02	LM04	2.16	LC02	5.59
HH16	0.001	EO32	1.02	KL18	2.26	KL09	5.7
LC06	0.274	EO02	1.03	LC20	2.33	R12	5.95
KL28	0.328	EO13	1.05	KL03	2.39	LC08	5.97
LC19	0.347	EO10	1.08	KL12	2.54	HH06	6.10
EO19	0.349	LM05	1.1	LM15	2.56	KL19	6.52
EO09	0.496	EO11	1.13	KL13	2.59	LC17	6.86
R10	0.52	EO24	1.14	LM07	2.85	R02	7.13
LM21	0.543	EO27	1.14	LC23	2.9	LC16	7.31
EO30	0.579	EO08	1.15	LC07	3.02	LM19	7.31
EO22	0.587	EO35	1.21	KL25	3.12	KL05	7.38
EO31	0.633	KL24	1.29	HH17	3.13	LM01	7.53
KL26	0.637	R03	1.29	HH18	3.32	KL27	7.7
EO15	0.655	EO36	1.31	LM17	3.32	LC15	7.7
EO21	0.661	KL16	1.31	LC22	3.38	LC18	7.94
EO26	0.693	EO07	1.45	KL22	3.59	KL15	8.63
EO34	0.757	LM22	1.48	LC10B	3.79	KL04	8.71
EO23	0.783	LM14	1.52	KL06	3.82	LC05	10.3
EO20	0.806	KL02	1.56	KL14	3.84	LC09	10.6
LM16	0.809	R05	1.61	HH11.4	4.04	HH13	11.5
KL07	0.814	KL01	1.62	LC11	4.11	R01	11.9
EO33	0.826	R15	1.64	HH11.5	4.29	R14	12.9
EO25	0.83	LC21	1.67	HH11.1	4.51	LC01	17.5
EO01	0.846	KL20	1.73	LM08	4.74	KL21	26.1
KL30	0.884	LC03	1.73	HH05	4.78	R13	45.4
KL23	0.915	LC14	1.74	LM02	4.8	HH14	85.4

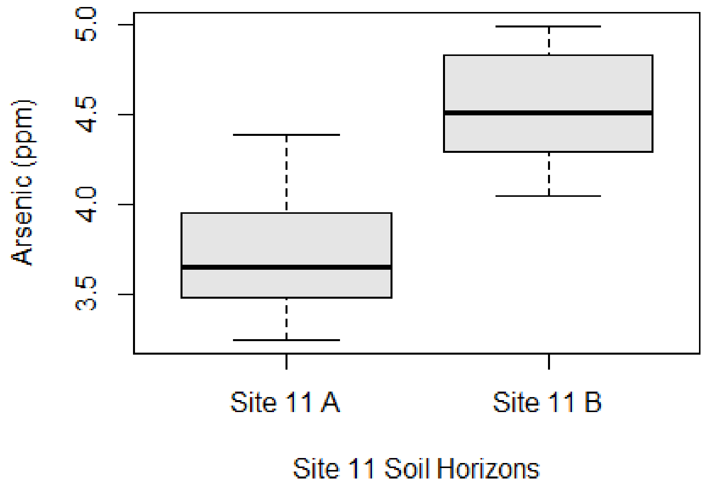

Figure 9. Variance of raw arsenic values within the A and the B horizons at Site 11. The boxplot shows two distinct populations.

Table 14. Comparison on Site 11 A and B horizons indicates center of data between horizons is significantly different.

Statistical Tests Site HH 11	**Raw Values Test Result**	**p-value (a=0.05)**
Shapiro-Wilk	W = 0.9737	0.8981 (A horizon)
	W = 0.9676	0.8596 (B horizon)
F-test	F = 1.2997	0.8056
Welch Two Sample t-test	t = -3.0161	0.01699

5.3 DISTRIBUTION OF ARSENIC IN SOUTHWEST OREGON BY PROVINCE

The Oregon Department of Environmental Quality (DEQ) reported new maximum levels by province. Maximum concentration of arsenic at each PSU site (136 total sites) was compared to the modified DEQ data set (673 sites after PSU sites were removed) for the provinces in southwest Oregon. Summary statistics and background calculations for the two data sets are listed in Table 15 and Table 16, which mirror the format of the DEQ report (2013) for easy comparison. The DEQ data set used in this study only includes data for provinces covered in this study, and does not include the sites collected by former PSU students. As such, these DEQ results differ slightly from the Oregon statewide report by DEQ (DEQ, 2013). It is also important to note that DEQ averaged the concentrations of arsenic for each site to calculate statistics—PSU studies used the maximum value for each site—to define maximum levels.

Summary statistics report detectable arsenic in 92.8% of DEQ data and 87.6% in PSU data. Both DEQ and PSU data sets report Willamette Valley to have the highest average concentrations. All other rankings differ. The maximum detected concentration and also the largest standard deviation was in the Cascades for DEQ data and Willamette Valley for PSU data. The lowest detection was in the Basin and Range for DEQ data but is in the Klamath Mountains for PSU data. For the PSU data, the highest and average concentrations with standard deviation for each province, respectively, are: South Willamette Valley, 85.4 and 21.99 ± 10.5 ppm; Klamath Mountains, 45.4 and 5.42 ± 3.0 ppm; Cascade Range, 11.9 and 2.76 ± 1.2 ppm; Coast Range, 10.6 and 5.15 ± 3.0 ppm; Basin and Range, 2.32 and 1.29 ± 0.5 ppm; High Lava Plains, 1.5 and 1.20 ± 0.2 ppm. The geological units with the maximum concentration for each province for PSU data are Tfee for Willamette Valley, Jub for Klamath Mountains, Tbaa in the Cascade Range, Ty in the Coast Range, Qba in the Basin and Range and Tmv in the High Lava Plains.

Nonparametric background statistics for data sets with non-detects was run using ProUCL, v4.1.1 to compute reliable upper percentiles of background arsenic concentrations, upper tolerance limits (UTLs) and upper prediction limits (UPLs). See Table 16 for background calculation results.

DEQ is currently using 95% UPLs as the new not-to-exceed values (DEQ, 2013). Background calculation ranks the 95% Upper Prediction Limit (UPL) from highest to lowest for the DEQ data set as Cascades (20.5), South Willamette Valley (17.9), Basin and Range (12.8), Coast Range (12.7), Klamath Mountains (9.9) and High Lava Plains (20.5). For PSU data, provinces are ranked South Willamette Valley (70.1), Klamath Mountains (19.0), Coast Range (10.6), Cascades (7.0), Basin and Range (2.1) and High Lava Plains (1.7). The 95% UPL set for the state of Oregon (DEQ, 2013) by province is Cascades (19), South Willamette Valley (18), Basin and Range (12), Coast Range (12), Klamath Mountains (12) and High Lava Plains (7.2). Removing the PSU data from the DEQ data set resulted in 95% UPLs greater than the Oregon limit for Basin and Range, Cascades Coast Range and High Lava Plains in the new DEQ data set and in higher UPLs in the Klamath Mountains and South Willamette Valley for the PSU data set. There are 31 detected values (4.6% of data set) in the DEQ data and 4 values (3.2% of data set) in the PSU data that are greater than the new Oregon limits.

Table 15. Summary statistics for the DEQ and PSU data sets were run for comparison using ProUCL v4.1.

Province	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
DEQ Summary Statistics: All Concentrations in ppm								
Basin and Range	111	80	58.12%	0.7	43	4.29	5.13	Kaplan-Meier
Cascades	143	2	98.62%	0.288	73.4	6.17	8.64	Kaplan-Meier
Coast Range	119	0	100.00%	0.9	16.4	5.72	3.44	Standard
High Lava Plains	89	10	89.90%	1.28	14	3.67	2.21	Kaplan-Meier
Klamath Mountains	59	2	96.72%	1.38	12.8	5.14	2.80	Kaplan-Meier
Willamette Valley	58	0	100.00%	1.96	58.9	9.64	8.20	Standard

Province	Number of Detects	Number Non-Detects	Detection Frequency	Minimum Detected Concentration	Maximum Detected Concentration	Mean	Standard Deviation	Calculation Method (Mean and SD)
PSU Summary Statistics: All Concentrations in ppm								
Basin and Range	15	4	78.95%	0.496	2.3	1.29	0.49	Kaplan-Meier
Cascades	37	2	94.87%	0.349	11.9	2.76	1.21	Kaplan-Meier
Coast Range	19	0	100.00%	0.799	10.6	5.15	2.97	Standard
High Lava Plains	6	2	75.00%	0.762	1.5	1.20	0.22	Kaplan-Meier
Klamath Mountains	42	1	97.67%	0.301	45.4	5.42	2.97	Kaplan-Meier
Willamette Valley	6	2	75.00%	2.08	85.4	22.00	10.47	Kaplan-Meier

Table 16. Background calculation for the DEQ and PSU data sets were run for comparison using ProUCL v4.1.

Province	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
DEQ Background Calculations: All Concentrations in ppm								
Basin and Range	10.87	12.74	Nonparametric KM(z)	11.5	10.9	90% UTL 90% Coverage; 90% KM UPL(t)	12.8	95% KM UPL(t)
Cascades	17.24	20.37	Nonparametric KM(z)	18.6	17.3	90% UTL 90% Coverage; 90% KM UPL(t)	20.5	95% KM UPL(t)
Coast Range	10.49	12.16	Nonparametric	11.4	10.9	90% UTL 90% Coverage; 90% UPL	12.7	95% UPL
High Lava Plains	6.50	7.31	Nonparametric KM(z)	6.9	6.5	90% UTL 90% Coverage; 90% KM UPL(t)	7.4	95% KM UPL(t)
Klamath Mountains	8.73	9.75	Nonparametric KM(z)	9.4	8.8	90% UTL 90% Coverage; 90% KM UPL(t)	9.9	95% KM UPL(t)
Willamette Valley	16.12	17.53	Nonparametric	17.5	16.9	90% UTL 90% Coverage; 90% UPL	17.9	95% UPL

Province	90th Percentile	95th Percentile	Calculation Method (Percentiles)	90% UTL	90% UPL	Calculation Method	95% UPL	Calculation Method
PSU Background Calculations: All Concentrations in ppm								
Basin and Range	1.81	2.00	Nonparametric KM(z)	2.1	1.9	90% UTL 90% Coverage; 90% KM UPL(t)	2.1	95% KM UPL(t)
Cascades	5.88	6.80	Nonparametric KM(z)	6.7	6.0	90% UTL 90% Coverage; 90% KM UPL(t)	7.0	95% KM UPL(t)
Coast Range	8.41	10.33	Nonparametric	10.3	10.3	90% UTL 90% Coverage; 90% UPL	10.6	95% UPL
High Lava Plains	1.51	1.62	Nonparametric KM(z)	1.8	1.6	90% UTL 90% Coverage; 90% KM UPL(t)	1.7	95% KM UPL(t)
Klamath Mountains	15.59	18.5	Nonparametric KM(z)	18.0	15.9	90% UTL 90% Coverage; 90% KM UPL(t)	19.0	95% KM UPL(t)
Willamette Valley	50.9	60.5	Nonparametric KM(z)	75.7	56.7	90% UTL 90% Coverage; 90% KM UPL(t)	70.1	95% KM UPL(t)

CHAPTER VI: DISCUSSION

The primary purpose of this study was to measure the range of naturally occurring arsenic concentrations in southwestern Oregon soils. I will now discuss the distribution of arsenic within horizons, why the DEQ and PSU data differ, as well as what natural factors may be contributing to those levels. Regression tests were applied to assess potential causal relationships between arsenic and environmental factors.

6.1 LEVELS OF ARSENIC IN SOUTHWEST OREGON SOILS

6.1.1 DISTRIBUTION OF ARSENIC IN A AND B HORIZONS

The box plot (Figure 8) for Site HH11 samples illustrates that the A and B horizons are separate populations, and demonstrates the necessity of sampling separate horizons in order to correctly determine the largest concentration of arsenic at a site. The A and B horizon comparisons for the 119 PSU sites taken as a whole set of numbers did not show the horizons to be statistically different. However, if only the A horizon was sampled (Table 12), 53% of the higher concentrations found in the B horizon (Table 13) would have been missed. Likewise, if only the B horizon was sampled, 40% of the samples would have been incorrectly assessed. This practice would result in the interpretation that naturally occurring arsenic concentrations are lower than is actually the case. It is clear that sampling both horizons is important to increase the probability that the highest value within the profile is collected.

6.1.2 COMPARISON BETWEEN DEQ AND PSU DATA SETS

Mapped arsenic concentrations (Figure 7) of the PSU samples show that arsenic from the Cascade Range, and eastward within the study area, only contain low levels of arsenic (<2.82 ppm). This finding is not in agreement with the 95% limit of upper concentrations (7.2 and 12 mg/kg, respectively) set by the Oregon DEQ for the High Lava Plains and Basin and Range provinces. The DEQ data set includes sites that are outside the study area. To obtain the 95% limit used as the DEQ standard (DEQ, 2013), sites to the east of the study area must have much higher concentrations of arsenic in soils. No other spatial relationship is evident between arsenic concentrations and province; west of the Cascade Range, low to moderate soil arsenic concentrations (0-17.5 ppm) were measured.

The difference from the new set standard (DEQ, 2013) in the modified DEQ data set was not large but the 95% UPL calculated for the PSU data set was significantly different from the standard (Table 16). For the PSU data set, UPLs in the Klamath Mountains and South Willamette Valley were higher than the new standard (DEQ, 2013) but much lower for all other provinces. The PSU data set is small enough that it may not be representative of the spectrum of arsenic concentrations in Oregon. Also, the sites in the PSU data set are constrained to the study area, whereas the modified DEQ data set includes all sites within the listed provinces; spatial data was not a part of the DEQ data set and so sites outside the study area could not be removed. This means that sites from formations that are not found within the study area are represented in the modified DEQ data set. Another probable factor contributing to these differences is that DEQ used an average of all values collected at each site to calculate maximum background levels; PSU used the maximum value. In any event, the relationship of arsenic in soils is much more complex than can be defined by the province it is located in.

6.1.3 COMPARISON WITH A FORMER PSU DATA SET

In a study of arsenic concentrations in northwest Oregon, Ricker (2013) evaluated 186 samples from both the A and B horizons. The northwest Oregon study area also included the Coast Range, Cascade Range and Willamette Valley provinces. Results for mean and standard deviation for A and B horizons, respectively, are 6.09 ± 2.65 and 10.26 ± 4.65 for the Coast Range, 3.59 ± 3.72 and 3.25 ± 2.23 for Willamette Valley and 2.45 ± 4.29 and 3.12 ± 4.47 for the Cascade Range.

In comparison, southwest Oregon results for mean and standard deviation for the set of 136 maximum values are 5.15 ± 2.97 for the Coast Range, 21.99 ± 10.47 for South Willamette Valley and 2.76 ± 1.21 for the Cascade Range. The difference in values between studies can be explained by differences in geology in different parts of these provinces. For example, mid-Miocene Columbia River Basalt volcanics occur in the central and northern extent of the Coast Range, but do not extend into the southern part of the range which is dominated by both fluvial and marine deposits of the Umpqua Group — Roseburg (Tmsm), Lookingglass (Tmsc) and Flournoy (Tmss) Formations — and the Tyee (Tt) Formation. Eugene Formation silts and sands (Tfe, marine Tfee) and Fisher Formation tuffs and conglomerates (Tfe) are marine and nearshore deposits (Orr and Orr, 2012) from the late Eocene, when the eastern border of what became Willamette Valley was ocean shoreline (Orr and Orr, 2012). In the late Quaternary, the Missoula Floods brought silts from Montana into Willamette Valley to Eugene (McClaughry et al, 2010);

samples in this study were taken south of Eugene. Samples and statistics by Ricker (2013) for the Willamette Valley likely reflect Missoula Flood deposits. In contrast, the Eugene and Fisher Formations exposed in South Willamette Valley have long been known to have high arsenic (Ravenscroft et al., 2009; Hinkle and Polette, 1999). The values for the Cascade Range are similar because the Cascades are younger soils; the soils have not had enough time to develop a B horizon where oxides accumulate and can adsorb and concentrate higher levels of naturally occurring arsenic.

6.2 RELATIONSHIP OF ARSENIC WITH ENVIRONMENTAL FACTORS

6.2.1 REGRESSION TREE

Regression analysis was done to assess the relationship of six environmental factors to arsenic concentrations: rock type, rock age, soil order, soil color, elevation and geomorphic province. Rock and soil factors were chosen because former studies have stated correlations with rock type (Ravenscroft et al., 2009; Hinkle and Polette, 1999) or with clays (Ravenscroft et al., 2009) to high arsenic. Elevation and province were chosen to investigate potential spatial relationships, since new DEQ limits are delineated by province.

Using a statistical regression tree produced the root, node 1: soil order, node 2: elevation and node 3: rock type as the strongest influences on arsenic concentrations (Figure 10). Each node was looked at individually and tested for normality and variance using the Shapiro-Wilk test and the F-Test, respectively (Ellison and Gotelli, 2013). The leaves of the tree report the number of observations and mean of arsenic concentrations.

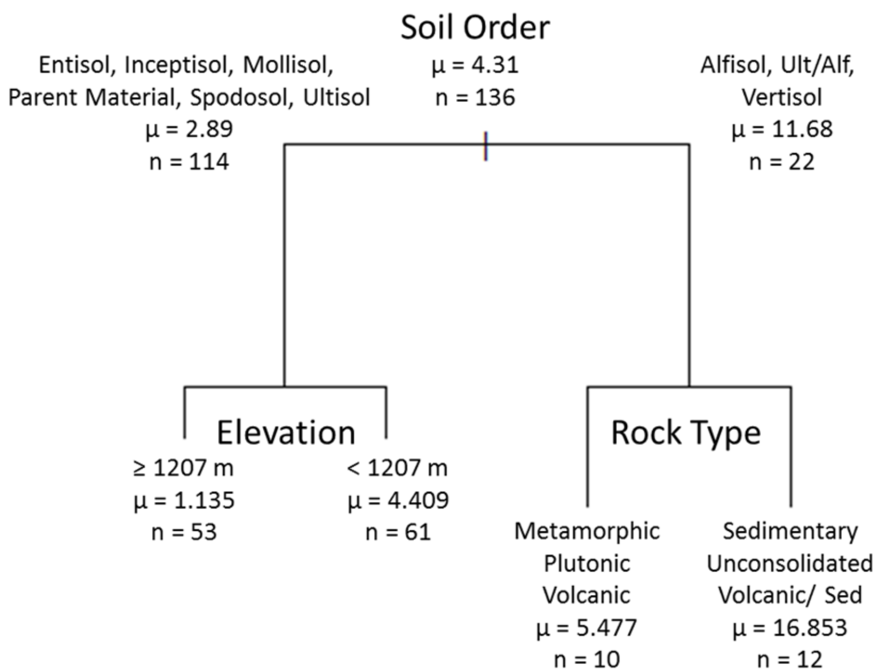

Figure 10: Regression tree indicates soil order, elevation and rock type are key factors. The regression splits groups with higher mean arsenic concentration to the right branches.

Node 1, soil order, splits the data at the mean of arsenic (μ=4.31).This splits the data into groups Node 1L and Node 1R. Node 1L (n=114) consists of soil order groups Entisols, Inceptisols, Mollisols, Parent Material, Spodosols and Ultisols. Node 1R (n=22) consists of Alfisols, Ultisols/Alfisols and Vertisols. Node 2, the left split from Node 1L, is based on the elevation of the 114 samples that do not include Alfisol or Vertisol orders. Node 2L consists of elevations greater than or equal to 1,207 meters (n=53). Node2R contains elevations less than or equal to 1,207 meters (n=61). Node 3 splits Alfisols, Ultisol/Alfisols and Vertisols by rock type into Node 3L (n=10) and Node 3R (n=12). Node 3L includes metamorphic, plutonic and volcanic rock types, and Node 3R includes sedimentary, unconsolidated sediments and mixed volcanic/sedimentary units.

6.2.2 FOREST REGRESSION

The random forest was performed on the data set multiple times using the R Party Package; a conditional permutation scheme provides unbiased variable selection and variable importance for predictor variables of different types, as well as reduces the appearance that correlated predictor variables are more important that uncorrelated ones (Strobl et al., 2009). Conditional variable importance is calculated by randomly shuffling the values of a given independent variable thereby "breaking" the variable's bond to the response. Then, the difference of the model accuracy before and after the random permutations, averaged over all trees in the forest, tells us how important that predictor is for determining the outcome (Shih, 2011; Strobl et al., 2009).

At 2,000 trees, the results were consistent between forests with different random seeds set (Table 17). The variable importance plot ranked elevation high, followed by soil order and rock type (Figure 11). The forest regression predicts the same three variables as the regression tree for significant predictors of arsenic, however, the regression tree ranked soil order as more significant than elevation. Predictors in the forest regression are considered significant when they rank larger than the absolute value of the largest negative value in the variable importance test.

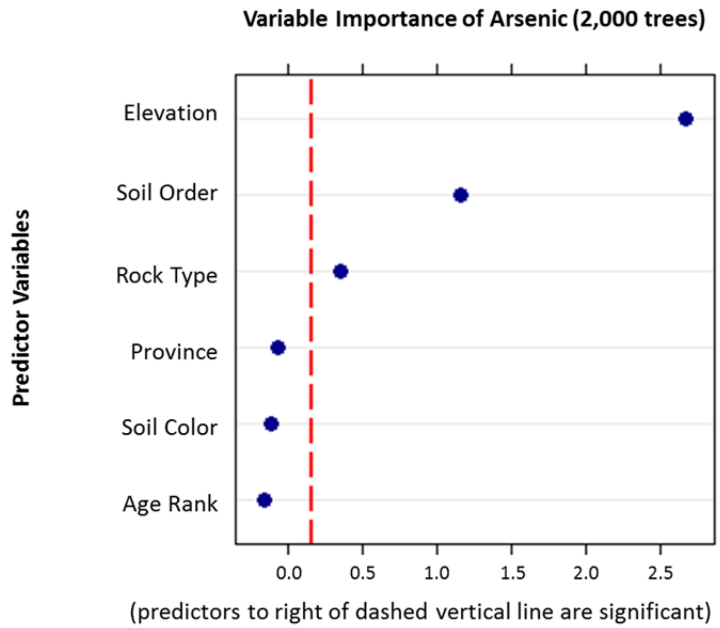

Figure 11: Variable importance plot showing the predictive ranking of variables using a 2,000 trees forest and random seed of 729.

Table 17. Using the Party Package in R, forest regressions were done with increasing tree numbers until ranking for significant predictors did not vary with different seeds.

Variable Importance Results from Three 2,000-Tree Forests

Seed	Elevation	Soil Order	Rock Type	Province	Soil Color	Age Rank
729	2.6674	1.1541	0.3470	-0.0632	-0.1080	-0.1564
1052	2.8072	1.4535	0.3697	-0.1224	-0.1390	-0.2547
2594	2.6708	1.2964	0.3773	-0.1837	-0.1018	-0.1484

6.2.3 RELATIONSHIP OF ARSENIC TO SOIL ORDER

The box plot for Node 1 (Figure 12) shows the variance within each sub-group. A comparison between the soil order sub-groups indicates that Alfisol and Vertisol soils have a much higher variation. The Shapiro-Wilk normality test shows that neither Node 1R nor Node 1L has a normal distribution (p-values: 1.2e-06 and 5.8e-09, respectively). Box-Cox analysis was completed to see if a normal distribution could be obtained through transformation ($\lambda = 0.2626$ at 95% confidence interval), and indicated cube root transformation would convert raw data to a distribution closer to normal. Cube transformation resulted in a normal distribution for Node 1R, only (Shapiro-Wilk p-values: 0.125 versus 1.59e-4 for Node 1L) so node data was not transformed for regression tests. Data were cube root transformed for variance plots for visual clarity. The means of the two groups are widely separated compared to within each group (F-ratio: 55.8534), so variance in Node 1R is unequal to the variance in Node 1L.

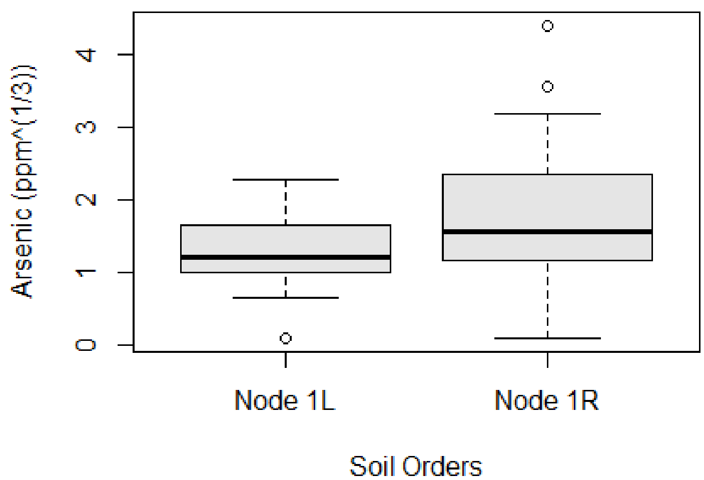

Figure 12: Cube root transformed variance of Alfisols, Ultisols/Alfisols and Vertisols (Node 1R) versus Entisols, Inceptisols, Mollisols, Parent Material, Spodosols and Ultisols.

To determine if there is a significant difference between soil order groups a nonparametric test was used, since it does not require normal distributions or equal variance to be valid. The Wilcoxon rank sum test (Ellison and Gotelli, 2013), which is moderately robust for non-normal distributions and unequal variance, was used and the results indicate that the means of arsenic concentrations in the two soil order groups are significantly different (p-value = 0.01463). The F-ratio and Wilcoxon test support that Node 1R and Node 1L are statistically different; the arsenic concentrations for soil orders that include Alfisols and Vertisols are significantly different than arsenic concentrations for soil orders that do not include Alfisols and Vertisols. This is a reasonable division; Alfisols, Ultisols and Vertisols are older than the other soils, and therefore have had more time to accumulate the oxides and clays that retain and concentrate arsenic. Statistical results are listed in Table 18.

Table 18: Summary of statistical tests run on Node 1 of the regression tree for soil order by split: orders that include Alfisols and Vertisols versus other orders.

Data Type: Node 1	Statistical Test	Test value	p-value (α=0.05)
Raw Arsenic Values	Shapiro -Wilk	W = 0.5957	1.193e-06 (Alfisols, Ult/Alfs and Vertisols)
		W = 0.8605	5.814e-09 (non-Alfisol and Vertisol soils)
	F-test	F = 55.8534	< 2.2e-16
	Wilcoxon Rank Sum	W = 1667.5	0.01463
Cube Root Arsenic Values	Shapiro -Wilk	W = 0.9304	0.125 (Alfisols, Ult/Alfs and Vertisols)
		W = 0.9456	1.59e-4 (non-Alfisol and Vertisol soils)
	F-test	F = 3.6943	6.837e-06
	Wilcoxon Rank Sum	W = 1667.5	0.01463

6.2.4 RELATIONSHIP OF ARSENIC TO ELEVATION

The two subsets from Node 2 of the regression tree were split based on elevation. Higher arsenic concentrations occur in the lower elevation subset which also has more variability as can be seen in the box plots that were created to graphically represent these two subsets (Figure 13). The Shapiro-Wilk normality test indicates that arsenic concentrations in the low elevation subset (Node 2R) is not normally distributed, but data at elevations greater than 1,207 meters are normally distributed (p-values: 2.759e-16 and 0.0797, respectively). To see if normality could be attained by transforming the data, Box-Cox analysis (Gotelli and Ellison, 2013) was conducted (λ = 0.2626 at 95%

confidence interval). The lambda (λ) value from the Box-Cox indicates that a cube root transformation of arsenic data may show normal distributions for arsenic concentrated in samples collected from low elevation. Results from the Shapiro-Wilk normality test show that subsets defined by Node 2R and Node 2L are not normally distributed despite cube root transformation of the data, so raw data were again used for further analysis (Shapiro-Wilk p-values: 9.5e-06 and 6.7e-08, respectively). The cube root transformed data were again used for variance plots for visual clarity and for comparability.

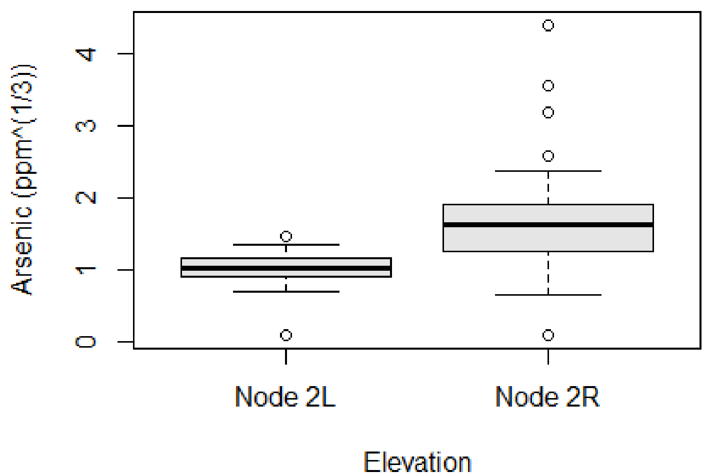

Figure 13: Box plots for subsets created by the regression tree at Node 2. Node 2L contains the data set with elevations above 1,207 m. while Node 2R is the data set below 1,207 m.

The F-ratio test indicates that the two data sets do not have equal variance (F-ratio: 238.4). Since distribution is not normal, the Wilcoxon test was again used; the means of Node2R and Node 2L are statistically different (p-value: 4.4e-13). Higher soil arsenic concentrations are found at elevations lower than 1,207 meters. Statistical results are listed in Table 1.

Table 19: Summary of statistical tests run on Node 2 of the regression tree for both elevation splits: less than or equal to 1,207 m. and greater than or equal to 1,207 m.

Data Type	**Statistical Test**	**Test value**	**p-value (α=0.05)**
Raw Arsenic Values	Shapiro -Wilk	W = 0.4275	2.759e-16 (1,207 m)
		W = 0.9614	0.0797 (1,207 m)
	F-test	F = 238.4135	< 2.2e-16
	Wilcoxon Rank Sum	W = 3842.5	4.4e-13
Cube Root Arsenic Values	Shapiro -Wilk	W = 0.8997	9.483e-06 (1,167 m)
		W = 0.7655	6.718e-08 (1,167 m)
	F-test	F = 2.8591	7.891e-05
	Wilcoxon Rank Sum	W = 3842.5	4.4e-13

6.2.5 RELATIONSHIP OF ARSENIC TO ROCK TYPES

Node three of the regression tree separated subsets based on rock type. The most variability of all the subsets analyzed occurs in the group containing sedimentary and mixed volcanic and sedimentary rock types and unconsolidated sediments. The highest arsenic concentrations are also in this subset (Node 3R) as can be seen by the box plots that were created to graphically present both subsets of Node 3 (Figure 14).

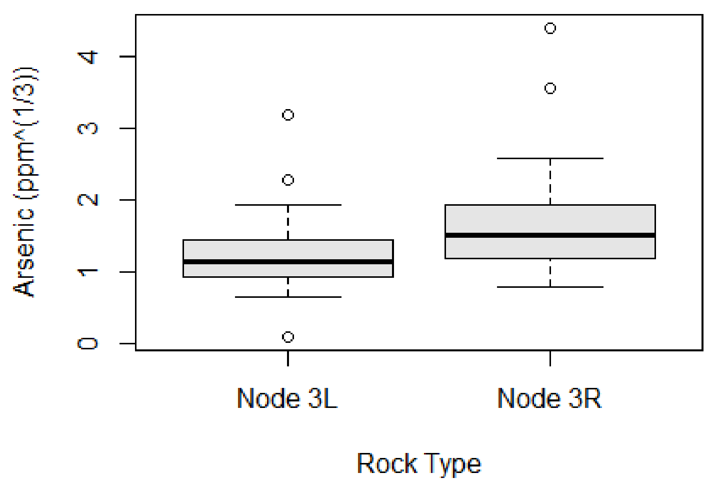

Figure 14: Box plots of arsenic values for the subsets created by the regression tree at Node 3. Node 3R contains sedimentary, mixed volcanic/ sedimentary rock types and unconsolidated sediments while Node 3L contains metamorphic, plutonic and volcanic rock types.

Results of the Shapiro-Wilk normality test (Table 20) indicate that arsenic concentrations in both splits of Node 3 do not have normal distributions (p-values: 3.6e-14 and 1.1e-14, respectively). Box-Cox analysis indicates that the two subsets may show normal distributions after cube root transformation of the data ($\lambda = 0.2626$ at a 95% confidence interval). The Shapiro-Wilk normality test was conducted on the cube transformed data, and the results for the rock type groups defined by Node 3R and Node 3L (p-values: 1.3e-06 and 2.8e-04, respectively) still show that the data sets are not normally distributed. Therefore, raw data were preserved for regression analyses, and again, cube root transformed data were used for variance plots for visual clarity and comparability.

Table 20: Summary of statistical tests run on Node 3 subsets for both rock type origin splits: sedimentary with mixed sedimentary/volcanic and unconsolidated sediments versus metamorphic, plutonic and volcanic rock types.

Data Type	Statistical Test	Test value	p-value (α=0.05)
Raw Arsenic Values	Shapiro -Wilk	W = 0.4079	3.637e-14 (Sedimentary, Volcanic/ Sed, Unconsolidated)
		W = 0.4984	1.087e-14 (Metamorphic, Plutonic, Volcanic)
	F-test	F = 238.4135	< 2.2e-16
	Wilcoxon Rank Sum	W = 3326.5	4.527e-06
Cube Root Arsenic Values	Shapiro -Wilk	W = 0.8373	1.315e-06 (Sedimentary, Volcanic/ Sed, Unconsolidated)
		W = 0.9264	0.0002829 (Metamorphic, Plutonic, Volcanic)
	F-test	F = 1.166	0.5267
	Welch's T-Test	t = 4.7053	6.751e-06

The F-ratio test was conducted and shows that there is not equal variance between the two subsets (F-ratio: 238.4) and indicates there is a large separation in the means of these groups compared to within each group. Since the two subsets failed to show normal distributions the Wilcoxon rank sum test was used to see if arsenic concentrations are significantly different between rock type subsets. The test results (Table 20) indicate that there is a significant difference between the two subsets (p-value: 4.5e-06).

6.2.6 SUMMARY OF TOP THREE PREDICTORS

Statistical analyses of 255 soil samples were studied to determine any relationships that exist between six environmental predictors and arsenic concentrations in southwestern Oregon. Initial analysis included a Classification and Regression Trees (CART) model, which determined that three of the six environmental predictors are influential on arsenic levels: soil order, elevation and rock type. Validation of the CART model with random forest analysis resulted in the same three variables selected as important predictors. Non-parametric analysis using the Wilcoxon test was used as the raw data for three predictors did not show equal variance or normal distribution. For all three predictors, the null hypothesis was rejected as there is a significant difference between the median within each subgroup. This validates the logic of the splits in the CART models.

According to Ravenscroft et al. (2009), high soil-As or inorganic arsenic is associated with carbonaceous shales and volcanic materials and rocks, with silt and clayey soils generally containing more arsenic than sandy soils. This study was found to concur that soil with more clay contain higher arsenic; percent clay was not tested, however soil orders defined as having a well-developed B-horizon, which accumulates clay minerals, were grouped as having a higher mean of arsenic concentrated in soil. Sedimentary rocks showed the highest arsenic levels; soils collected from sample sites underlain by sedimentary, mixed sedimentary and volcanic or unconsolidated rock had the highest mean of arsenic (μ=16.85).

The first important predictor of arsenic levels was soil order. The few soil orders that do contain Alfisol, Ultisol/Alfisol and Vertisol soils (n=22), showed greater variation and higher arsenic levels ranging from 0.001-85.4 ppm (Figure 12). Entisols, Inceptisols, Mollisols, Spodosols, Ultisols, and Parent Material, (n=114), have less variation in arsenic levels, 0.001-11.9 ppm. In general, Alfisols, Ultisols and Vertisols have increased weathering, soil and clay development and support literature that arsenic levels are greater in soil orders with increased clay development (Ravenscroft et al., 2009). Despite Ultisol being the most well developed soil, it was grouped by the regression tree with less developed soils. The mean for Ultisol soils was 3.52 and 3.94 for the A and B horizons, respectively. The Ult/Alf order had a higher mean of 8.2 for the A horizon and 15.12 for the B horizon. The pH and reclassification of the Ult/Alf samples to Ultisol or Alfisol orders would be necessary to determine if these higher values would raise the mean arsenic for Ultisols enough to fit with the other well developed soils in the regression analysis.

Elevation was a second important predictor of arsenic levels (the most important predictor by forest regression). Samples taken from lower elevation 1,207 m, (n=61), have higher levels of arsenic between 0.001-85.4 ppm, while samples collected at higher elevation 1,207 m, (n=53), were found to contain lower levels of arsenic, 0.001-3.12 ppm (Figure 13). The highest values were in Eugene, Oregon at only 292 meters.

Rock weathering is a natural process leading to the release of arsenic and its introduction to the aquatic environment (Mitsunobu et al., 2006). The mountain ranges of this study area receive a considerable amount of rain, where arsenic is carried downstream in water or sediments and accumulates in low-lying areas. These findings may indicate that biota and communities at lower elevations are at a greater risk for exposure to arsenic but to what degree is not a part of this study.

Node 3 split arsenic concentrations by rock type. Study of rock type revealed that variation in arsenic levels with mixed volcanic and sedimentary, sedimentary and unconsolidated rock (n=12) is greater with a range of 0.496-85.4 ppm, compared to arsenic levels in Metamorphic, Plutonic and Volcanic origins (n=10), with a range of 0.001-32.6 ppm (Figure 14). The split by the CART model again seems logical; volcanic activity and rock weathering release arsenic, hydrologic processes transport arsenic from high mountain ranges to areas below where sediments accumulate, then arsenic adsorbs to sediments. The highest arsenic concentrations in this study are within a region where the high arsenic concentration in aquifers is associated with volcanic and sedimentary rock (Hinkle and Polette, 1999). Lastly, the map scale of 1:500,000 (Walker and MacLeod, 1991) only provides for the dominant rock type where the sample was taken, so error may be introduced if it is not the parent material for that soil.

A potential issue in the study of arsenic concentration is how non-detect samples are reported for analyses. Helsel (2006) indicates that replacing the detection limit with an arbitrary fraction results in inaccurate analyses of regression slopes, correlation coefficients, means and standard deviation. As further research on arsenic concentration is conducted, this must be factored into the analysis. R packages (NADA) are available to help analyze non-detects (Helsel, 2006), and the ProUCL software has tests specifically for data sets that include non-detect samples.

Caution was exercised when creating the data set for our CART model to avoid inflating predictors; the maximum sample from each site was selected instead of including all data and treating each sample as independent despite being taken from the same site. Development of proximal horizons certainly share the same environmental influences, however, the degree of influence on one horizon from another is difficult to measure and beyond the scope of this study.

