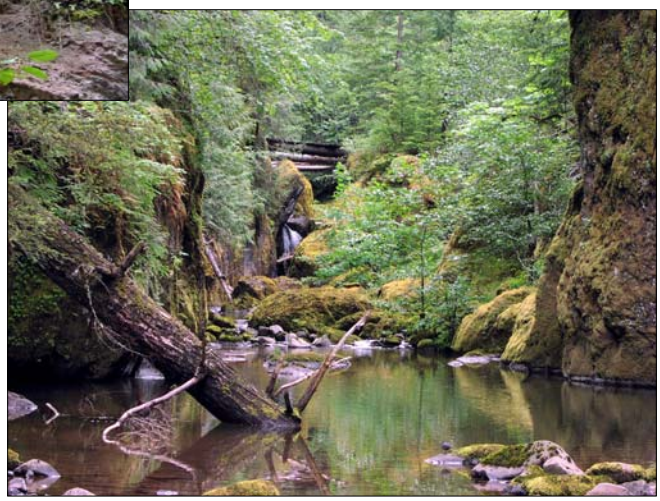

Site Inspection Report - Final
Kiggins and Nisbet Mines
Mt. Hood National Forest

March 2004

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SITE INSPECTION REPORT - FINAL
Kiggins and Nisbet Mines
Mt. Hood National Forest

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Prepared for: USDA Forest Service
Mt. Hood National Forest

Site Location: Kiggins and Nisbet Mines
Mt. Hood National Forest
Clackamas County, Oregon

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Cover Photos: Nisbet Mine Furnace (top left), and looking east and upstream to Station OGF-04 (bottom right).

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EXECUTIVE SUMMARY

A Site Inspection (SI) was performed at the Kiggins and Nisbet Mines (Site), located in the Mt. Hood National Forest, near Estacada, Oregon. The SI was conducted to assess if the Site poses an immediate and potential threat to human health and the environment, and to collect sufficient information to support a decision regarding the need for further action.

The Site consists of two mines: the Kiggins Mine with three reported adits (two are collapsed and one is open) and several waste rock piles, and the Nisbet Mine with five reported adits and one shaft (four adits and the shaft are collapsed) with several waste rock and tailings piles. The Site is situated adjacent to the Oak Grove Fork (OGF) of the Clackamas River, a tributary of the Clackamas River in northern Oregon. Mining waste appears to have been introduced into the surface water by historic disposal practices, and by erosion of fine-grained waste rock during high rainfall events and during spring snowmelt.

The SI consisted of the following tasks 1) background information research and file review, 2) onsite and offsite site reconnaissance and ecological assessment, and 3) collection of soil, waste rock, plant tissue, surface water, pore water, sediment, and benthic macroinvertebrate samples. Based on the information gathered during these tasks, the results indicate the following:

- **Groundwater Pathway:** Groundwater is used for drinking water within 4-miles of the Site from two wells located downstream of the Site. However, the nearest downgradient well is over 1 mile west of the Site and both are located north of the OGF and topographically at a higher elevation. Based on this, the groundwater pathway appears to be incomplete and no further assessment is warranted.

- **Surface Water Pathway:** Arsenic and mercury have been released into the OGF from the Site, and appear to have slightly impacted stream sediments, surface water, and pore-water. However, arsenic and mercury concentrations at one background station and a station adjacent to the Fall Vein were higher than several of the applicable comparison criteria and most of the downstream samples, which indicates another source of metals to the OGF above the Site and raises questions as to the actual degree of impact caused by the Site. Although the surface water pathway appears to be in part impacted by metal sources other than the Site, the surface water pathway is complete and further assessment is warranted. Results of the benthic macroinvertebrate sampling suggest little or no difference in invertebrate populations upstream, adjacent to and downstream of the Site.

- **Soil Pathway:** The soil pathway is complete for both human and ecological receptors, and a release of hazardous substances has been documented in this SI. Waste rock and waste source samples exceeded the Environmental Protection Agency Industrial Preliminary Remediation Goals for both arsenic and mercury. In addition, onsite vegetation appears to be impacted by activities associated with the Site. Arsenic concentrations in plant tissue samples collected from waste piles ranged up to ten times higher than the concentrations measured in tissue samples collected from background locations.

- **Air Pathway:** The air pathway is considered complete because arsenic and mercury impacted soil and waste material is concentrated at the surface where human and ecological receptors could be exposed to particulate matter. Because the air pathway is directly linked to the soil exposure pathway, addressing and/or eliminating the soil exposure pathway will likely render the air exposure pathway incomplete.

Based on the information gathered as part of the SI and presented in this report, CES recommends performing a streamlined Engineering Evaluation / Cost Analysis (EECA) at the Kiggins and Nisbet Mine. As part of the streamlined EECA, a risk assessment should be performed to assess the human and ecological impacts, establish removal cleanup standards, and assess if a removal action is warranted.

SITE INSPECTION DATA SUMMARY SHEET

Project Name: Kiggins and Nisbet Mine Site Inspection
Project Location: Section 5, Township 6 South, Range 7 East of the Willamette Meridian **Latitude:** 48° 06' 22" **Longitude:** 120° 02' 21"
Nearest Surface Water Body: Oak Grove Fork of the Clackamas River
Area of Disturbance: Kiggins Mine ~ 2 acre, Nisbet Mine ~ 1 acre

SUMMARY OF ANALYTICAL/DOCUMENTED CONTAMINATION

Media	**Sample Location**	**Rate of Discharge/Volume** (cfs, gpm, or CY)	Contaminant	**Highest Concentration**	**Lowest Criteria** Eco – Ecological HH – Human Health	**Background Concentration**
Surface Water	OGF-SW-6	24 cfs	Zinc, TR	50 ug/L	30 ug/L – Eco	10B ug/L
	KM-SW-1	10 gpm	Aluminum, TR	230 ug/L	87 ug/L – Eco	<30 ug/L
	KM-SW-2	5 gpm	Aluminum, TR Mercury, TR	420 ug/L 0.308 ug/L	87 ug/L – Eco 0.012 ug/L – Eco	<30 ug/L 0.00242 ug/L
Pore Water	OGF-PW-4	23 cfs – surface water	Mercury, Diss	0.0473ug/L	0.012 ug/L – Eco	0.00634 ug/L
	OGF-PW-6	24 cfs – surface water	Arsenic V, Diss Mercury, Diss	20.445 ug/L 0.222 ug/L	3.1 ug/L – Eco 0.012 ug/L – Eco	3.543 ug/L 0.00634 ug/L
	OGF-PW-7	36 cfs – surface water	Copper, Diss	4.0 ug/L	0.23 ug/L – Eco	<0.5 ug/L
Sediment	OGF-SS-3	Note Applicable (NA)	Arsenic	32 mg/kg	5.9 mg/kg – Eco	16.4 mg/kg
	OGF-SS-7	NA	Arsenic III Arsenic	11.89 mg/kg 61.178 mg/kg	6 mg/kg – Eco 5.9 mg/kg – Eco	0.067 mg/kg 14.225 mg/kg
	KM-SS-2	NA	Arsenic	24.7 mg/kg	5.9 mg/kg – Eco	16.4 mg/kg
Waste Rock / Waste Material (All Samples)	Kiggins Mine	~750 CY Total	Antimony Arsenic Iron Lead Mercury Thallium Vanadium Zinc	29 mg/kg 1,140 mg/kg 135,000 mg/kg 119 mg/kg 37,100 mg/kg 7.91 mg/kg 424 mg/kg 164 mg/kg	5 mg/kg – Eco 1.6 mg/kg – HH 10 mg/kg – Eco 16 mg/kg – Eco 0.1 mg/kg – Eco 1.0 mg/kg – Eco 2.0 mg/kg – Eco 8.5 mg/kg - Eco	0.37 mg/kg 90.97 mg/kg 53,366 mg/kg 7.5 mg/kg 8.23 mg/kg 0.73 mg/kg 120 mg/kg 75.33 mg/kg
Waste Rock / Waste Material (All Samples)	Nisbet Mine	~100 CY Total	Antimony Arsenic III Arsenic Mercury Thallium	15 mg/kg 24.2 mg/kg 5,229 mg/kg 3,300 mg/kg 22.3 mg/kg	5 mg/kg – Eco 10 mg/kg – Eco 1.6 mg/kg – HH 0.1 mg/kg – Eco 1.0 mg/kg – Eco	0.37 mg/kg NA 90.97 mg/kg 8.23 mg/kg 0.73 mg/kg