Power is a factor that must be considered when performing data analysis. As data are reformatted and transformed away from their original format, power is lost. When data have unequal variance and non-normal distribution, non-parametric tests like the Wilcoxon Rank Sum test are used. This statistic ranks data, thereby lowering the power. The lower the power of the test, the higher will be the probability of a type II error as power is the probability of rejecting the null hypothesis when it is false (Crawley, 2007).

Further, caution is imperative when studying real world problems. Arsenic concentrations have dire effects on the health of our ecosystem and therefore human consumption. While this study only shows sample location and arsenic concentration, and the investigation of potential arsenic sources does not prescribe remediation, the potential for error was still heavily taken into account. In this analysis, we are claiming that we are

95% confident that the hypothesis is true while we are okay with a 5% chance of making a type I or type II error, where a test statistic of $\alpha=0.05$, was used.

A type I error using the Shapiro-Wilk test as an example would occur if the null hypothesis that arsenic concentrations are normally distributed is rejected when it is true. The fact that arsenic concentrations are higher at lower elevations may not be addressed, thereby undermining the importance of elevation as a predictor of arsenic. On the other hand, a type II error would occur if the null hypothesis that ranked medians of arsenic are not different at high and lower elevations is not rejected when the difference is significant. Either type of error could result in wasted resources in research time and false claims by investigating a predictor variable that does not have a true effect on the level of arsenic, or by undermining the importance of an environmental predictor.

The findings from this study are in general agreement with literature (Ravenscroft et al., 2009) where arsenic levels are higher in soils with increased weathering and clay development, in this case Alfisols, Ultisol/Alfisols and Vertisols. Samples taken from lower elevations than 1,207 m were found to contain higher levels of arsenic as natural weather events carry arsenic downstream and is adsorbed to and concentrates within sediments (Mitsunobu et al., 2006). Further, samples of sedimentary rock origin were also found to have higher levels of arsenic by Hinkle and Polette (1999).

CHAPTER VII: CONCLUSIONS

There are 255 total samples from 136 sites in this study; 123 samples are from the A horizon (Table 12) and 132 samples were taken from the B horizon (Table 13). The highest value in the A and B horizons, respectively, are 63.2 ppm and 85.4 ppm. These maximum values are both from the Eugene Formation (Tfe, or Tfee where mapped separately as marine).

Comparison of arsenic between the A and B horizons at site HH11 showed arsenic to be centered on different means with low deviation. This supports that collection of one sample per horizon is a reliable representation of the level of arsenic within that horizon. This also demonstrates the necessity of sampling separate horizons in order to correctly determine the largest concentration of arsenic at a site.

Comparison of A and B horizons for all 119 PSU sites that had arsenic in both A and B did not show a statistical difference. In this study arsenic was not found to be higher in the A or the B horizon; if just the A or just the B horizon were sampled, the maximum concentration would not have been collected half the time. In this study 39.5% of sites are higher in arsenic in the A horizon while 52.9% are higher in the B horizon, with 7.6% of sites having no detectible arsenic (at minimum detection limit of 0.20 ppm). Collection from both horizons ensures the site is better represented and that the sample of maximum value is used for analysis.

Regression analysis of six environmental factors was done to assess for potential predictors for arsenic in undisturbed soils. The regression tree indicated soil order, elevation and rock type to have the strongest relationship with arsenic. In this study area arsenic concentrations were found in greater levels within Alfisol and Ultisol/Alfisol and Vertisol soil orders, at lower elevations below 1,207 meters, and within soils from sedimentary, mixed volcanic/sedimentary and unconsolidated rock types. The regression forest confirmed the same factors as environmental predictors with elevation the strongest predictor, followed by soil order and rock type. Province, soil color and the age ranking of rock deposition were not considered significant.

Marine sediments have higher arsenic values than other lithologies. Data with the highest value and highest mean are in the South Willamette Valley. This site was mapped as the Eugene Formation, a marine sedimentary deposit, by both Walker and MacLeod (1991) and McClaughry et al. (2010). Marine sediments were also found to have the highest (>7 ppm) concentrations of arsenic in the northwest Oregon study area (Ricker, 2013).

The map units associated with the maximum values for each province are all described as either having a marine sediment composition (Jub, Tfe, Tfee, Ty), or as basaltic (Jub, Tbaa, Qba) or mafic (Tmv) by Walker and MacLeod (1991). This is in keeping with other research that sedimentary rocks reach much higher levels of arsenic than igneous and metamorphic sources (Ravenscroft et al., 2009), although basalt can also have a large range (0.18 – 113 ppm) for arsenic concentration (Ravenscroft et al., 2009).

A summary of the three important factors for each of the high-value samples and the mean arsenic of each province are listed in Table 21. Factor descriptions for these representative sites are in alignment with the results of the regression analyses. Rock types for the highest value sites include sedimentary and mixed igneous volcanic and sedimentary rock types, as well as igneous volcanic. The sedimentary and mixed rock types are the highest by mean concentration (5.15 – 21.99 ppm) with all igneous volcanic sites lower by mean (1.20 – 2.76 ppm). The soil orders for the two highest value sites are the Alfisol or Ultisol soils; these soils are older and have had time to concentrate higher levels of arsenic. Lastly, arsenic is higher in lower elevations and less concentrated at higher elevations. Weathering, gravity and topography result in sediment transportation and accumulation in sinks or valleys, however, topographical influences were outside the scope of this study.

Table 21. Summary of results for arsenic level and three important factors by province.

Province	Highest Value (ppm)	Map Unit	Rock Type	Soil Order	Elevation (meters)	Mean (ppm)
S. Willamette Valley	85.4	Tfe, Tfee	Sedimentary	Alfisol	292	21.99
Klamath Mountains	45.4	Jub	Mixed Volc./ Sed.	Alf/Ult	730	5.42
Cascade Range	11.9	Tbaa	Volcanic	Inceptisol	803	2.76
Coast Range	10.6	Ty	Sedimentary	Mollisol	134	5.15
Basin and Range	2.32	Qba	Volcanic	Mollisol	1289	1.29
High Lava Plains	1.5	Tmv	Volcanic	Entisol	1891	1.20

CHAPTER VIII: FUTURE WORK

This study tested for arsenic in undisturbed soils, increasing the coverage of arsenic data from different rock types found in southwest Oregon. The purpose of this study was to provide location and arsenic concentration data to DEQ to increase the current data set. While Oregon coverage is now fairly robust, the causes driving the concentration of arsenic are still being explored.

In order to study environmental variables as potential causes or predictors of arsenic, it first would be necessary to verify the accuracy each environmental variable in the field and lab. Elevation and geomorphic region are easy to verify, but soil order and rock type should be verified at the site and with lab testing (pH for soils and X-ray diffraction to determine parent material) as the site could vary from the mapped soil order and unit, which are generally mapped over a much larger area. In the lab, percent clay content should be determined to hone its relationship as and adsorber of arsenic. Also, enough samples should be collected per site in order to make statistical analyses valid. Further analysis could also be done using separate CART models for the A and B horizons for a comparison of important predictor variables between horizons.

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APPENDIX A: Stratigraphy of Provinces within Southwest Oregon

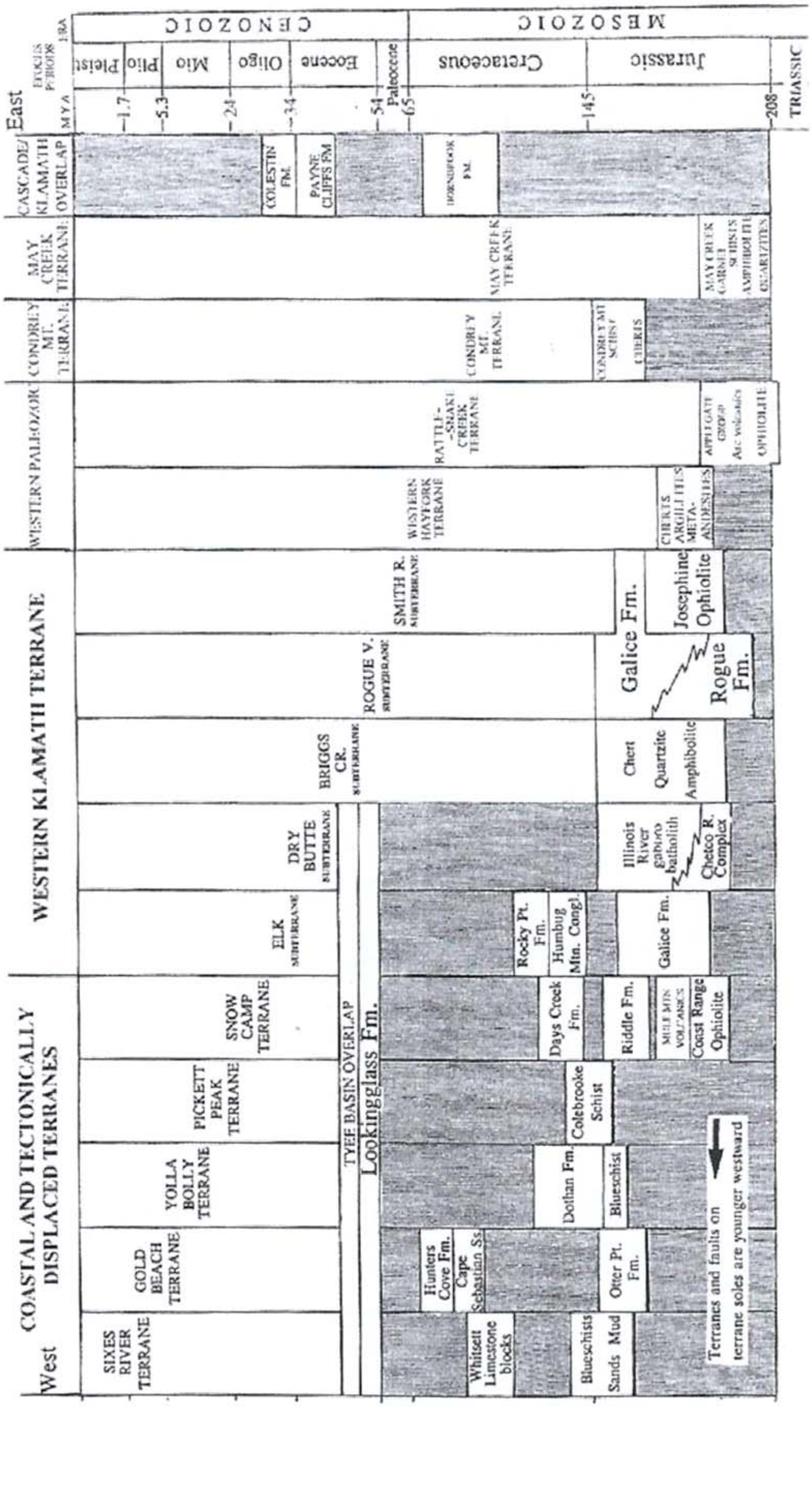


Figure A.1. The stratigraphy of the Klamath Mountains. Copied from Orr and Orr (2012).

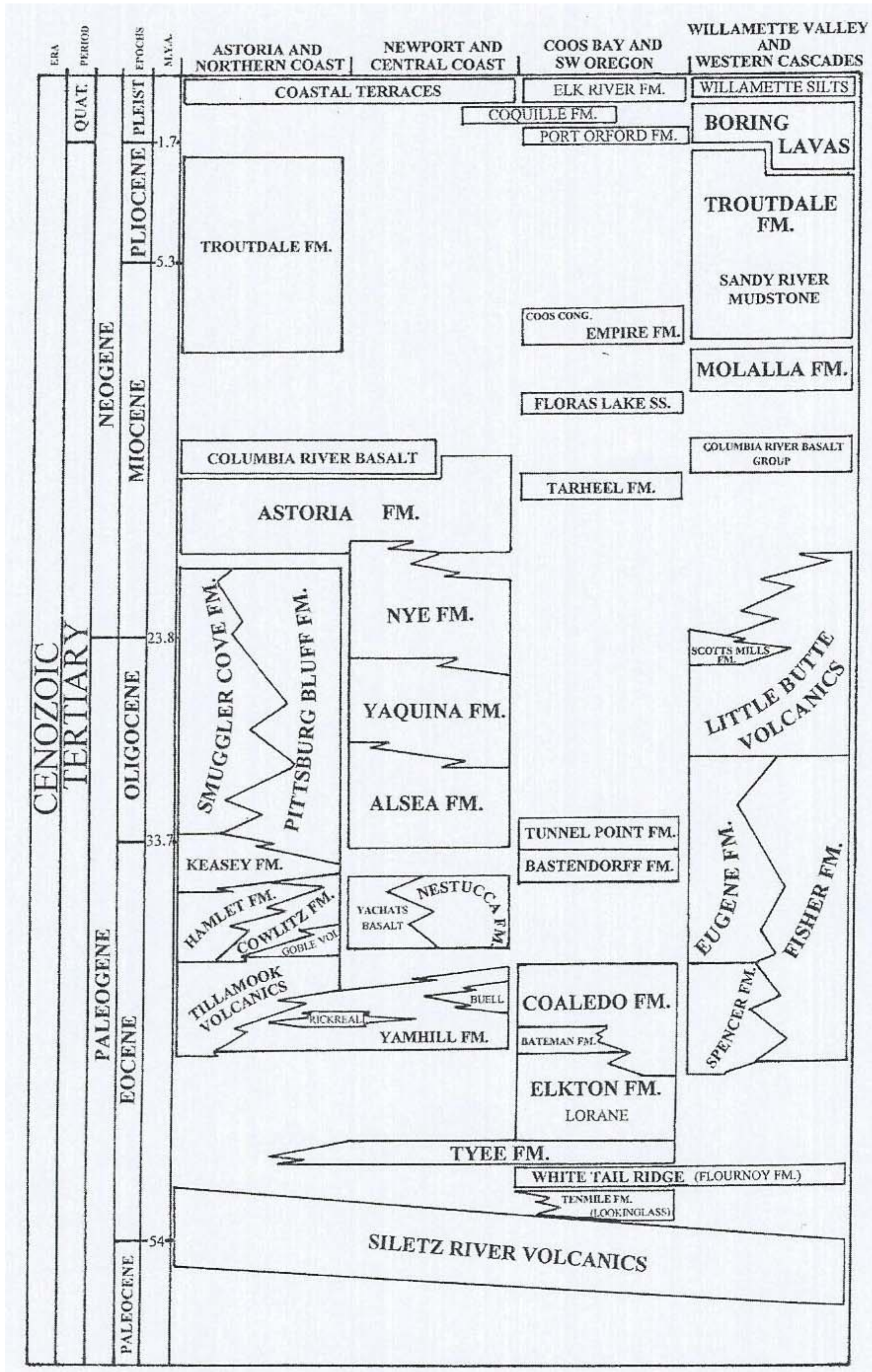


Figure A.2. The stratigraphy of the Coast Range province. Coos Bay and SW Oregon formations are within the study area. Copied from Orr and Orr (2012).

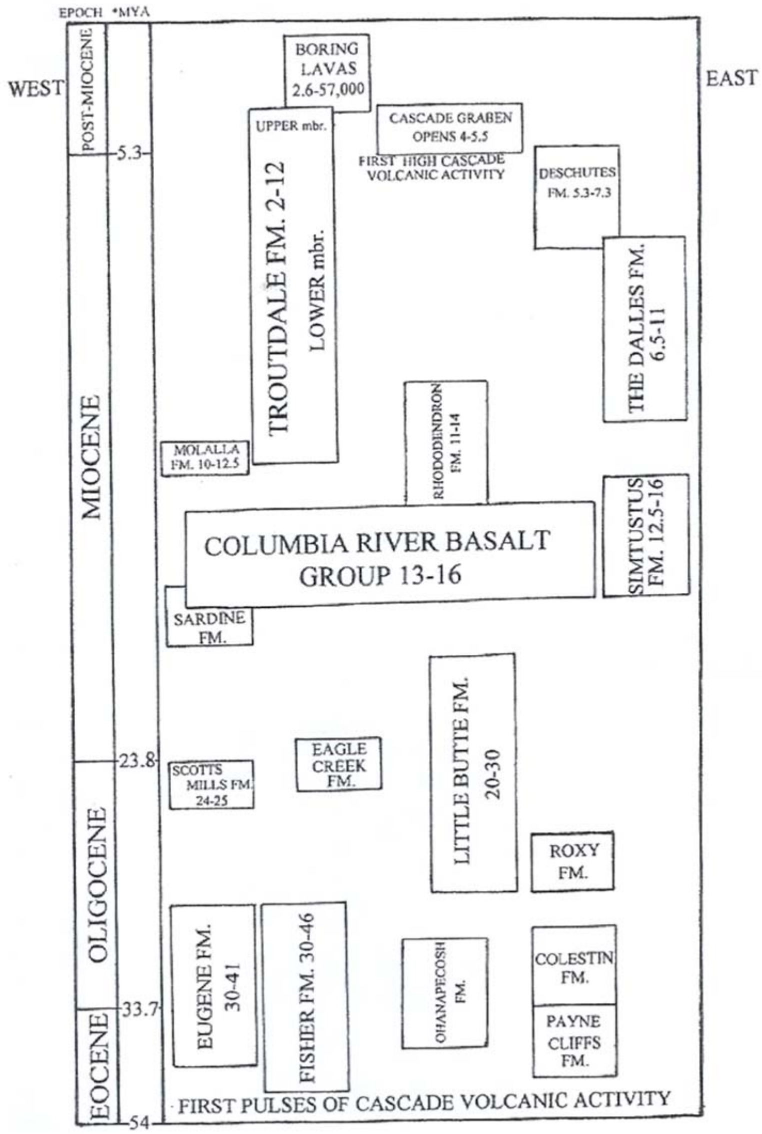
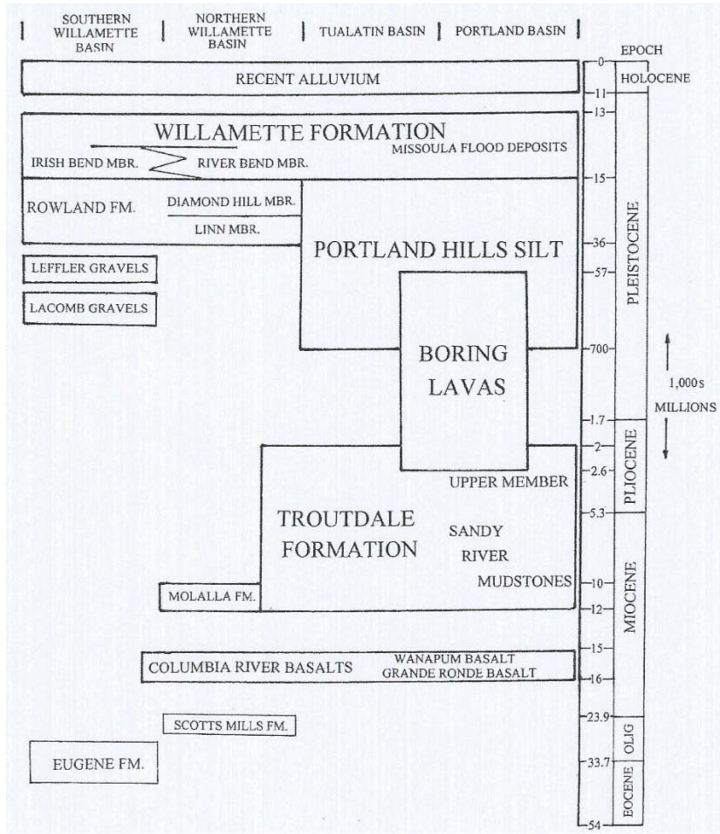


Figure A.3. The stratigraphy of the Cascade Range province. Copied from Orr and Orr (2012).



FigureA.4. The stratigraphy of the Willamette Valley province. Copied from Orr and Orr (2012).

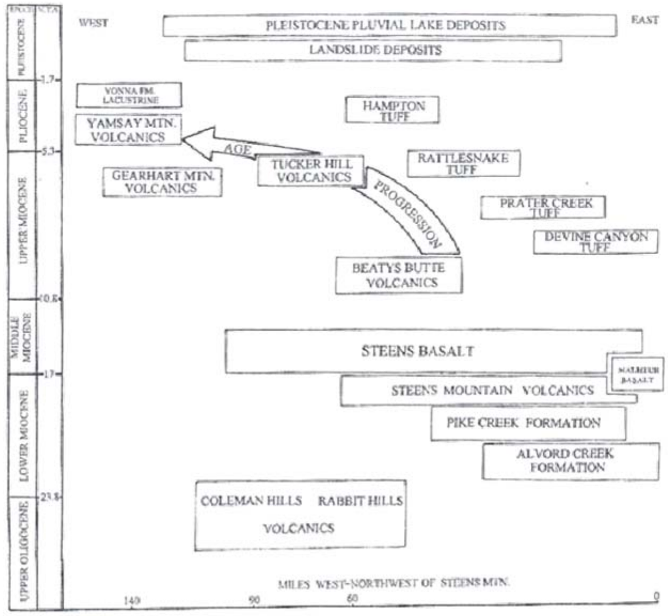


Figure A.5. The stratigraphy of the Basin and Range province. Copied from Orr and Orr (2012).

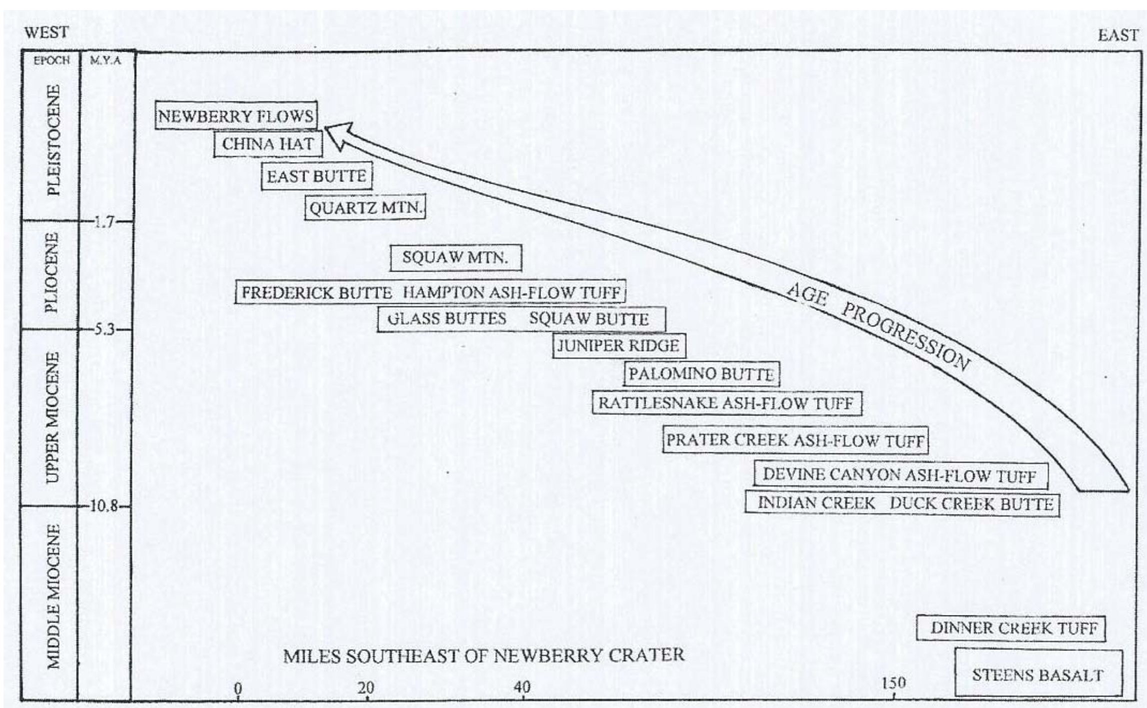


Figure A.6. The stratigraphy of the High Lava Plains province. Copied from Orr and Orr (2012).

APPENDIX B: Description of Geologic Units (Walker and MacLeod, 1991) by Province (DEQ, 2013) that Correlate with Sample Locations

Basin and Range

Qba **Basaltic andesite and basalt (Holocene? and Pleistocene)**—Flows and flow breccia dominantly of basaltic andesite containing plagioclase, olivine, and pyroxene phenocrysts and olivine-bearing basalt representing part of the volcanic sequence of the High Cascade Range. Unit mostly forms small shield volcanoes, gentle-sided lava cones, and, in places, intracanyon flows.

Qf **Fanglomerate (Holocene? and Pleistocene)**—Poorly sorted and poorly stratified alluvial fan debris, slope wash, colluvium, and talus; composed mostly of silt and fragments of basalt, basaltic andesite, and andesite. In places includes small areas of pediment gravels and colluvium.

Qma **Mazama ash-flow deposits (Holocene)**—Rhyodacitic to andesitic ash-flow deposits related to climactic eruptions of Mount Mazama about 6,845 yr B.P. (^{14}C).

QTb **Basalt (Pleistocene and Pliocene)**—Thin flows and minor flow breccia of open-textured (diktytaxitic) olivine basalt in southeastern part of map area. Locally contains thin interbeds of sedimentary rocks. Grades laterally through palagonite tuff and breccia into sedimentary rocks (unit QTs).

QTs **Sedimentary rocks (Pleistocene and Pliocene)**—Semiconsolidated lacustrine and fluvial ashy and palagonitic sedimentary rocks, mostly tuffaceous sandstone and siltstone; locally contains abundant palagonitized basaltic debris and some pebble conglomerate. In places, grades laterally through palagonite tuff and breccia into basalt flows (Qtb).

QTvm **Mafic vent deposits (Pleistocene, Pliocene, and Miocene?)**—Mostly in small stratovolcanoes or shield volcanoes and lava cones of basalt and andesite.

Includes agglomerate, breccia, scoria, cinder, ash, restricted flows, and small basaltic intrusive bodies. Transitional into pyroclastic rocks of cinder cones (QTp). May also include rocks of late Miocene (?) age.

Tb **Basalt (upper and middle Miocene)**—Basalt flows, flow breccia, and basaltic peperite; minor andesite flows; some interbeds of tuff and tuffaceous sedimentary rocks. Basalt is aphyric to moderately porphyritic with phenocrysts of plagioclase and olivine and exhibits both subophitic and diktytaxitic textures.

Tob **Olivine basalt (Pliocene and Miocene)**—Thin, commonly open-textured (diktytaxitic), subophitic to intergranular olivine basalt flows, intercalated with and grades laterally through palagonite breccia and tuff into tuffaceous sedimentary rocks (unit Ts). In places includes flows of platy olivine andesite or basaltic andesite.

Tp **Basaltic and andesitic ejecta**—Mostly unconsolidated, oxidized, fine to coarse, scoriaceous cinders, bombs, and agglutinate deposited in subaerial environment.

Tps **Subaqueous pyroclastic rocks of basaltic cinder cones**—Deposits of bombs, breccia, and mafic to intermediate tuff occurs as palagonitic tuff and breccia cones, rings, and ridges. In places interbedded with lacustrine sedimentary rocks.

Trh **Rhyolite and dacite (Pliocene? and Miocene)**—Ash-flow tuff, lava flows, pumice-lapilli tuff, coarse pumicite, blow breccia, and domal complexes of rhyolitic, rhyodacitic, and dacitic composition; in places includes peralkaline rhyolite and some andesite and andesite breccia. Locally porphyritic with phenocrysts of alkali feldspar, plagioclase, and minor augite, ferro-hedenbergite, hornblende, hypersthene, or biotite. Commonly flow banded; locally glassy. Many of the ash-flow tuffs exhibit flow features and only obscure vitro-clastic textures.

Ts **Tuffaceous sedimentary rocks and tuff (Pliocene and Miocene)**—
Semiconsolidated to well-consolidated mostly lacustrine tuffaceous sandstone,

siltstone, mudstone, concretionary claystone, pumicite, diatomite, air-fall and water-deposited vitric ash, palagonitic tuff and tuff breccia, and fluvial sandstone and conglomerate. Palagonitic tuff and breccia grade laterally into altered and unaltered basalt flows of unit Tob. In places includes layers of fluvial conglomerate and, in parts of the Deschutes-Umatilla Plateau, extensive deposits of fanglomerate composed mostly of Miocene basalt debris and silt. Also includes thin, welded and nonwelded ash-flow tuffs.

Tvm **Mafic and intermediate vent rocks (Pliocene? and Miocene)**—Basaltic and andesitic agglomerate, breccia, scoria, cinders, flow, and intrusive masses forming lava cones and small shields.

Tvs **Silicic vent rocks (Pliocene, Miocene, Oligocene, and Eocene?)**—Plugs and domal complexes of rhyolitic, rhyodactic, and dacitic composition; includes related near-vent flows, flow breccia, and deposits of obsidian, perlite, and pumice. Locally includes resurgent domes related to caldera complexes.

Cascade Range

Qa **Andesite (Holocene and Pleistocene)**—Forms major stratovolcanoes dominantly of aphyric to porphyritic basaltic andesite and andesite; phenocrysts are principally pyroxene, olivine, plagioclase, and, rarely, hornblende. Locally includes dacite and minor basalt.

Qal **Alluvial deposits (Holocene)**—Sand, gravel, and silt forming flood plains and filling channels of present streams. In places includes talus and slope wash. Locally includes soils containing abundant organic material, and thin peat beds.

Qba **Basaltic andesite and basalt (Holocene? and Pleistocene)**—Flows and flow breccia dominantly of basaltic andesite containing plagioclase, olivine, and pyroxene phenocrysts and olivine-bearing basalt representing part of the volcanic sequence of the High Cascade Range. Unit mostly forms small shield volcanoes, gentle-sided lava cones, and, in places, intracanyon flows.

Qg **Glacial deposits (Pleistocene)**—Unsorted boulder gravel, sand, and rock flour in ground, terminal, and lateral moraines. Locally include: glaciofluvial deposits (Qgf).

Qgf **Glaciofluvial deposits**—Partly sorted.

Qls **Landslide and debris-flow deposits (Holocene and Pleistocene)**—Unstratified mixtures of fragments of adjacent bedrock. Locally includes slope wash and colluvium. Largest slides and debris flow occur where thick sections of basalt and andesite flows overlie clayey tuffaceous rocks. May include some deposits of late Pliocene age.

Qma **Mazama ash-flow deposits (Holocene)**—Rhyodacitic to andesitic ash-flow deposits related to climactic eruptions of Mount Mazama about 6,845 yr B.P. (^{14}C).

Qmp **Mazama pumice deposits (Holocene)**—Primary and reworked air-fall rhyodacite pumice related to climactic eruptions of Mount Mazama about 6,845 yr B.P. (^{14}C). Mapped only where it extensively covers older units. Thickness shown by isopachs (in meters).

Qrd **Rhyolite and dacite (Holocene and Pleistocene)**—Domes and related flows and flow breccia of aphyric and plagioclase and hornblende porphyritic rhyolite and dacite. Includes rhyolite and dacite on Newberry volcano and at South Sister volcano in the Cascade Range that are younger than Mazama ash deposits (Qma, Qmp; radiometrically dated by ^{14}C methods at approximately 6,800 yr old).

Qs **Lacustrine and fluvial sedimentary rocks (Pleistocene)**—Unconsolidated to semiconsolidated lacustrine clay, silt, sand, and gravel; in places includes mudflow and fluvial deposits and discontinuous layers of peat.

Qta **Andesite (Pleistocene and Pliocene)**—Flows and flow breccia in the High Cascade Province composed dominantly of aphyric to porphyritic basaltic andesite and andesite. Mostly represents remnants of moderately to deeply eroded staratovolcanoes. Phenocrysts are mostly plagioclase, olivine, clinopyroxene, and lesser hypersthene and hornblende.

QTba **Basalt and basaltic andesite (Pleistocene and Pliocene)**—Flows, flow breccia, and pyroclastic deposits of the High Cascades Province. Flows are aphanitic to finely crystalline, commonly diktytaxitic, and aphyric to porphyritic. Textures are mostly intergranular grading to intersertal; some andesite flows are finely trachytic and a few basalt flows are subophitic. Phenocrysts, mostly unaltered, include bytownite and labradorite, olivine, calcic augite, and hypersthene. Flows and breccia form shields, lava cones, and valley fill; in places greatly dissected and modified by glacial and fluvial erosion.

QTmv **Mafic vent complexes (Pleistocene, Pliocene, and Miocene?)**—Plugs, dikes, and related near-vent flows, breccia, cinders, and agglutinate of basalt, basaltic andesite, and andesite; commonly in the form of either little-modified lava cones or partly eroded piles of reddish, iron-stained thin flows and fragmental ejecta cut by mafic intrusions. May also include rocks of late Miocene(?) age.

QTp **Basaltic and andesitic ejecta**—Mostly unconsolidated, oxidized, fine to coarse, scoriaceous cinders, bombs, and agglutinate deposited in subaerial environment.

Tbaa **Basaltic and andesitic rocks (upper and middle Miocene)**—Lava flows and flow breccia of hypersthene and olivine andesite, basaltic andesite containing plagioclase and pyroxene phenocrysts, and basalt; many flows contain phenocrysts of both hypersthene and augite. Includes interbedded volcaniclastic and epiclastic rocks mostly of andesitic composition, but partly of dacitic or rhyodacitic composition. Includes areally restricted flows of silicic andesite or dacite. Upper part of unit mostly unaltered, although olivine crystals are locally altered to clay minerals. Lower parts commonly altered; secondary minerals include nontronite and saponite, chalcedony, calcite, and zeolites. Older parts of this unit locally are propylitically altered adjacent to larger intrusions. Erupted mostly from widespread, northwest- and north-trending dikes and dike swarms and related plugs and lava cones.

Tfc **Flows and clastic rocks, undifferentiated (Miocene)**—Chiefly basaltic andesite and andesite lava flows and flow breccia containing plagioclase and pyroxene (hypersthene and augite) phenocrysts, mudflows (lahars), and volcanic conglomerates; locally includes some dacite flows. Includes lesser, coarse- to fine- grained epiclastic volcanic sedimentary rocks and ash-flow and air-fall tuffs. Partly equivalent in age to unit Tba and may be partly coeval with younger parts of unit Tstb. Locally altered adjacent to larger intrusions.

Thi **Hypabyssal intrusive rocks (Miocene)**—Hypabyssal, medium-grained, hornblende diorite and quartz diorite in small stocks and large dikes; includes intrusions of medium- to fine-grained gabbro and plugs and small stocks of commonly porphyritic biotite quartz monzonite and leucocratic granodiorite. Many of these intrusive bodies are moderately to intensely propylitized, as are wallrocks they intrude; locally, along shears, the rocks also are sericitized.

Tmsc **Marine siltstone, sandstone, and conglomerate (lower Eocene)**—Cobble and pebble conglomerate, pebbly sandstone, lithic sandstone, siltstone, and mudstone; massive to thin bedded; shelf and slope depositional setting. Contains foraminiferal faunas referred to the Penutian Stage of early Eocene age.

Tn **Nonmarine sedimentary rocks (Eocene)**—Continentally derived conglomerate, pebble conglomerate, sandstone, siltstone, and mudstone containing abundant biotite and muscovite, Dominantly nonvolcanic; clastic material derived from underlying older rocks.

Trb **Ridge-capping basalt and basaltic andesite (Pliocene and upper Miocene)**—Flows and flow breccia of basaltic andesite and lesser diktytaxitic to intergranular olivine basalt. Includes some dense, aphyric flows, commonly with either cryptocrystalline of pilotaxitic to trachytic texture, and porphyritic flows with phenocrysts and glomerocrysts of olivine, hypersthene, and labradorite, A few flows contain both hypersthene and calcic augite phenocrysts. Olivine mostly fresh or slightly altered to iddingsite in flows high in section; flow low in section show some alteration to clays (nontronite and saponite), secondary silica minerals, and calcite; pinkish-brown glass in some flows unaltered. Locally includes some andesite and dacite.

Tsv **Silicic vent complexes (Pliocene, Miocene, and upper Oligocene)**—Large, rhyolitic to dacitic vent areas in the Cascade Range that commonly include multiple intrusions and much associated silicic eruptive breccia and erosional debris and some flows.

Tu **Undifferentiated tuffaceous sedimentary rocks, tuffs, and basalt (Miocene and Oligocene)**—Heterogeneous assemblage of continental, largely volcanogenic deposits of basalt and basaltic andesite, including flows and breccia, complexly interstratified with epiclastic and volcaniclastic deposits of basaltic to rhyodacitic composition. Includes extensive rhyodacitic to andesitic ash-flow and air-fall tuffs, abundant lapilli tuff and tuff breccia, andesitic to dacitic mudflow (lahar) deposits, poorly bedded to well-bedded, fine- to coarse-grained tuffaceous sedimentary rocks, and volcanic conglomerate. In places subdivided into: sedimentary and volcaniclastic rocks (Tus), tuff (Tut) and basaltic lava flows (Tub).

Tub **Basaltic lava flows**—Basaltic and basaltic andesite lava flows and breccia; grades laterally into rare bedded palagonitic tuff and breccia.

Tus **Sedimentary and volcaniclastic rocks**—Lapilli tuff, mudflow deposits (lahars), flow breccia, and volcanic conglomerate, mostly of basaltic to dacitic composition; rare iron-stained palagonitic tuff and breccia of basaltic and andesitic composition; and ash-flow, air-fall, and water-laid tuff of dacitic to rhyolitic composition. The palagonite tuff and breccia grade laterally into peperite and into lava flows of basalt and basaltic andesite.

Tut **Tuff**—Welded to unwelded, mostly vitric crystal and vitric ash-flow tuff of several ages. Glass in tuff locally altered to clay, zeolites, and secondary silica minerals.

Coast Range

Qal **Alluvial deposits (Holocene)**—Sand, gravel, and silt forming flood plains and filling channels of present streams. In places includes talus and slope wash. Locally includes soils containing abundant organic material, and thin peat beds.

Qd **Dune sand (Holocene)**—Large areas of windblown sand composed of rock-forming minerals, mostly feldspar and small amounts of quartz.

Qls **Landslide and debris-flow deposits (Holocene and Pleistocene)**—Unstratified mixtures of fragments of adjacent bedrock. Locally includes slope wash and colluvium. Largest slides and debris flow occur where thick sections of basalt and andesite flows overlie clayey tuffaceous rocks. May include some deposits of late Pliocene age.

Qt **Terrace, pediment, and lag gravels (Holocene and Pleistocene)**—Unconsolidated deposits of gravel, cobbles, and boulders intermixed and locally interlayered with clay, silt, and sand. Mostly on terraces and pediments above present flood plains.

Ti **Mafic intrusions (Oligocene)**—Sheets, sills and dikes of massive granophyric ferrogabbro; some bodies strongly differentiated and include pegmatitic gabbro, ferrogranophyre, and granophyre.

Tmsm **Marine sandstone, siltstone and mudstone (lower Eocene and Paleocene?)**—Rhythmically interbedded sandstone, siltstone, and mudstone with minor conglomerate; deposited in deep-sea fan depositional setting on submarine basalts of the Siletz River Volcanics.