Notes: This table only lists sample concentrations that are at least 1.5 times higher than the lowest criteria and/or background concentration. These exceedances are considered the major contaminants of concern (COCs) and not a complete list of all COCs.
Highest background concentration in waters and sediments used since only two samples were collected; background soil concentrations listed are the average of three samples.
TR = Total Recoverable Metals; Diss. = Dissolved Metals; ug/L = micrograms per liter; mg/kg = milligrams per kilogram; NA = Not Analyzed

1.0 INTRODUCTION AND OBJECTIVES

The United States Forest Service (USFS) retained Cascade Earth Sciences (CES) to perform a Site Inspection (SI) at the Kiggins and Nisbet Mines (Site). The SI was performed in accordance to the U.S. Environmental Protection Agency (EPA) publication, *Guidance for Performing Site Inspections Under CERCLA* (EPA, 1992). The purpose of the SI is to determine the potential threat to human health and the environment from issues identified during the Abbreviated Preliminary Assessment (APA) conducted by the USFS at the Site. The work was performed under our existing 5-year USFS Contract (#10181-1-D007) and in accordance with the Purchase Order #53-05K3-3-021.

In general, the objectives of the SI were to (1) assess the immediate or potential threat that (mining) wastes pose to human health and/or the environment, and (2) collect sufficient information to support a decision regarding the need for further action. The information was collected in general accordance with CERCLA protocols and documentation requirements for assessments involving hazardous substances. Specifically, as outlined in the EPA CERCLA guidance document (EPA, 1992), "the sampling locations are strategically planned to identify the substances present, determine whether hazardous substances are being released to the environment, and determine whether hazardous substances have impacted specific targets."

The SI field activities included sampling and analysis of soil, waste rock, plant tissue, surface water, pore-water, and sediment samples from the Site and vicinity. This SI was performed following the Field Operation Plan (FOP) developed by CES, and approved by the USFS on September 9, 2003 (CES, 2003). The FOP was developed based on the APA completed by the USFS in 2002 and the Statement of Work (SOW) provided by the USFS in the request for proposals dated February 25, 2003. During and prior to field activities, CES made several modifications to the sampling locations and analyses after discussions and concurrence with the USFS Contracting Officers Representative (COR). These changes are summarized in a letter to the USFS dated December 11, 2004 (Appendix A).

2.0 SITE DESCRIPTION AND OPERATIONAL HISTORY

The following sections give a specific description of the Site location and an operational history of the Site. Photographs of the Site and sampling locations are included in Appendix B. No regulatory removal actions have been undertaken at the Site. In addition, no permits, violations, and/or regulatory inspections have been documented at the Site. Historical maps, sketches and miscellaneous information are included in Appendix C.

2.1 Description and Location

The Site is located in the Mt. Hood National Forest (MHNF) in Clackamas County, approximately 31 miles southeast of Estacada, Oregon (Plate 1). According to the USGS 7 ½ Minute Quadrangle Map - Mt. Mitchell (USGS, 1990), the Site location is described as:

- Section 5, Township 6 South, Range 7 East of the Willamette Meridian;
- Latitude – 48^{o} 06' 22"
- Longitude – 120^{o} 02' 21"
- Elevation – 1,800 to 2,100 feet above mean seal level (amsl).