Tmss **Marine sandstone and siltstone (middle Eocene)**—Thin- to thick-bedded, crossbedded, well-sorted, fine- to medium-grain sandstone, siltstone, and mudstone; characterized by sparse fine white mica; shallow marine depositional setting at least partly of deltaic origin.

Tpb **Porphyritic basalt (upper Eocene)**—Subaerial lava flows and breccia of porphyritic basalt, minor basaltic andesite, and rare dacite.

Tsr **Siletz River Volcanics and related rocks (middle and lower Eocene and Paleocene)**—Aphanitic to porphyritic, vesicular pillow flows, tuff-breccias, massive lava flows and sills of tholeiitic and alkali basalt. Upper part of sequence contains numerous interbeds of basaltic siltstone and sandstone, basaltic tuff, and locally derived basalt conglomerate. Rocks of unit pervasively zeolitized and veined with calcite. Most of these rocks are of marine origin and have been interpreted as oceanic crust and seamounts.

Tss **Tuffaceous siltstone an sandstone (upper and middle Eocene)**—Thick- to thin-bedded marine tuffaceous mudstone, siltstone, and sandstone; fine to coarse grained. Contains calcareous concretions and, in places, is carbonaceous and micaceous.

Tt **Tyee Formation (middle Eocene)**—Very thick sequence of rhythmically bedded, medium- to fine-grained micaceous, feldspathic, lithic, or arkosic marine sandstone and micaceous carbonaceous siltstone; contains minor interbeds of dacite tuff in upper part.

Ty **Yamhill Formation and related rocks (upper and middle Eocene)**—Massive to thin-bedded concretionary marine siltstone and thin interbeds of arkosic, glauconitic, and basaltic sandstone; locally contains interlayered basalt lava flows and lapilli tuff.

High Lava Plains

Qb **Basalt and basaltic andesite (Holocene and Pleistocene)**—Thin flows of aphyric and porphyritic basalt and basaltic andesite, and open-textured (diktytaxitic), generally nonporphyritic, subophitic olivine basalt that commonly is highly feldspathic. Also includes some dissected intracanyon flows of porphyritic basalt and related vent complexes. Pressure ridges and tumuli on upper surfaces well preserved. Occurs principally along crest of Cascade Range; also in areas near and east of Newberry volcano, along southeast margin of Harney Basin, and in Rome Basin.

QTps **Subaqueous basaltic and andesitic ejecta of basaltic and andesitic cinder cones (Holocene, Pleistocene, Pliocene, and Miocene?)**—Partly consolidated, palagonitized, fine to coarse, scoriaceous altered cinders, bobs, breccia, and minor agglutinate, mostly deposited in subaqueous environment. Commonly with some interlayers and intermixed lacustrine sedimentary rocks. Forms palagonitic tuff and breccia cones and rings (maars) and, in places, palagonitic tuff ridges.

QTst **Tuffaceous sedimentary rocks and tuffs (lower? Pleistocene or Pliocene)**—Rhyolitic to andesitic ash-flow tuffs, pumice-fall deposits, minor mud flows, and older alluvium on the flanks of Newberry volcano.

Qyb **Youngest basalt and basaltic andesite (Holocene)**—Little-modified flows and associated breccia of basaltic andesite and some basalt on slopes of Newberry Volcano. Relations to Mazama pumice deposits indicate most of these rocks are less than 6,800 yr old (^{14}C); isotopic ages on flows range from about 1,000 to 6,000 yr B.P. (^{14}C).

Tat **Silicic ash-flow tuff (lower Pliocene and upper Miocene)**—Ash-flow tuff and associated pumiceous air-fall tuff mostly of rhyolitic and rhyodacitic composition; includes minor tuffaceous sedimentary rocks. Grades laterally through lessdensely welded tuff to nonwelded ash-flow tuff and interlayered tuffaceous sediments of unit Ts.

Tmv **Mafic vent complexes (Miocene)**—Intrusive plugs and dike swarms and related near-vent flows, breccias, cinders, and agglutinate of basaltic andesite, basalt, and andesite; commonly in the form of eroded piles of red, iron-stained thin flows, cinders, and agglutinate cut by mafic intrusions.

Klamath Mountains

bc **Amphibolite of Briggs Creek (Mesozoic or Paleozoic)**— Consists of amphibolite, micaceous quartzite, quartz schist, and recrystallized manganiferous chert. Includes structurally complex amphibole schist and quartz-rich hornblende gneiss of unknown age exposed at and near Chetco Peak west of Cave Junction.

cm **Condrey Mountain Schist (Triassic? and Paleozoic?)**—Consists of a variety of schistose rocks characterized by different proportions of muscovite, quartz, graphite, chlorite, actinolite, and epidote, rare thin layers of metachert, and clinozoisite-actinolite-albite-garnet metagabbro.

cs **Colebrooke Schist (Mesozoic or Paleozoic)**—Metamorphosed politic sedimentary rocks and subordinate metamorphosed submarine pillow lavas and pyroclastic beds of basaltic composition. Metamorphic age is Early Cretaceous (about 130 Ma).

Jm **Mélange (Jurassic)**—Structurally complex mixture of basaltic rocks, serpentinite, chert, argillite, conglomerate, silty sandstone, and lenses of marble composing the mélange of the Takilma area.

Jop **Otter Point Formation of Dott (1971) and related rocks (Upper Jurassic)**—Highly sheared greywacke, mudstone, siltstone, and shale with lenses and pods of sheared greenstone, limestone, chert, blueschist, and serpentine. Identified as mélange by some investigators.

Js **Sedimentary rocks (Jurassic)**—Black and gray mudstone, shale, siltstone, graywacke, andesitic to dacitic water-laid tuff, porcelaneous tuff, and minor interlayers and lenses of limestone and fine-grained sediments metamorphosed to phyllite or slate. Locally includes some felsite, andesite and basalt flows, breccia, and agglomerate. Marine invertebrate fauna indicates age range from Early Jurassic (Hettangian) to early Late Jurassic (Oxfordian). In Klamath Mountains of southwest Oregon, includes Galice Formation and unnamed, hornblende- and (or) pyroxene-bearing clastic rocks of Jurassic age.

Jss **Shale, mudstone, and sandstone (Jurassic)**—Black to gray shale, mudstone, and sandstone with local lenses of pebble conglomerate. Overlies Josephine ophiolite (unit Ju).

JTrgd **Granite and diorite (Jurassic and Triassic)**—Felsic to intermediate, granitoid intrusive rocks. Includes Jurassic muscovite granodiorite, hornblende gabbro, tonalite, and quartz diorite of southwest Oregon.

Ju **Ultramafic and related rocks of ophiolite sequences (Jurassic)**—Predominantly harzburgite and dunite with both cumulate and tectonite fabrics. Locally altered to serpentinite. Includes gabbroic rocks and sheeted diabasic dike complexes. Comprises Josephine ophiolite, ophiolites of Onion Mountain, Sexton Mountain, Pearsoll Peak, Rogue River, and Riddle areas and Coast Range ophiolite and serpentinite mélange. In southwest Oregon, locally includes small bodies of early Mesozoic or late Paleozoic serpentinized and sheared ultramafic rocks, mostly in shear zones. Locally, volcanic and sedimentary rocks shown separately.

Jub **Basaltic volcanic and sedimentary rocks**—Basalt flows, flow breccia, agglomerate, pillow basalt and pillow breccia, and lesser shale, chert siltstone, and mudstone of ophiolitic complexes.

Jv **Volcanic rocks (Jurassic)**—Lava flows, flow breccia, and agglomerate dominantly of plagioclase, pyroxene, and hornblende porphyritic and aphyric andesite. Includes flow rocks that range in composition from basalt to rhyolite as well as some interlayered tuff and tuffaceous sedimentary rocks. Commonly metamorphosed to greenschist facies; locally foliated, schistose or gneissic. Includes the Rogue Formation and volcanic rocks commonly assigned to the Galice Formation. Considered to be accreted island-arc terrane.

Kc **Clastic sedimentary rocks (Upper and Lower Cretaceous)**—Locally fossiliferous sandstone and conglomerate; marine fossils indicate Early Cretaceous (Albian) age.

KJds **Sedimentary rocks related to the Dothan Formation (Lower Cretaceous and Upper Jurassic)**—Sandstone, conglomerate, graywacke, rhythmically banded chert lenses. Includes western Dothan and Otter Point Formations.

KJdv **Volcanic rocks related to the Dothan Formation (Lower Cretaceous and Upper Jurassic)**—Basaltic pillow lavas, volcanic breccia, and silicified basalt lava flows.

KJg **Granitic rocks (Cretaceous and Jurassic)**—Mostly tonalite and quartz diorite but including lesser amounts of other granitoid rocks. Potassium-argon ages determined on hornblende indicates plutons range in age from 143 to 166 Ma.

KJgu **Gabbro and ultramafic rocks associated with granitic plutons (Cretaceous and Jurassic)**—Predominantly hornblende gabbro, gabbro, and olivine gabbro, but includes pyroxenite, hornblende pyroxene, and minor peridotite, dunite, and serpentinite.

KJm **Myrtle Group (Lower Cretaceous and Upper Jurassic)**—Conglomerate, sandstone, siltstone, and limestone. Locally fossiliferous. As shown, includes Riddle and Days Creek Formations.

Ks **Sedimentary rocks (Cretaceous)**—Marine graywacke, subgraywacke, conglomerate, and shale. Pebbles and cobbles in conglomerate are well-rounded volcanic and metavolcanic rocks, low-grade metasedimentary rocks, quartzite, chert, and minor silicic and intermediate plutonic rocks, Shales are gray to black and are fissile to blocky, Sandstones commonly display graded bedding; conglomerate beds are commonly thick and poorly bedded. Shales, near Mitchell, have yielded latest Early Cretaceous (Albian) fossils' some earliest Late Cretaceous (Cenomanian) fossils occur in beds southeast of Mitchell.

mc **May Creek Schist (Paleozoic)**—Layered amphibolite, schist, gneiss, and quartzite. Protolith considered to be of Paleozoic age.

Qt **Terrace, pediment, and lag gravels (Holocene and Pleistocene)**—Unconsolidated deposits of gravel, cobbles, and boulders intermixed and locally interlayered with clay, silt, and sand. Mostly on terraces and pediments above present flood plains. Includes older alluvium in the Klamath Mountains and both high- and low-level terraces along Oregon coast.

Tmss **Marine sandstone and siltstone (middle Eocene)**—Thin- to thick-bedded, crossbedded, well-sorted, fine- to medium-grain sandstone, siltstone, and mudstone; characterized by sparse fine white mica; shallow marine depositional setting at least partly of deltaic origin. Contains foraminiferal and molluscan faunas of early middle Eocene age.

Tn **Nonmarine sedimentary rocks (Eocene)**—Continentally derived conglomerate, pebble conglomerate, sandstone, siltstone, and mudstone containing abundant biotite and muscovite, dominantly nonvolcanic; clastic material derived from underlying older rocks.

TrPv **Volcanic rocks (Triassic and Permian)**—Massive flows of porphyritic meta-andesite, metabasalt, spilite, and keratophyre, volcanic breccia, and subordinate amounts of fine-grained volcaniclastic rocks. In southwest Oregon includes hornblende, pyroxene, and plagioclase porphyritic andesite flows, breccia, agglomerate, tuff, and locally, some basalt flows and dacitic tuffs of the Applegate Group.

TrPzm **Mélange of Dutchmans Peak (Triassic or Paleozoic)**—Heterogeneous mixture of interlayered metasedimentary and metavolcanic rocks metamorphosed to upper greenschist and (or) almandine-amphibolite facies, and serpentinite, gabbro, and metagabbro.

TrPzs **Sedimentary rocks, partly metamorphosed (Triassic and Paleozoic)**—Poorly bedded argillite, chert, phyllite, phyllitic quartzite, calc-phyllite, impure limestone, and marble. In places rocks are strongly foliated. In Klamath Mountains of southwest Oregon, includes shale, mudstone, volcaniclastic sandstone, graywacke, conglomerate, tuff, and minor radiolarian chert and marble of the Applegate Group.

Tsr **Siletz River Volcanics and related rocks (middle and lower Eocene and Paleocene)**—Aphanitic to porphyritic, vesicular pillow flows, tuff-breccias, massive lava flows and sills of tholeiitic and alkali basalt. Upper part of sequence contains numerous interbeds of basaltic siltstone and sandstone, basaltic tuff, and locally derived basalt conglomerate. Rocks of unit pervasively zeolitized and veined with calcite. Most of these rocks are of marine origin and have been interpreted as oceanic crust and seamounts.

Willamette Valley

Qs **Lacustrine and fluvial sedimentary rocks (Pleistocene)**—Unconsolidated to semiconsolidated lacustrine clay, silt, sand, and gravel; in places includes mudflow and fluvial deposits and discontinuous layers of peat.

Qt **Terrace, pediment, and lag gravels (Holocene and Pleistocene)**—Unconsolidated deposits of gravel, cobbles, and boulders intermixed and locally interlayered with clay, silt, and sand. Mostly on terraces and pediments above present flood plains. Includes older alluvium in the Klamath Mountains and both high- and low-level terraces along Oregon coast.

Tfe **Fisher and Eugene Formations and correlative rocks (Oligocene and upper Eocene)**—Thin to moderately thick bedded, coarse-to fine-grained arkosic and micaceous sandstone and siltstone, locally highly pumiceous, of the marine Eugene Formation; and coeval and older andesitic lapilli tuff, breccia, water-laid and air-fall silicic ash of the continental Fisher and Colestin Formations; upper parts of the Fisher Formation apparently lap onto ad interfingers with the Eugene Formation.

Tfeb **Basaltic rocks**—Probably part of Fisher Formation.

Tfee **Marine Eugene Formation, where mapped separately.**

APPENDIX C: Site and soil Pit Images for HH Sites. (Rock units in parentheses.)

Site **HH01** and **HH02** are both from the south edge of the Newberry Lava Flow (Qyb).

Site **HH0**3 (QTa)

Site **HH0**4 (QTa)

Site **HH0**5 (Thi)

Site **HH06** (Thi)

Site **HH07** (upper left) and **HH08** had the same vegetation (Tvs)

Site **HH09** (upper left) and **HH10** had the same vegetation (Tvm)

Site **HH11** (KJdv)

Site **HH12** (KJdv)

Site **HH13** (Tfee)

Site **HH14** (Tfee)

Site **HH15** (Tfeb)

Site **HH16** (Tfeb)

Dr. Burns points to a demarcation in the Bt (20-60+ cm) horizon at Site **HH17** (Ti), where below the soil is a darker red.

Site **HH18** (Ti)

APPENDIX D: Soil Data

A Horizon

A Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
EO01	0.666			(no color data)	
EO02	1.36			(no color data)	
EO07	1.46	10 YR	4/3	brown	9
EO08	1.57	10 YR	4/2	dark grayish brown	6
EO14	0.869	10 YR	3/2	very dark grayish brown	6
EO15	0.776	2.5 Y	4/3	olive brown	6
EO16	1.31	2.5 Y	4/2	dark grayish brown	4
EO17	1.47	2.5 Y	4/3	olive brown	6
EO18	0.718	2.5 Y	4/3	olive brown	6
EO20	0.724	2.5 Y	4/3	olive brown	6
EO21	0.687	2.5 Y	4/2	dark grayish brown	4
EO22	1.12	2.5 Y	5/3	grayish brown	6
EO23	0.845	2.5 Y	4/2	dark grayish brown	4
EO24	1.22	2.5 Y	4/3	olive brown	6
EO25	0.892	2.5 Y	5/3	grayish brown	6
EO26	0.483	2.5 Y	4/2	dark grayish brown	4
EO27	2.15	2.5 Y	4/3	olive brown	6
EO30	0.762	2.5 Y	7/4	pale yellow	8
EO31	0.821	2.5 Y	4/3	olive brown	6
EO32	1.5	2.5 Y	4/3	olive brown	6
EO33	1.07	2.5 Y	4/3	olive brown	6
EO34	1.15	2.5 Y	5/3	grayish brown	6
EO35	1.62	10 YR	5/4	yellowish brown	12
EO36	1.57	10 YR	3/3	dark brown	9
HH01	<0.20	7.5 YR	3/1	very dark gray	4
HH02	<0.20	7.5 YR	3/1	very dark gray	4
HH03	<0.20	5 YR	3/1	very dark gray	5
HH04	<0.20	10 YR	4/2	dark grayish brown	6
HH05	4.88	7.5 YR	4/2	brown	8
HH06	7.29	7.5 YR	4/3	brown	12
HH07	<0.20	10 YR	4/2	dark grayish brown	6
HH08	<0.20	10 YR	4/3	brown	9
HH09	<0.20	7.5 YR	4/3	brown	12
HH10	<0.20	10 YR	4/2	dark grayish brown	6

APPENDIX D: Soil Data, A Horizon (cont.)

A Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
HH11.1	4.38	10 YR	4/3	brown	9
HH11.2	3.95	5 YR	4/2	dark reddish gray	10
HH11.3	3.24	10 YR	4/3	brown	9
HH11.4	3.48	10 YR	4/3	brown	9
HH11.5	3.65	10 YR	4/3	brown	9
HH12	<0.20	10 YR	6/3	pale brown	9
HH13	13.5	10 YR	4/3	brown	9
HH14	63.2	10 YR	3/2	very dark grayish brown	6
HH15	<0.20	7.5 YR	4/3	brown	12
HH16	<0.20	10 YR	4/2	dark grayish brown	6
HH17	4.28	5 YR	5/6	yellowish red	30
HH18	4.54	5 YR	4/4	reddish brown	20
KL01	1.49	10 YR	5/6	yellowish brown	18
KL02	0.995	2.5 Y	4/3	olive brown	6
KL03	2.57	10 YR	6/6	brownish yellow	18
KL04	7.97	10 YR	4/4	dark yellowish brown	12
KL05	5.26	10 YR	4/3	brown	9
KL06	3.43	7.5 YR	5/6	strong brown	24
KL07	0.765	2.5 Y	3/1	very dark gray	2
KL08	5.11	10 YR	3/3	dark brown	9
KL09	3.5	7.5 YR	5/6	strong brown	24
KL10	3.19	10 YR	4/3	brown	9
KL11	2.59	10 YR	4/4	dark yellowish brown	12
KL12	2.82	10 YR	4/4	dark yellowish brown	12
KL13	2.36	10 YR	3/3	dark brown	9
KL14	2.67	10 YR	4/3	brown	9
KL15	5.14	10 YR	4/3	brown	9
KL16	1.7	5 YR	4/6	yellowish red	30
KL17	1.43	10 YR	4/4	dark yellowish brown	12
KL18	2.22	2.5 Y	5/3	grayish brown	6
KL19	4.88	10 YR	5/4	yellowish brown	12
KL20	1.44	10 YR	4/4	dark yellowish brown	12
KL21	32.6	10 YR	4/4	dark yellowish brown	12
KL22	1.57	10 YR	4/3	brown	9
KL23	0.438	2.5 Y	5/3	grayish brown	6
KL24	1.22	10 YR	3/2	very dark grayish brown	6
KL25	2.88	10 YR	3/3	dark brown	9
KL26	1.3	10 YR	4/3	brown	9

APPENDIX D: Soil Data, A Horizon (cont.)

A Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
KL27	7.48	7.5 YR	4/4	brown	16
KL28	0.1085	2.5 Y	4/3	olive brown	6
KL30	0.761	5 YR	3/3	dark reddish brown	15
LC01	17.2	2.5 Y	5/2	grayish brown	4
LC02	10.1	7.5 YR	3/3	dark brown	12
LC03	2.08	2.5 Y	5/3	grayish brown	6
LC04	2.1	10 YR	5/4	yellowish brown	12
LC05	8.74	2.5 Y	5/4	light olive brown	8
LC06	0.301	10 YR	4/4	dark yellowish brown	12
LC07	3.64	10 YR	4/4	dark yellowish brown	12
LC08	4.96	10 YR	4/2	dark grayish brown	6
LC09	7.36	1.5 Y	5.5/4	light yellowish olive brown	10
LC10A	4.58	10 YR	4/2	dark grayish brown	6
LC11	4.96	10 YR	5/4	yellowish brown	12
LC12	4.27	1.5 Y	4/3	olive brown	7.5
LC13	2.52	2.5 Y	5/2	grayish brown	4
LC14	1.25	10 YR	4/1	dark gray	3
LC15	6.44	10 YR	3/2	very dark grayish brown	6
LC16	3.73			(no color data)	
LC17	2.28	10 YR	3/2	very dark grayish brown	6
LC18	6.95	10 YR	3/2	very dark grayish brown	6
LC19	0.799	10 YR	4/4	dark yellowish brown	12
LC20	2.58	10 YR	4/2	dark grayish brown	6
LC21	3.09	7.5 YR	4/4	brown	16
LC22	3.29	6.5 YR	4/4	brown	18
LC23	2.66	7.5 YR	4/4	brown	16
LM01	6.35	10 YR	4/3	brown	9
LM02	5.04	10 YR	4/2	dark grayish brown	6
LM03A	1.92	10 YR	3/2	very dark grayish brown	6
LM05	1.26	10 YR	3/2	very dark grayish brown	6
LM06	0.914	2.5 Y	4/3	olive brown	6
LM07	2.99	2.5 Y	4/3	olive brown	6
LM08	3.71	10 YR	3/2	very dark grayish brown	6
LM09	0.608	10 YR	3/2	very dark grayish brown	6
LM10	0.371	10 YR	4/2	dark grayish brown	6
LM11	0.957	10 YR	3/2	very dark grayish brown	6
LM12	2.1	10 YR	3/2	very dark grayish brown	6
LM13	1.81	10 YR	3/2	very dark grayish brown	6

APPENDIX D: Soil Data, A Horizon (cont.)

A Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
LM14	1.63	7.5 YR	3/2	dark brown	8
LM15	2.38	10 YR	4/4	dark yellowish brown	12
LM16	2.32	10 YR	4/3	brown	9
LM17	3.13	10 YR	4/3	brown	9
LM20	2.57			(no color data)	
LM21	1.03	10 YR	4/3	brown	9
LM22	0.965	10 YR	3/2	very dark grayish brown	6
R01	7.94	10 YR	5/2	grayish brown	6
R02	3.47	2.5 Y	3/2	very dark grayish brown	4
R03	1.72	2.5 Y	4/3	olive brown	6
R13	13.6	10 YR	3/3	dark brown	9
R14	10	7.5 YR	6/5	reddish yellow	20
R15	1	10 YR	5/5	yellowish brown	15

B Horizon

B Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
EO01	0.846			(no color data)	
EO02	1.03			(no color data)	
EO07	1.45	10 YR	4/4	dark yellowish brown	12
EO08	1.15	10 YR	4/2	dark grayish brown	6
EO09	0.496	10 YR	5/2	grayish brown	6
EO10	1.08	2.5 Y	6/4	light yellowish brown	8
EO11	1.13	2.5 Y	6/3	light yellowish brown	6
EO12	0.941	2.5 Y	6/4	light yellowish brown	8
EO13	1.05	2.5 Y	6/3	light yellowish brown	6
EO14	1.02	10 YR	6/4	light yellowish brown	12
EO15	0.655	2.5 Y	6/4	light yellowish brown	8
EO16	1.01	2.5 Y	6/4	light yellowish brown	8
EO17	0.965	2.5 Y	6/4	light yellowish brown	8
EO18	0.923	2.5 Y	6/4	light yellowish brown	8
EO19	0.349			(no color data)	
EO20	0.806	2.5 Y	6/6	olive yellow	8
EO21	0.661	2.5 Y	6/4	light yellowish brown	8
EO22	0.587	2.5 Y	7/3	pale yellow	6
EO23	0.783	2.5 Y	6/4	light yellowish brown	8
EO24	1.14	10 YR	6/4	light yellowish brown	12
EO25	0.83	2.5 Y	7/3	pale yellow	6
EO26	0.693	2.5 Y	5/6	light olive brown	12
EO27	1.14	2.5 Y	7/4	pale yellow	8
EO30	0.579	2.5 Y	7/4	pale yellow	8
EO31	0.633	2.5 Y	7/3	pale yellow	6
EO32	1.02	2.5 Y	6/4	light yellowish brown	8
EO33	0.826	2.5 Y	6/4	light yellowish brown	8
EO34	0.757	2.5 Y	6/4	light yellowish brown	8
EO35	1.21	9 YR	5/4	yellowish brown	14
EO36	1.31	10 YR	5/4	yellowish brown	12
HH03	<0.20	10 YR	5/4	yellowish brown	12
HH04	<0.20	10 YR	5/4	yellowish brown	12
HH05	4.78	7.5 YR	4/3	brown	12
HH06	6.10	7.5 YR	4/4	brown	16
HH07	<0.20	10 YR	5/3	brown	9
HH08	<0.20	7.5 YR	5/4	brown	16

APPENDIX D: Soil Data, B Horizon (cont.)

B Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
HH09	<0.20	7.5 YR	4/3	brown	12
HH10	<0.20	7.5 YR	4/3	brown	12
HH11.1	4.51	7.5 YR	5/6	strong brown	24
HH11.2	4.83	7.5 YR	5/4	brown	16
HH11.3	4.99	7.5 YR	5/4	brown	16
HH11.4	4.04	7.5 YR	5/4	brown	16
HH11.5	4.29	7.5 YR	4/4	brown	16
HH12	<0.20	10 YR	6/4	light yellowish brown	12
HH13	11.5	10 YR	4/3	brown	9
HH14	85.4	7.5 YR	3/3	dark brown	12
HH15	<0.20	7.5 YR	4/4	brown	16
HH16	<0.20	10 YR	3/3	dark brown	9
HH17	3.13	2.5 YR	4/6	red	36
HH18	3.32	2.5 YR	4/6	red	36
KL01	1.62	7.5 YR	6/6	reddish yellow	24
KL02	1.56	10 YR	5/6	yellowish brown	18
KL03	2.39	10 YR	7/6	yellow	18
KL04	8.71	2.5 YR	5/4	reddish brown	24
KL05	7.38	10 YR	6/5	brownish yellow	15
KL06	3.82	5 YR	5/6	yellowish red	30
KL07	0.814	2.5 Y	5/3	light olive brown	6
KL08	5.04	10 YR	4/4	dark yellowish brown	12
KL09	5.70	7.5 YR	5/6	strong brown	24
KL10	5.28	10 YR	5/3	brown	9
KL11	5.38	10 YR	3/4	dark yellowish brown	12
KL12	2.54	10 YR	4/4	dark yellowish brown	12
KL13	2.59	10 YR	3/3	dark brown	9
KL14	3.84	10 YR	5/6	yellowish brown	18
KL15	8.63	10 YR	3/4	dark yellowish brown	12
KL16	1.31	2.5 YR	3/8	dark red	48
KL17	1.90	7.5 YR	4/4	brown	16
KL18	2.26	10 YR	6/6	brownish yellow	18
KL19	6.52	10 YR	6/6	brownish yellow	18
KL20	1.73	7.5 YR	4/6	strong brown	24
KL21	26.1	7.5 YR	5/6	strong brown	24
KL22	3.59	10 YR	6/6	brownish yellow	18
KL23	0.915	2.5 Y	5/4	light olive brown	8
KL24	1.29	10 YR	4/4	dark yellowish brown	12

APPENDIX D: Soil Data, B Horizon (cont.)

B Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
KL25	3.12	10 YR	4/4	dark yellowish brown	12
KL26	0.637	10 YR	5/4	yellowish brown	12
KL27	7.70	7.5 YR	5/6	strong brown	24
KL28	0.328	2.5 Y	5/3	light olive brown	6
KL30	0.884	5 YR	4/6	yellowish red	30
LC01	17.5	2.5 Y	5/2	grayish brown	4
LC02	5.59	7.5 YR	5/8	strong brown	32
LC03	1.73	2.5 Y	6/4	light yellowish brown	8
LC04	4.90	10 YR	5/4	yellowish brown	12
LC05	10.3	2.5 Y	5/4	light olive brown	8
LC06	0.274	10 YR	4/4	dark yellowish brown	12
LC07	3.02	10 YR	6/4	light yellowish brown	12
LC08	5.97	10 YR	6/4	light yellowish brown	12
LC09	10.6	1.5 Y	5/6	light olive brown	15
LC10B	3.79	10 YR	4/4	dark yellowish brown	12
LC11	4.11	10 YR	4/3	brown	9
LC12	4.98	10 YR	5/4	yellowish brown	12
LC14	1.74	10 YR	6/7	brownish yellow	21
LC15	7.70	10 YR	4/4	dark yellowish brown	12
LC16	7.31			(no color data)	
LC17	6.86	10 YR	5/4	yellowish brown	12
LC18	7.94	10 YR	4/4	dark yellowish brown	12
LC19	0.347	10 YR	4/4	dark yellowish brown	12
LC20	2.33	10 YR	4/3	brown	9
LC21	1.67	7.5 YR	5/8	strong brown	32
LC22	3.38	4 YR	4/4	reddish brown	20
LC23	2.90	6.5 YR	4/4	brown	16
LM02	4.80	10 YR	5/3	brown	9
LM03B	1.96	10 YR	6/4	light yellowish brown	12
LM04	2.16	2.5 Y	6/4	light yellowish brown	8
LM05	1.10	10 YR	6/4	light yellowish brown	12
LM06	1.00	2.5 Y	7/4	pale yellow	8
LM07	2.85	2.5 Y	5/3	light olive brown	6
LM08	4.74	10 YR	4/4	dark yellowish brown	12
LM09	1.79	10 YR	6/3	pale brown	9
LM1	7.53	10 YR	5/4	yellowish brown	12
LM10	1.00	10 YR	6/4	light yellowish brown	12
LM11	0.977	10 YR	6/4	light yellowish brown	12

APPENDIX D: Soil Data, B Horizon (cont.)

B Horizon Samples		Munsell Colors (dry)			Color Index
Sample	As (ppm)	Hue	Value/ Chroma	Munsell Color	B-W
LM12	1.86	10 YR	3/3	dark brown	9
LM13	2.03	10 YR	4/4	dark yellowish brown	12
LM14	1.52	7.5 YR	4/4	brown	16
LM15	2.56	7.5 YR	4/4	brown	16
LM16	0.809	10 YR	4/3	brown	9
LM17	3.32	10 YR	5/4	yellowish brown	12
LM19	7.31	2.5 Y	5/3	light olive brown	6
LM20	2.02			(no color data)	
LM21	0.543	10 YR	5/4	yellowish brown	12
LM22	1.48	10 YR	6/4	light yellowish brown	12
R01	11.9	10 YR	6/2	light brownish gray	6
R02	7.13	2.5 Y	7/2	light gray	4
R03	1.29	2.5 Y	6/4	light yellowish brown	8
R05	1.61	9 YR	5/6	yellowish brown	21
R07	2.02	10 YR	6/4	light yellowish brown	12
R10	0.520	2.5 Y	5/4	light olive brown	8
R12	5.95	10 YR	6/4	light yellowish brown	12
R13	45.4	5 YR	4/8	yellowish red	40
R14	12.9	7.5 YR	6/6	reddish yellow	24
R15	1.64	9 YR	5/6	yellowish brown	21

APPENDIX E: SAMPLING SITE CHARACTERISTICS

SITE	PROVINCE	COUNTY NAME	QUADRANGLE	MRC	GEOLOGIC UNIT	SOIL ORDER	VEGETATION	LAT	LONG	ELEV (m)
EO02	High Lava Plains	Deschutes	Benham Falls	43121-H4	Qb	Inceptisol	p	43.91	-121.40	1368
EO07	Basin and Range	Klamath	Sprague River West	42121-D5	Tb	Mollisol	p	42.39	-121.55	1398
EO08	Basin and Range	Klamath	Swan Lake Point	42121-D6	QTb	Mollisol	f, p	42.41	-121.65	1885
EO09	Basin and Range	Klamath	Chiloquin	42121-E7	Ts	Entisol	p, br, g	42.60	-121.77	1286
EO10	Basin and Range	Klamath	Calimus Butte	42121-F5	QTb	Entisol	p, br	42.68	-121.55	1617
EO11	Basin and Range	Klamath	Buckhorn Springs	42121-G5	Ts	Entisol	p	42.79	-121.52	1447
EO12	Basin and Range	Klamath	Fuego Mountain	42121-F4	Tob	Entisol	p	42.72	-121.39	1484
EO13	Basin and Range	Klamath	Gordon Lake	42121-H4	QTs	Entisol	p	42.98	-121.46	1423
EO14	Basin and Range	Klamath	Fuego	42121-G7	Qma	Inceptisol	p	42.87	-121.81	1377
EO15	Cascade Range	Klamath	Odell Butte	43121-D7	Qs	Entisol	p	43.46	-121.77	1392
EO16	High Lava Plains	Deschutes	Finley Butte	43121-F4	QTst	Entisol	p	43.70	-121.38	1435
EO17	High Lava Plains	Deschutes	Paulina Peak	43121-F3	QTst	Entisol	p	43.70	-121.30	1836
EO18	Cascade Range	Deschutes	Davis Mountain	43121-F7	QTba	Inceptisol	p	43.69	-121.85	1398
EO19	Cascade Range	Deschutes	Davis Mountain	43121-F7	Qyb	Parent	none	43.66	-121.80	1332
EO20	Cascade Range	Deschutes	Davis Mountain	43121-F7	QTmv	Entisol	f, p	43.63	-121.77	1824
EO21	Cascade Range	Klamath	Hamner Butte	43121-E7	QTba	Entisol	f, p	43.61	-121.82	1338
EO22	Cascade Range	Klamath	Muttonchop Butte	43121-C7	QTp	Entisol	p	43.36	-121.85	1514
EO23	Cascade Range	Klamath	Burn Butte	43121-C8	Qmp	Entisol	p	43.37	-121.88	1471
EO24	Cascade Range	Klamath	Pothole Butte	42121-H8	Qrd	Entisol	f, p	42.97	-121.94	1824
EO25	Cascade Range	Klamath	Crater Lake East	42122-H1	QTba	Entisol		42.92	-122.01	1569
EO26	Basin and Range	Klamath	Sun Pass	42121-G8	Qf	Entisol	p	42.86	-121.90	1386

APPENDIX E: Sampling Sites Characteristics (cont.)

SITE	PROVINCE	COUNTY NAME	QUADRANGLE	MRC	GEOLOGIC UNIT	SOIL ORDER	VEGETATION	LAT	LONG	ELEV (m)
EO27	Basin and Range	Klamath	Sun Pass	42121-G8	Tob	Entisol	f, p	42.76	-121.98	1435
EO30	High Lava Plains	Lake	Big Hole	43121-D3	QTps	Entisol	p, g, br	43.42	-121.31	1404
EO31	High Lava Plains	Lake	Big Hole	43121-D3	Tat	Entisol	p, br	43.38	-121.30	1490
EO32	High Lava Plains	Klamath	Sugarpine Mountain	43121-A5	Tmv	Entisol	p, g, br	43.11	-121.61	1891
EO33	Basin and Range	Klamath	Gordon Lake	42121-H4	Tp	Entisol	p	43.00	-121.42	1526
EO34	Basin and Range	Klamath	Chiloquin	42121-E7	Tps	Entisol	p, br	42.62	-121.81	1325
EO35	Basin and Range	Klamath	S'Ocholis Canyon	42121-E6	QTvm	Inceptisol	f, p	42.53	-121.66	1544
EO36	Basin and Range	Klamath	Sprague River East	42121-D4	Trh	Mollisol	f, p, g	42.41	-121.46	1569
HH01	High Lava Plains	Deschutes	Benham Falls	43121-H4	Qyb	Parent	none	43.91	-121.38	1328
HH02	High Lava Plains	Deschutes	Lava Butte	43121-H3	Qyb	Parent	none	43.91	-121.36	1379
HH03	Cascade Range	Douglas	Pumice Desert West	43122-A2	Qta	Inceptisol	f	43.09	-122.21	1672
HH04	Cascade Range	Douglas	Pumice Desert West	43122-A2	Qta	Inceptisol	f, h	43.09	-122.21	1644
HH05	Cascade Range	Jackson	McLeod	42122-F6	Thi	Alfisol	md, o, p	42.70	-122.63	688
HH06	Cascade Range	Jackson	McLeod	42122-F6	Thi	Alfisol	c, md, o, p	42.69	-122.63	646
HH07	Basin and Range	Klamath	Yonna	42121-C4	Tvs	Inceptisol	c, md, p	42.35	-121.40	1551
HH08	Basin and Range	Klamath	Yonna	42121-C4	Tvs	Inceptisol	c, md, p	42.35	-121.40	1567
HH09	Basin and Range	Klamath	Yainax Butte	42121-C3	Tvm	Inceptisol	c, md, p	42.36	-121.37	1618
HH10	Basin and Range	Klamath	Yainax Butte	42121-C3	Tvm	Inceptisol	c, md, p	42.36	-121.37	1620
HH11	Klamath	Douglas	Dixonville	43123-B2	KJdv	Inceptisol	g, md, p, o	43.17	-123.20	275
HH12	Klamath	Douglas	Dixonville	43123-B2	KJdv	Inceptisol	c, frn, p	43.16	-123.20	282
HH13	Willamette	Lane	Creswell	43123-H1	Tfee	Alfisol	f	43.97	-123.06	264
HH14	Willamette	Lane	Creswell	43123-H1		Alfisol	frn, f, hz, md	43.97	-123.06	292
HH15	Willamette	Lane	Springfield	44122-A8	Tfeb	Alfisol	f, g, o	44.01	-122.98	201

APPENDIX E: Sampling Sites Characteristics (cont.)