Figures 1 and 2 provide a general layout of the Kiggins and Nisbet Mines, including 2-foot contours and pertinent features. The following were identified as major features at each mine.

Kiggins Mine

- The mine is accessed by crossing a dilapidated wood bridge from FR 4630-024.
- According to Brook (1963), three adits are associated with the mine. During the field activities, only Adits 1 and 2 were located. In addition, what appeared to be an adit vent (corrugated metal pipe) was observed below and slightly north of Adit 1 (this may be the original access to Adit 2). The exact location of Adit 3 was not located; however, a timbered structure was observed in the area around the Adit 3 area. It is likely that the timbered structure is a powderhouse; this is based on the construction (overlapped timbers on the sides and back indicate construction as a free-standing structure) and the letters "TNT" observed on a nearby tree (see photographs in Appendix B). Based on this, it is likely that Adit 3 is covered by the recent landslide southwest of the powderhouse. During the SI field activities, no water or evidence of water was observed flowing from any of the adits/vent.
- Sam Creek flows through the eastern portion of the mine and through associated recent flood debris, adjacent and through what appeared to be the foundations of the former living quarters and an outhouse. Sam Creek discharges to the Oak Grove Fork of the Clackamas River (OGF), which borders the mine to the north.
- A small unnamed perennial creek bisects the mine. The creek enters the mine from the steep hillside southeast of Adit 1 and flows through the mine to a ponded area. Based on field observations, it does not appear that the creek flows overland to OGF. The headwaters of this creek could not be located due to unsafe access conditions (i.e., steep slope and slippery conditions).
- Several waste rock and waste material piles (approximately 750 cubic yards) were observed scattered throughout the mine. The well-graded nature of the mine area indicates that waste rock may have been used to fill and level much of the mine, thus complicating an estimate of the extent of the material. No burnt ore/tailings were observed at the mine. The burnt ore/tailings were likely discharged into the OGF from the primary furnace that was built into the cliff wall immediately above the OGF.
- The following ore beneficiation/processing structures and foundations were observed: furnace foundation, ore bin/hopper, crusher, retort foundation, and a wood building with a small furnace/retort. The original furnace was built into the cliff wall along the OGF, with retort condenser tubes being scattered throughout the area.
- The Fall Vein was observed immediately upstream of the main mining area and was observed in the floodplain and rock outcroppings of the OGF.

Nisbet Mine

- According to Brooks 1963, five adits and one shaft existed at the mine. During the SI field activities only two adits could be located. Adit 1 is located on the south side of the OGF and on the east side of the main mine area. The floor of Adit 1 was damp, but standing water was not observed. It is possible that during wet times of the year Adit 1 discharges to the OGF. Adit 2 is collapsed and is located approximately 350 feet southwest of Adit 1. According to Brooks (1963) ore from Adit 2 was trammed to the furnace for processing. The remainder of the adits were not located and it is likely that they have collapsed over the years. In the likely area of the shaft, several depressions and waste piles (discussed below) were observed. It is not known if these depressions and/or waste piles are associated with the shaft or collapsed workings.
- A seep appears to be present east of Adit 1. At the time of the reconnaissance, water was not observed flowing directly into the OGF.
- Two burnt ore/tailings piles are located adjacent to the OGF. Based on field observations, it appears that piles were at one time one large pile, but over the years the OGF has cut into the toes and the pile(s) has broken apart and sloughed down in the floodplain. The piles are solid and the calcite material has been naturally cemented over time. In addition, three waste rock piles are scattered along the hillside and appear to be associated with exploration trenching and Adit 2. The total volume of waste rock and material at the Nisbet Mine is estimated at 100 CY.
- A furnace foundation and tramline trestle are located upgradient of the tailings piles and built into the rock wall. Observations of the furnace area were limited because it was considered too dangerous to access the area due to steep slopes and slipper conditions.
- The Oak Grove Vein was visible as an outcrop in the OGF adjacent to the mine.

2.1.1 Operational History and Waste Characteristics

Little information is available regarding the operational history of the Kiggins and Nisbet Mines. The following information was gleaned from *Quicksilver in Oregon (Schuette, 1938 and Brooks, 1963) and*

Quicksilver Deposits in Oregon (Brooks, 1971). The following information is a chronological summary of the operational history of the Site and the estimated mercury production.

- 1923 to 24 - George Nisbet located the Vermilion group of claims.
- 1925 - Nisbet located the Oak Grove group of claims.
- 1926 - Nisbet constructed furnace near Vermilion group in rock cliff along OGF,
- 1927 - D.E. Kiggins given a 1/8 interest in the claims.
- 1927 to 1938 – Kiggins and Nisbet worked as partners.
- 1930 - Cylindrical shaft-type furnace erected on Oak Grove Group, capacity ~ 15 tons/day.
- 1938 - Nisbet gave Kiggins his interest in Vermilion group and took ownership of Oak Grove group for himself.
- 1940 - Option given on Kiggins claims to Horse Heaven Mines, Inc, which failed to exercise its option and property reverted to its owner.
- 1940 - Nisbet claims leased to Oregon Quicksilver, Inc headed by George S. Barton.
- 1940-41 – Oregon Quicksilver, Inc. produced 66 flasks from the Nisbet property using cylindrical shaft furnace.
- 1942 – E.O. Emil produced 3 flasks from Nisbet claims.

Production Estimates (in flasks of mercury)

	Kiggins Mine	Nisbet Mine
1934	20	NA
1935	16	NA
1936	12	NA
1937	NA	18
1938	5	7
1939	9	5
1940	5	57
1941	4	9
1942	NA	3
1943	NA	3
Totals	**71**	**102**

2.1.2 Climate

Climate data were compiled from the Western Regional Climate Center (WRCC, 2003). Climate in Clackamas County varies depending on elevation and distance from the Cascade summit. Precipitation increases and temperatures decrease as elevation rises to the summit of the Cascade Range. The Site lies along the foothills of the western slope of the Cascade Range at an elevation of approximately 1,800 to 2,000 feet amsl. The following climate data was compiled from the Three Lynx, Oregon monitoring station, located approximately 6 miles northwest of the Site at an elevation of 1100 feet amsl. The Site, approximately 700 feet higher in elevation than Three Lynx, likely receives more total precipitation and has lower minimum and maximum temperatures. The annual prevailing wind direction is to the east-southeast; however, it shifts to the north-northwest in the summer.

- Total average precipitation is approximately 70 inches per year.
- The average minimum temperature of approximately 31° F occurs in January.
- The average maximum temperature of approximately 78° F occurs in July.
- Temperature extremes range from approximately 105° F in the summer months to 6° F in the winter months.

3.0 PATHWAYS AND ENVIRONMENTAL HAZARD ASSESSMENT

3.1 Groundwater Exposure Pathway

3.1.1 Geologic Setting

Regional geologic information presented in this section was obtained from Orr and Orr (1999). Site-specific geology was compiled from (Brooks 1963 and 1971), as well as site-specific reconnaissance performed by a CES Oregon Registered Geologist.

3.1.1.1 Regional Geology

The Kiggins and Nisbet Mines are located in the Cascade Mountain physiographic province. The province is further subdivided into the High Cascades dominated by high glaciated volcanic peaks and rocks less than 10 million years in age, and the older more-weathered Western Cascades with rocks ranging from approximately 42 to 10 million years in age. The Kiggins and Nisbet Mines are located near the boundary of these two sub-provinces and on the extreme eastern edge of the older Western Cascades.

Geology in the vicinity of the Site consists of Pliocene and Miocene age basalt and basaltic andesite in flows, flow breccia and pyroclastic deposits. In addition, an area of more recent landslide and debris flow deposits is mapped immediately west of the Site. Regional faulting is dominated by southeast to northwest trending normal faults (USGS, 1991).