SITE	PROVINCE	COUNTY NAME	QUADRANGLE	MRC	GEOLOGIC UNIT	SOIL ORDER	VEGETATION	LAT	LONG	ELEV (m)
HH16	Willamette	Lane	Springfield	44122-A8	Tfeb	Inceptisol	f, o	44.01	-122.98	214
HH17	Coast Range	Lane	Noti	44123-A4	Ti	Ultisol	b, f	44.03	-123.43	240
HH18	Coast Range	Lane	Noti	44123-A4	Ti	Ultisol	b, f	44.03	-123.43	228
KL01	Klamath	Josephine	Galice	42123-E5	Js	Ultisol	p, f(old)	42.57	-123.54	426
KL02	Klamath	Josephine	Wilderville	42123-D4	KJg	Inceptisol	m, f, p	42.50	-123.43	316
KL03	Klamath	Josephine	Galice	42123-E5	Jv	Alfisol	f	42.61	-123.60	228
KL04	Klamath	Curry	Marial	42123-F8	KJds	Inceptisol	df(old)	42.64	-123.91	1094
KL05	Klamath	Curry	Agness	42124-E1	Tmss	Alfisol	f, po, g	42.58	-124.04	122
KL06	Klamath	Curry	Soldier Camp Mtn.	42124-E2	cs	Alfisol	p, f	42.53	-124.14	195
KL07	Klamath	Curry	Cape Blanco	42124-G5	Qt	Inceptisol	f	42.82	-124.50	52
KL08	Klamath	Curry	Cape Blanco	42124-G5	Qt	Inceptisol	p	42.83	-124.54	61
KL09	Klamath	Curry	Port Orford	42124-F4	JTrgd	Ultisol	f, m, a	42.71	-124.38	219
KL10	Klamath	Curry	Father Mountain	42124-F3	Ks	Inceptisol	f (old), m	42.71	-124.28	170
KL11	Klamath	Curry	Father Mountain	42124-F3	Js	Inceptisol	f	42.72	-124.32	146
KL12	Klamath	Curry	Brushy Bald Mountain	42124-E3	cs	Ultisol	f	42.60	-124.35	24
KL13	Klamath	Curry	Gold Beach	42124-D4	Jop	Inceptisol	f	42.49	-124.41	49
KL14	Klamath	Josephine	Selma	42123-C5	Jss	Alfisol	f	42.34	-123.58	462
KL15	Klamath	Josephine	Cave Junction	42123-B6	Jss	Inceptisol	f	42.24	-123.64	389
KL16	Klamath	Josephine	Cave Junction	42123-B6	Ju	Ultisol	f, p	42.24	-123.69	365
KL17	Klamath	Josephine	Takilma	42123-A5	Jm	Alf/Ult	f	42.05	-123.58	584
KL18	Klamath	Josephine	Oregon Caves	42123-A4	TrPzs	Alfisol	f(old)	42.10	-123.41	1021
KL19	Klamath	Jackson	Tallowbox Mountain	42123-B2	TrPv	Alf/Ult	f	42.18	-123.21	657
KL20	Klamath	Josephine	Grayback Mountain	42123-A3	TrPzs	Inceptisol	f, p	42.04	-123.30	1386

APPENDIX E: Sampling Sites Characteristics (cont.)

SITE	PROVINCE	COUNTY NAME	QUADRANGLE	MRC	GEOLOGIC UNIT	SOIL ORDER	VEGETATION	LAT	LONG	ELEV (m)
KL21	Klamath	Jackson	Carberry Creek	42123-A2	cm	Alfisol	f, p	42.02	-123.13	657
KL22	Klamath	Jackson	Squaw Lakes	42123-A1	TrPv	Inceptisol	f, p	42.12	-123.05	584
KL23	Klamath	Josephine	Buckskin Peak	42123-A7	JTrgd	Alfisol	f, p	42.05	-123.84	1143
KL24	Klamath	Jackson	Siskiyou Peak	42122-A7	TrPzm	Alfisol	f (old)	42.05	-122.83	2019
KL25	Klamath	Jackson	Dutchman Peak	42122-A8	TrPzm	Inceptisol	f	42.04	-122.91	1946
KL26	Klamath	Jackson	Mount Ashland	42122-A6	KJg	Inceptisol	f	42.08	-122.72	2043
KL27	Klamath	Jackson	King Mountain	42123-F2	Kc	Alf/Ult	f	42.67	-123.20	778
KL28	Klamath	Jackson	Skeleton Mountain	42123-F1	mc	Inceptisol	f, p	42.64	-123.10	754
KL30	Klamath	Josephine	Mount Peavine	42123-E6	bc	Alfisol	o, f, p	42.53	-123.66	745
LC01	Willamette	Lane	Eugene West	44123-A2	Qs	Mollisol	g	44.05	-123.17	119
LC02	Willamette	Lane	Eugene West	44123-A2	Tfee	Ultisol	df(young)	44.02	-123.16	249
LC03	Willamette	Lane	Veneta	44123-A3	Qt	Mollisol	df	44.03	-123.30	106
LC04	Coast Range	Douglas	Drain	43123-F3	Tt	Ultisol	df	43.71	-123.34	219
LC05	Coast Range	Douglas	Sutherlin	43123-D3	Tmsm	Inceptisol	o, df	43.47	-123.32	269
LC06	Klamath	Douglas	Winchester	43123-C3	Tsr	Mollisol	o, lp	43.26	-123.32	213
LC07	Cascade Range	Douglas	Fish Mountain	43122-A4	Tmsc	Inceptisol	df, lp	43.03	-122.38	316
LC08	Coast Range	Douglas	Camas Valley	43123-A6	Tmss	Inceptisol	df	43.01	-123.73	340
LC09	Coast Range	Douglas	Devils Graveyard	43123-F6	Ty	Mollisol	df, o	43.64	-123.64	134
LC10A	Klamath	Douglas	Oak Creek Valley	43123-C2	Tsr	Ultisol	lp, f, g	43.32	-123.22	182
LC10B	Coast Range	Douglas	Scottsburg	43123-F7	Ty	Ultisol	h, c	43.67	-123.78	24
LC11	Coast Range	Douglas	Scottsburg	43123-F7	Qal	Inceptisol	w, m	43.67	-123.81	0
LC12	Coast Range	Douglas	Scottsburg	43123-F7	Tt	Inceptisol	m, f	43.65	-123.83	24
LC13	Coast Range	Douglas	Winchester Bay	43124-F2	Qd	Entisol	mb, sb	43.66	-124.20	0

APPENDIX E: Sampling Sites Characteristics (cont.)

SITE	PROVINCE	COUNTY NAME	QUADRANGLE	MRC	GEOLOGIC UNIT	SOIL ORDER	VEGETATION	LAT	LONG	ELEV (m)
LC14	Coast Range	Douglas	Winchester Bay	43124-F2	Qd	Spodosol	df, cs, s	43.66	-124.19	0
LC15	Coast Range	Coos	Lakeside	43124-E2	Tss	Inceptisol	f, a	43.59	-124.17	24
LC16	Coast Range	Coos	Lakeside	43124-E2	Qt	Inceptisol	f	43.59	-124.18	0
LC17	Coast Range	Coos	Cape Arago	43124-C4	Qt	Ultisol	f(old)	43.33	-124.38	0
LC18	Coast Range	Coos	Charleston	43124-C3	Tss	Ultisol	f(old)	43.32	-124.36	109
LC19	Coast Range	Coos	Coquille	43124-B2	Tsr	Ultisol	f, m,a	43.15	-124.15	27
LC20	Coast Range	Douglas	Bone Mountain	42123-H7	Qls	Inceptisol	a, f	42.97	-123.82	170
LC21	Coast Range	Douglas	Chipmunk Ridge	43123-H6	Tmss	Alfisol	f, cs	43.00	-123.72	334
LC22	Willamette	Lane	Fox Hollow	43123-H2	Tfe	Ultisol	f	43.90	-123.20	489
LC23	Coast Range	Lane	Mercer Lake	44124-A1	Tpb	Inceptisol	f	44.08	-124.08	397
LM01	Cascade Range	Douglas	Old Fairview	43122-C8	Qls	Inceptisol	df, m, a	43.30	-122.91	268
LM02	Cascade Range	Douglas	Mace Mountain	43122-C7	Tus	Inceptisol	df	43.31	-122.84	316
LM03A	Cascade Range	Douglas	Illahee Rock	43122-C5	Tus	Inceptisol	df	43.30	-122.62	438
LM03B	Cascade Range	Douglas	Fish Creek Desert	43122-B4	QTba	Inceptisol	df	43.25	-122.40	827
LM04	Cascade Range	Douglas	Diamond Lake	43122-B2	Qg	Entisol	p	43.19	-122.13	1301
LM05	Cascade Range	Douglas	Pumice Desert East	43122-A1	Qma	Entisol	p, df	43.10	-122.10	1860
LM06	Cascade Range	Klamath	Miller Lake	43121-B8	Qmp	Entisol	p, df	43.22	-121.93	1745
LM07	Cascade Range	Lane	Westfir West	43122-G5	Qal	Inceptisol	m,df, c, cw	43.82	-122.60	292
LM08	Cascade Range	Lane	Holland Point	43122-F5	Tu	Ultisol	df	43.73	-122.54	778
LM09	Cascade Range	Lane	Willamette Pass	43122-E1	Qba	Inceptisol	df	43.61	-122.12	1240
LM10	Cascade Range	Klamath	Odell Lake	43121-E8	Qg	Entisol	p	43.54	-121.95	1453
LM11	Cascade Range	Klamath	Odell Butte	43121-D7	QTmv	Entisol	df	43.47	-121.87	1873
LM12	Cascade Range	Jackson	Hyatt Reservoir	42122-B4	Tub	Mollisol	gf, df(old)	42.18	-122.48	1654

APPENDIX E: Sampling Sites Characteristics (cont.)

SITE	PROVINCE	COUNTY NAME	QUADRANGLE	MRC	GEOLOGIC UNIT	SOIL ORDER	VEGETATION	LAT	LONG	ELEV (m)
LM13	Cascade Range	Jackson	Hyatt Reservoir	42122-B4	Tus	Mollisol	df	42.20	-122.44	1526
LM14	Cascade Range	Klamath	Little Chinquapin Mtn.	42122-B3	Trb	Mollisol	df	42.14	-122.27	1325
LM15	Cascade Range	Klamath	Mule Hill	42122-A2	QTba	Mollisol	df(old)	42.12	-122.16	1350
LM16	Basin and Range	Klamath	Spencer Creek	42122-B1	Qba	Mollisol	p	42.13	-122.03	1289
LM17	Cascade Range	Lane	Lowell	43122-H7	Qal	Mollisol	df, m, p	43.93	-122.83	182
LM19	Cascade Range	Lane	Westfir West	43122-G5	Tut	Inceptisol	df	43.86	-122.56	486
LM20	Cascade Range	Lane	Saddleblanket Mtn.	43122-H5	Tsv	Inceptisol	df	43.96	-122.61	292
LM21	Cascade Range	Lane	Chucksney Mountain	43122-H1	Qgf	Inceptisol	df(old)	43.96	-122.12	730
LM22	Cascade Range	Lane	Cougar Reservoir	44122-A2	Tfc	Inceptisol	df, m	44.04	-122.14	462
R01	Cascade Range	Lane	Mount David Douglas	43122-F2	Tbaa	Inceptisol	df(old)	43.66	-122.21	803
R02	Cascade Range	Lane	Mount David Douglas	43122-F2	Tbaa	Inceptisol	df(old), vm	43.64	-122.15	1094
R03	Cascade Range	Klamath	Crater Lake West	42122-H2	Qa	Inceptisol	lp, h (old)	42.96	-122.20	1933
R05	Cascade Range	Klamath	Pelican Bay	42122-D1	QTp	Inceptisol	pp, df(few)	42.44	-122.11	1277
R07	Klamath	Jackson	Boswell Mountain	42122-E8	Tn	Inceptisol	md , pp, po	42.55	-122.91	456
R10	Klamath	Josephine	Murphy Mountain	42123-C4	KJgu	Alf/Ult	md, po, pp	42.36	-123.38	353
R12	Klamath	Josephine	Selma	42123-C5	Jub	Inceptisol	df, md, pi	42.33	-123.61	486
R13	Klamath	Josephine	Golden	42123-F3	Jub	Alf/Ult	df, md (few)	42.64	-123.26	730
R14	Klamath	Douglas	Canyonville	42123-H3	KJm	Alf/Ult	df, md, pp	42.92	-123.32	340
R15	Klamath	Douglas	Dixonville	43123-B2	KJm	Alf/Ult	df, pp, md	43.15	-123.16	271

Appendix E Key
MRC = Map Reference Code
Vegetation: a alder, b blackberry, br brush, c cedar, cs citrus spruce, cw cottonwood, df Douglas fir, f fir, frn fern, g grass, gf ground, h hemlock, hz hazelnut, lp lodgepole pine, m maple, mb myrtle bush, md madrone, mgc mossy ground cover, ml mountain laurel, o oak, p pine, pi poison ivy, po poison oak, pp ponderosa pine, sb scotch broom, s salal, ss sitka spruce, w willow, wmb wax myrtle bush, wp wetland and prairie plants.

APPENDIX F: Analysis Categories Data

Site	As	BW	Soil Order	Province	Origin	Age Rank	Elev (m)
EO02	1.36	no data	Inceptisol	High Lava Plains	V	1.30	1372
EO07	1.46	9	Mollisol	Basin and Range	V	10.65	1402
EO08	1.57	6	Mollisol	Basin and Range	V	2.66	1896
EO09	0.496	6	Entisol	Basin and Range	VS	12.80	1295
EO10	1.08	8	Entisol	Basin and Range	V	2.66	1634
EO11	1.13	6	Entisol	Basin and Range	VS	12.80	1457
EO12	0.941	8	Entisol	Basin and Range	V	7.60	1494
EO13	1.05	6	Entisol	Basin and Range	S	2.66	1433
EO14	1.02	12	Inceptisol	Basin and Range	V	0.005	1382
EO15	0.776	6	Entisol	Cascade Range	U	1.31	1398
EO16	1.31	4	Entisol	High Lava Plains	VS	3.55	1442
EO17	1.47	6	Entisol	High Lava Plains	VS	3.55	1847
EO18	0.923	8	Inceptisol	Cascade Range	V	2.66	1405
EO19	0.349	no data	Parent Material	Cascade Range	V	0.005	1332
EO20	0.806	8	Entisol	Cascade Range	V	11.51	1829
EO21	0.687	4	Entisol	Cascade Range	V	2.66	1347
EO22	1.12	6	Entisol	Cascade Range	U	11.50	1521
EO23	0.845	4	Entisol	Cascade Range	V	0.005	1481
EO24	1.22	6	Entisol	Cascade Range	V	1.30	1835
EO25	0.892	6	Entisol	Cascade Range	V	1.30	1579
EO26	0.693	12	Entisol	Basin and Range	U	1.30	1396
EO27	2.15	6	Entisol	Basin and Range	V	7.60	1445
EO30	0.762	8	Entisol	High Lava Plains	V	11.50	1410
EO31	0.821	6	Entisol	High Lava Plains	V	7.60	1494
EO32	1.5	6	Entisol	High Lava Plains	V	14.15	1899
EO33	1.07	6	Entisol	Basin and Range	VS	13.30	1530
EO34	1.15	6	Entisol	Basin and Range	V	13.30	1335
EO35	1.62	12	Inceptisol	Basin and Range	V	11.51	1554
EO36	1.57	9	Mollisol	Basin and Range	V	12.80	1579
HH01	0.001	4	Parent Material	High Lava Plains	V	0.005	1328
HH02	0.001	4	Parent Material	High Lava Plains	V	0.005	1379
HH03	0.001	12	Inceptisol	Cascade Range	V	2.66	1672
HH04	0.001	12	Inceptisol	Cascade Range	V	2.66	1644
HH05	4.88	8	Alfisol	Cascade Range	P	14.15	688

APPENDIX F: Analysis Categories Data (cont.)

Site	As	BW	Soil Order	Province	Origin	Age Rank	Elev (m)
HH06	7.29	12	Alfisol	Cascade Range	P	14.15	646
HH07	0.001	9	Inceptisol	Basin and Range	V	29.20	1551
HH08	0.001	16	Inceptisol	Basin and Range	V	29.20	1567
HH09	0.001	12	Inceptisol	Basin and Range	V	12.80	1618
HH10	0.001	12	Inceptisol	Basin and Range	V	12.80	1620
HH11.1	4.51	24	Inceptisol	Klamath Mountains	V	130.30	275
HH11.2	4.83	16	Inceptisol	Klamath Mountains	V	130.30	275
HH11.3	4.99	16	Inceptisol	Klamath Mountains	V	130.30	275
HH11.4	4.04	16	Inceptisol	Klamath Mountains	V	130.30	275
HH11.5	4.29	16	Inceptisol	Klamath Mountains	V	130.30	275
HH12	0.001	12	Inceptisol	Klamath Mountains	V	130.30	282
HH13	13.5	9	Alfisol	Willamette Valley	S	28.45	264
HH14	85.4	12	Alfisol	Willamette Valley	S	28.45	292
HH15	0.001	16	Alfisol	Willamette Valley	V	31.70	201
HH16	0.001	9	Inceptisol	Willamette Valley	V	31.70	214
HH17	4.28	30	Ultisol	Coast Range	P	28.45	240
HH18	4.54	20	Ultisol	Coast Range	P	28.45	228
KL01	1.62	24	Alfisol	Klamath Mountains	S	173.55	434
KL02	1.56	18	Inceptisol	Klamath Mountains	P	133.55	317
KL03	2.57	18	Alfisol	Klamath Mountains	V	173.55	236
KL04	8.71	24	Inceptisol	Klamath Mountains	S	130.30	1097
KL05	7.38	15	Alfisol	Klamath Mountains	S	44.50	122
KL06	3.82	30	Alfisol	Klamath Mountains	M	303.75	207
KL07	0.814	6	Inceptisol	Klamath Mountains	U	1.30	52
KL08	5.11	9	Inceptisol	Klamath Mountains	U	1.30	62
KL09	5.7	24	Ultisol	Klamath Mountains	P	198.25	232
KL10	5.28	9	Inceptisol	Klamath Mountains	S	105.50	183
KL11	5.38	12	Inceptisol	Klamath Mountains	S	173.55	158
KL12	2.82	12	Ultisol	Klamath Mountains	M	303.75	24
KL13	2.59	9	Inceptisol	Klamath Mountains	M	153.25	61
KL14	3.84	18	Alfisol	Klamath Mountains	S	173.55	475
KL15	8.63	12	Inceptisol	Klamath Mountains	S	173.55	402
KL16	1.7	30	Ultisol	Klamath Mountains	VS	173.55	378
KL17	1.9	16	Ultisol	Klamath Mountains	M	173.55	597

APPENDIX F: Analysis Categories Data (cont.)

Site	As	BW	Soil Order	Province	Origin	Age Rank	Elev (m)
KL18	2.26	18	Alfisol	Klamath Mountains	S	371.80	1036
KL19	6.52	18	Ultisol	Klamath Mountains	V	250.30	671
KL20	1.73	24	Inceptisol	Klamath Mountains	S	371.80	1402
KL21	32.6	12	Alfisol	Klamath Mountains	M	250.30	671
KL22	3.59	18	Inceptisol	Klamath Mountains	V	250.30	597
KL23	0.915	8	Alfisol	Klamath Mountains	P	198.25	1158
KL24	1.29	12	Alfisol	Klamath Mountains	M	371.80	2036
KL25	3.12	12	Inceptisol	Klamath Mountains	M	371.80	1963
KL26	1.3	9	Inceptisol	Klamath Mountains	P	133.55	2060
KL27	7.7	24	Alfisol	Klamath Mountains	S	105.50	792
KL28	0.328	6	Inceptisol	Klamath Mountains	M	396.50	768
KL30	0.884	30	Alfisol	Klamath Mountains	M	303.75	754
LC01	17.5	4	Vertisol	Willamette Valley	U	1.31	119
LC02	10.1	12	Ultisol	Willamette Valley	S	28.45	253
LC03	2.08	6	Mollisol	Willamette Valley	U	1.30	114
LC04	4.9	12	Ultisol	Coast Range	S	44.50	232
LC05	10.3	8	Inceptisol	Coast Range	S	57.05	269
LC06	0.301	12	Mollisol	Klamath Mountains	V	52.95	213
LC07	3.64	12	Inceptisol	Cascade Range	S	52.20	317
LC08	5.97	12	Inceptisol	Coast Range	S	44.50	341
LC09	10.6	15	Inceptisol	Coast Range	S	41.25	134
LC10A	4.58	6	Mollisol	Klamath Mountains	V	52.95	195
LC10B	3.79	12	Mollisol	Coast Range	S	41.25	24
LC11	4.96	12	Inceptisol	Coast Range	U	0.005	12
LC12	4.98	12	Inceptisol	Coast Range	S	44.50	24
LC13	2.52	4	Entisol	Coast Range	U	0.005	12
LC14	1.74	21	Spodosol	Coast Range	U	0.005	12
LC15	7.7	12	Inceptisol	Coast Range	VS	41.25	37
LC16	7.31	no data	Inceptisol	Coast Range	U	1.30	12
LC17	6.86	12	Ultisol	Coast Range	U	1.30	12
LC18	7.94	12	Ultisol	Coast Range	VS	41.25	110
LC19	0.799	12	Ultisol	Coast Range	V	52.95	27
LC20	2.58	6	Inceptisol	Coast Range	U	1.30	171
LC21	3.09	16	Alfisol	Coast Range	S	44.50	343

APPENDIX F: Analysis Categories Data (cont.)

Site	As	BW	Soil Order	Province	Origin	Age Rank	Elev (m)
LC22	3.38	20	Ultisol	Willamette Valley	VS	31.70	489
LC23	2.9	16	Inceptisol	Coast Range	V	37.15	397
LM01	7.53	12	Inceptisol	Cascade Range	U	1.30	280
LM02	5.04	6	Inceptisol	Cascade Range	VS	19.60	329
LM03A	1.92	6	Inceptisol	Cascade Range	VS	19.60	445
LM03B	1.96	12	Inceptisol	Cascade Range	V	2.66	841
LM04	2.16	8	Inceptisol	Cascade Range	U	1.31	1317
LM05	1.26	6	Inceptisol	Cascade Range	V	0.005	1865
LM06	1	8	Inceptisol	Cascade Range	V	0.005	1753
LM07	2.99	6	Inceptisol	Cascade Range	U	0.005	305
LM08	4.74	12	Inceptisol	Cascade Range	VS	19.60	792
LM09	1.79	9	Ultisol	Cascade Range	V	1.30	1256
LM10	1	12	Inceptisol	Cascade Range	U	1.31	1460
LM11	0.977	12	Inceptisol	Cascade Range	V	11.51	1881
LM12	2.1	6	Inceptisol	Cascade Range	V	19.60	1664
LM13	2.03	12	Mollisol	Cascade Range	VS	19.60	1530
LM14	1.63	8	Mollisol	Cascade Range	V	7.10	1335
LM15	2.56	16	Mollisol	Cascade Range	V	2.66	1359
LM16	2.32	9	Mollisol	Basin and Range	V	1.30	1298
LM17	3.32	12	Mollisol	Cascade Range	U	0.005	189
LM19	7.31	6	Mollisol	Cascade Range	V	19.60	500
LM20	2.57	ND	Inceptisol	Cascade Range	V	15.50	305
LM21	1.03	9	Inceptisol	Cascade Range	U	1.31	744
LM22	1.48	12	Inceptisol	Cascade Range	V	14.15	463
R01	11.9	6	Inceptisol	Cascade Range	V	10.65	817
R02	7.13	4	Inceptisol	Cascade Range	V	10.65	1158
R03	1.72	6	Inceptisol	Cascade Range	V	1.30	1942
R05	1.61	21	Inceptisol	Cascade Range	U	11.50	1280
R07	2.02	12	Inceptisol	Klamath Mountains	S	44.85	465
R10	0.52	8	Ult/Alf	Klamath Mountains	P	133.55	354
R12	5.95	12	Inceptisol	Klamath Mountains	VS	173.55	488
R13	45.4	40	Ult/Alf	Klamath Mountains	VS	173.55	732
R14	12.9	24	Ult/Alf	Klamath Mountains	S	130.30	354
R15	1.64	21	Ult/Alf	Klamath Mountains	S	130.30	271

APPENDIX F: Analysis Categories Data (cont.)

Site	As	BW	Soil Order	Province	Origin	Age Rank	Elev (m)
LC22	3.38	20	Ultisol	Willamette Valley	VS	31.70	489
LC23	2.9	16	Inceptisol	Coast Range	V	37.15	397
LM01	7.53	12	Inceptisol	Cascade Range	U	1.30	280
LM02	5.04	6	Inceptisol	Cascade Range	VS	19.60	329
LM03A	1.92	6	Inceptisol	Cascade Range	VS	19.60	445
LM03B	1.96	12	Inceptisol	Cascade Range	V	2.66	841
LM04	2.16	8	Inceptisol	Cascade Range	U	1.31	1317
LM05	1.26	6	Inceptisol	Cascade Range	V	0.005	1865
LM06	1	8	Inceptisol	Cascade Range	V	0.005	1753
LM07	2.99	6	Inceptisol	Cascade Range	U	0.005	305
LM08	4.74	12	Inceptisol	Cascade Range	VS	19.60	792
LM09	1.79	9	Ultisol	Cascade Range	V	1.30	1256
LM10	1	12	Inceptisol	Cascade Range	U	1.31	1460
LM11	0.977	12	Inceptisol	Cascade Range	V	11.51	1881
LM12	2.1	6	Inceptisol	Cascade Range	V	19.60	1664
LM13	2.03	12	Mollisol	Cascade Range	VS	19.60	1530
LM14	1.63	8	Mollisol	Cascade Range	V	7.10	1335
LM15	2.56	16	Mollisol	Cascade Range	V	2.66	1359
LM16	2.32	9	Mollisol	Basin and Range	V	1.30	1298
LM17	3.32	12	Mollisol	Cascade Range	U	0.005	189
LM19	7.31	6	Mollisol	Cascade Range	V	19.60	500
LM20	2.57	ND	Inceptisol	Cascade Range	V	15.50	305
LM21	1.03	9	Inceptisol	Cascade Range	U	1.31	744
LM22	1.48	12	Inceptisol	Cascade Range	V	14.15	463
R01	11.9	6	Inceptisol	Cascade Range	V	10.65	817
R02	7.13	4	Inceptisol	Cascade Range	V	10.65	1158
R03	1.72	6	Inceptisol	Cascade Range	V	1.30	1942
R05	1.61	21	Inceptisol	Cascade Range	U	11.50	1280
R07	2.02	12	Inceptisol	Klamath Mountains	S	44.85	465
R10	0.52	8	Ult/Alf	Klamath Mountains	P	133.55	354
R12	5.95	12	Inceptisol	Klamath Mountains	VS	173.55	488
R13	45.4	40	Ult/Alf	Klamath Mountains	VS	173.55	732
R14	12.9	24	Ult/Alf	Klamath Mountains	S	130.30	354
R15	1.64	21	Ult/Alf	Klamath Mountains	S	130.30	271

Appendix F Key:

Rock type defined in Table 10.
Age Rank is the average of minimum and maximum deposition age as defined by Walker and MacLeod (1999).

APPENDIX G: Apex Labs Sample ID and Control Data

This appendix contains sample identification, quality control results, sample preparation information and notes and definitions used in Apex Labs reports for the following work orders:

- A10D053
- A10D059
- A10D066
- A10D071
- A10D077
- A10E125

These samples were tested for concentrations of various metals for Oregon, but only arsenic results were used in this study. The pages reporting results from different metals are not included, but results for arsenic concentrations in soils collected by PSU are in Appendix D.

Apex Labs

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Thursday, May 13, 2010

Neil Morton
GeoEngineers -Seattle
600 Stewart St. Suite 1700
Seattle, WA 98101

RE: Oregon Metals Evaluation / 2787-050-000

Enclosed are the results of analyses for work order A10D053, which was received by the laboratory on 4/2/2010 at 3:35:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

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Philip Nerenberg For Darwin Thomas, Business Development Director

Apex Labs

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
P05B	A10D053-01	Soil	01/01/94 00:00	04/02/10 15:35
P06A1a	A10D053-02	Soil	01/01/94 00:00	04/02/10 15:35
P06B1a	A10D053-03	Soil	01/01/94 00:00	04/02/10 15:35
P07A1a	A10D053-04	Soil	01/01/94 00:00	04/02/10 15:35
P07B1a	A10D053-05	Soil	01/01/94 00:00	04/02/10 15:35
P08A1a	A10D053-06	Soil	01/01/94 00:00	04/02/10 15:35
P08B1a	A10D053-07	Soil	01/01/94 00:00	04/02/10 15:35
P09A1a	A10D053-08	Soil	01/01/94 00:00	04/02/10 15:35
P09B1a	A10D053-09	Soil	01/01/94 00:00	04/02/10 15:35
P10A1a	A10D053-10	Soil	01/01/94 00:00	04/02/10 15:35
P10B1a	A10D053-11	Soil	01/01/94 00:00	04/02/10 15:35
P11A1a	A10D053-12	Soil	01/01/94 00:00	04/02/10 15:35
P11C1a	A10D053-13	Soil	01/01/94 00:00	04/02/10 15:35
P12A1a	A10D053-14	Soil	01/01/94 00:00	04/02/10 15:35
P12B1a	A10D053-15	Soil	01/01/94 00:00	04/02/10 15:35
P13A1a	A10D053-16	Soil	01/01/94 00:00	04/02/10 15:35
P13B1a	A10D053-17	Soil	01/01/94 00:00	04/02/10 15:35
P14A1a	A10D053-18	Soil	01/01/94 00:00	04/02/10 15:35
P14C1a	A10D053-19	Soil	01/01/94 00:00	04/02/10 15:35
P15A1a	A10D053-20	Soil	01/01/94 00:00	04/02/10 15:35
P15B1a	A10D053-21	Soil	01/01/94 00:00	04/02/10 15:35
P16A1a	A10D053-22	Soil	01/01/94 00:00	04/02/10 15:35
P16B1a	A10D053-23	Soil	01/01/94 00:00	04/02/10 15:35
P16C1a	A10D053-24	Soil	01/01/94 00:00	04/02/10 15:35
P17A1a	A10D053-25	Soil	01/01/94 00:00	04/02/10 15:35
P17B1a	A10D053-26	Soil	01/01/94 00:00	04/02/10 15:35
P17C1a	A10D053-27	Soil	01/01/94 00:00	04/02/10 15:35
P18A1a	A10D053-28	Soil	01/01/94 00:00	04/02/10 15:35
P18B1a	A10D053-29	Soil	01/01/94 00:00	04/02/10 15:35
S02A1a	A10D053-30	Soil	01/01/94 00:00	04/02/10 15:35
S02B1a	A10D053-31	Soil	01/01/94 00:00	04/02/10 15:35
S03A1a	A10D053-32	Soil	01/01/94 00:00	04/02/10 15:35
S04A	A10D053-33	Soil	01/01/94 00:00	04/02/10 15:35
S05A1a	A10D053-34	Soil	01/01/94 00:00	04/02/10 15:35
S05B1a	A10D053-35	Soil	01/01/94 00:00	04/02/10 15:35

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
S06A1a	A10D053-36	Soil	01/01/94 00:00	04/02/10 15:35
S06B1a	A10D053-37	Soil	01/01/94 00:00	04/02/10 15:35
S07A1a	A10D053-38	Soil	01/01/94 00:00	04/02/10 15:35
S07B1a	A10D053-39	Soil	01/01/94 00:00	04/02/10 15:35
S08A1b	A10D053-40	Soil	01/01/94 00:00	04/02/10 15:35
S08B1b	A10D053-41	Soil	01/01/94 00:00	04/02/10 15:35
S09A1a	A10D053-42	Soil	01/01/94 00:00	04/02/10 15:35
S09B1a	A10D053-43	Soil	01/01/94 00:00	04/02/10 15:35
S10A1a	A10D053-44	Soil	01/01/94 00:00	04/02/10 15:35
S10B1a	A10D053-45	Soil	01/01/94 00:00	04/02/10 15:35
S11A1b	A10D053-46	Soil	01/01/94 00:00	04/02/10 15:35
S11B1b	A10D053-47	Soil	01/01/94 00:00	04/02/10 15:35
S12A1a	A10D053-48	Soil	01/01/94 00:00	04/02/10 15:35
S12B1a	A10D053-49	Soil	01/01/94 00:00	04/02/10 15:35
W01A1a	A10D053-50	Soil	01/01/94 00:00	04/02/10 15:35
W01B2a	A10D053-51	Soil	01/01/94 00:00	04/02/10 15:35
W02A1a	A10D053-52	Soil	01/01/94 00:00	04/02/10 15:35
W02B2a	A10D053-53	Soil	01/01/94 00:00	04/02/10 15:35
W03A1a	A10D053-54	Soil	01/01/94 00:00	04/02/10 15:35
W03B2a	A10D053-55	Soil	01/01/94 00:00	04/02/10 15:35
W04A2a	A10D053-56	Soil	01/01/94 00:00	04/02/10 15:35
W04B2a	A10D053-57	Soil	01/01/94 00:00	04/02/10 15:35
W05A2b	A10D053-58	Soil	01/01/94 00:00	04/02/10 15:35
W05B2a	A10D053-59	Soil	01/01/94 00:00	04/02/10 15:35
W06A2a	A10D053-60	Soil	01/01/94 00:00	04/02/10 15:35
W06B2a	A10D053-61	Soil	01/01/94 00:00	04/02/10 15:35
W07A1a	A10D053-62	Soil	01/01/94 00:00	04/02/10 15:35
W07B1a	A10D053-63	Soil	01/01/94 00:00	04/02/10 15:35
W08A1a	A10D053-64	Soil	01/01/94 00:00	04/02/10 15:35
W08B1a	A10D053-65	Soil	01/01/94 00:00	04/02/10 15:35
W09A1a	A10D053-66	Soil	01/01/94 00:00	04/02/10 15:35
W09B1a	A10D053-67	Soil	01/01/94 00:00	04/02/10 15:35
R01Aa	A10D053-68	Soil	01/01/94 00:00	04/02/10 15:35
R01Ba	A10D053-69	Soil	01/01/94 00:00	04/02/10 15:35
R02Aa	A10D053-70	Soil	01/01/94 00:00	04/02/10 15:35

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GeoEngineers - Seattle	Project: Oregon Metals Evaluation	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	Reported:
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
R02Ba	A10D053-71	Soil	01/01/94 00:00	04/02/10 15:35
R03Aa	A10D053-72	Soil	01/01/94 00:00	04/02/10 15:35
R03Ba	A10D053-73	Soil	01/01/94 00:00	04/02/10 15:35
R05Ba	A10D053-74	Soil	01/01/94 00:00	04/02/10 15:35
R07Ba	A10D053-75	Soil	01/01/94 00:00	04/02/10 15:35
R10Ba	A10D053-76	Soil	01/01/94 00:00	04/02/10 15:35
R12Ba	A10D053-77	Soil	01/01/94 00:00	04/02/10 15:35
R13Aa	A10D053-78	Soil	01/01/94 00:00	04/02/10 15:35
R13Ba	A10D053-79	Soil	01/01/94 00:00	04/02/10 15:35
R14Aa	A10D053-80	Soil	01/01/94 00:00	04/02/10 15:35
R14Ba	A10D053-81	Soil	01/01/94 00:00	04/02/10 15:35
R15Aa	A10D053-82	Soil	01/01/94 00:00	04/02/10 15:35
R15Ba	A10D053-83	Soil	01/01/94 00:00	04/02/10 15:35
KL01A1	A10D053-84	Soil	01/01/94 00:00	04/02/10 15:35
KL01B1	A10D053-85	Soil	01/01/94 00:00	04/02/10 15:35
KL02A1	A10D053-86	Soil	01/01/94 00:00	04/02/10 15:35
KL02B1	A10D053-87	Soil	01/01/94 00:00	04/02/10 15:35
KL03A1	A10D053-88	Soil	01/01/94 00:00	04/02/10 15:35
KL03B1	A10D053-89	Soil	01/01/94 00:00	04/02/10 15:35
KL04A1	A10D053-90	Soil	01/01/94 00:00	04/02/10 15:35

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Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004105 - EPA 3051A							**Soil**					
Blank (1004105-BLK1)					Prepared: 04/08/10 09:29	Analyzed: 04/08/10 16:16						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004105-BS1)					Prepared: 04/08/10 09:29	Analyzed: 04/08/10 15:58						
EPA 6020												
Antimony	25.8	0.100	1.00	mg/kg wet	10	25.0	---	103	80-120%	---	---	
Arsenic	48.9	0.200	2.00	"	"	50.0	---	98	"	---	---	
Beryllium	24.7	0.200	1.00	"	"	25.0	---	99	"	---	---	
Cadmium	50.1	0.100	1.00	"	"	50.0	---	100	"	---	---	
Lead	46.6	0.100	1.00	"	"	"	---	93	"	---	---	
Selenium	23.9	0.400	2.00	"	"	25.0	---	96	"	---	---	
Silver	24.6	0.100	1.00	"	"	"	---	99	"	---	---	
Thallium	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
Duplicate (1004105-DUP1)					Prepared: 04/08/10 09:29	Analyzed: 04/08/10 16:54						
QC Source Sample: P07B1a (A10D053-05)												
EPA 6020												
Antimony	**0.300**	0.111	1.11	mg/kg dry	10	---	0.352	---	---	16	40%	J
Arsenic	**2.69**	0.222	2.22	"	"	---	2.81	---	---	5	40%	
Beryllium	**0.477**	0.222	1.11	"	"	---	0.494	---	---	3	40%	J
Cadmium	**0.111**	0.111	1.11	"	"	---	0.176	---	---	45	40%	Q-05, J
Lead	**16.2**	0.111	1.11	"	"	---	15.9	---	---	2	40%	
Selenium	ND	0.444	2.22	"	"	---	ND	---	---		40%	
Silver	ND	0.111	1.11	"	"	---	ND	---	---		40%	
Thallium	**0.133**	0.111	1.11	"	"	---	0.143	---	---	7	40%	J
Matrix Spike (1004105-MS1)					Prepared: 04/08/10 09:29	Analyzed: 04/08/10 16:57						
QC Source Sample: P07B1a (A10D053-05)												

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004105 - EPA 3051A							**Soil**					
Matrix Spike (1004105-MS1)					Prepared: 04/08/10 09:29	Analyzed: 04/08/10 16:57						
QC Source Sample: P07B1a (A10D053-05)												
EPA 6020												
Antimony	23.8	0.112	1.12	mg/kg dry	10	28.0	0.352	84	75-125%	---	---	
Arsenic	53.0	0.224	2.24	"	"	56.0	2.81	90	"	---	---	
Beryllium	26.0	0.224	1.12	"	"	28.0	0.494	91	"	---	---	
Cadmium	53.2	0.112	1.12	"	"	56.0	0.176	95	"	---	---	
Lead	65.1	0.112	1.12	"	"	"	15.9	88	"	---	---	
Selenium	25.3	0.448	2.24	"	"	28.0	ND	91	"	---	---	
Silver	26.2	0.112	1.12	"	"	"	ND	94	"	---	---	
Thallium	25.4	0.112	1.12	"	"	"	0.143	90	"	---	---	
Matrix Spike (1004105-MS2)					Prepared: 04/08/10 09:29	Analyzed: 04/08/10 17:34						
QC Source Sample: P12A1a (A10D053-14)												
EPA 6020												
Antimony	21.0	0.108	1.08	mg/kg dry	10	26.9	0.186	77	75-125%	---	---	
Arsenic	52.3	0.215	2.15	"	"	53.8	2.95	92	"	---	---	
Beryllium	25.2	0.215	1.08	"	"	26.9	0.616	91	"	---	---	
Cadmium	52.1	0.108	1.08	"	"	53.8	0.442	96	"	---	---	
Lead	72.4	0.108	1.08	"	"	"	27.0	84	"	---	---	
Selenium	24.9	0.431	2.15	"	"	26.9	ND	93	"	---	---	
Silver	25.2	0.108	1.08	"	"	"	ND	94	"	---	---	
Thallium	24.7	0.108	1.08	"	"	"	ND	92	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004114 - EPA 3051A							**Soil**					
Blank (1004114-BLK1)						Prepared: 04/08/10 12:16 Analyzed: 04/08/10 17:51						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004114-BS1)						Prepared: 04/08/10 12:16 Analyzed: 04/08/10 17:54						
EPA 6020												
Antimony	24.1	0.100	1.00	mg/kg wet	10	25.0	---	97	80-120%	---	---	
Arsenic	47.6	0.200	2.00	"	"	50.0	---	95	"	---	---	
Beryllium	24.4	0.200	1.00	"	"	25.0	---	98	"	---	---	
Cadmium	48.2	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	46.7	0.100	1.00	"	"	"	---	93	"	---	---	
Selenium	24.1	0.400	2.00	"	"	25.0	---	96	"	---	---	
Silver	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
Thallium	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
Duplicate (1004114-DUP1)						Prepared: 04/08/10 12:16 Analyzed: 04/08/10 18:15						
QC Source Sample: P16B1a (A10D053-23)												
EPA 6020												
Antimony	**0.233**	0.111	1.11	mg/kg dry	10	---	0.244	---	---	5	40%	J
Arsenic	**4.70**	0.222	2.22	"	"	---	4.80	---	---	2	40%	
Beryllium	**0.676**	0.222	1.11	"	"	---	0.676	---	---	0	40%	J
Cadmium	**0.310**	0.111	1.11	"	"	---	0.244	---	---	24	40%	J
Lead	**6.43**	0.111	1.11	"	"	---	6.63	---	---	3	40%	
Selenium	ND	0.443	2.22	"	"	---	ND	---	---		40%	
Silver	ND	0.111	1.11	"	"	---	ND	---	---		40%	
Thallium	**0.155**	0.111	1.11	"	"	---	0.155	---	---	0	40%	J
Matrix Spike (1004114-MS1)						Prepared: 04/08/10 12:16 Analyzed: 04/08/10 18:18						
QC Source Sample: P16B1a (A10D053-23)												

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Philip Nerenberg

Philip Nerenberg For Darwin Thomas, Business Development Director

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004114 - EPA 3051A — **Soil**

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Matrix Spike (1004114-MS1)						Prepared: 04/08/10 12:16 Analyzed: 04/08/10 18:18						
QC Source Sample: F16B1a (A10D053-23)												
EPA 6020												
Antimony	23.0	0.114	1.14	mg/kg dry	10	28.5	0.244	80	75-125%	---	---	
Arsenic	58.3	0.228	2.28	"	"	57.0	4.80	94	"	---	---	
Beryllium	27.0	0.228	1.14	"	"	28.5	0.676	92	"	---	---	
Cadmium	56.4	0.114	1.14	"	"	57.0	0.244	98	"	---	---	
Lead	58.1	0.114	1.14	"	"	"	6.63	90	"	---	---	
Selenium	26.5	0.456	2.28	"	"	28.5	ND	93	"	---	---	
Silver	27.4	0.114	1.14	"	"	"	ND	96	"	---	---	
Thallium	26.4	0.114	1.14	"	"	"	0.155	92	"	---	---	
Matrix Spike (1004114-MS2)						Prepared: 04/08/10 12:16 Analyzed: 04/09/10 19:23						
QC Source Sample: S06B1a (A10D053-37)												
EPA 6020												
Antimony	18.7	0.114	1.14	mg/kg dry	10	28.6	0.277	64	75-125%	---	---	Q-01
Arsenic	54.6	0.228	2.28	"	"	57.1	4.99	87	"	---	---	
Beryllium	28.1	0.228	1.14	"	"	28.6	1.29	94	"	---	---	
Cadmium	55.8	0.114	1.14	"	"	57.1	0.450	97	"	---	---	
Lead	71.7	0.114	1.14	"	"	"	22.9	86	"	---	---	
Selenium	24.7	0.457	2.28	"	"	28.6	0.889	83	"	---	---	
Silver	27.5	0.114	1.14	"	"	"	ND	96	"	---	---	
Thallium	25.6	0.114	1.14	"	"	"	0.277	89	"	---	---	
Post Spike (1004114-PS1)						Prepared: 04/12/10 11:45 Analyzed: 04/12/10 12:31						
QC Source Sample: S06B1a (A10D053-37)												
EPA 6020												
Antimony	129			ug/L	10	128	2.37	99	80-120%		---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004123 - EPA 3051A							Soil					
Blank (1004123-BLK1)					Prepared: 04/09/10 08:49 Analyzed: 04/09/10 19:29							
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004123-BS1)					Prepared: 04/09/10 08:49 Analyzed: 04/09/10 19:32							
EPA 6020												
Antimony	26.2	0.100	1.00	mg/kg wet	10	25.0	---	105	80-120%	---	---	
Arsenic	49.4	0.200	2.00	"	"	50.0	---	99	"	---	---	
Beryllium	24.4	0.200	1.00	"	"	25.0	---	98	"	---	---	
Cadmium	46.7	0.100	1.00	"	"	50.0	---	93	"	---	---	
Lead	45.8	0.100	1.00	"	"	"	---	92	"	---	---	
Selenium	24.0	0.400	2.00	"	"	25.0	---	96	"	---	---	
Silver	23.6	0.100	1.00	"	"	"	---	94	"	---	---	
Thallium	23.0	0.100	1.00	"	"	"	---	92	"	---	---	
Duplicate (1004123-DUP1)					Prepared: 04/09/10 08:49 Analyzed: 04/09/10 19:44							
QC Source Sample: S09A1a (A10D053-42)												
EPA 6020												
Antimony	**0.182**	0.101	1.01	mg/kg dry	10	---	0.226	---	---	22	40%	J
Arsenic	**4.80**	0.203	2.03	"	"	---	5.01	---	---	4	40%	
Beryllium	**0.567**	0.203	1.01	"	"	---	0.566	---	---	0.2	40%	J
Cadmium	**0.344**	0.101	1.01	"	"	---	0.381	---	---	10	40%	J
Lead	**6.99**	0.101	1.01	"	"	---	7.11	---	---	2	40%	
Selenium	**0.446**	0.405	2.03	"	"	---	ND	---	---		40%	J
Silver	ND	0.101	1.01	"	"	---	ND	---	---		40%	
Thallium	ND	0.101	1.01	"	"	---	ND	---	---		40%	
Matrix Spike (1004123-MS1)					Prepared: 04/09/10 08:49 Analyzed: 04/09/10 19:47							
QC Source Sample: S09A1a (A10D053-42)												

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004123 - EPA 3051A						**Soil**						
Matrix Spike (1004123-MS1)					Prepared: 04/09/10 08:49 Analyzed: 04/09/10 19:47							
QC Source Sample: S09A1a (A10D053-42)												
EPA 6020												
Antimony	21.7	0.105	1.05	mg/kg dry	10	26.3	0.226	82	75-125%	---	---	
Arsenic	52.7	0.210	2.10	"	"	52.6	5.01	91	"	---	---	
Beryllium	25.0	0.210	1.05	"	"	26.3	0.566	93	"	---	---	
Cadmium	49.8	0.105	1.05	"	"	52.6	0.381	94	"	---	---	
Lead	52.8	0.105	1.05	"	"	"	7.11	87	"	---	---	
Selenium	23.9	0.421	2.10	"	"	26.3	ND	91	"	---	---	
Silver	24.6	0.105	1.05	"	"	"	ND	94	"	---	---	
Thallium	23.0	0.105	1.05	"	"	"	ND	87	"	---	---	
Matrix Spike (1004123-MS2)					Prepared: 04/09/10 08:49 Analyzed: 04/12/10 12:28							
QC Source Sample: W04B2a (A10D053-57)												
EPA 6020												
Antimony	18.6	0.109	1.09	mg/kg dry	10	27.2	0.176	68	75-125%	---	---	Q-01
Arsenic	55.6	0.218	2.18	"	"	54.4	5.29	92	"	---	---	
Beryllium	25.0	0.218	1.09	"	"	27.2	0.925	89	"	---	---	
Cadmium	53.2	0.109	1.09	"	"	54.4	0.375	97	"	---	---	
Lead	56.5	0.109	1.09	"	"	"	7.29	90	"	---	---	
Selenium	25.2	0.435	2.18	"	"	27.2	0.551	91	"	---	---	
Silver	25.5	0.109	1.09	"	"	"	ND	94	"	---	---	
Thallium	24.4	0.109	1.09	"	"	"	0.143	89	"	---	---	
Post Spike (1004123-PS1)					Prepared: 04/12/10 14:04 Analyzed: 04/12/10 14:07							
QC Source Sample: W04B2a (A10D053-57)												
EPA 6020												
Antimony	180			ug/L	10	196	1.57	91	80-120%		---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004125 - EPA 3051A							**Soil**					
Blank (1004125-BLK1)						Prepared: 04/09/10 11:01	Analyzed: 04/12/10 13:33					
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	**0.200**	0.200	2.00	"	"	---	---	---	---	---	---	J
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004125-BS1)						Prepared: 04/09/10 11:01	Analyzed: 04/12/10 13:36					
EPA 6020												
Antimony	25.7	0.100	1.00	mg/kg wet	10	25.0	---	103	80-120%	---	---	
Arsenic	48.4	0.200	2.00	"	"	50.0	---	97	"	---	---	
Beryllium	24.1	0.200	1.00	"	"	25.0	---	96	"	---	---	
Cadmium	48.9	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	48.6	0.100	1.00	"	"	"	---	97	"	---	---	
Selenium	24.3	0.400	2.00	"	"	25.0	---	97	"	---	---	
Silver	24.4	0.100	1.00	"	"	"	---	98	"	---	---	
Thallium	24.4	0.100	1.00	"	"	"	---	98	"	---	---	
Duplicate (1004125-DUP1)						Prepared: 04/09/10 11:01	Analyzed: 04/12/10 14:16					
QC Source Sample: W08B1a (A10D053-65)												
EPA 6020												
Antimony	**0.267**	0.116	1.16	mg/kg dry	10	---	0.273	---	---	2	40%	J
Arsenic	**5.03**	0.232	2.32	"	"	---	4.86	---	---	3	40%	
Beryllium	**1.17**	0.232	1.16	"	"	---	1.20	---	---	2	40%	
Cadmium	**0.476**	0.116	1.16	"	"	---	0.459	---	---	4	40%	J
Lead	**12.5**	0.116	1.16	"	"	---	12.4	---	---	1	40%	
Selenium	ND	0.464	2.32	"	"	---	ND	---	---		40%	
Silver	ND	0.116	1.16	"	"	---	ND	---	---		40%	
Thallium	**0.290**	0.116	1.16	"	"	---	0.284	---	---	2	40%	J
Matrix Spike (1004125-MS1)						Prepared: 04/09/10 11:01	Analyzed: 04/12/10 14:19					
QC Source Sample: W08B1a (A10D053-65)												

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004125 - EPA 3051A							**Soil**					
Matrix Spike (1004125-MS1)						Prepared: 04/09/10 11:01 Analyzed: 04/12/10 14:19						
QC Source Sample: W08B1a (A10D053-65)												
EPA 6020												
Antimony	18.1	0.109	1.09	mg/kg dry	10	27.3	0.273	65	75-125%	---	---	Q-01
Arsenic	53.5	0.219	2.19	"	"	54.7	4.86	89	"	---	---	
Beryllium	25.6	0.219	1.09	"	"	27.3	1.20	89	"	---	---	
Cadmium	54.4	0.109	1.09	"	"	54.7	0.459	99	"	---	---	
Lead	63.4	0.109	1.09	"	"	"	12.4	93	"	---	---	
Selenium	24.8	0.437	2.19	"	"	27.3	ND	91	"	---	---	
Silver	26.7	0.109	1.09	"	"	"	ND	98	"	---	---	
Thallium	25.7	0.109	1.09	"	"	"	0.284	93	"	---	---	
Matrix Spike (1004125-MS2)						Prepared: 04/09/10 11:01 Analyzed: 04/12/10 15:01						
QC Source Sample: R10Ba (A10D053-76)												
EPA 6020												
Antimony	18.7	0.113	1.13	mg/kg dry	10	28.2	ND	66	75-125%	---	---	Q-01
Arsenic	53.4	0.226	2.26	"	"	56.4	0.520	94	"	---	---	
Beryllium	26.3	0.226	1.13	"	"	28.2	ND	93	"	---	---	
Cadmium	56.1	0.113	1.13	"	"	56.4	ND	99	"	---	---	
Lead	54.5	0.113	1.13	"	"	"	0.571	96	"	---	---	
Selenium	26.5	0.451	2.26	"	"	28.2	ND	94	"	---	---	
Silver	27.9	0.113	1.13	"	"	"	ND	99	"	---	---	
Thallium	26.8	0.113	1.13	"	"	"	ND	95	"	---	---	
Post Spike (1004125-PS1)						Prepared: 04/12/10 15:02 Analyzed: 04/12/10 15:05						
QC Source Sample: W08B1a (A10D053-65)												
EPA 6020												
Antimony	186			ug/L	10	196	2.45	93	80-120%		---	
Post Spike (1004125-PS2)						Prepared: 04/12/10 15:08 Analyzed: 04/12/10 15:38						
QC Source Sample: R10Ba (A10D053-76)												
EPA 6020												
Antimony	184			ug/L	10	196	0.196	94	80-120%		---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004142 - EPA 3051A							**Soil**					
Blank (1004142-BLK1)					Prepared: 04/12/10 10:03 Analyzed: 04/12/10 16:36							
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004142-BS1)					Prepared: 04/12/10 10:03 Analyzed: 04/12/10 16:39							
EPA 6020												
Antimony	25.7	0.100	1.00	mg/kg wet	10	25.0	---	103	80-120%	---	---	
Arsenic	47.5	0.200	2.00	"	"	50.0	---	95	"	---	---	
Beryllium	23.6	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	48.0	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	47.8	0.100	1.00	"	"	"	---	96	"	---	---	
Selenium	23.4	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	24.4	0.100	1.00	"	"	"	---	98	"	---	---	
Thallium	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
LCS (1004142-BS2)					Prepared: 04/12/10 13:05 Analyzed: 04/12/10 16:41							
EPA 6020												
Antimony	25.5	0.100	1.00	mg/kg wet	10	25.0	---	102	80-120%	---	---	
Arsenic	48.4	0.200	2.00	"	"	50.0	---	97	"	---	---	
Beryllium	23.3	0.200	1.00	"	"	25.0	---	93	"	---	---	
Cadmium	48.2	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	47.6	0.100	1.00	"	"	"	---	95	"	---	---	
Selenium	23.4	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	25.1	0.100	1.00	"	"	"	---	101	"	---	---	
Thallium	23.6	0.100	1.00	"	"	"	---	95	"	---	---	
Duplicate (1004142-DUP1)					Prepared: 04/12/10 10:03 Analyzed: 04/12/10 17:11							
QC Source Sample: R15Aa (A10D053-82)												
EPA 6020												
Antimony	**0.186**	0.117	1.17	mg/kg dry	10	---	0.175	---	---	6	40%	J

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Geo Engineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004142 - EPA 3051A							**Soil**					
Duplicate (1004142-DUP1)					Prepared: 04/12/10 10:03 Analyzed: 04/12/10 17:11							
QC Source Sample: R15Aa (A10D053-82)												
Arsenic	**1.12**	0.233	2.33	mg/kg dry	"	---	1.00	---	---	11	40%	J
Beryllium	**0.315**	0.233	1.17	"	"	---	0.304	---	---	4	40%	J
Cadmium	**0.186**	0.117	1.17	"	"	---	0.140	---	---	28	40%	J
Lead	**5.76**	0.117	1.17	"	"	---	5.42	---	---	6	40%	
Selenium	ND	0.466	2.33	"	"	---	ND	---	---		40%	
Silver	ND	0.117	1.17	"	"	---	ND	---	---		40%	
Thallium	ND	0.117	1.17	"	"	---	ND	---	---		40%	
Matrix Spike (1004142-MS1)					Prepared: 04/12/10 10:03 Analyzed: 04/12/10 17:14							
QC Source Sample: R15Aa (A10D053-82)												
EPA 6020												
Antimony	22.9	0.115	1.15	mg/kg dry	10	28.7	0.175	79	75-125%	---	---	
Arsenic	52.2	0.229	2.29	"	"	57.4	1.00	89	"	---	---	
Beryllium	26.5	0.229	1.15	"	"	28.7	0.304	91	"	---	---	
Cadmium	55.6	0.115	1.15	"	"	57.4	0.140	97	"	---	---	
Lead	58.5	0.115	1.15	"	"	"	5.42	93	"	---	---	
Selenium	26.0	0.459	2.29	"	"	28.7	ND	91	"	---	---	
Silver	28.0	0.115	1.15	"	"	"	ND	98	"	---	---	
Thallium	26.7	0.115	1.15	"	"	"	ND	93	"	---	---	

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Philip Nerenberg

Philip Nerenberg For Darwin Thomas, Business Development Director

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004144 - EPA 3051A							**Soil**					
Blank (1004144-BLK1)					Prepared: 04/12/10 10:52 Analyzed: 04/14/10 13:57							
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	**0.310**	0.200	2.00	"	"	---	---	---	---	---	---	J
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	**0.180**	0.100	1.00	"	"	---	---	---	---	---	---	J
Selenium	**2.02**	0.400	2.00	"	"	---	---	---	---	---	---	B
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004144-BS1)					Prepared: 04/12/10 10:52 Analyzed: 04/14/10 14:00							
EPA 6020												
Antimony	26.0	0.100	1.00	mg/kg wet	10	25.0	---	104	80-120%	---	---	
Arsenic	47.8	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.5	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	48.5	0.100	1.00	"	"	50.0	---	97	"	---	---	
Lead	46.8	0.100	1.00	"	"	"	---	94	"	---	---	
Selenium	23.4	0.400	2.00	"	"	25.0	---	94	"	---	---	B
Silver	24.1	0.100	1.00	"	"	"	---	96	"	---	---	
Thallium	23.1	0.100	1.00	"	"	"	---	93	"	---	---	
Post Spike (1004144-PS1)					Prepared: 04/14/10 16:46 Analyzed: 04/14/10 16:48							
QC Source Sample: Post Spike (A10D059-06)												
EPA 6020												
Antimony	244			ug/L	10	244	2.15	99	80-120%		---	
Post Spike (1004144-PS2)					Prepared: 04/14/10 16:46 Analyzed: 04/14/10 16:51							
QC Source Sample: Post Spike (A10D059-14)												
EPA 6020												
Antimony	232			ug/L	10	244	1.76	94	80-120%		---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004136 - Dry Weight						Soil						
Duplicate (1004136-DUP2)					Prepared: 04/10/10 13:53 Analyzed: 04/11/10 09:57							
QC Source Sample: F07B1a (A10D053-05)												
D2216												
% Solids	**98.0**	---	1.00	% by Weight	1	---	98.1	---	---	0.1	20%	
Batch 1004146 - Dry Weight						Soil						
Duplicate (1004146-DUP1)					Prepared: 04/12/10 11:10 Analyzed: 04/13/10 09:16							
QC Source Sample: S05B1a (A10D053-35)												
D2216												
% Solids	**92.8**	---	1.00	% by Weight	1	---	92.8	---	---	0	20%	
Batch 1004169 - Dry Weight						Soil						
Duplicate (1004169-DUP1)					Prepared: 04/13/10 14:13 Analyzed: 04/14/10 09:22							
QC Source Sample: S11B1b (A10D053-47)												
D2216												
% Solids	**95.0**	---	1.00	% by Weight	1	---	94.9	---	---	0.1	20%	
Duplicate (1004169-DUP2)					Prepared: 04/13/10 14:13 Analyzed: 04/14/10 09:22							
QC Source Sample: W04A2a (A10D053-56)												
D2216												
% Solids	**95.6**	---	1.00	% by Weight	1	---	95.5	---	---	0.1	20%	
Duplicate (1004169-DUP3)					Prepared: 04/13/10 14:13 Analyzed: 04/14/10 09:22							
QC Source Sample: W09A1a (A10D053-66)												
D2216												
% Solids	**96.3**	---	1.00	% by Weight	1	---	96.3	---	---	0	20%	
Duplicate (1004169-DUP4)					Prepared: 04/13/10 14:13 Analyzed: 04/14/10 09:22							
QC Source Sample: R13Ba (A10D053-79)												
D2216												
% Solids	**96.3**	---	1.00	% by Weight	1	---	96.3	---	---	0	20%	
Duplicate (1004169-DUP5)					Prepared: 04/13/10 14:13 Analyzed: 04/14/10 09:22							
QC Source Sample: KL03B1 (A10D053-89)												

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004169 - Dry Weight							**Soil**					
Duplicate (1004169-DUP5)					Prepared: 04/13/10 14:13 Analyzed: 04/14/10 09:22							
QC Source Sample: KL03B1 (A10D053-89)												
D2216												
% Solids	**96.6**	---	1.00	% by Weight	1	---	96.6	---	---	0	20%	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1004105							
A10D053-01	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.474g/50mL	0.5g/50mL	1.05
A10D053-02	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.455g/50mL	0.5g/50mL	1.10
A10D053-03	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.465g/50mL	0.5g/50mL	1.08
A10D053-04	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.464g/50mL	0.5g/50mL	1.08
A10D053-05	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.464g/50mL	0.5g/50mL	1.08
A10D053-06	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.45g/50mL	0.5g/50mL	1.11
A10D053-07	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.505g/50mL	0.5g/50mL	0.99
A10D053-08	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.498g/50mL	0.5g/50mL	1.00
A10D053-09	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.475g/50mL	0.5g/50mL	1.05
A10D053-10	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.491g/50mL	0.5g/50mL	1.02
A10D053-11	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.46g/50mL	0.5g/50mL	1.09
A10D053-12	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.465g/50mL	0.5g/50mL	1.08
A10D053-13	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.451g/50mL	0.5g/50mL	1.11
A10D053-14	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.452g/50mL	0.5g/50mL	1.11
A10D053-15	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.504g/50mL	0.5g/50mL	0.99
A10D053-16	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.472g/50mL	0.5g/50mL	1.06
A10D053-17	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.473g/50mL	0.5g/50mL	1.06
A10D053-18	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.486g/50mL	0.5g/50mL	1.03
A10D053-19	Soil	EPA 6020	01/01/94 00:00	04/08/10 09:29	0.46g/50mL	0.5g/50mL	1.09
Batch: 1004114							
A10D053-20	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.475g/50mL	0.5g/50mL	1.05
A10D053-21	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.525g/50mL	0.5g/50mL	0.95
A10D053-22	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.517g/50mL	0.5g/50mL	0.97
A10D053-23	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.463g/50mL	0.5g/50mL	1.08
A10D053-24	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.501g/50mL	0.5g/50mL	1.00
A10D053-25	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.472g/50mL	0.5g/50mL	1.06
A10D053-26	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.486g/50mL	0.5g/50mL	1.03
A10D053-27	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.529g/50mL	0.5g/50mL	0.95
A10D053-28	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.473g/50mL	0.5g/50mL	1.06
A10D053-29	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.482g/50mL	0.5g/50mL	1.04
A10D053-30	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.499g/50mL	0.5g/50mL	1.00
A10D053-31	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.441g/50mL	0.5g/50mL	1.13
A10D053-32	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.446g/50mL	0.5g/50mL	1.12

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GeoEngineers -Seattle	Project: Oregon Metals Evaluation	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	Reported:
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D053-33	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.472g/50mL	0.5g/50mL	1.06
A10D053-34	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.456g/50mL	0.5g/50mL	1.10
A10D053-35	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.479g/50mL	0.5g/50mL	1.04
A10D053-36	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.46g/50mL	0.5g/50mL	1.09
A10D053-37	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.45g/50mL	0.5g/50mL	1.11
A10D053-38	Soil	EPA 6020	01/01/94 00:00	04/08/10 12:16	0.51g/50mL	0.5g/50mL	0.98
Batch: 1004123							
A10D053-39	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.503g/50mL	0.5g/50mL	0.99
A10D053-41	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.5g/50mL	0.5g/50mL	1.00
A10D053-42	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.501g/50mL	0.5g/50mL	1.00
A10D053-43	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.48g/50mL	0.5g/50mL	1.04
A10D053-44	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.49g/50mL	0.5g/50mL	1.02
A10D053-45	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.497g/50mL	0.5g/50mL	1.01
A10D053-46	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.479g/50mL	0.5g/50mL	1.04
A10D053-47	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.515g/50mL	0.5g/50mL	0.97
A10D053-48	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.51g/50mL	0.5g/50mL	0.98
A10D053-49	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.48g/50mL	0.5g/50mL	1.04
A10D053-50	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.469g/50mL	0.5g/50mL	1.07
A10D053-51	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.501g/50mL	0.5g/50mL	1.00
A10D053-53	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.484g/50mL	0.5g/50mL	1.03
A10D053-54	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.482g/50mL	0.5g/50mL	1.04
A10D053-55	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.493g/50mL	0.5g/50mL	1.01
A10D053-56	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.487g/50mL	0.5g/50mL	1.03
A10D053-57	Soil	EPA 6020	01/01/94 00:00	04/09/10 08:49	0.488g/50mL	0.5g/50mL	1.02
Batch: 1004125							
A10D053-58	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.455g/50mL	0.5g/50mL	1.10
A10D053-59	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.492g/50mL	0.5g/50mL	1.02
A10D053-60	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.496g/50mL	0.5g/50mL	1.01
A10D053-61	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.453g/50mL	0.5g/50mL	1.10
A10D053-62	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.441g/50mL	0.5g/50mL	1.13
A10D053-63	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.482g/50mL	0.5g/50mL	1.04
A10D053-64	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.484g/50mL	0.5g/50mL	1.03
A10D053-65	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.477g/50mL	0.5g/50mL	1.05
A10D053-66	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.466g/50mL	0.5g/50mL	1.07

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D053-67	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.465g/50mL	0.5g/50mL	1.08
A10D053-68	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.454g/50mL	0.5g/50mL	1.10
A10D053-69	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.479g/50mL	0.5g/50mL	1.04
A10D053-70	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.404g/50mL	0.5g/50mL	1.24
A10D053-71	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.493g/50mL	0.5g/50mL	1.01
A10D053-72	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.452g/50mL	0.5g/50mL	1.11
A10D053-73	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.515g/50mL	0.5g/50mL	0.97
A10D053-74	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.516g/50mL	0.5g/50mL	0.97
A10D053-75	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.469g/50mL	0.5g/50mL	1.07
A10D053-76	Soil	EPA 6020	01/01/94 00:00	04/09/10 11:01	0.506g/50mL	0.5g/50mL	0.99
Batch: 1004142							
A10D053-40	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.205g/50mL	0.5g/50mL	2.44
A10D053-77	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.473g/50mL	0.5g/50mL	1.06
A10D053-78	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.443g/50mL	0.5g/50mL	1.13
A10D053-79	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.456g/50mL	0.5g/50mL	1.10
A10D053-80	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.466g/50mL	0.5g/50mL	1.07
A10D053-81	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.52g/50mL	0.5g/50mL	0.96
A10D053-82	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.44g/50mL	0.5g/50mL	1.14
A10D053-83	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.46g/50mL	0.5g/50mL	1.09
A10D053-84	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.445g/50mL	0.5g/50mL	1.12
A10D053-85	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.5g/50mL	0.5g/50mL	1.00
A10D053-86	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.456g/50mL	0.5g/50mL	1.10
A10D053-87	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.459g/50mL	0.5g/50mL	1.09
A10D053-88	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.478g/50mL	0.5g/50mL	1.05
A10D053-89	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.516g/50mL	0.5g/50mL	0.97
A10D053-90	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.455g/50mL	0.5g/50mL	1.10
Batch: 1004144							
A10D053-52	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.505g/50mL	0.5g/50mL	0.99

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Thursday, May 13, 2010

Neil Morton
GeoEngineers -Seattle
600 Stewart St. Suite 1700
Seattle, WA 98101

RE: Oregon Metals Evaluation / 2787-050-000

Enclosed are the results of analyses for work order A10D059, which was received by the laboratory on 4/2/2010 at 3:35:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

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Philip Nerenberg

Philip Nerenberg For Darwin Thomas, Business Development Director

Apex Labs

12232 S.W. Garden Place
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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
C01A2b	A10D059-01	Soil	01/01/94 00:00	04/02/10 15:35
C01B2b	A10D059-02	Soil	01/01/94 00:00	04/02/10 15:35
C02A1b	A10D059-03	Soil	01/01/94 00:00	04/02/10 15:35
C02B1b	A10D059-04	Soil	01/01/94 00:00	04/02/10 15:35
C03A2B	A10D059-05	Soil	01/01/94 00:00	04/02/10 15:35
C03B2b	A10D059-06	Soil	01/01/94 00:00	04/02/10 15:35
C04A2a	A10D059-07	Soil	01/01/94 00:00	04/02/10 15:35
C04B2a	A10D059-08	Soil	01/01/94 00:00	04/02/10 15:35
C05A1b	A10D059-09	Soil	01/01/94 00:00	04/02/10 15:35
C05B1b	A10D059-10	Soil	01/01/94 00:00	04/02/10 15:35
C06A1b	A10D059-11	Soil	01/01/94 00:00	04/02/10 15:35
C06B1b	A10D059-12	Soil	01/01/94 00:00	04/02/10 15:35
C07A1b	A10D059-13	Soil	01/01/94 00:00	04/02/10 15:35
C07B1b	A10D059-14	Soil	01/01/94 00:00	04/02/10 15:35
C08A2a	A10D059-15	Soil	01/01/94 00:00	04/02/10 15:35
C08B2a	A10D059-16	Soil	01/01/94 00:00	04/02/10 15:35
C09A2b	A10D059-17	Soil	01/01/94 00:00	04/02/10 15:35
C09B2b	A10D059-18	Soil	01/01/94 00:00	04/02/10 15:35
C10A1b	A10D059-19	Soil	01/01/94 00:00	04/02/10 15:35
C10B1b	A10D059-20	Soil	01/01/94 00:00	04/02/10 15:35
C11A2a	A10D059-21	Soil	01/01/94 00:00	04/02/10 15:35
C11B2a	A10D059-22	Soil	01/01/94 00:00	04/02/10 15:35
C12A1b	A10D059-23	Soil	01/01/94 00:00	04/02/10 15:35
C12B1b	A10D059-24	Soil	01/01/94 00:00	04/02/10 15:35
C13A1a	A10D059-25	Soil	01/01/94 00:00	04/02/10 15:35
C13B1a	A10D059-26	Soil	01/01/94 00:00	04/02/10 15:35
C14A1a	A10D059-27	Soil	01/01/94 00:00	04/02/10 15:35
C14B1a	A10D059-28	Soil	01/01/94 00:00	04/02/10 15:35
C15A1a	A10D059-29	Soil	01/01/94 00:00	04/02/10 15:35
C15B1a	A10D059-30	Soil	01/01/94 00:00	04/02/10 15:35
C15C1a	A10D059-31	Soil	01/01/94 00:00	04/02/10 15:35
C16A1a	A10D059-32	Soil	01/01/94 00:00	04/02/10 15:35
C16B1a	A10D059-33	Soil	01/01/94 00:00	04/02/10 15:35
M01A2b	A10D059-34	Soil	01/01/94 00:00	04/02/10 15:35
M01B2b	A10D059-35	Soil	01/01/94 00:00	04/02/10 15:35

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
M02A2b	A10D059-36	Soil	01/01/94 00:00	04/02/10 15:35
M02B2b	A10D059-37	Soil	01/01/94 00:00	04/02/10 15:35
M03A1b	A10D059-38	Soil	01/01/94 00:00	04/02/10 15:35
M03B1b	A10D059-39	Soil	01/01/94 00:00	04/02/10 15:35
M04A2b	A10D059-40	Soil	01/01/94 00:00	04/02/10 15:35
M04B2b	A10D059-41	Soil	01/01/94 00:00	04/02/10 15:35
M05A1a	A10D059-42	Soil	01/01/94 00:00	04/02/10 15:35
M05B1a	A10D059-43	Soil	01/01/94 00:00	04/02/10 15:35
M06A2a	A10D059-44	Soil	01/01/94 00:00	04/02/10 15:35
M06B2a	A10D059-45	Soil	01/01/94 00:00	04/02/10 15:35
M07A2b	A10D059-46	Soil	01/01/94 00:00	04/02/10 15:35
M07B2b	A10D059-47	Soil	01/01/94 00:00	04/02/10 15:35
M08A2b	A10D059-48	Soil	01/01/94 00:00	04/02/10 15:35
M08B2a	A10D059-49	Soil	01/01/94 00:00	04/02/10 15:35
M09A1b	A10D059-50	Soil	01/01/94 00:00	04/02/10 15:35
M09B1b	A10D059-51	Soil	01/01/94 00:00	04/02/10 15:35
M10A1a	A10D059-52	Soil	01/01/94 00:00	04/02/10 15:35
M10B1a	A10D059-53	Soil	01/01/94 00:00	04/02/10 15:35
M11A1a	A10D059-54	Soil	01/01/94 00:00	04/02/10 15:35
M11B1a	A10D059-55	Soil	01/01/94 00:00	04/02/10 15:35
M12A2a	A10D059-56	Soil	01/01/94 00:00	04/02/10 15:35
M12B2a	A10D059-57	Soil	01/01/94 00:00	04/02/10 15:35
M13A1a	A10D059-58	Soil	01/01/94 00:00	04/02/10 15:35
M13B1a	A10D059-59	Soil	01/01/94 00:00	04/02/10 15:35
M14A1a	A10D059-60	Soil	01/01/94 00:00	04/02/10 15:35
M14B1a	A10D059-61	Soil	01/01/94 00:00	04/02/10 15:35
M14B2a	A10D059-62	Soil	01/01/94 00:00	04/02/10 15:35
M15A1a	A10D059-63	Soil	01/01/94 00:00	04/02/10 15:35
M15B1a	A10D059-64	Soil	01/01/94 00:00	04/02/10 15:35
M16A2a	A10D059-65	Soil	01/01/94 00:00	04/02/10 15:35
M16B2a	A10D059-66	Soil	01/01/94 00:00	04/02/10 15:35
M17A2a	A10D059-67	Soil	01/01/94 00:00	04/02/10 15:35
M17B2a	A10D059-68	Soil	01/01/94 00:00	04/02/10 15:35
M18A2a	A10D059-69	Soil	01/01/94 00:00	04/02/10 15:35
M18B2a	A10D059-70	Soil	01/01/94 00:00	04/02/10 15:35

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Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
M19A2a	A10D059-71	Soil	01/01/94 00:00	04/02/10 15:35
M20A2a	A10D059-72	Soil	01/01/94 00:00	04/02/10 15:35
M20B1a	A10D059-73	Soil	01/01/94 00:00	04/02/10 15:35
M21A2a	A10D059-74	Soil	01/01/94 00:00	04/02/10 15:35
M21B2a	A10D059-75	Soil	01/01/94 00:00	04/02/10 15:35
M22A1a	A10D059-76	Soil	01/01/94 00:00	04/02/10 15:35
M22B1a	A10D059-77	Soil	01/01/94 00:00	04/02/10 15:35
M23A1a	A10D059-78	Soil	01/01/94 00:00	04/02/10 15:35
M23B1a	A10D059-79	Soil	01/01/94 00:00	04/02/10 15:35
M24A2a	A10D059-80	Soil	01/01/94 00:00	04/02/10 15:35
M24B2a	A10D059-81	Soil	01/01/94 00:00	04/02/10 15:35
P01A	A10D059-82	Soil	01/01/94 00:00	04/02/10 15:35
P01B	A10D059-83	Soil	01/01/94 00:00	04/02/10 15:35
P02A	A10D059-84	Soil	01/01/94 00:00	04/02/10 15:35
P02B	A10D059-85	Soil	01/01/94 00:00	04/02/10 15:35
P03A	A10D059-86	Soil	01/01/94 00:00	04/02/10 15:35
P03B	A10D059-87	Soil	01/01/94 00:00	04/02/10 15:35
P04A	A10D059-88	Soil	01/01/94 00:00	04/02/10 15:35
P04B	A10D059-89	Soil	01/01/94 00:00	04/02/10 15:35
P05A	A10D059-90	Soil	01/01/94 00:00	04/02/10 15:35

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QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004142 - EPA 3051A							Soil					
Blank (1004142-BLK1)					Prepared: 04/12/10 10:03	Analyzed: 04/12/10 16:36						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004142-BS1)					Prepared: 04/12/10 10:03	Analyzed: 04/12/10 16:39						
EPA 6020												
Antimony	25.7	0.100	1.00	mg/kg wet	10	25.0	---	103	80-120%	---	---	
Arsenic	47.5	0.200	2.00	"	"	50.0	---	95	"	---	---	
Beryllium	23.6	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	48.0	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	47.8	0.100	1.00	"	"	"	---	96	"	---	---	
Selenium	23.4	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	24.4	0.100	1.00	"	"	"	---	98	"	---	---	
Thallium	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
LCS (1004142-BS2)					Prepared: 04/12/10 13:05	Analyzed: 04/12/10 16:41						
EPA 6020												
Antimony	25.5	0.100	1.00	mg/kg wet	10	25.0	---	102	80-120%	---	---	
Arsenic	48.4	0.200	2.00	"	"	50.0	---	97	"	---	---	
Beryllium	23.3	0.200	1.00	"	"	25.0	---	93	"	---	---	
Cadmium	48.2	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	47.6	0.100	1.00	"	"	"	---	95	"	---	---	
Selenium	23.4	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	25.1	0.100	1.00	"	"	"	---	101	"	---	---	
Thallium	23.6	0.100	1.00	"	"	"	---	95	"	---	---	
Matrix Spike (1004142-MS2)					Prepared: 04/12/10 10:03	Analyzed: 04/12/10 17:56						
QC Source Sample: C02A1b (A10D059-03)												
EPA 6020												
Antimony	23.9	0.105	1.05	mg/kg dry	10	26.3	0.276	90	75-125%	---	---	

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Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004142 - EPA 3051A							**Soil**					
Matrix Spike (1004142-MS2)						Prepared: 04/12/10 10:03 Analyzed: 04/12/10 17:56						
QC Source Sample: C02A1b (A10D059-03)												
Arsenic	53.0	0.210	2.10	mg/kg dry	"	52.5	3.26	95	"	---	---	
Beryllium	24.6	0.210	1.05	"	"	26.3	0.584	91	"	---	---	
Cadmium	53.1	0.105	1.05	"	"	52.5	0.639	100	"	---	---	
Lead	92.1	0.105	1.05	"	"	"	41.6	96	"	---	---	
Selenium	25.2	0.420	2.10	"	"	26.3	ND	96	"	---	---	
Silver	26.7	0.105	1.05	"	"	"	ND	102	"	---	---	
Thallium	25.3	0.105	1.05	"	"	"	0.187	96	"	---	---	