3.1.1.2 Site Specific Mining Geology

The only reported commodity at the Site was mercury. The primary mineral is cinnabar and the gangue is calcite and stilbite. The ore deposits are found in fissure veins constituted mainly of banded calcite and at least one stilbite vein, and in narrow fracture fillings in the basalt adjacent to the veins. Ore veins reportedly ranged from 6 inches to about 6 feet in width in zones 10 to 15 feet wide. One vein reportedly contained from 10 to 90% stibnite and was 2 to 12 inch wide.

The calcite veins appear to have been introduced into open fractures in the basalt. Displacement along the fractures is evidently slight, although locally the basalt adjacent to the veins is brecciated and has been altered by hydrothermal solutions to a dark, gray-green rock, which contains considerable clay and is locally stained by limonite. The calcite veins commonly have a banded structure. Crystal interspaces in the veins commonly are filled with felted mixtures of quartz, opal, heulandite or stilbite, calcite and locally pyrite, ilsemannite, jordisite and cinnabar.

The following site-specific geology is summarized from *Quicksilver in Oregon (Schuette, 1938 and Brooks, 1963)* and based on field observations. The reader is directed to the full report for more details.

Kiggins Mine

- The mine includes 330 feet of drifts and stopes and 200 feet of crosscuts among three adits.
- Three veins are exposed, Vermillion, Stope and Falls, all of which lie in the northwest quadrant and dip to the northeast.
- The workings are near the same altitude near the back edge of a river terrace.
- The No. 1 Adit follows the Vermillion vein 180 feet northwestward.
- The Stope vein is also present in the No. 1 Adit, which extends westward 30 feet and upward 17 feet. The Stope vein was 8 inches thick with about 6 pounds of mercury per ton of vein material.
- The No. 2 Adit followed the downward extension of the Vermillion vein which has a pitch 50 degrees to the east.

- The No. 3 Adit explored the southeast extension of the Vermillion vein, which in that adit, dipped 35 degrees northeast.
- The Fall vein crops out in the channel of the OGF from a point east of the existing bridge (north of the "powderhouse") downstream for a distance of 250 feet. The river follows the more easily eroding vein, which is 3 to 5 feet in width and 10 to 20 feet deep.

Nisbet Mine

- The mine includes approximately 500 feet of underground workings divided among five adits and a shaft. The mine also includes several open crosscuts. Only Adit No. 1, near the base of the slope adjacent to the OGF remains open; the other adits and the shaft are caved or collapsed.
- The mine is developed around four veins: the Zeolite vein, the Oak Grove vein, the Sluice vein, and the Ben vein. The Zeolite vein was responsible for most of the production of the mine.
- The Zeolite vein was developed by an adit, an inclined shaft, and a stope; The Oak Grove vein by two adits and a surface trench; and the Ben vein by one adit and a small stope.
- The Oak Grove vein strikes east and dips 70 to 80 degrees north. It was explored with a horizontal distance of 100 feet and a vertical distance of 100 feet. It ranged from 6 inches to 6 feet thick.
- The Oak Grove vein is mineralized with cinnabar, calcite, and silica.
- Additional workings explored the West and Top Hole veins.

3.1.2 Hydrogeology

The Site is located within the Oak Grove Fork of the Clackamas River watershed. A review of the Oregon Water Resources Department (OWRD) well log database indicates that four water supply wells are located within a 4-mile radius of the Site. The approximate locations of the wells are represented as red dots on Plate 1. Depths of completed wells range from 74 feet below ground surface (BGS) to 280 feet BGS. In general, static water levels in the wells were observed to be between 14 to 220 feet BGS. A review of well logs indicates the shallow geology of the Oak Grove Fork of the Clackamas River watershed consists of interbeds of silt and clay to depths of 5 to 20 feet BGS. Gravels and boulders were encountered during well drilling activities at depths of 5 to 40 feet BGS. Bedrock was encountered at depths of 18 to 150 feet BGS. Copies of the well logs reviewed are available in the USFS Project File. None of the wells were observed or sampled during the SI field activities. None of the adits associated with the Site had flowing seeps during the field reconnaissance.