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QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004144 - EPA 3051A							Soil					
Blank (1004144-BLK1)						Prepared: 04/12/10 10:52 Analyzed: 04/14/10 13:57						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	**0.310**	0.200	2.00	"	"	---	---	---	---	---	---	J
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	**0.180**	0.100	1.00	"	"	---	---	---	---	---	---	J
Selenium	**2.02**	0.400	2.00	"	"	---	---	---	---	---	---	B
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004144-BS1)						Prepared: 04/12/10 10:52 Analyzed: 04/14/10 14:00						
EPA 6020												
Antimony	26.0	0.100	1.00	mg/kg wet	10	25.0	---	104	80-120%	---	---	
Arsenic	47.8	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.5	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	48.5	0.100	1.00	"	"	50.0	---	97	"	---	---	
Lead	46.8	0.100	1.00	"	"	"	---	94	"	---	---	
Selenium	23.4	0.400	2.00	"	"	25.0	---	94	"	---	---	B
Silver	24.1	0.100	1.00	"	"	"	---	96	"	---	---	
Thallium	23.1	0.100	1.00	"	"	"	---	93	"	---	---	
Duplicate (1004144-DUP1)						Prepared: 04/12/10 10:52 Analyzed: 04/14/10 14:21						
QC Source Sample: C03B2b (A10D059-06)												
EPA 6020												
Antimony	**0.262**	0.109	1.09	mg/kg dry	10	---	0.244	---	---	7	40%	J
Arsenic	**8.06**	0.219	2.19	"	"	---	8.40	---	---	4	40%	
Beryllium	**0.809**	0.219	1.09	"	"	---	0.797	---	---	1	40%	J
Cadmium	**0.448**	0.109	1.09	"	"	---	0.399	---	---	12	40%	J
Lead	**17.4**	0.109	1.09	"	"	---	18.0	---	---	3	40%	
Selenium	ND	0.437	2.19	"	"	---	0.443	---	---		40%	
Silver	ND	0.109	1.09	"	"	---	ND	---	---		40%	
Thallium	**0.262**	0.109	1.09	"	"	---	0.266	---	---	1	40%	J
Matrix Spike (1004144-MS1)						Prepared: 04/12/10 10:52 Analyzed: 04/14/10 14:24						
QC Source Sample: C03B2b (A10D059-06)												

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QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004144 - EPA 3051A							**Soil**					
Matrix Spike (1004144-MS1)					Prepared: 04/12/10 10:52 Analyzed: 04/14/10 14:24							
QC Source Sample: C03B2b (A10D059-06)												
EPA 6020												
Antimony	10.6	0.115	1.15	mg/kg dry	10	28.8	0.244	36	75-125%	---	---	Q-01
Arsenic	57.5	0.231	2.31	"	"	57.7	8.40	85	"	---	---	
Beryllium	26.5	0.231	1.15	"	"	28.8	0.797	89	"	---	---	
Cadmium	57.8	0.115	1.15	"	"	57.7	0.399	100	"	---	---	
Lead	70.6	0.115	1.15	"	"	"	18.0	91	"	---	---	
Selenium	24.7	0.461	2.31	"	"	28.8	0.443	84	"	---	---	B
Silver	27.8	0.115	1.15	"	"	"	ND	96	"	---	---	
Thallium	26.3	0.115	1.15	"	"	"	0.266	90	"	---	---	
Matrix Spike (1004144-MS2)					Prepared: 04/12/10 10:52 Analyzed: 04/14/10 14:57							
QC Source Sample: C07BD (A10D059-14)												
EPA 6020												
Antimony	18.3	0.120	1.20	mg/kg dry	10	30.0	0.208	60	75-125%	---	---	Q-01
Arsenic	61.4	0.240	2.40	"	"	60.0	7.12	90	"	---	---	
Beryllium	25.4	0.240	1.20	"	"	30.0	0.947	82	"	---	---	
Cadmium	57.5	0.120	1.20	"	"	60.0	0.196	95	"	---	---	
Lead	63.4	0.120	1.20	"	"	"	10.7	88	"	---	---	
Selenium	26.7	0.480	2.40	"	"	30.0	ND	89	"	---	---	B
Silver	28.8	0.120	1.20	"	"	"	0.243	95	"	---	---	
Thallium	27.0	0.120	1.20	"	"	"	0.289	89	"	---	---	
Post Spike (1004144-PS1)					Prepared: 04/14/10 16:46 Analyzed: 04/14/10 16:48							
QC Source Sample: C03B2b (A10D059-06)												
EPA 6020												
Antimony	244			ug/L	10	244	2.15	99	80-120%		---	
Post Spike (1004144-PS2)					Prepared: 04/14/10 16:46 Analyzed: 04/14/10 16:51							
QC Source Sample: C07BD (A10D059-14)												
EPA 6020												
Antimony	232			ug/L	10	244	1.76	94	80-120%		---	

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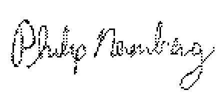

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004156 - EPA 3051A							**Soil**					
Blank (1004156-BLK1)						Prepared: 04/13/10 09:28 Analyzed: 04/14/10 15:03						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004156-BS1)						Prepared: 04/13/10 09:28 Analyzed: 04/14/10 15:06						
EPA 6020												
Antimony	25.3	0.100	1.00	mg/kg wet	10	25.0	---	101	80-120%	---	---	
Arsenic	48.0	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.5	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	48.1	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	47.2	0.100	1.00	"	"	"	---	94	"	---	---	
Selenium	23.1	0.400	2.00	"	"	25.0	---	92	"	---	---	
Silver	24.5	0.100	1.00	"	"	"	---	98	"	---	---	
Thallium	23.4	0.100	1.00	"	"	"	---	94	"	---	---	
Duplicate (1004156-DUP1)						Prepared: 04/13/10 09:28 Analyzed: 04/14/10 15:26						
QC Source Sample: C10A1b (A10D059-19)												
EPA 6020												
Antimony	**0.469**	0.124	1.24	mg/kg dry	10	---	0.445	---	---	5	40%	J
Arsenic	**7.95**	0.247	2.47	"	"	---	8.26	---	---	4	40%	
Beryllium	ND	0.247	1.24	"	"	---	ND	---	---		40%	
Cadmium	ND	0.124	1.24	"	"	---	0.120	---	---		40%	
Lead	**89.5**	0.124	1.24	"	"	---	81.4	---	---	9	40%	
Selenium	**2.01**	0.494	2.47	"	"	---	2.16	---	---	7	40%	J
Silver	**0.185**	0.124	1.24	"	"	---	0.180	---	---	3	40%	J
Thallium	ND	0.124	1.24	"	"	---	ND	---	---		40%	
Matrix Spike (1004156-MS1)						Prepared: 04/13/10 09:28 Analyzed: 04/14/10 15:29						
QC Source Sample: C10A1b (A10D059-19)												

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GeoEngineers -Seattle	Project **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004156 - EPA 3051A — **Soil**

Matrix Spike (1004156-MS1) Prepared: 04/13/10 09:28 Analyzed: 04/14/10 15:29

QC Source Sample: C10A1b (A10D059-19)
EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	26.4	0.124	1.24	mg/kg dry	10	30.9	0.445	84	75-125%	---	---	
Arsenic	65.1	0.248	2.48	"	"	61.9	8.26	92	"	---	---	
Beryllium	27.6	0.248	1.24	"	"	30.9	ND	89	"	---	---	
Cadmium	57.8	0.124	1.24	"	"	61.9	0.120	93	"	---	---	
Lead	143	0.124	1.24	"	"	"	81.4	99	"	---	---	
Selenium	30.2	0.495	2.48	"	"	30.9	2.16	90	"	---	---	
Silver	28.9	0.124	1.24	"	"	"	0.180	93	"	---	---	
Thallium	28.0	0.124	1.24	"	"	"	ND	91	"	---	---	

Matrix Spike (1004156-MS2) Prepared: 04/13/10 09:28 Analyzed: 04/14/10 16:24

QC Source Sample: M01A2b (A10D059-34)
EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	28.1	0.114	1.14	mg/kg dry	10	28.6	0.222	98	75-125%	---	---	
Arsenic	56.3	0.229	2.29	"	"	57.2	1.26	96	"	---	---	
Beryllium	26.7	0.229	1.14	"	"	28.6	ND	93	"	---	---	
Cadmium	55.2	0.114	1.14	"	"	57.2	0.246	96	"	---	---	
Lead	83.8	0.114	1.14	"	"	"	32.7	89	"	---	---	
Selenium	27.8	0.458	2.29	"	"	28.6	0.554	95	"	---	---	
Silver	27.9	0.114	1.14	"	"	"	ND	98	"	---	---	
Thallium	27.0	0.114	1.14	"	"	"	ND	95	"	---	---	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004187 - EPA 3051A							**Soil**					
Blank (1004187-BLK1)						Prepared: 04/14/10 14:42 Analyzed: 04/16/10 16:33						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004187-BS1)						Prepared: 04/14/10 14:42 Analyzed: 04/16/10 16:36						
EPA 6020												
Antimony	25.7	0.100	1.00	mg/kg wet	10	25.0	---	103	80-120%	---	---	
Arsenic	48.0	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.7	0.200	1.00	"	"	25.0	---	95	"	---	---	
Cadmium	49.2	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	48.3	0.100	1.00	"	"	"	---	97	"	---	---	
Selenium	23.3	0.400	2.00	"	"	25.0	---	93	"	---	---	
Silver	24.6	0.100	1.00	"	"	"	---	98	"	---	---	
Thallium	23.6	0.100	1.00	"	"	"	---	94	"	---	---	
Duplicate (1004187-DUP1)						Prepared: 04/14/10 14:42 Analyzed: 04/16/10 17:06						
QC Source Sample: M04A2b (A10D059-40)												
EPA 6020												
Antimony	**0.477**	0.165	1.65	mg/kg dry	10	---	0.352	---	---	30	40%	J
Arsenic	**1.65**	0.329	3.29	"	"	---	1.71	---	---	4	40%	J
Beryllium	ND	0.329	1.65	"	"	---	ND	---	---		40%	
Cadmium	**0.263**	0.165	1.65	"	"	---	0.319	---	---	19	40%	J
Lead	**175**	0.165	1.65	"	"	---	186	---	---	6	40%	
Selenium	ND	0.658	3.29	"	"	---	0.805	---	---		40%	
Silver	ND	0.165	1.65	"	"	---	ND	---	---		40%	
Thallium	ND	0.165	1.65	"	"	---	ND	---	---		40%	
Matrix Spike (1004187-MS1)						Prepared: 04/14/10 14:42 Analyzed: 04/16/10 17:09						
QC Source Sample: M04A2b (A10D059-40)												

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004187 - EPA 3051A — **Soil**

Matrix Spike (1004187-MS1) — Prepared: 04/14/10 14:42 Analyzed: 04/16/10 17:09

QC Source Sample: M04A2b (A10D059-40)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	36.2	0.151	1.51	mg/kg dry	10	37.7	0.352	95	75-125%	---	---	
Arsenic	73.2	0.302	3.02	"	"	75.4	1.71	95	"	---	---	
Beryllium	34.7	0.302	1.51	"	"	37.7	ND	92	"	---	---	
Cadmium	72.2	0.151	1.51	"	"	75.4	0.319	95	"	---	---	
Lead	245	0.151	1.51	"	"	"	186	78	"	---	---	
Selenium	35.5	0.603	3.02	"	"	37.7	0.805	92	"	---	---	
Silver	36.0	0.151	1.51	"	"	"	ND	96	"	---	---	
Thallium	33.8	0.151	1.51	"	"	"	ND	90	"	---	---	

Matrix Spike (1004187-MS2) — Prepared: 04/14/10 14:42 Analyzed: 04/16/10 17:44

QC Source Sample: M08B2a (A10D059-49)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	22.5	0.104	1.04	mg/kg dry	10	26.1	0.116	86	75-125%	---	---	
Arsenic	49.7	0.209	2.09	"	"	52.2	0.582	94	"	---	---	
Beryllium	25.0	0.209	1.04	"	"	26.1	0.381	94	"	---	---	
Cadmium	50.4	0.104	1.04	"	"	52.2	0.211	96	"	---	---	
Lead	49.3	0.104	1.04	"	"	"	2.68	89	"	---	---	
Selenium	22.9	0.418	2.09	"	"	26.1	ND	88	"	---	---	
Silver	25.3	0.104	1.04	"	"	"	ND	97	"	---	---	
Thallium	22.9	0.104	1.04	"	"	"	ND	88	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004193 - EPA 3051A							Soil					
Blank (1004193-BLK1)						Prepared: 04/15/10 09:00 Analyzed: 04/16/10 17:59						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004193-BS1)						Prepared: 04/15/10 09:00 Analyzed: 04/16/10 18:02						
EPA 6020												
Antimony	26.6	0.100	1.00	mg/kg wet	10	25.0	---	106	80-120%	---	---	
Arsenic	49.0	0.200	2.00	"	"	50.0	---	98	"	---	---	
Beryllium	24.0	0.200	1.00	"	"	25.0	---	96	"	---	---	
Cadmium	48.5	0.100	1.00	"	"	50.0	---	97	"	---	---	
Lead	47.7	0.100	1.00	"	"	"	---	95	"	---	---	
Selenium	23.6	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	24.6	0.100	1.00	"	"	"	---	99	"	---	---	
Thallium	23.4	0.100	1.00	"	"	"	---	94	"	---	---	
Duplicate (1004193-DUP1)						Prepared: 04/15/10 09:00 Analyzed: 04/16/10 18:29						
QC Source Sample: M12B2a (A10D059-57)												
EPA 6020												
Antimony	ND	0.104	1.04	mg/kg dry	10	---	ND	---	---		40%	
Arsenic	**2.08**	0.207	2.07	"	"	---	2.14	---	---	2	40%	
Beryllium	**0.539**	0.207	1.04	"	"	---	0.585	---	---	8	40%	J
Cadmium	**0.270**	0.104	1.04	"	"	---	0.298	---	---	10	40%	J
Lead	**6.97**	0.104	1.04	"	"	---	6.96	---	---	0.1	40%	
Selenium	ND	0.415	2.07	"	"	---	ND	---	---		40%	
Silver	ND	0.104	1.04	"	"	---	ND	---	---		40%	
Thallium	**0.124**	0.104	1.04	"	"	---	0.123	---	---	1	40%	J
Matrix Spike (1004193-MS1)						Prepared: 04/15/10 09:00 Analyzed: 04/16/10 18:32						
QC Source Sample: M12B2a (A10D059-57)												

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004193 - EPA 3051A							Soil					
Matrix Spike (1004193-MS1)					Prepared: 04/15/10 09:00 Analyzed: 04/16/10 18:32							
QC Source Sample: M12B2a (A10D059-57)												
EPA 6020												
Antimony	20.9	0.104	1.04	mg/kg dry	10	26.0	ND	81	75-125%	---	---	
Arsenic	48.7	0.208	2.08	"	"	52.0	2.14	90	"	---	---	
Beryllium	24.6	0.208	1.04	"	"	26.0	0.585	92	"	---	---	
Cadmium	50.0	0.104	1.04	"	"	52.0	0.298	96	"	---	---	
Lead	53.7	0.104	1.04	"	"	"	6.96	90	"	---	---	
Selenium	21.9	0.416	2.08	"	"	26.0	ND	84	"	---	---	
Silver	25.1	0.104	1.04	"	"	"	ND	97	"	---	---	
Thallium	23.0	0.104	1.04	"	"	"	0.123	88	"	---	---	
Matrix Spike (1004193-MS2)					Prepared: 04/15/10 09:00 Analyzed: 04/16/10 19:01							
QC Source Sample: M15B1a (A10D059-64)												
EPA 6020												
Antimony	21.1	0.105	1.05	mg/kg dry	10	26.2	ND	80	75-125%	---	---	
Arsenic	50.8	0.210	2.10	"	"	52.4	1.78	93	"	---	---	
Beryllium	26.3	0.210	1.05	"	"	26.2	1.23	95	"	---	---	
Cadmium	51.3	0.105	1.05	"	"	52.4	0.231	97	"	---	---	
Lead	58.7	0.105	1.05	"	"	"	12.3	89	"	---	---	
Selenium	23.6	0.420	2.10	"	"	26.2	ND	90	"	---	---	
Silver	25.7	0.105	1.05	"	"	"	ND	98	"	---	---	
Thallium	22.9	0.105	1.05	"	"	"	0.147	87	"	---	---	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004200 - EPA 3051A							Soil					
Blank (1004200-BLK1)						Prepared: 04/15/10 11:03 Analyzed: 04/16/10 19:28						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004200-BS1)						Prepared: 04/15/10 11:03 Analyzed: 04/16/10 19:31						
EPA 6020												
Antimony	26.8	0.100	1.00	mg/kg wet	10	25.0	---	107	80-120%	---	---	
Arsenic	49.8	0.200	2.00	"	"	50.0	---	100	"	---	---	
Beryllium	24.6	0.200	1.00	"	"	25.0	---	98	"	---	---	
Cadmium	49.8	0.100	1.00	"	"	50.0	---	100	"	---	---	
Lead	48.7	0.100	1.00	"	"	"	---	97	"	---	---	
Selenium	24.0	0.400	2.00	"	"	25.0	---	96	"	---	---	
Silver	25.6	0.100	1.00	"	"	"	---	102	"	---	---	
Thallium	24.2	0.100	1.00	"	"	"	---	97	"	---	---	
Duplicate (1004200-DUP1)						Prepared: 04/15/10 11:03 Analyzed: 04/16/10 19:52						
QC Source Sample: M22A1a (A10D059-76)												
EPA 6020												
Antimony	ND	0.103	1.03	mg/kg dry	10	---	ND	---	---		40%	
Arsenic	**0.547**	0.207	2.07	"	"	---	0.588	---	---	7	40%	J
Beryllium	**0.227**	0.207	1.03	"	"	---	0.278	---	---	20	40%	J
Cadmium	**0.186**	0.103	1.03	"	"	---	0.206	---	---	10	40%	J
Lead	**24.4**	0.103	1.03	"	"	---	29.9	---	---	20	40%	
Selenium	ND	0.413	2.07	"	"	---	ND	---	---		40%	
Silver	ND	0.103	1.03	"	"	---	ND	---	---		40%	
Thallium	ND	0.103	1.03	"	"	---	ND	---	---		40%	
Matrix Spike (1004200-MS1)						Prepared: 04/15/10 11:03 Analyzed: 04/16/10 19:55						
QC Source Sample: M22A1a (A10D059-76)												

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004200 - EPA 3051A — **Soil**

Matrix Spike (1004200-MS1) — Prepared: 04/15/10 11:03 Analyzed: 04/16/10 19:55

QC Source Sample: M22A1a (A10D059-76)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	24.4	0.104	1.04	mg/kg dry	10	26.0	ND	94	75-125%	---	---	
Arsenic	50.8	0.208	2.08	"	"	52.1	0.588	96	"	---	---	
Beryllium	25.0	0.208	1.04	"	"	26.0	0.278	95	"	---	---	
Cadmium	50.3	0.104	1.04	"	"	52.1	0.206	96	"	---	---	
Lead	74.7	0.104	1.04	"	"	"	29.9	86	"	---	---	
Selenium	24.0	0.417	2.08	"	"	26.0	ND	92	"	---	---	
Silver	25.4	0.104	1.04	"	"	"	ND	97	"	---	---	
Thallium	23.1	0.104	1.04	"	"	"	ND	89	"	---	---	

Matrix Spike (1004200-MS2) — Prepared: 04/15/10 11:03 Analyzed: 04/16/10 20:30

QC Source Sample: P02B (A10D059-85)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	20.6	0.105	1.05	mg/kg dry	10	26.2	0.313	77	75-125%	---	---	
Arsenic	54.1	0.209	2.09	"	"	52.3	6.55	91	"	---	---	
Beryllium	24.4	0.209	1.05	"	"	26.2	0.615	91	"	---	---	
Cadmium	50.4	0.105	1.05	"	"	52.3	0.490	95	"	---	---	
Lead	67.8	0.105	1.05	"	"	"	23.0	86	"	---	---	
Selenium	21.8	0.419	2.09	"	"	26.2	ND	83	"	---	---	
Silver	25.0	0.105	1.05	"	"	"	ND	95	"	---	---	
Thallium	22.5	0.105	1.05	"	"	"	0.125	85	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004214 - EPA 3051A							**Soil**					
Blank (1004214-BLK1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:08						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004214-BS1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:11						
EPA 6020												
Antimony	25.3	0.100	1.00	mg/kg wet	10	25.0	---	101	80-120%	---	---	
Arsenic	46.3	0.200	2.00	"	"	50.0	---	93	"	---	---	
Beryllium	23.5	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	47.5	0.100	1.00	"	"	50.0	---	95	"	---	---	
Lead	45.5	0.100	1.00	"	"	"	---	91	"	---	---	
Selenium	23.8	0.400	2.00	"	"	25.0	---	95	"	---	---	
Silver	23.6	0.100	1.00	"	"	"	---	95	"	---	---	
Thallium	22.8	0.100	1.00	"	"	"	---	91	"	---	---	

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Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004169 - Dry Weight							Soil					
Duplicate (1004169-DUP6)					Prepared: 04/13/10 16:30		Analyzed: 04/14/10 09:22					
QC Source Sample: C15B1a (A10D059-30)												
D2216												
% Solids	**95.3**	---	1.00	% by Weight	1	---	95.3	---	---	0	20%	
Duplicate (1004169-DUP7)					Prepared: 04/13/10 16:30		Analyzed: 04/14/10 09:22					
QC Source Sample: C08A2a (A10D059-15)												
D2216												
% Solids	**91.0**	---	1.00	% by Weight	1	---	91.0	---	---	0	20%	
Duplicate (1004169-DUP8)					Prepared: 04/13/10 16:30		Analyzed: 04/14/10 09:22					
QC Source Sample: C03B2b (A10D059-06)												
D2216												
% Solids	**96.1**	---	1.00	% by Weight	1	---	96.1	---	---	0	20%	
Batch 1004177 - Dry Weight							Soil					
Duplicate (1004177-DUP1)					Prepared: 04/14/10 09:48		Analyzed: 04/15/10 08:59					
QC Source Sample: M02A2b (A10D059-36)												
D2216												
% Solids	**92.5**	---	1.00	% by Weight	1	---	92.6	---	---	0.1	20%	
Duplicate (1004177-DUP2)					Prepared: 04/14/10 09:48		Analyzed: 04/15/10 08:59					
QC Source Sample: M06A2a (A10D059-44)												
D2216												
% Solids	**91.4**	---	1.00	% by Weight	1	---	91.3	---	---	0.1	20%	
Duplicate (1004177-DUP3)					Prepared: 04/14/10 09:48		Analyzed: 04/15/10 08:59					
QC Source Sample: M13A1a (A10D059-58)												
D2216												
% Solids	**98.0**	---	1.00	% by Weight	1	---	98.0	---	---	0	20%	
Duplicate (1004177-DUP4)					Prepared: 04/14/10 09:48		Analyzed: 04/15/10 08:59					
QC Source Sample: M16B2a (A10D059-66)												
D2216												
% Solids	**97.8**	---	1.00	% by Weight	1	---	97.8	---	---	0	20%	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004177 - Dry Weight							Soil					
Duplicate (1004177-DUP5)						Prepared: 04/14/10 09:48 Analyzed: 04/15/10 08:59						
QC Source Sample: M22B1a (A10D059-77)												
D2216												
% Solids	**96.0**	---	1.00	% by Weight	1	---	96.0	---	---	0	20%	
Duplicate (1004177-DUP6)						Prepared: 04/14/10 09:48 Analyzed: 04/15/10 08:59						
QC Source Sample: P02B (A10D059-85)												
D2216												
% Solids	**97.0**	---	1.00	% by Weight	1	---	97.1	---	---	0.1	20%	
Duplicate (1004177-DUP8)						Prepared: 04/14/10 09:48 Analyzed: 04/15/10 08:59						
QC Source Sample: C15C1a (A10D059-31)												
D2216												
% Solids	**96.0**	---	1.00	% by Weight	1	---	96.1	---	---	0.1	20%	

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1004142							
A10D059-01	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.491g/50mL	0.5g/50mL	1.02
A10D059-02	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.481g/50mL	0.5g/50mL	1.04
A10D059-03	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:03	0.468g/50mL	0.5g/50mL	1.07
A10D059-03	Soil	EPA 6020	01/01/94 00:00	04/12/10 13:06	0.468g/50mL	0.5g/50mL	1.07
Batch: 1004144							
A10D059-04	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.502g/50mL	0.5g/50mL	1.00
A10D059-05	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.395g/50mL	0.5g/50mL	1.27
A10D059-06	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.47g/50mL	0.5g/50mL	1.06
A10D059-07	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.413g/50mL	0.5g/50mL	1.21
A10D059-08	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.445g/50mL	0.5g/50mL	1.12
A10D059-09	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.411g/50mL	0.5g/50mL	1.22
A10D059-10	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.47g/50mL	0.5g/50mL	1.06
A10D059-11	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.417g/50mL	0.5g/50mL	1.20
A10D059-12	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.455g/50mL	0.5g/50mL	1.10
A10D059-13	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.435g/50mL	0.5g/50mL	1.15
A10D059-14	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.449g/50mL	0.5g/50mL	1.11
A10D059-15	Soil	EPA 6020	01/01/94 00:00	04/12/10 10:52	0.342g/50mL	0.5g/50mL	1.46
Batch: 1004156							
A10D059-16	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.458g/50mL	0.5g/50mL	1.09
A10D059-17	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.456g/50mL	0.5g/50mL	1.10
A10D059-18	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.46g/50mL	0.5g/50mL	1.09
A10D059-19	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.452g/50mL	0.5g/50mL	1.11
A10D059-20	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.485g/50mL	0.5g/50mL	1.03
A10D059-21	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.475g/50mL	0.5g/50mL	1.05
A10D059-22	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.478g/50mL	0.5g/50mL	1.05
A10D059-23	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.459g/50mL	0.5g/50mL	1.09
A10D059-24	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.434g/50mL	0.5g/50mL	1.15
A10D059-25	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.517g/50mL	0.5g/50mL	0.97
A10D059-26	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.469g/50mL	0.5g/50mL	1.07
A10D059-27	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.457g/50mL	0.5g/50mL	1.09
A10D059-28	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.47g/50mL	0.5g/50mL	1.06
A10D059-29	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.444g/50mL	0.5g/50mL	1.13
A10D059-30	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.473g/50mL	0.5g/50mL	1.06

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	Reported:
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D059-31	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.451g/50mL	0.5g/50mL	1.11
A10D059-32	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.477g/50mL	0.5g/50mL	1.05
A10D059-33	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.435g/50mL	0.5g/50mL	1.15
A10D059-34	Soil	EPA 6020	01/01/94 00:00	04/13/10 09:28	0.434g/50mL	0.5g/50mL	1.15
Batch: 1004187							
A10D059-35	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.493g/50mL	0.5g/50mL	1.01
A10D059-36	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.501g/50mL	0.5g/50mL	1.00
A10D059-37	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.489g/50mL	0.5g/50mL	1.02
A10D059-38	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.487g/50mL	0.5g/50mL	1.03
A10D059-39	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.493g/50mL	0.5g/50mL	1.01
A10D059-40	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.322g/50mL	0.5g/50mL	1.55
A10D059-41	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.482g/50mL	0.5g/50mL	1.04
A10D059-42	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.475g/50mL	0.5g/50mL	1.05
A10D059-43	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.493g/50mL	0.5g/50mL	1.01
A10D059-44	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.329g/50mL	0.5g/50mL	1.52
A10D059-45	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.495g/50mL	0.5g/50mL	1.01
A10D059-46	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.341g/50mL	0.5g/50mL	1.47
A10D059-47	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.48g/50mL	0.5g/50mL	1.04
A10D059-48	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.487g/50mL	0.5g/50mL	1.03
A10D059-49	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.485g/50mL	0.5g/50mL	1.03
A10D059-50	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.505g/50mL	0.5g/50mL	0.99
A10D059-51	Soil	EPA 6020	01/01/94 00:00	04/14/10 14:42	0.485g/50mL	0.5g/50mL	1.03
Batch: 1004193							
A10D059-52	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.49g/50mL	0.5g/50mL	1.02
A10D059-53	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.497g/50mL	0.5g/50mL	1.01
A10D059-54	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.492g/50mL	0.5g/50mL	1.02
A10D059-55	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.483g/50mL	0.5g/50mL	1.04
A10D059-56	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.495g/50mL	0.5g/50mL	1.01
A10D059-57	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.5g/50mL	0.5g/50mL	1.00
A10D059-58	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.492g/50mL	0.5g/50mL	1.02
A10D059-59	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.499g/50mL	0.5g/50mL	1.00
A10D059-60	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.486g/50mL	0.5g/50mL	1.03
A10D059-61	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.491g/50mL	0.5g/50mL	1.02
A10D059-62	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.486g/50mL	0.5g/50mL	1.03

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:32

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D059-63	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.492g/50mL	0.5g/50mL	1.02
A10D059-64	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.493g/50mL	0.5g/50mL	1.01
A10D059-65	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.484g/50mL	0.5g/50mL	1.03
A10D059-66	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.495g/50mL	0.5g/50mL	1.01
A10D059-67	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.492g/50mL	0.5g/50mL	1.02
A10D059-68	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.499g/50mL	0.5g/50mL	1.00
A10D059-69	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.488g/50mL	0.5g/50mL	1.02
A10D059-70	Soil	EPA 6020	01/01/94 00:00	04/15/10 09:00	0.498g/50mL	0.5g/50mL	1.00
Batch: 1004200							
A10D059-71	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.474g/50mL	0.5g/50mL	1.05
A10D059-72	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.487g/50mL	0.5g/50mL	1.03
A10D059-73	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.487g/50mL	0.5g/50mL	1.03
A10D059-74	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.489g/50mL	0.5g/50mL	1.02
A10D059-75	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.496g/50mL	0.5g/50mL	1.01
A10D059-76	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.499g/50mL	0.5g/50mL	1.00
A10D059-77	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.497g/50mL	0.5g/50mL	1.01
A10D059-78	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.505g/50mL	0.5g/50mL	0.99
A10D059-79	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.503g/50mL	0.5g/50mL	0.99
A10D059-80	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.495g/50mL	0.5g/50mL	1.01
A10D059-81	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.497g/50mL	0.5g/50mL	1.01
A10D059-82	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.488g/50mL	0.5g/50mL	1.02
A10D059-83	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.495g/50mL	0.5g/50mL	1.01
A10D059-84	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.493g/50mL	0.5g/50mL	1.01
A10D059-85	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.494g/50mL	0.5g/50mL	1.01
A10D059-86	Soil	EPA 6020	01/01/94 00:00	04/15/10 11:03	0.496g/50mL	0.5g/50mL	1.01
Batch: 1004214							
A10D059-87	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.487g/50mL	0.5g/50mL	1.03
A10D059-88	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.496g/50mL	0.5g/50mL	1.01
A10D059-89	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.499g/50mL	0.5g/50mL	1.00
A10D059-90	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.495g/50mL	0.5g/50mL	1.01

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Philip Nerenberg For Darwin Thomas, Business Development Director

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Thursday, May 13, 2010

Neil Morton
GeoEngineers -Seattle
600 Stewart St. Suite 1700
Seattle, WA 98101

RE: Oregon Metals Evaluation / 2787-050-000

Enclosed are the results of analyses for work order A10D066 , which was received by the laboratory on 4/5/2010 at 3:35:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
KL04B1	A10D066-01	Soil	01/01/94 00:00	04/05/10 15:35
KL05A1	A10D066-02	Soil	01/01/94 00:00	04/05/10 15:35
KL05B1	A10D066-03	Soil	01/01/94 00:00	04/05/10 15:35
KL06A1	A10D066-04	Soil	01/01/94 00:00	04/05/10 15:35
KL06B1	A10D066-05	Soil	01/01/94 00:00	04/05/10 15:35
KL07A1	A10D066-06	Soil	01/01/94 00:00	04/05/10 15:35
KL07B1	A10D066-07	Soil	01/01/94 00:00	04/05/10 15:35
KL08A1	A10D066-08	Soil	01/01/94 00:00	04/05/10 15:35
KL08B1	A10D066-09	Soil	01/01/94 00:00	04/05/10 15:35
KL08B2	A10D066-10	Soil	01/01/94 00:00	04/05/10 15:35
KL09A1	A10D066-11	Soil	01/01/94 00:00	04/05/10 15:35
KL09B1	A10D066-12	Soil	01/01/94 00:00	04/05/10 15:35
KL10A1	A10D066-13	Soil	01/01/94 00:00	04/05/10 15:35
KL10B1	A10D066-14	Soil	01/01/94 00:00	04/05/10 15:35
KL11A1	A10D066-15	Soil	01/01/94 00:00	04/05/10 15:35
KL11B1	A10D066-16	Soil	01/01/94 00:00	04/05/10 15:35
KL12A2	A10D066-17	Soil	01/01/94 00:00	04/05/10 15:35
KL12B2	A10D066-18	Soil	01/01/94 00:00	04/05/10 15:35
KL13A2	A10D066-19	Soil	01/01/94 00:00	04/05/10 15:35
KL13B2	A10D066-20	Soil	01/01/94 00:00	04/05/10 15:35
KL14A1	A10D066-21	Soil	01/01/94 00:00	04/05/10 15:35
KL14B1	A10D066-22	Soil	01/01/94 00:00	04/05/10 15:35
KL15A1	A10D066-23	Soil	01/01/94 00:00	04/05/10 15:35
KL15B1	A10D066-24	Soil	01/01/94 00:00	04/05/10 15:35
KL16A1	A10D066-25	Soil	01/01/94 00:00	04/05/10 15:35
KL16B1	A10D066-26	Soil	01/01/94 00:00	04/05/10 15:35
KL16B2	A10D066-27	Soil	01/01/94 00:00	04/05/10 15:35
KL17A1	A10D066-28	Soil	01/01/94 00:00	04/05/10 15:35
KL17B1	A10D066-29	Soil	01/01/94 00:00	04/05/10 15:35
KL18A1	A10D066-30	Soil	01/01/94 00:00	04/05/10 15:35
KL18B1	A10D066-31	Soil	01/01/94 00:00	04/05/10 15:35
KL20A1	A10D066-32	Soil	01/01/94 00:00	04/05/10 15:35
KL20B1	A10D066-33	Soil	01/01/94 00:00	04/05/10 15:35
KL21A1	A10D066-34	Soil	01/01/94 00:00	04/05/10 15:35
KL21B1	A10D066-35	Soil	01/01/94 00:00	04/05/10 15:35

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Philip Nerenberg

Philip Nerenberg For Darwin Thomas, Business Development Director

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
KL23A1	A10D066-36	Soil	01/01/94 00:00	04/05/10 15:35
KL23B1	A10D066-37	Soil	01/01/94 00:00	04/05/10 15:35
KL25A1	A10D066-38	Soil	01/01/94 00:00	04/05/10 15:35
KL25B1	A10D066-39	Soil	01/01/94 00:00	04/05/10 15:35
KL26A1	A10D066-40	Soil	01/01/94 00:00	04/05/10 15:35
KL26B1	A10D066-41	Soil	01/01/94 00:00	04/05/10 15:35
KL28A1	A10D066-42	Soil	01/01/94 00:00	04/05/10 15:35
KL28B1	A10D066-43	Soil	01/01/94 00:00	04/05/10 15:35
LM01A1	A10D066-44	Soil	01/01/94 00:00	04/05/10 15:35
LM01B1	A10D066-45	Soil	01/01/94 00:00	04/05/10 15:35
LM01B2	A10D066-46	Soil	01/01/94 00:00	04/05/10 15:35
LM02A1	A10D066-47	Soil	01/01/94 00:00	04/05/10 15:35
LM03B1	A10D066-48	Soil	01/01/94 00:00	04/05/10 15:35
LM05A	A10D066-49	Soil	01/01/94 00:00	04/05/10 15:35
LM05B2	A10D066-50	Soil	01/01/94 00:00	04/05/10 15:35
LM06B1	A10D066-51	Soil	01/01/94 00:00	04/05/10 15:35
LM07A1	A10D066-52	Soil	01/01/94 00:00	04/05/10 15:35
LM08A1	A10D066-53	Soil	01/01/94 00:00	04/05/10 15:35
LM08B1	A10D066-54	Soil	01/01/94 00:00	04/05/10 15:35
LM10A1	A10D066-55	Soil	01/01/94 00:00	04/05/10 15:35
LM10B1	A10D066-56	Soil	01/01/94 00:00	04/05/10 15:35
LM11B1	A10D066-57	Soil	01/01/94 00:00	04/05/10 15:35
LM12A1	A10D066-58	Soil	01/01/94 00:00	04/05/10 15:35
LM13A1	A10D066-59	Soil	01/01/94 00:00	04/05/10 15:35
LM13B1	A10D066-60	Soil	01/01/94 00:00	04/05/10 15:35
LM15A1	A10D066-61	Soil	01/01/94 00:00	04/05/10 15:35
LM15B1	A10D066-62	Soil	01/01/94 00:00	04/05/10 15:35
LM16B1	A10D066-63	Soil	01/01/94 00:00	04/05/10 15:35
LM17A1	A10D066-64	Soil	01/01/94 00:00	04/05/10 15:35
LM19B1	A10D066-65	Soil	01/01/94 00:00	04/05/10 15:35
LM20A2	A10D066-66	Soil	01/01/94 00:00	04/05/10 15:35
LM21B2	A10D066-67	Soil	01/01/94 00:00	04/05/10 15:35
LM22A2	A10D066-68	Soil	01/01/94 00:00	04/05/10 15:35
LM22B2	A10D066-69	Soil	01/01/94 00:00	04/05/10 15:35
EO02A2	A10D066-70	Soil	01/01/94 00:00	04/05/10 15:35

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
EO02B1	A10D066-71	Soil	01/01/94 00:00	04/05/10 15:35
EO07A1	A10D066-72	Soil	01/01/94 00:00	04/05/10 15:35
EO08A2	A10D066-73	Soil	01/01/94 00:00	04/05/10 15:35
EO08B2	A10D066-74	Soil	01/01/94 00:00	04/05/10 15:35
EO09B1	A10D066-75	Soil	01/01/94 00:00	04/05/10 15:35
EO11B1	A10D066-76	Soil	01/01/94 00:00	04/05/10 15:35
EO13B1	A10D066-77	Soil	01/01/94 00:00	04/05/10 15:35
EO14A2	A10D066-78	Soil	01/01/94 00:00	04/05/10 15:35
EO14B2	A10D066-79	Soil	01/01/94 00:00	04/05/10 15:35
EO16A2	A10D066-80	Soil	01/01/94 00:00	04/05/10 15:35
EO16B2	A10D066-81	Soil	01/01/94 00:00	04/05/10 15:35
EO17A2	A10D066-82	Soil	01/01/94 00:00	04/05/10 15:35
EO17B2	A10D066-83	Soil	01/01/94 00:00	04/05/10 15:35
EO18B2	A10D066-84	Soil	01/01/94 00:00	04/05/10 15:35
EO20A2	A10D066-85	Soil	01/01/94 00:00	04/05/10 15:35
EO20B2	A10D066-86	Soil	01/01/94 00:00	04/05/10 15:35
EO22A2	A10D066-87	Soil	01/01/94 00:00	04/05/10 15:35
EO22B2	A10D066-88	Soil	01/01/94 00:00	04/05/10 15:35
EO23A2	A10D066-89	Soil	01/01/94 00:00	04/05/10 15:35
EO23B2	A10D066-90	Soil	01/01/94 00:00	04/05/10 15:35
EO24A2	A10D066-91	Soil	01/01/94 00:00	04/05/10 15:35

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004214 - EPA 3051A							Soil					
Blank (1004214-BLK1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:08						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004214-BS1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:11						
EPA 6020												
Antimony	25.3	0.100	1.00	mg/kg wet	10	25.0	---	101	80-120%	---	---	
Arsenic	46.3	0.200	2.00	"	"	50.0	---	93	"	---	---	
Beryllium	23.5	0.200	1.00	"	"	25.0	---	94	"	---	---	
Cadmium	47.5	0.100	1.00	"	"	50.0	---	95	"	---	---	
Lead	45.5	0.100	1.00	"	"	"	---	91	"	---	---	
Selenium	23.8	0.400	2.00	"	"	25.0	---	95	"	---	---	
Silver	23.6	0.100	1.00	"	"	"	---	95	"	---	---	
Thallium	22.8	0.100	1.00	"	"	"	---	91	"	---	---	
Duplicate (1004214-DUP1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:38						
QC Source Sample: KL05A1 (A10D066-02)												
EPA 6020												
Antimony	**0.231**	0.110	1.10	mg/kg dry	10	---	0.122	---	---	62	40%	Q-05, J
Arsenic	**4.74**	0.220	2.20	"	"	---	5.26	---	---	11	40%	
Beryllium	**0.330**	0.220	1.10	"	"	---	0.365	---	---	10	40%	J
Cadmium	**0.220**	0.110	1.10	"	"	---	0.144	---	---	42	40%	Q-05, J
Lead	**12.7**	0.110	1.10	"	"	---	13.2	---	---	4	40%	
Selenium	**0.527**	0.440	2.20	"	"	---	ND	---	---		40%	J
Silver	ND	0.110	1.10	"	"	---	ND	---	---		40%	
Thallium	ND	0.110	1.10	"	"	---	ND	---	---		40%	
Matrix Spike (1004214-MS1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:41						
QC Source Sample: KL05A1 (A10D066-02)												

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004214 - EPA 3051A							**Soil**					
Matrix Spike (1004214-MS1)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 14:41						
QC Source Sample: KL05A1 (A10D066-02)												
EPA 6020												
Antimony	23.7	0.111	1.11	mg/kg dry	10	27.7	0.122	85	75-125%	---	---	
Arsenic	57.7	0.222	2.22	"	"	55.4	5.26	95	"	---	---	
Beryllium	25.3	0.222	1.11	"	"	27.7	0.365	90	"	---	---	
Cadmium	54.4	0.111	1.11	"	"	55.4	0.144	98	"	---	---	
Lead	64.1	0.111	1.11	"	"	"	13.2	92	"	---	---	
Selenium	26.6	0.443	2.22	"	"	27.7	ND	96	"	---	---	
Silver	26.5	0.111	1.11	"	"	"	ND	96	"	---	---	
Thallium	25.2	0.111	1.11	"	"	"	ND	91	"	---	---	
Matrix Spike (1004214-MS2)						Prepared: 04/16/10 10:18 Analyzed: 04/18/10 15:04						
QC Source Sample: KL08B1 (A10D066-09)												
EPA 6020												
Antimony	21.6	0.106	1.06	mg/kg dry	10	26.6	0.127	81	75-125%	---	---	
Arsenic	51.2	0.213	2.13	"	"	53.2	5.04	87	"	---	---	
Beryllium	24.2	0.213	1.06	"	"	26.6	ND	91	"	---	---	
Cadmium	51.2	0.106	1.06	"	"	53.2	ND	96	"	---	---	
Lead	53.8	0.106	1.06	"	"	"	6.45	89	"	---	---	
Selenium	23.5	0.426	2.13	"	"	26.6	2.51	79	"	---	---	
Silver	25.0	0.106	1.06	"	"	"	ND	94	"	---	---	
Thallium	23.1	0.106	1.06	"	"	"	ND	87	"	---	---	

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GeoEngineers -Seattle 600 Stewart St. Suite 1700 Seattle, WA 98101	Project: **Oregon Metals Evaluation** Project Number: 2787-050-000 Project Manager: Neil Morton	**Reported:** 05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004274 - EPA 3051A							**Soil**					
Blank (1004274-BLK1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 16:38						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	**0.100**	0.100	1.00	"	"	---	---	---	---	---	---	J
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004274-BS1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 16:41						
EPA 6020												
Antimony	25.1	0.100	1.00	mg/kg wet	10	25.0	---	100	80-120%	---	---	
Arsenic	48.0	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.0	0.200	1.00	"	"	25.0	---	92	"	---	---	
Cadmium	48.9	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	48.0	0.100	1.00	"	"	"	---	96	"	---	---	
Selenium	23.3	0.400	2.00	"	"	25.0	---	93	"	---	---	
Silver	24.0	0.100	1.00	"	"	"	---	96	"	---	---	
Thallium	23.6	0.100	1.00	"	"	"	---	95	"	---	---	
Duplicate (1004274-DUP1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 17:03						
QC Source Sample: KL14A1 (A10D066-21)												
EPA 6020												
Antimony	ND	0.106	1.06	mg/kg dry	10	---	ND	---	---		40%	
Arsenic	**2.73**	0.212	2.12	"	"	---	2.67	---	---	2	40%	
Beryllium	**0.244**	0.212	1.06	"	"	---	0.252	---	---	3	40%	J
Cadmium	**0.297**	0.106	1.06	"	"	---	0.294	---	---	0.8	40%	J
Lead	**428**	0.106	1.06	"	"	---	427	---	---	0.4	40%	
Selenium	**0.466**	0.424	2.12	"	"	---	ND	---	---		40%	J
Silver	ND	0.106	1.06	"	"	---	ND	---	---		40%	
Thallium	ND	0.106	1.06	"	"	---	ND	---	---		40%	
Matrix Spike (1004274-MS1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 17:11						
QC Source Sample: KL14A1 (A10D066-21)												

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004274 - EPA 3051A							Soil					
Matrix Spike (1004274-MS1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 17:11						
QC Source Sample: KL14A1 (A10D066-21)												
EPA 6020												
Antimony	21.5	0.105	1.05	mg/kg dry	10	26.3	ND	82	75-125%	---	---	
Arsenic	51.7	0.210	2.10	"	"	52.5	2.67	93	"	---	---	
Beryllium	24.0	0.210	1.05	"	"	26.3	0.252	91	"	---	---	
Cadmium	51.1	0.105	1.05	"	"	52.5	0.294	97	"	---	---	
Lead	491	0.105	1.05	"	"	"	427	124	"	---	---	
Selenium	21.9	0.420	2.10	"	"	26.3	ND	84	"	---	---	
Silver	24.6	0.105	1.05	"	"	"	ND	94	"	---	---	
Thallium	24.0	0.105	1.05	"	"	"	ND	91	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004324 - EPA 3051A							**Soil**					
Blank (1004324-BLK2)						Prepared: 04/22/10 08:28	Analyzed: 04/22/10 20:13					
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Blank (1004324-BLK3)						Prepared: 04/22/10 08:28	Analyzed: 04/23/10 15:54					
EPA 6020												
Silver	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	Q-16
LCS (1004324-BS2)						Prepared: 04/22/10 08:28	Analyzed: 04/22/10 20:16					
EPA 6020												
Antimony	27.0	0.100	1.00	mg/kg wet	10	25.0	---	108	80-120%	---	---	
Arsenic	49.3	0.200	2.00	"	"	50.0	---	99	"	---	---	
Beryllium	24.4	0.200	1.00	"	"	25.0	---	98	"	---	---	
Cadmium	50.1	0.100	1.00	"	"	50.0	---	100	"	---	---	
Lead	48.4	0.100	1.00	"	"	"	---	97	"	---	---	
Selenium	24.2	0.400	2.00	"	"	25.0	---	97	"	---	---	
Silver	21.2	0.100	1.00	"	"	"	---	85	"	---	---	
Thallium	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
Duplicate (1004324-DUP1)						Prepared: 04/22/10 08:28	Analyzed: 04/26/10 19:06					
QC Source Sample: KL20A1 (A10D066-32)												
EPA 6020												
Antimony	ND	0.126	1.26	mg/kg dry	10	---	ND	---	---		40%	
Arsenic	**1.39**	0.251	2.51	"	"	---	1.44	---	---	3	40%	J
Beryllium	**0.377**	0.251	1.26	"	"	---	0.407	---	---	8	40%	J
Cadmium	**0.427**	0.126	1.26	"	"	---	0.407	---	---	5	40%	J
Lead	**8.04**	0.126	1.26	"	"	---	7.78	---	---	3	40%	
Selenium	ND	0.503	2.51	"	"	---	ND	---	---		40%	
Silver	ND	0.126	1.26	"	"	---	ND	---	---		40%	
Thallium	**0.880**	0.126	1.26	"	"	---	0.802	---	---	9	40%	J

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004324 - EPA 3051A							**Soil**					
Matrix Spike (1004324-MS1)						Prepared: 04/22/10 08:28 Analyzed: 04/26/10 19:15						
QC Source Sample: KL20A1 (A10D066-32)												
EPA 6020												
Antimony	26.4	0.122	1.22	mg/kg dry	10	30.5	ND	86	75-125%	---	---	
Arsenic	59.3	0.244	2.44	"	"	61.0	1.44	95	"	---	---	
Beryllium	29.1	0.244	1.22	"	"	30.5	0.407	94	"	---	---	
Cadmium	62.3	0.122	1.22	"	"	61.0	0.407	102	"	---	---	
Lead	65.4	0.122	1.22	"	"	"	7.78	94	"	---	---	
Selenium	25.6	0.488	2.44	"	"	30.5	ND	84	"	---	---	
Silver	25.6	0.122	1.22	"	"	"	ND	84	"	---	---	
Thallium	29.5	0.122	1.22	"	"	"	0.802	94	"	---	---	
Matrix Spike (1004324-MS2)						Prepared: 04/22/10 08:28 Analyzed: 04/26/10 19:38						
QC Source Sample: KL25B1 (A10D066-39)												
EPA 6020												
Antimony	22.8	0.112	1.12	mg/kg dry	10	28.0	ND	81	75-125%	---	---	
Arsenic	56.0	0.224	2.24	"	"	56.0	3.12	94	"	---	---	
Beryllium	26.3	0.224	1.12	"	"	28.0	0.272	93	"	---	---	
Cadmium	55.2	0.112	1.12	"	"	56.0	ND	99	"	---	---	
Lead	54.3	0.112	1.12	"	"	"	2.55	92	"	---	---	
Selenium	25.1	0.448	2.24	"	"	28.0	ND	90	"	---	---	
Silver	23.2	0.112	1.12	"	"	"	ND	83	"	---	---	
Thallium	25.7	0.112	1.12	"	"	"	ND	92	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004361 - EPA 3051A — **Soil**

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Blank (1004361-BLK1)						Prepared: 04/23/10 12:27 Analyzed: 04/27/10 11:26						
EPA 6020												
Antimony	ND	0.100	2.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004361-BS1)						Prepared: 04/23/10 12:27 Analyzed: 04/27/10 11:29						
EPA 6020												
Antimony	26.2	0.100	2.00	mg/kg wet	10	25.0	---	105	80-120%	---	---	
Arsenic	49.0	0.200	2.00	"	"	50.0	---	98	"	---	---	
Beryllium	23.6	0.200	1.00	"	"	25.0	---	95	"	---	---	
Cadmium	50.0	0.100	1.00	"	"	50.0	---	100	"	---	---	
Lead	48.6	0.100	1.00	"	"	"	---	97	"	---	---	
Selenium	23.5	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	24.2	0.100	1.00	"	"	"	---	97	"	---	---	
Thallium	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
Duplicate (1004361-DUP1)						Prepared: 04/23/10 12:27 Analyzed: 04/27/10 11:45						
QC Source Sample: LM01B2 (A10D066-46)												
EPA 6020												
Antimony	**1.53**	0.105	2.11	mg/kg dry	10	---	2.12	---	---	32	40%	J
Arsenic	**6.60**	0.211	2.11	"	"	---	7.53	---	---	13	40%	
Beryllium	**0.548**	0.211	1.05	"	"	---	0.582	---	---	6	40%	J
Cadmium	**0.148**	0.105	1.05	"	"	---	0.123	---	---	18	40%	J
Lead	**35.0**	0.105	1.05	"	"	---	39.5	---	---	12	40%	
Selenium	ND	0.422	2.11	"	"	---	ND	---	---		40%	
Silver	ND	0.105	1.05	"	"	---	ND	---	---		40%	
Thallium	ND	0.105	1.05	"	"	---	ND	---	---		40%	
Matrix Spike (1004361-MS1)						Prepared: 04/23/10 12:27 Analyzed: 04/27/10 11:48						
QC Source Sample: LM01B2 (A10D066-46)												

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004361 - EPA 3051A							**Soil**					
Matrix Spike (1004361-MS1)						Prepared: 04/23/10 12:27 Analyzed: 04/27/10 11:48						
QC Source Sample: LM01B2 (A10D066-46)												
EPA 6020												
Antimony	23.7	0.114	2.28	mg/kg dry	10	28.6	2.12	76	75-125%	---	---	
Arsenic	59.3	0.228	2.28	"	"	57.1	7.53	91	"	---	---	
Beryllium	27.1	0.228	1.14	"	"	28.6	0.582	93	"	---	---	
Cadmium	55.1	0.114	1.14	"	"	57.1	0.123	96	"	---	---	
Lead	100	0.114	1.14	"	"	"	39.5	107	"	---	---	
Selenium	23.6	0.457	2.28	"	"	28.6	ND	83	"	---	---	
Silver	27.3	0.114	1.14	"	"	"	ND	96	"	---	---	
Thallium	26.1	0.114	1.14	"	"	"	ND	91	"	---	---	
Matrix Spike (1004361-MS2)						Prepared: 04/23/10 12:27 Analyzed: 04/27/10 12:42						
QC Source Sample: LM11B1 (A10D066-57)												
EPA 6020												
Antimony	26.0	0.108	2.16	mg/kg dry	10	27.0	ND	96	75-125%	---	---	
Arsenic	51.9	0.216	2.16	"	"	54.0	0.977	94	"	---	---	
Beryllium	25.5	0.216	1.08	"	"	27.0	ND	94	"	---	---	
Cadmium	53.1	0.108	1.08	"	"	54.0	0.160	98	"	---	---	
Lead	53.6	0.108	1.08	"	"	"	3.09	94	"	---	---	
Selenium	23.9	0.432	2.16	"	"	27.0	ND	89	"	---	---	
Silver	26.0	0.108	1.08	"	"	"	ND	96	"	---	---	
Thallium	24.9	0.108	1.08	"	"	"	ND	92	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004367 - EPA 3051A							**Soil**					
Blank (1004367-BLK1)						Prepared: 04/23/10 16:56 Analyzed: 04/27/10 12:45						
EPA 6020												
Antimony	ND	0.100	2.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004367-BS1)						Prepared: 04/23/10 16:56 Analyzed: 04/27/10 12:48						
EPA 6020												
Antimony	26.5	0.100	2.00	mg/kg wet	10	25.0	---	106	80-120%	---	---	
Arsenic	49.0	0.200	2.00	"	"	50.0	---	98	"	---	---	
Beryllium	24.1	0.200	1.00	"	"	25.0	---	96	"	---	---	
Cadmium	49.1	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	47.4	0.100	1.00	"	"	"	---	95	"	---	---	
Selenium	23.5	0.400	2.00	"	"	25.0	---	94	"	---	---	
Silver	24.1	0.100	1.00	"	"	"	---	97	"	---	---	
Thallium	23.5	0.100	1.00	"	"	"	---	94	"	---	---	
Duplicate (1004367-DUP1)						Prepared: 04/23/10 16:56 Analyzed: 04/27/10 13:12						
QC Source Sample: LM15A1 (A10D066-61)												
EPA 6020												
Antimony	**0.249**	0.124	2.49	mg/kg dry	10	---	ND	---	---		40%	J
Arsenic	**2.46**	0.249	2.49	"	"	---	2.38	---	---	3	40%	J
Beryllium	**1.02**	0.249	1.24	"	"	---	0.892	---	---	13	40%	J
Cadmium	**0.460**	0.124	1.24	"	"	---	0.352	---	---	26	40%	J
Lead	**11.5**	0.124	1.24	"	"	---	11.4	---	---	1	40%	
Selenium	ND	0.497	2.49	"	"	---	ND	---	---		40%	
Silver	ND	0.124	1.24	"	"	---	ND	---	---		40%	
Thallium	**0.174**	0.124	1.24	"	"	---	0.154	---	---	12	40%	J
Matrix Spike (1004367-MS1)						Prepared: 04/23/10 16:56 Analyzed: 04/27/10 13:15						
QC Source Sample: LM15A1 (A10D066-61)												

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004367 - EPA 3051A — **Soil**

Matrix Spike (1004367-MS1) — Prepared: 04/23/10 16:56 Analyzed: 04/27/10 13:15

QC Source Sample: LM15A1 (A10D066-61)
EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	24.6	0.121	2.43	mg/kg dry	10	30.4	ND	81	75-125%	---	---	
Arsenic	59.0	0.243	2.43	"	"	60.7	2.38	93	"	---	---	
Beryllium	29.0	0.243	1.21	"	"	30.4	0.892	93	"	---	---	
Cadmium	60.3	0.121	1.21	"	"	60.7	0.352	99	"	---	---	
Lead	67.7	0.121	1.21	"	"	"	11.4	93	"	---	---	
Selenium	25.0	0.486	2.43	"	"	30.4	ND	83	"	---	---	
Silver	29.5	0.121	1.21	"	"	"	ND	97	"	---	---	
Thallium	27.3	0.121	1.21	"	"	"	0.154	89	"	---	---	

Matrix Spike (1004367-MS2) — Prepared: 04/23/10 16:56 Analyzed: 04/27/10 14:11

QC Source Sample: EO11B1 (A10D066-76)
EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	28.6	0.119	2.37	mg/kg dry	10	29.7	ND	96	75-125%	---	---	
Arsenic	59.1	0.237	2.37	"	"	59.3	1.13	98	"	---	---	
Beryllium	28.9	0.237	1.19	"	"	29.7	0.301	96	"	---	---	
Cadmium	59.0	0.119	1.19	"	"	59.3	0.129	99	"	---	---	
Lead	57.8	0.119	1.19	"	"	"	2.74	93	"	---	---	
Selenium	27.4	0.475	2.37	"	"	29.7	ND	93	"	---	---	
Silver	28.9	0.119	1.19	"	"	"	ND	98	"	---	---	
Thallium	27.3	0.119	1.19	"	"	"	ND	92	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
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Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004371 - EPA 3051A							**Soil**					
Blank (1004371-BLK1)						Prepared: 04/23/10 18:42 Analyzed: 04/27/10 14:23						
EPA 6020												
Antimony	**0.110**	0.100	2.00	mg/kg wet	10	---	---	---	---	---	---	J
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004371-BS1)						Prepared: 04/23/10 18:42 Analyzed: 04/27/10 14:26						
EPA 6020												
Antimony	26.3	0.100	2.00	mg/kg wet	10	25.0	---	105	80-120%	---	---	
Arsenic	48.8	0.200	2.00	"	"	50.0	---	98	"	---	---	
Beryllium	23.7	0.200	1.00	"	"	25.0	---	95	"	---	---	
Cadmium	48.9	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	45.8	0.100	1.00	"	"	"	---	92	"	---	---	
Selenium	23.1	0.400	2.00	"	"	25.0	---	93	"	---	---	
Silver	23.8	0.100	1.00	"	"	"	---	95	"	---	---	
Thallium	22.8	0.100	1.00	"	"	"	---	91	"	---	---	
Duplicate (1004371-DUP1)						Prepared: 04/23/10 18:42 Analyzed: 04/27/10 14:41						
QC Source Sample: E016A2 (A10D066-80)												
EPA 6020												
Antimony	ND	0.103	2.06	mg/kg dry	10	---	ND	---	---		40%	
Arsenic	**1.18**	0.206	2.06	"	"	---	1.31	---	---	11	40%	J
Beryllium	**0.350**	0.206	1.03	"	"	---	0.351	---	---	0.2	40%	J
Cadmium	**0.278**	0.103	1.03	"	"	---	0.372	---	---	29	40%	J
Lead	**7.49**	0.103	1.03	"	"	---	8.20	---	---	9	40%	
Selenium	ND	0.412	2.06	"	"	---	ND	---	---		40%	
Silver	ND	0.103	1.03	"	"	---	ND	---	---		40%	
Thallium	ND	0.103	1.03	"	"	---	ND	---	---		40%	
Matrix Spike (1004371-MS1)						Prepared: 04/23/10 18:42 Analyzed: 04/27/10 14:44						
QC Source Sample: E016A2 (A10D066-80)												

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004371 - EPA 3051A							Soil					
Matrix Spike (1004371-MS1)						Prepared: 04/23/10 18:42 Analyzed: 04/27/10 14:44						
QC Source Sample: E016A2 (A10D066-80)												
EPA 6020												
Antimony	23.4	0.105	2.10	mg/kg dry	10	26.2	ND	89	75-125%	---	---	
Arsenic	50.0	0.210	2.10	"	"	52.5	1.31	93	"	---	---	
Beryllium	23.9	0.210	1.05	"	"	26.2	0.351	90	"	---	---	
Cadmium	49.4	0.105	1.05	"	"	52.5	0.372	93	"	---	---	
Lead	52.8	0.105	1.05	"	"	"	8.20	85	"	---	---	
Selenium	23.2	0.420	2.10	"	"	26.2	ND	88	"	---	---	
Silver	24.2	0.105	1.05	"	"	"	ND	92	"	---	---	
Thallium	22.8	0.105	1.05	"	"	"	ND	87	"	---	---	
Matrix Spike (1004371-MS2)						Prepared: 04/23/10 18:42 Analyzed: 04/27/10 15:37						
QC Source Sample: E024A2 (A10D066-91)												
EPA 6020												
Antimony	25.0	0.109	2.17	mg/kg dry	10	27.2	0.218	91	75-125%	---	---	
Arsenic	53.4	0.217	2.17	"	"	54.4	1.22	96	"	---	---	
Beryllium	25.2	0.217	1.09	"	"	27.2	0.240	92	"	---	---	
Cadmium	52.1	0.109	1.09	"	"	54.4	0.240	95	"	---	---	
Lead	56.1	0.109	1.09	"	"	"	8.55	87	"	---	---	
Selenium	24.1	0.435	2.17	"	"	27.2	ND	89	"	---	---	
Silver	25.4	0.109	1.09	"	"	"	ND	93	"	---	---	
Thallium	23.8	0.109	1.09	"	"	"	0.120	87	"	---	---	

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The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004201 - Dry Weight							**Soil**					
Duplicate (1004201-DUP1)					Prepared: 04/15/10 11:15 Analyzed: 04/16/10 10:31							
QC Source Sample: KL05B1 (A10D066-03)												
D2216												
% Solids	**97.4**	---	1.00	% by Weight	1	---	97.4	---	---	0	20%	
Duplicate (1004201-DUP2)					Prepared: 04/15/10 11:15 Analyzed: 04/16/10 10:31							
QC Source Sample: KL09A1 (A10D066-11)												
D2216												
% Solids	**96.0**	---	1.00	% by Weight	1	---	96.1	---	---	0.1	20%	
Duplicate (1004201-DUP3)					Prepared: 04/15/10 11:15 Analyzed: 04/16/10 10:31							
QC Source Sample: KL15B1 (A10D066-24)												
D2216												
% Solids	**94.6**	---	1.00	% by Weight	1	---	94.6	---	---	0	20%	
Duplicate (1004201-DUP4)					Prepared: 04/15/10 11:15 Analyzed: 04/16/10 10:31							
QC Source Sample: KL23A1 (A10D066-36)												
D2216												
% Solids	**97.0**	---	1.00	% by Weight	1	---	97.1	---	---	0.1	20%	
Duplicate (1004201-DUP5)					Prepared: 04/15/10 11:15 Analyzed: 04/16/10 10:31							
QC Source Sample: LM02A1 (A10D066-47)												
D2216												
% Solids	**95.8**	---	1.00	% by Weight	1	---	95.5	---	---	0.3	20%	
Duplicate (1004201-DUP8)					Prepared: 04/15/10 16:12 Analyzed: 04/16/10 10:31							
QC Source Sample: LM08A1 (A10D066-53)												
D2216												
% Solids	**92.1**	---	1.00	% by Weight	1	---	91.9	---	---	0.2	20%	
Duplicate (1004201-DUP9)					Prepared: 04/15/10 16:12 Analyzed: 04/16/10 10:31							
QC Source Sample: LM19B1 (A10D066-65)												
D2216												
% Solids	**95.6**	---	1.00	% by Weight	1	---	95.5	---	---	0.1	20%	
Duplicate (1004201-DUPA)					Prepared: 04/15/10 16:12 Analyzed: 04/16/10 10:31							

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GeoEngineers -Seattle 600 Stewart St. Suite 1700 Seattle, WA 98101	Project: **Oregon Metals Evaluation** Project Number: 2787-050-000 Project Manager: Neil Morton	**Reported:** 05/13/10 22:44

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004201 - Dry Weight							**Soil**					
Duplicate (1004201-DUPA)					Prepared: 04/15/10 16:12 Analyzed: 04/16/10 10:31							
QC Source Sample: E0 09B1 (A10D066-75)												
D2216												
% Solids	**97.7**	---	1.00	% by Weight	1	---	97.9	---	---	0.2	20%	
Duplicate (1004201-DUPB)					Prepared: 04/15/10 16:12 Analyzed: 04/16/10 10:31							
QC Source Sample: E0 23A2 (A10D066-89)												
D2216												
% Solids	**97.5**	---	1.00	% by Weight	1	---	97.4	---	---	0.1	20%	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1004214							
A10D066-01	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.501g/50mL	0.5g/50mL	1.00
A10D066-02	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.475g/50mL	0.5g/50mL	1.05
A10D066-03	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.499g/50mL	0.5g/50mL	1.00
A10D066-04	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.5g/50mL	0.5g/50mL	1.00
A10D066-05	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.494g/50mL	0.5g/50mL	1.01
A10D066-06	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.5g/50mL	0.5g/50mL	1.00
A10D066-07	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.495g/50mL	0.5g/50mL	1.01
A10D066-08	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.489g/50mL	0.5g/50mL	1.02
A10D066-09	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.497g/50mL	0.5g/50mL	1.01
A10D066-10	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.493g/50mL	0.5g/50mL	1.01
A10D066-11	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.479g/50mL	0.5g/50mL	1.04
A10D066-12	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.492g/50mL	0.5g/50mL	1.02
A10D066-13	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.477g/50mL	0.5g/50mL	1.05
A10D066-14	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.487g/50mL	0.5g/50mL	1.03
A10D066-15	Soil	EPA 6020	01/01/94 00:00	04/16/10 10:18	0.494g/50mL	0.5g/50mL	1.01
Batch: 1004274							
A10D066-16	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.494g/50mL	0.5g/50mL	1.01
A10D066-17	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.499g/50mL	0.5g/50mL	1.00
A10D066-18	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.49g/50mL	0.5g/50mL	1.02
A10D066-19	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.495g/50mL	0.5g/50mL	1.01
A10D066-20	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.493g/50mL	0.5g/50mL	1.01
A10D066-21	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.501g/50mL	0.5g/50mL	1.00
A10D066-22	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.501g/50mL	0.5g/50mL	1.00
A10D066-23	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.489g/50mL	0.5g/50mL	1.02
A10D066-24	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.487g/50mL	0.5g/50mL	1.03
A10D066-25	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.49g/50mL	0.5g/50mL	1.02
A10D066-26	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.499g/50mL	0.5g/50mL	1.00
Batch: 1004324							
A10D066-27	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.47g/50mL	0.5g/50mL	1.06
A10D066-28	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.427g/50mL	0.5g/50mL	1.17
A10D066-29	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.487g/50mL	0.5g/50mL	1.03
A10D066-30	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.487g/50mL	0.5g/50mL	1.03
A10D066-31	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.462g/50mL	0.5g/50mL	1.08

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:44

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D066-32	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.434g/50mL	0.5g/50mL	1.15
A10D066-33	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.467g/50mL	0.5g/50mL	1.07
A10D066-34	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.477g/50mL	0.5g/50mL	1.05
A10D066-35	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.469g/50mL	0.5g/50mL	1.07
A10D066-36	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.47g/50mL	0.5g/50mL	1.06
A10D066-37	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.512g/50mL	0.5g/50mL	0.98
A10D066-38	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.47g/50mL	0.5g/50mL	1.06
A10D066-39	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.454g/50mL	0.5g/50mL	1.10
A10D066-40	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.471g/50mL	0.5g/50mL	1.06
A10D066-41	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.525g/50mL	0.5g/50mL	0.95
A10D066-42	Soil	EPA 6020	01/01/94 00:00	04/22/10 08:28	0.474g/50mL	0.5g/50mL	1.05
Batch: 1004361							
A10D066-43	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.467g/50mL	0.5g/50mL	1.07
A10D066-44	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.437g/50mL	0.5g/50mL	1.14
A10D066-45	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.486g/50mL	0.5g/50mL	1.03
A10D066-46	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.465g/50mL	0.5g/50mL	1.08
A10D066-47	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.437g/50mL	0.5g/50mL	1.14
A10D066-48	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.492g/50mL	0.5g/50mL	1.02
A10D066-49	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.435g/50mL	0.5g/50mL	1.15
A10D066-50	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.512g/50mL	0.5g/50mL	0.98
A10D066-51	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.439g/50mL	0.5g/50mL	1.14
A10D066-52	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.503g/50mL	0.5g/50mL	0.99
A10D066-53	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.474g/50mL	0.5g/50mL	1.05
A10D066-54	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.486g/50mL	0.5g/50mL	1.03
A10D066-55	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.428g/50mL	0.5g/50mL	1.17
A10D066-56	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.448g/50mL	0.5g/50mL	1.12
A10D066-57	Soil	EPA 6020	01/01/94 00:00	04/23/10 12:27	0.511g/50mL	0.5g/50mL	0.98
Batch: 1004367							
A10D066-58	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.442g/50mL	0.5g/50mL	1.13
A10D066-59	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.454g/50mL	0.5g/50mL	1.10
A10D066-60	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.447g/50mL	0.5g/50mL	1.12
A10D066-61	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.484g/50mL	0.5g/50mL	1.03
A10D066-62	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.43g/50mL	0.5g/50mL	1.16
A10D066-63	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.458g/50mL	0.5g/50mL	1.09

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GeoEngineers -Seattle
600 Stewart St. Suite 1700
Seattle, WA 98101

Project: **Oregon Metals Evaluation**
Project Number: 2787-050-000
Project Manager: Neil Morton

Reported: 05/13/10 22:44

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D066-64	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.459g/50mL	0.5g/50mL	1.09
A10D066-65	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.435g/50mL	0.5g/50mL	1.15
A10D066-66	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.445g/50mL	0.5g/50mL	1.12
A10D066-67	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.475g/50mL	0.5g/50mL	1.05
A10D066-68	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.438g/50mL	0.5g/50mL	1.14
A10D066-69	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.456g/50mL	0.5g/50mL	1.10
A10D066-70	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.464g/50mL	0.5g/50mL	1.08
A10D066-71	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.477g/50mL	0.5g/50mL	1.05
A10D066-72	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.462g/50mL	0.5g/50mL	1.08
A10D066-73	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.439g/50mL	0.5g/50mL	1.14
A10D066-74	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.472g/50mL	0.5g/50mL	1.06
A10D066-75	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.494g/50mL	0.5g/50mL	1.01
A10D066-76	Soil	EPA 6020	01/01/94 00:00	04/23/10 16:56	0.474g/50mL	0.5g/50mL	1.05
Batch: 1004371							
A10D066-77	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.499g/50mL	0.5g/50mL	1.00
A10D066-78	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.487g/50mL	0.5g/50mL	1.03
A10D066-79	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.489g/50mL	0.5g/50mL	1.02
A10D066-80	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.497g/50mL	0.5g/50mL	1.01
A10D066-81	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.484g/50mL	0.5g/50mL	1.03
A10D066-82	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.478g/50mL	0.5g/50mL	1.05
A10D066-83	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.487g/50mL	0.5g/50mL	1.03
A10D066-84	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.485g/50mL	0.5g/50mL	1.03
A10D066-85	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.489g/50mL	0.5g/50mL	1.02
A10D066-86	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.48g/50mL	0.5g/50mL	1.04
A10D066-87	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.487g/50mL	0.5g/50mL	1.03
A10D066-88	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.491g/50mL	0.5g/50mL	1.02
A10D066-89	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.492g/50mL	0.5g/50mL	1.02
A10D066-90	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.488g/50mL	0.5g/50mL	1.02
A10D066-91	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.474g/50mL	0.5g/50mL	1.05

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Philip Nerenberg For Darwin Thomas, Business Development Director

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Thursday, May 13, 2010

Neil Morton
GeoEngineers -Seattle
600 Stewart St. Suite 1700
Seattle, WA 98101

RE: Oregon Metals Evaluation / 2787-050-000

Enclosed are the results of analyses for work order A10D071, which was received by the laboratory on 4/2/2010 at 3:35:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
E025A2	A10D071-01	Soil	01/01/94 00:00	04/02/10 15:35
E025B2	A10D071-02	Soil	01/01/94 00:00	04/02/10 15:35
E026B2	A10D071-03	Soil	01/01/94 00:00	04/02/10 15:35
E027A2	A10D071-04	Soil	01/01/94 00:00	04/02/10 15:35
E030A2	A10D071-05	Soil	01/01/94 00:00	04/02/10 15:35
E030B2	A10D071-06	Soil	01/01/94 00:00	04/02/10 15:35
E031B2	A10D071-07	Soil	01/01/94 00:00	04/02/10 15:35
E032A2	A10D071-08	Soil	01/01/94 00:00	04/02/10 15:35
E032B2	A10D071-09	Soil	01/01/94 00:00	04/02/10 15:35
E034A2	A10D071-10	Soil	01/01/94 00:00	04/02/10 15:35
E034B2	A10D071-11	Soil	01/01/94 00:00	04/02/10 15:35
E035A2	A10D071-12	Soil	01/01/94 00:00	04/02/10 15:35
E036B2	A10D071-13	Soil	01/01/94 00:00	04/02/10 15:35
LC01A1	A10D071-14	Soil	01/01/94 00:00	04/02/10 15:35
LC01B1	A10D071-15	Soil	01/01/94 00:00	04/02/10 15:35
LC02Bt11	A10D071-16	Soil	01/01/94 00:00	04/02/10 15:35
LC03A1	A10D071-17	Soil	01/01/94 00:00	04/02/10 15:35
LC03B1	A10D071-18	Soil	01/01/94 00:00	04/02/10 15:35
LC04A1	A10D071-19	Soil	01/01/94 00:00	04/02/10 15:35
LC04B1	A10D071-20	Soil	01/01/94 00:00	04/02/10 15:35
LC06A1	A10D071-21	Soil	01/01/94 00:00	04/02/10 15:35
LC06B1	A10D071-22	Soil	01/01/94 00:00	04/02/10 15:35
LC08A1	A10D071-23	Soil	01/01/94 00:00	04/02/10 15:35
LC08B1	A10D071-24	Soil	01/01/94 00:00	04/02/10 15:35
LC09A1	A10D071-25	Soil	01/01/94 00:00	04/02/10 15:35
LC09B1	A10D071-26	Soil	01/01/94 00:00	04/02/10 15:35
LC11A1	A10D071-27	Soil	01/01/94 00:00	04/02/10 15:35
LC11B1	A10D071-28	Soil	01/01/94 00:00	04/02/10 15:35
LC11B2	A10D071-29	Soil	01/01/94 00:00	04/02/10 15:35
LC12B1	A10D071-30	Soil	01/01/94 00:00	04/02/10 15:35
LC13A1	A10D071-31	Soil	01/01/94 00:00	04/02/10 15:35
LC13C1	A10D071-32	Soil	01/01/94 00:00	04/02/10 15:35
LC14A1	A10D071-33	Soil	01/01/94 00:00	04/02/10 15:35
LC15B2	A10D071-34	Soil	01/01/94 00:00	04/02/10 15:35
LC16A1	A10D071-35	Soil	01/01/94 00:00	04/02/10 15:35

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
LC17B1	A10D071-36	Soil	01/01/94 00:00	04/02/10 15:35
LC18A1	A10D071-37	Soil	01/01/94 00:00	04/02/10 15:35
LC18B1	A10D071-38	Soil	01/01/94 00:00	04/02/10 15:35
LC19A1	A10D071-39	Soil	01/01/94 00:00	04/02/10 15:35
LC20B1	A10D071-40	Soil	01/01/94 00:00	04/02/10 15:35
LC21A1	A10D071-41	Soil	01/01/94 00:00	04/02/10 15:35
LC22B1	A10D071-42	Soil	01/01/94 00:00	04/02/10 15:35
LC23A1	A10D071-43	Soil	01/01/94 00:00	04/02/10 15:35
LC23B1	A10D071-44	Soil	01/01/94 00:00	04/02/10 15:35
EO22B1	A10D071-45	Soil	01/01/94 00:00	04/02/10 15:35
M19B2a	A10D071-46	Soil	01/01/94 00:00	04/02/10 15:35

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600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004235 - EPA 3051A							**Soil**					
Blank (1004235-BLK1)						Prepared: 04/18/10 12:07 Analyzed: 04/19/10 18:21						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004235-BS1)						Prepared: 04/18/10 12:07 Analyzed: 04/19/10 18:24						
EPA 6020												
Antimony	27.4	0.100	1.00	mg/kg wet	10	25.0	---	110	80-120%	---	---	
Arsenic	49.5	0.200	2.00	"	"	50.0	---	99	"	---	---	
Beryllium	23.9	0.200	1.00	"	"	25.0	---	96	"	---	---	
Cadmium	48.2	0.100	1.00	"	"	50.0	---	96	"	---	---	
Lead	45.8	0.100	1.00	"	"	"	---	92	"	---	---	
Selenium	24.6	0.400	2.00	"	"	25.0	---	98	"	---	---	
Silver	24.0	0.100	1.00	"	"	"	---	96	"	---	---	
Thallium	23.0	0.100	1.00	"	"	"	---	92	"	---	---	
Duplicate (1004235-DUP1)						Prepared: 04/18/10 12:07 Analyzed: 04/19/10 18:45						
QC Source Sample: E027A2 (A10D071-04)												
EPA 6020												
Antimony	**0.256**	0.111	1.11	mg/kg dry	10	---	ND	---	---		40%	J
Arsenic	**1.99**	0.222	2.22	"	"	---	2.15	---	---	8	40%	J
Beryllium	**0.278**	0.222	1.11	"	"	---	0.291	---	---	5	40%	J
Cadmium	**0.267**	0.111	1.11	"	"	---	0.315	---	---	17	40%	J
Lead	**16.0**	0.111	1.11	"	"	---	16.7	---	---	4	40%	
Selenium	ND	0.445	2.22	"	"	---	ND	---	---		40%	
Silver	ND	0.111	1.11	"	"	---	ND	---	---		40%	
Thallium	**0.267**	0.111	1.11	"	"	---	0.291	---	---	9	40%	J
Matrix Spike (1004235-MS1)						Prepared: 04/18/10 12:07 Analyzed: 04/19/10 18:47						
QC Source Sample: E027A2 (A10D071-04)												

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004235 - EPA 3051A							Soil					
Matrix Spike (1004235-MS1)					Prepared: 04/18/10 12:07 Analyzed: 04/19/10 18:47							
QC Source Sample: E027A2 (A10D071-04)												
EPA 6020												
Antimony	29.6	0.125	1.25	mg/kg dry	10	31.2	ND	95	75-125%	---	---	
Arsenic	63.1	0.249	2.49	"	"	62.4	2.15	98	"	---	---	
Beryllium	29.1	0.249	1.25	"	"	31.2	0.291	92	"	---	---	
Cadmium	59.2	0.125	1.25	"	"	62.4	0.315	94	"	---	---	
Lead	70.0	0.125	1.25	"	"	"	16.7	85	"	---	---	
Selenium	29.8	0.499	2.49	"	"	31.2	ND	96	"	---	---	
Silver	29.0	0.125	1.25	"	"	"	ND	93	"	---	---	
Thallium	27.3	0.125	1.25	"	"	"	0.291	87	"	---	---	
Matrix Spike (1004235-MS2)					Prepared: 04/18/10 12:07 Analyzed: 04/19/10 19:41							
QC Source Sample: LC04A1 (A10D071-19)												
EPA 6020												
Antimony	21.8	0.100	1.00	mg/kg dry	10	25.1	0.101	86	75-125%	---	---	
Arsenic	49.8	0.201	2.01	"	"	50.1	2.10	95	"	---	---	
Beryllium	24.1	0.201	1.00	"	"	25.1	0.393	95	"	---	---	
Cadmium	48.4	0.100	1.00	"	"	50.1	ND	96	"	---	---	
Lead	56.6	0.100	1.00	"	"	"	10.5	92	"	---	---	
Selenium	22.2	0.401	2.01	"	"	25.1	ND	89	"	---	---	
Silver	23.7	0.100	1.00	"	"	"	ND	95	"	---	---	
Thallium	22.7	0.100	1.00	"	"	"	0.141	90	"	---	---	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004268 - EPA 3051A — **Soil**

Blank (1004268-BLK1) Prepared: 04/20/10 08:27 Analyzed: 04/20/10 20:55

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	

LCS (1004268-BS1) Prepared: 04/20/10 08:27 Analyzed: 04/20/10 20:58

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	25.1	0.100	1.00	mg/kg wet	10	25.0	---	100	80-120%	---	---	
Arsenic	48.0	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.2	0.200	1.00	"	"	25.0	---	93	"	---	---	
Cadmium	47.7	0.100	1.00	"	"	50.0	---	95	"	---	---	
Lead	45.4	0.100	1.00	"	"	"	---	91	"	---	---	
Selenium	22.8	0.400	2.00	"	"	25.0	---	91	"	---	---	
Silver	23.4	0.100	1.00	"	"	"	---	94	"	---	---	
Thallium	22.9	0.100	1.00	"	"	"	---	92	"	---	---	

Duplicate (1004268-DUP1) Prepared: 04/20/10 08:27 Analyzed: 04/20/10 21:19

QC Source Sample: LC09A1 (A10D071-25)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	**0.325**	0.105	1.05	mg/kg dry	10	---	0.272	---	---	18	40%	J
Arsenic	**8.28**	0.209	2.09	"	"	---	7.36	---	---	12	40%	
Beryllium	**1.15**	0.209	1.05	"	"	---	1.11	---	---	4	40%	
Cadmium	**0.188**	0.105	1.05	"	"	---	0.188	---	---	0.2	40%	J
Lead	**12.8**	0.105	1.05	"	"	---	12.2	---	---	5	40%	
Selenium	ND	0.419	2.09	"	"	---	ND	---	---		40%	
Silver	ND	0.105	1.05	"	"	---	ND	---	---		40%	
Thallium	**0.230**	0.105	1.05	"	"	---	0.209	---	---	10	40%	J

Matrix Spike (1004268-MS1) Prepared: 04/20/10 08:27 Analyzed: 04/20/10 21:22

QC Source Sample: LC09A1 (A10D071-25)

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Batch 1004268 - EPA 3051A — **Soil**

Matrix Spike (1004268-MS1) Prepared: 04/20/10 08:27 Analyzed: 04/20/10 21:22

QC Source Sample: LC09A1 (A10D071-25)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	22.2	0.104	1.04	mg/kg dry	10	26.0	0.272	84	75-125%	---	---	
Arsenic	59.1	0.208	2.08	"	"	52.0	7.36	100	"	---	---	
Beryllium	23.8	0.208	1.04	"	"	26.0	1.11	87	"	---	---	
Cadmium	50.8	0.104	1.04	"	"	52.0	0.188	97	"	---	---	
Lead	60.7	0.104	1.04	"	"	"	12.2	93	"	---	---	
Selenium	24.0	0.416	2.08	"	"	26.0	ND	92	"	---	---	
Silver	24.3	0.104	1.04	"	"	"	ND	93	"	---	---	
Thallium	23.6	0.104	1.04	"	"	"	0.209	90	"	---	---	

Matrix Spike (1004268-MS2) Prepared: 04/20/10 08:27 Analyzed: 04/20/10 21:51

QC Source Sample: LC13C1 (A10D071-32)

EPA 6020

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Antimony	24.8	0.102	1.02	mg/kg dry	10	25.6	ND	97	75-125%	---	---	
Arsenic	50.9	0.205	2.05	"	"	51.2	2.31	95	"	---	---	
Beryllium	23.3	0.205	1.02	"	"	25.6	ND	91	"	---	---	
Cadmium	49.2	0.102	1.02	"	"	51.2	ND	96	"	---	---	
Lead	48.1	0.102	1.02	"	"	"	0.742	92	"	---	---	
Selenium	22.7	0.410	2.05	"	"	25.6	ND	89	"	---	---	
Silver	24.0	0.102	1.02	"	"	"	ND	94	"	---	---	
Thallium	23.6	0.102	1.02	"	"	"	ND	92	"	---	---	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004274 - EPA 3051A							**Soil**					
Blank (1004274-BLK1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 16:38						
EPA 6020												
Antimony	ND	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	**0.100**	0.100	1.00	"	"	---	---	---	---	---	---	J
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1004274-BS1)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 16:41						
EPA 6020												
Antimony	25.1	0.100	1.00	mg/kg wet	10	25.0	---	100	80-120%	---	---	
Arsenic	48.0	0.200	2.00	"	"	50.0	---	96	"	---	---	
Beryllium	23.0	0.200	1.00	"	"	25.0	---	92	"	---	---	
Cadmium	48.9	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	48.0	0.100	1.00	"	"	"	---	96	"	---	---	
Selenium	23.3	0.400	2.00	"	"	25.0	---	93	"	---	---	
Silver	24.0	0.100	1.00	"	"	"	---	96	"	---	---	
Thallium	23.6	0.100	1.00	"	"	"	---	95	"	---	---	
Matrix Spike (1004274-MS2)						Prepared: 04/20/10 11:59 Analyzed: 04/23/10 17:38						
QC Source Sample: LC20B1 (A10D071-40)												
EPA 6020												
Antimony	19.4	0.106	1.06	mg/kg dry	10	26.5	ND	73	75-125%	---	---	Q-02, Q-04
Arsenic	51.2	0.212	2.12	"	"	53.0	2.33	92	"	---	---	
Beryllium	23.5	0.212	1.06	"	"	26.5	0.451	87	"	---	---	
Cadmium	51.3	0.106	1.06	"	"	53.0	0.147	97	"	---	---	
Lead	92.8	0.106	1.06	"	"	"	43.9	92	"	---	---	
Selenium	22.2	0.424	2.12	"	"	26.5	ND	84	"	---	---	
Silver	25.2	0.106	1.06	"	"	"	ND	95	"	---	---	
Thallium	23.7	0.106	1.06	"	"	"	ND	89	"	---	---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004219 - Dry Weight							Soil					
Duplicate (1004219-DUP1)					Prepared: 04/16/10 11:43 Analyzed: 04/17/10 10:06							
QC Source Sample: E030A2 (A10D071-05)												
D2216												
% Solids	**98.7**	---	1.00	% by Weight	1	---	98.7	---	---	0	20%	
Duplicate (1004219-DUP2)					Prepared: 04/16/10 11:43 Analyzed: 04/17/10 10:06							
QC Source Sample: LC09A1 (A10D071-25)												
D2216												
% Solids	**95.9**	---	1.00	% by Weight	1	---	95.9	---	---	0	20%	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1004235							
A10D071-01	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.434g/50mL	0.5g/50mL	1.15
A10D071-02	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.485g/50mL	0.5g/50mL	1.03
A10D071-03	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.441g/50mL	0.5g/50mL	1.13
A10D071-04	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.43g/50mL	0.5g/50mL	1.16
A10D071-05	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.485g/50mL	0.5g/50mL	1.03
A10D071-06	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.49g/50mL	0.5g/50mL	1.02
A10D071-07	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.455g/50mL	0.5g/50mL	1.10
A10D071-08	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.46g/50mL	0.5g/50mL	1.09
A10D071-09	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.484g/50mL	0.5g/50mL	1.03
A10D071-10	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.45g/50mL	0.5g/50mL	1.11
A10D071-11	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.488g/50mL	0.5g/50mL	1.02
A10D071-12	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.47g/50mL	0.5g/50mL	1.06
A10D071-13	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.448g/50mL	0.5g/50mL	1.12
A10D071-14	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.429g/50mL	0.5g/50mL	1.17
A10D071-15	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.492g/50mL	0.5g/50mL	1.02
A10D071-16	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.451g/50mL	0.5g/50mL	1.11
A10D071-17	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.47g/50mL	0.5g/50mL	1.06
A10D071-18	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.478g/50mL	0.5g/50mL	1.05
A10D071-19	Soil	EPA 6020	01/01/94 00:00	04/18/10 12:07	0.51g/50mL	0.5g/50mL	0.98
Batch: 1004268							
A10D071-20	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.497g/50mL	0.5g/50mL	1.01
A10D071-21	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.495g/50mL	0.5g/50mL	1.01
A10D071-22	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.501g/50mL	0.5g/50mL	1.00
A10D071-23	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.494g/50mL	0.5g/50mL	1.01
A10D071-24	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.503g/50mL	0.5g/50mL	0.99
A10D071-25	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.499g/50mL	0.5g/50mL	1.00
A10D071-26	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.486g/50mL	0.5g/50mL	1.03
A10D071-27	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.492g/50mL	0.5g/50mL	1.02
A10D071-28	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.496g/50mL	0.5g/50mL	1.01
A10D071-29	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.5g/50mL	0.5g/50mL	1.00
A10D071-30	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.494g/50mL	0.5g/50mL	1.01
A10D071-31	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.493g/50mL	0.5g/50mL	1.01
A10D071-32	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.494g/50mL	0.5g/50mL	1.01

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:51

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D071-33	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.485g/50mL	0.5g/50mL	1.03
A10D071-34	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.492g/50mL	0.5g/50mL	1.02
A10D071-35	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.501g/50mL	0.5g/50mL	1.00
A10D071-36	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.497g/50mL	0.5g/50mL	1.01
A10D071-37	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.498g/50mL	0.5g/50mL	1.00
A10D071-38	Soil	EPA 6020	01/01/94 00:00	04/20/10 08:27	0.492g/50mL	0.5g/50mL	1.02
Batch: 1004274							
A10D071-39	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.498g/50mL	0.5g/50mL	1.00
A10D071-40	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.497g/50mL	0.5g/50mL	1.01
A10D071-41	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.5g/50mL	0.5g/50mL	1.00
A10D071-42	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.484g/50mL	0.5g/50mL	1.03
A10D071-43	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.491g/50mL	0.5g/50mL	1.02
A10D071-44	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.495g/50mL	0.5g/50mL	1.01
A10D071-45	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.497g/50mL	0.5g/50mL	1.01
A10D071-46	Soil	EPA 6020	01/01/94 00:00	04/20/10 11:59	0.497g/50mL	0.5g/50mL	1.01

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Thursday, May 13, 2010

Neil Morton
GeoEngineers -Seattle
600 Stewart St. Suite 1700
Seattle, WA 98101

RE: Oregon Metals Evaluation As / 2727-050-00

Enclosed are the results of analyses for work order A10D077, which was received by the laboratory on 4/2/2010 at 3:35:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: pnerenberg@apex-labs.com, or by phone at 503-718-2323.

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
KL19A1	A10D077-01	Soil	01/01/94 00:00	04/02/10 15:35
KL19B1	A10D077-02	Soil	01/01/94 00:00	04/02/10 15:35
KL22A2	A10D077-03	Soil	01/01/94 00:00	04/02/10 15:35
KL22B2	A10D077-04	Soil	01/01/94 00:00	04/02/10 15:35
KL24A1	A10D077-05	Soil	01/01/94 00:00	04/02/10 15:35
KL24B1	A10D077-06	Soil	01/01/94 00:00	04/02/10 15:35
KL27A1	A10D077-07	Soil	01/01/94 00:00	04/02/10 15:35
KL27B1	A10D077-08	Soil	01/01/94 00:00	04/02/10 15:35
KL30A1	A10D077-09	Soil	01/01/94 00:00	04/02/10 15:35
KL30B1	A10D077-10	Soil	01/01/94 00:00	04/02/10 15:35
LM02B1	A10D077-11	Soil	01/01/94 00:00	04/02/10 15:35
LM03A1	A10D077-12	Soil	01/01/94 00:00	04/02/10 15:35
LM04B1	A10D077-13	Soil	01/01/94 00:00	04/02/10 15:35
LM06A1	A10D077-14	Soil	01/01/94 00:00	04/02/10 15:35
LM07B1	A10D077-15	Soil	01/01/94 00:00	04/02/10 15:35
LM09A1	A10D077-16	Soil	01/01/94 00:00	04/02/10 15:35
LM09B1	A10D077-17	Soil	01/01/94 00:00	04/02/10 15:35
LM11A1	A10D077-18	Soil	01/01/94 00:00	04/02/10 15:35
LM12B1	A10D077-19	Soil	01/01/94 00:00	04/02/10 15:35
LM14A1	A10D077-20	Soil	01/01/94 00:00	04/02/10 15:35
LM14B1	A10D077-21	Soil	01/01/94 00:00	04/02/10 15:35
LM16A1	A10D077-22	Soil	01/01/94 00:00	04/02/10 15:35
LM17B1	A10D077-23	Soil	01/01/94 00:00	04/02/10 15:35
LM20B2	A10D077-24	Soil	01/01/94 00:00	04/02/10 15:35
LM21A2	A10D077-25	Soil	01/01/94 00:00	04/02/10 15:35
EO01A2	A10D077-26	Soil	01/01/94 00:00	04/02/10 15:35
EO01B2	A10D077-27	Soil	01/01/94 00:00	04/02/10 15:35
EO07B1	A10D077-28	Soil	01/01/94 00:00	04/02/10 15:35
EO10B1	A10D077-29	Soil	01/01/94 00:00	04/02/10 15:35
EO12B2	A10D077-30	Soil	01/01/94 00:00	04/02/10 15:35
EO15A2	A10D077-31	Soil	01/01/94 00:00	04/02/10 15:35
EO15B2	A10D077-32	Soil	01/01/94 00:00	04/02/10 15:35
EO18A2	A10D077-33	Soil	01/01/94 00:00	04/02/10 15:35
EO19B1	A10D077-34	Soil	01/01/94 00:00	04/02/10 15:35
EO21A2	A10D077-35	Soil	01/01/94 00:00	04/02/10 15:35

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
EO21B2	A10D077-36	Soil	01/01/94 00:00	04/02/10 15:35
EO24B2	A10D077-37	Soil	01/01/94 00:00	04/02/10 15:35
EO26A2	A10D077-38	Soil	01/01/94 00:00	04/02/10 15:35
EO27B2	A10D077-39	Soil	01/01/94 00:00	04/02/10 15:35
EO31A2	A10D077-40	Soil	01/01/94 00:00	04/02/10 15:35
EO33A2	A10D077-41	Soil	01/01/94 00:00	04/02/10 15:35
EO33B2	A10D077-42	Soil	01/01/94 00:00	04/02/10 15:35
EO35B1	A10D077-43	Soil	01/01/94 00:00	04/02/10 15:35
EO36A2	A10D077-44	Soil	01/01/94 00:00	04/02/10 15:35
LC02A1	A10D077-45	Soil	01/01/94 00:00	04/02/10 15:35
LC02Bt12	A10D077-46	Soil	01/01/94 00:00	04/02/10 15:35
LC05A1	A10D077-47	Soil	01/01/94 00:00	04/02/10 15:35
LC05B1	A10D077-48	Soil	01/01/94 00:00	04/02/10 15:35
LC07A1	A10D077-49	Soil	01/01/94 00:00	04/02/10 15:35
LC07B1	A10D077-50	Soil	01/01/94 00:00	04/02/10 15:35
LC10A1	A10D077-51	Soil	01/01/94 00:00	04/02/10 15:35
LC10B1	A10D077-52	Soil	01/01/94 00:00	04/02/10 15:35
LC12A1	A10D077-53	Soil	01/01/94 00:00	04/02/10 15:35
LC14B1	A10D077-54	Soil	01/01/94 00:00	04/02/10 15:35
LC15A2	A10D077-55	Soil	01/01/94 00:00	04/02/10 15:35
LC16B1	A10D077-56	Soil	01/01/94 00:00	04/02/10 15:35
LC17A1	A10D077-57	Soil	01/01/94 00:00	04/02/10 15:35
LC19B1	A10D077-58	Soil	01/01/94 00:00	04/02/10 15:35
LC20A1	A10D077-59	Soil	01/01/94 00:00	04/02/10 15:35
LC21B1	A10D077-60	Soil	01/01/94 00:00	04/02/10 15:35
LC22A1	A10D077-61	Soil	01/01/94 00:00	04/02/10 15:35
LC01B2	A10D077-62	Soil	01/01/94 00:00	04/02/10 15:35
EO22C1	A10D077-63	Soil	01/01/94 00:00	04/02/10 15:35

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004371 - EPA 3051A							**Soil**					
Blank (1004371-BLK1)						Prepared: 04/23/10 18:42	Analyzed: 04/27/10 14:23					
EPA 6020												
Arsenic	ND	0.200	2.00	mg/kg wet	10	---	---	---	---	---	---	
LCS (1004371-BS1)						Prepared: 04/23/10 18:42	Analyzed: 04/27/10 14:26					
EPA 6020												
Arsenic	48.8	0.200	2.00	mg/kg wet	10	50.0	---	98	80-120%	---	---	
Batch 1004372 - EPA 3051A							**Soil**					
Blank (1004372-BLK1)						Prepared: 04/24/10 09:34	Analyzed: 04/27/10 16:11					
EPA 6020												
Arsenic	ND	0.200	2.00	mg/kg wet	10	---	---	---	---	---	---	
LCS (1004372-BS1)						Prepared: 04/24/10 09:34	Analyzed: 04/27/10 15:55					
EPA 6020												
Arsenic	48.7	0.200	2.00	mg/kg wet	10	50.0	---	97	80-120%	---	---	
Duplicate (1004372-DUP1)						Prepared: 04/24/10 09:34	Analyzed: 04/27/10 16:28					
QC Source Sample: KL30B1 (A10D077-10)												
EPA 6020												
Arsenic	**0.715**	0.220	2.20	mg/kg dry	10	---	0.884	---	---	21	40%	J
Matrix Spike (1004372-MS1)						Prepared: 04/24/10 09:34	Analyzed: 04/27/10 16:31					
QC Source Sample: KL30B1 (A10D077-10)												
EPA 6020												
Arsenic	40.1	0.218	2.18	mg/kg dry	10	54.6	0.884	72	75-125%	---	---	Q-01
Matrix Spike (1004372-MS2)						Prepared: 04/24/10 09:34	Analyzed: 04/27/10 17:05					
QC Source Sample: LM09B1 (A10D077-17)												
EPA 6020												
Arsenic	55.2	0.223	2.23	mg/kg dry	10	55.8	1.79	96	75-125%	---	---	
Post Spike (1004372-PS1)						Prepared: 04/28/10 14:14	Analyzed: 04/28/10 14:42					
QC Source Sample: KL30B1 (A10D077-10)												
EPA 6020												
Arsenic	508			ug/L	10	476	7.52	105	80-120%		---	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004402 - EPA 3051A							Soil					
Blank (1004402-BLK1)						Prepared: 04/26/10 15:42 Analyzed: 04/27/10 21:11						
EPA 6020												
Arsenic	ND	0.200	2.00	mg/kg wet	10	---	---	---	---	---	---	
LCS (1004402-BS1)						Prepared: 04/26/10 15:42 Analyzed: 04/27/10 21:14						
EPA 6020												
Arsenic	48.0	0.200	2.00	mg/kg wet	10	50.0	---	96	80-120%	---	---	
Duplicate (1004402-DUP1)						Prepared: 04/26/10 15:42 Analyzed: 04/27/10 21:29						
QC Source Sample: E001B2 (A10D077-27)												
EPA 6020												
Arsenic	**0.661**	0.232	2.32	mg/kg dry	10	---	0.846	---	---	25	40%	J
Matrix Spike (1004402-MS1)						Prepared: 04/26/10 15:42 Analyzed: 04/27/10 21:32						
QC Source Sample: E001B2 (A10D077-27)												
EPA 6020												
Arsenic	52.1	0.216	2.16	mg/kg dry	10	54.0	0.846	95	75-125%	---	---	
Matrix Spike (1004402-MS2)						Prepared: 04/26/10 15:42 Analyzed: 04/27/10 22:40						
QC Source Sample: E035B1 (A10D077-43)												
EPA 6020												
Arsenic	46.9	0.202	2.02	mg/kg dry	10	50.6	1.21	90	75-125%	---	---	

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GeoEngineers - Seattle	Project **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004409 - EPA 3051A							**Soil**					
Blank (1004409-BLK1)						Prepared: 04/27/10 08:23 Analyzed: 04/28/10 15:56						
EPA 6020												
Arsenic	ND	0.200	2.00	mg/kg wet	10	---	---	---	---	---	---	
LCS (1004409-BS1)						Prepared: 04/27/10 08:23 Analyzed: 04/28/10 15:59						
EPA 6020												
Arsenic	50.2	0.200	2.00	mg/kg wet	10	50.0	---	100	80-120%	---	---	
Duplicate (1004409-DUP1)						Prepared: 04/27/10 08:23 Analyzed: 04/28/10 17:00						
QC Source Sample: LC07A1 (A10D077-49)												
EPA 6020												
Arsenic	**3.25**	0.380	3.80	mg/kg dry	10	---	3.64	---	---	11	40%	J
Matrix Spike (1004409-MS1)						Prepared: 04/27/10 08:23 Analyzed: 04/28/10 17:03						
QC Source Sample: LC07A1 (A10D077-49)												
EPA 6020												
Arsenic	96.4	0.382	3.82	mg/kg dry	10	95.6	3.64	97	75-125%	---	---	
Matrix Spike (1004409-MS2)						Prepared: 04/27/10 08:23 Analyzed: 04/28/10 17:49						
QC Source Sample: LC16B1 (A10D077-56)												
EPA 6020												
Arsenic	65.2	0.252	2.52	mg/kg dry	10	63.0	7.31	92	75-125%	---	---	

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Philip Nerenberg

Philip Nerenberg For Darwin Thomas, Business Development Director

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-030-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004219 - Dry Weight							Soil					
Duplicate (1004219-DUP3)					Prepared: 04/16/10 11:43 Analyzed: 04/17/10 10:06							
QC Source Sample: KL19A1 (A10D077-01)												
D2216												
% Solids	**97.6**	---	1.00	% by Weight	1	---	97.5	---	---	0.1	20%	
Duplicate (1004219-DUP4)					Prepared: 04/16/10 11:43 Analyzed: 04/17/10 10:06							
QC Source Sample: KL19B1 (A10D077-02)												
D2216												
% Solids	**92.9**	---	1.00	% by Weight	1	---	92.9	---	---	0	20%	
Batch 1004232 - Dry Weight							Soil					
Duplicate (1004232-DUP1)					Prepared: 04/18/10 09:49 Analyzed: 04/19/10 09:18							
QC Source Sample: KL27B1 (A10D077-08)												
D2216												
% Solids	**97.4**	---	1.00	% by Weight	1	---	97.4	---	---	0	20%	
Duplicate (1004232-DUP2)					Prepared: 04/18/10 09:49 Analyzed: 04/19/10 09:18							
QC Source Sample: LM12B1 (A10D077-19)												
D2216												
% Solids	**89.8**	---	1.00	% by Weight	1	---	89.8	---	---	0	20%	
Duplicate (1004232-DUP3)					Prepared: 04/18/10 09:49 Analyzed: 04/19/10 09:18							
QC Source Sample: EO01B2 (A10D077-27)												
D2216												
% Solids	**98.7**	---	1.00	% by Weight	1	---	98.7	---	---	0	20%	
Duplicate (1004232-DUP4)					Prepared: 04/18/10 09:49 Analyzed: 04/19/10 09:18							
QC Source Sample: EO26A2 (A10D077-38)												
D2216												
% Solids	**97.0**	---	1.00	% by Weight	1	---	97.2	---	---	0.2	20%	
Duplicate (1004232-DUP5)					Prepared: 04/18/10 09:49 Analyzed: 04/19/10 09:18							
QC Source Sample: LC02Bd12 (A10D077-46)												
D2216												
% Solids	**90.4**	---	1.00	% by Weight	1	---	90.4	---	---	0	20%	

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1004232 - Dry Weight							**Soil**					
Duplicate (1004232-DUP6)					Prepared: 04/18/10 09:49		Analyzed: 04/19/10 09:18					
QC Source Sample: LC01B2 (A10D077-62)												
D2216												
% Solids	**95.8**	---	1.00	% by Weight	1	---	95.8	---	---	0	20%	

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1004371							
A10D077-01	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.498g/50mL	0.5g/50mL	1.00
A10D077-02	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.481g/50mL	0.5g/50mL	1.04
A10D077-03	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.484g/50mL	0.5g/50mL	1.03
A10D077-04	Soil	EPA 6020	01/01/94 00:00	04/23/10 18:42	0.488g/50mL	0.5g/50mL	1.02
Batch: 1004372							
A10D077-05	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.48g/50mL	0.5g/50mL	1.04
A10D077-06	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.486g/50mL	0.5g/50mL	1.03
A10D077-07	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.493g/50mL	0.5g/50mL	1.01
A10D077-08	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.492g/50mL	0.5g/50mL	1.02
A10D077-09	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.487g/50mL	0.5g/50mL	1.03
A10D077-10	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.475g/50mL	0.5g/50mL	1.05
A10D077-11	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.49g/50mL	0.5g/50mL	1.02
A10D077-12	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.482g/50mL	0.5g/50mL	1.04
A10D077-13	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.485g/50mL	0.5g/50mL	1.03
A10D077-14	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.487g/50mL	0.5g/50mL	1.03
A10D077-15	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.501g/50mL	0.5g/50mL	1.00
A10D077-16	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.487g/50mL	0.5g/50mL	1.03
A10D077-17	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.491g/50mL	0.5g/50mL	1.02
A10D077-18	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.482g/50mL	0.5g/50mL	1.04
A10D077-19	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.481g/50mL	0.5g/50mL	1.04
A10D077-20	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.491g/50mL	0.5g/50mL	1.02
A10D077-21	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.488g/50mL	0.5g/50mL	1.02
A10D077-22	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.498g/50mL	0.5g/50mL	1.00
A10D077-23	Soil	EPA 6020	01/01/94 00:00	04/24/10 09:34	0.485g/50mL	0.5g/50mL	1.03
Batch: 1004402							
A10D077-24	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.502g/50mL	0.5g/50mL	1.00
A10D077-25	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.439g/50mL	0.5g/50mL	1.14
A10D077-26	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.457g/50mL	0.5g/50mL	1.09
A10D077-27	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.455g/50mL	0.5g/50mL	1.10
A10D077-28	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.507g/50mL	0.5g/50mL	0.99
A10D077-29	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.483g/50mL	0.5g/50mL	1.04
A10D077-30	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.513g/50mL	0.5g/50mL	0.98
A10D077-31	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.469g/50mL	0.5g/50mL	1.07

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Philip Nerenberg For Darwin Thomas, Business Development Director

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GeoEngineers - Seattle	Project: **Oregon Metals Evaluation As**	
600 Stewart St. Suite 1700	Project Number: 2727-050-00	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:55

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
A10D077-32	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.519g/50mL	0.5g/50mL	0.96
A10D077-33	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.447g/50mL	0.5g/50mL	1.12
A10D077-34	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.468g/50mL	0.5g/50mL	1.07
A10D077-35	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.463g/50mL	0.5g/50mL	1.08
A10D077-36	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.469g/50mL	0.5g/50mL	1.07
A10D077-37	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.472g/50mL	0.5g/50mL	1.06
A10D077-38	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.501g/50mL	0.5g/50mL	1.00
A10D077-39	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.461g/50mL	0.5g/50mL	1.08
A10D077-40	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.47g/50mL	0.5g/50mL	1.06
A10D077-41	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.462g/50mL	0.5g/50mL	1.08
A10D077-42	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.492g/50mL	0.5g/50mL	1.02
A10D077-43	Soil	EPA 6020	01/01/94 00:00	04/26/10 15:42	0.446g/50mL	0.5g/50mL	1.12
Batch: 1004409							
A10D077-44	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.446g/50mL	0.5g/50mL	1.12
A10D077-45	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.456g/50mL	0.5g/50mL	1.10
A10D077-46	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.45g/50mL	0.5g/50mL	1.11
A10D077-47	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.475g/50mL	0.5g/50mL	1.05
A10D077-48	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.502g/50mL	0.5g/50mL	1.00
A10D077-49	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.326g/50mL	0.5g/50mL	1.53
A10D077-50	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.502g/50mL	0.5g/50mL	1.00
A10D077-51	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.494g/50mL	0.5g/50mL	1.01
A10D077-52	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.475g/50mL	0.5g/50mL	1.05
A10D077-53	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.444g/50mL	0.5g/50mL	1.13
A10D077-54	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.501g/50mL	0.5g/50mL	1.00
A10D077-55	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.439g/50mL	0.5g/50mL	1.14
A10D077-56	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.453g/50mL	0.5g/50mL	1.10
A10D077-57	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.33g/50mL	0.5g/50mL	1.52
A10D077-58	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.501g/50mL	0.5g/50mL	1.00
A10D077-59	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.458g/50mL	0.5g/50mL	1.09
A10D077-60	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.483g/50mL	0.5g/50mL	1.04
A10D077-61	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.474g/50mL	0.5g/50mL	1.05
A10D077-62	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.488g/50mL	0.5g/50mL	1.02
A10D077-63	Soil	EPA 6020	01/01/94 00:00	04/27/10 08:23	0.508g/50mL	0.5g/50mL	0.98

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Philip Nerenberg For Darwin Thomas, Business Development Director

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Thursday, May 27, 2010

Neil Morton
GeoEngineers
15055 SW Sequoia Pkwy, # 140
Portland, OR 97224

RE: Oregon Metals Evaluation / 002787-050-00

Enclosed are the results of analyses for work order A10E125, which was received by the laboratory on 5/13/2010 at 2:05:00PM.

Thank you for using Apex Labs. We appreciate your business and strive to provide the highest quality services to the environmental industry.

If you have any questions concerning this report or the services we offer, please feel free to contact me by email at: AGreiner@Apex-Labs.com, or by phone at 503-718-2323.

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Allison Greiner For Darwin Thomas, Business Development Director

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GeoEngineers	Project: **Oregon Metals Evaluation**	
15055 SW Sequoia Pkwy, #140	Project Number: 002787-050-00	**Reported:**
Portland, OR 97224	Project Manager: Neil Morton	05/27/10 15:01

ANALYTICAL REPORT FOR SAMPLES

SAMPLE INFORMATION

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
TR1A	A10E125-01	Soil	05/12/10 00:00	05/13/10 14:05
TR1B	A10E125-02	Soil	05/12/10 00:00	05/13/10 14:05
TR2A	A10E125-03	Soil	05/12/10 00:00	05/13/10 14:05
TR2B	A10E125-04	Soil	05/12/10 00:00	05/13/10 14:05

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Allison Greiner For Darwin Thomas, Business Development Director

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GeoEngineers	Project: **Oregon Metals Evaluation**	
15055 S W Sequoia Pkwy, # 140	Project Number: 002787-050-00	**Reported:**
Portland, OR 97224	Project Manager: Neil Morton	05/27/10 15:01

QUALITY CONTROL (QC) SAMPLE RESULTS

Total Metals by EPA 6020 (ICPMS)

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 1005303 - EPA 3051A						**Soil**						
Blank (1005303-BLK1)						Prepared: 05/19/10 12:14 Analyzed: 05/19/10 16:02						
EPA 6020												
Antimony	**0.230**	0.100	1.00	mg/kg wet	10	---	---	---	---	---	---	J
Arsenic	ND	0.200	2.00	"	"	---	---	---	---	---	---	
Beryllium	ND	0.200	1.00	"	"	---	---	---	---	---	---	
Cadmium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Lead	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Selenium	ND	0.400	2.00	"	"	---	---	---	---	---	---	
Silver	ND	0.100	1.00	"	"	---	---	---	---	---	---	
Thallium	ND	0.100	1.00	"	"	---	---	---	---	---	---	
LCS (1005303-BS1)						Prepared: 05/19/10 12:14 Analyzed: 05/19/10 16:05						
EPA 6020												
Antimony	27.1	0.100	1.00	mg/kg wet	10	25.0	---	108	80-120%	---	---	
Arsenic	48.7	0.200	2.00	"	"	50.0	---	97	"	---	---	
Beryllium	23.7	0.200	1.00	"	"	25.0	---	95	"	---	---	
Cadmium	49.2	0.100	1.00	"	"	50.0	---	98	"	---	---	
Lead	45.0	0.100	1.00	"	"	"	---	90	"	---	---	
Selenium	22.7	0.400	2.00	"	"	25.0	---	91	"	---	---	
Silver	23.6	0.100	1.00	"	"	"	---	94	"	---	---	
Thallium	22.3	0.100	1.00	"	"	"	---	89	"	---	---	

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GeoEngineers	Project: **Oregon Metals Evaluation**	
15055 SW Sequoia Pkwy, #140	Project Number: 002787-050-00	**Reported:**
Portland, OR 97224	Project Manager: Neil Morton	05/27/10 15:01

QUALITY CONTROL (QC) SAMPLE RESULTS

Percent Dry Weight by D2216

Batch 1005248 - Dry Weight — **Soil**

Duplicate (1005248-DUP1) — Prepared: 05/17/10 10:00 Analyzed: 05/18/10 09:36

QC Source Sample: TR2B (A10E125-04)

Apex SOP

Analyte	Result	MDL	Reporting Limit	Units	Dil.	Spike Amount	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
% Solids	**95.1**	1.00	1.00	% by Weight	1	---	95.1	---	---	0	20%	

No Client related Batch QC samples analyzed for this batch. See notes page for more information.

Apex Labs

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GeoEngineers	Project: **Oregon Metals Evaluation**	
15055 SW Sequoia Pkwy, #140	Project Number: 002787-050-00	**Reported:**
Portland, OR 97224	Project Manager: Neil Morton	05/27/10 15:01

SAMPLE PREPARATION INFORMATION

Total Metals by EPA 6020 (ICPMS)

Prep: EPA 3051A

Lab Number	Matrix	Method	Sampled	Prepared	Sample Initial/Final	Default Initial/Final	RL Prep Factor
Batch: 1005303							
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-01	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.489g/50mL	0.5g/50mL	1.02
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-02	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.501g/50mL	0.5g/50mL	1.00
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-03	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.487g/50mL	0.5g/50mL	1.03
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01
A10E125-04	Soil	EPA 6020	05/12/10 00:00	05/19/10 12:14	0.493g/50mL	0.5g/50mL	1.01

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The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

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GeoEngineers -Seattle	Project: **Oregon Metals Evaluation**	
600 Stewart St. Suite 1700	Project Number: 2787-050-000	**Reported:**
Seattle, WA 98101	Project Manager: Neil Morton	05/13/10 22:21

Notes and Definitions

Qualifiers:

B	Analyte detected in an associated blank at a level above the MRL. (See Notes and Conventions below.)
H-01	This sample was analyzed outside the EPA recommended holding time.
H-06	This sample was received outside the EPA recommended holding time.
J	Estimated Result. Result detected below the lowest point of the calibration curve, but above the specified MDL.
Q-01	Percent recovery and/or RPD is outside acceptance limits.
Q-05	Analyses are not controlled on RPD values from sample or duplicate concentrations near or below the reporting level.

Notes and Conventions:

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis. Results listed as 'wet' or without 'dry' designation are not dry weight corrected.
RPD	Relative Percent Difference
MDL	If MDL is not listed, data has been evaluated to the Method Reporting Limit only.
WMSC	Water Miscible Solvent Correction has been applied to Results and MRLs for volatiles soil samples per EPA 8000C.
Batch QC	Unless specifically requested, this report contains only results for Batch QC derived from client samples included in this report. All analyses were performed with the appropriate Batch QC (including Sample Duplicates, Matrix Spikes and/or Matrix Spike Duplicates) in order to meet or exceed method and regulatory requirements. Any exceptions to this will be qualified in this report. Complete Batch QC results are available upon request. In cases where there is insufficient sample provided for Sample Duplicates and/or Matrix Spikes, a Lab Control Sample Duplicate (LCS Dup) is analyzed to demonstrate accuracy and precision of the extraction and analysis.
Blank Policy	Apex assesses blank data for potential high bias down to a level equal to ½ the method reporting limit (MRL), except for conventional chemistry and HCID analyses which are assessed only to the MRL. Sample results flagged with a B or B-02 qualifier are potentially biased high if they are less than ten times the level found in the blank for inorganic analyses or less than five times the level found in the blank for organic analyses. For accurate comparison of volatile results to the level found in the blank; water sample results should be divided by the dilution factor, and soil sample results should be divided by 1/50 of the sample dilution to account for the sample prep factor. Results qualified as reported below the MRL may include a potential high bias if associated with a B or B-02 qualified blank. B and B-02 qualifications are not applied to J qualified results reported below the MRL.

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