3.1.3 Targets

Targets are defined as receptors that are located within the target distance for a particular pathway. For the groundwater pathway, the target distance has been defined as 4-miles and example targets are drinking water wells, wellhead protection areas, etc (See Plate 1). No wellhead protection areas, and only four water supply wells, were identified within a 4-mile radius of the Site. Only two of the four wells are downgradient from the Site. There are approximately 250 year round residents within a 4-mile radius, all but one is associated with the Timber Lake Job Corp Center, all of which receive their drinking water from a well. The one resident not associated with the Timber Lake Job Corp Center is located near the Ripplebrook Ranger Station, the drinking water source is not known. Five campgrounds (Hideaway Lake, Rainbow, Ripplebrook, Lake Harriet, and Shellrock) are located within a 4-mile radius of the Site. However, each of the campgrounds either do not have drinking water facilities or receive drinking water from surface water (tributary to the OGF see 3.2.2.1), and only two are located downstream from the Site (Rainbow and Ripplebrook).

3.1.4 Groundwater Exposure Pathway Summary

Groundwater is used for drinking water within 4-miles of the Site from two wells located downstream of the Site. Both wells are located over 1 mile from the Site and are located at a higher elevation than the OGF. Therefore, it is unlikely that groundwater flowing from the Site would impact either well. Based on this, the groundwater pathway appears to be incomplete and no further assessment is warranted.

3.2 Surface Water Exposure Pathway

3.2.1 Hydrologic Setting

The Kiggins and Nisbet Mines are bordered on the northeast by the Oak Grove Fork of the Clackamas River (Plate 1 and Figure 3). According to the USGS 7½ minute quadrangle maps (USGS, 1990) of the area, the Oak Grove Fork watershed above the Site is approximately 83,540 acres or 130 square miles (Plate 1). Various springs and unnamed tributaries flow into OGF upstream of the Site. Sam Creek enters the OGF immediately upstream of the Kiggins Mine on the southwest side of the OGF; and a small unnamed creek bisects the Kiggins Mine. Overland flow (i.e. sheet flow) flows down the slope and across the waste rock piles and ultimately into the OGF.

At approximately 0.5 miles downstream of the Nisbet Mine an approximate 75-foot vertical waterfall completely impedes fish passage in the OGF. Downstream from the waterfall several creeks (i.e., in order, Canyon, Butte, John, Station, and Pint) enter the OGF. The OGF reaches the main stem of the Clackamas River approximately 4.25 miles downstream from the Nisbet Mine. The Clackamas River flows north and west for approximately 25 miles where it enters the North Fork Reservoir. Farther downstream, the Clackamas River discharges into the Willamette River and eventually into the Columbia River.

The flow rates in the Oak Grove Fork were measured on September 18, 2003, at each surface water Station (see Table 1). Flow rates in the Oak Grove Fork below the Lake Harriet Dam ranged from 5.9 cubic feet per second (cfs) at Station OGF-02, above Kiggins Mine, to 36.3 cfs at Station OGF-07, the most downstream Station below Nisbet Mine. Flow rates generally increased from upstream to downstream. Furthermore, the flow rate of the Oak Grove Fork measured at OGF-01, located immediately upstream of Lake Harriet (near USGS Station 12449760) was measured at 176.3 cfs. Most, if not all, of the Oak Grove Fork is diverted from Lake Harriet and piped via aqueduct to downstream towns and cities for drinking water.

3.2.2 Targets

For the surface water pathway, the target distance has been defined as 15-miles, and example targets are surface water intakes supplying drinking water, sensitive environments (i.e., wetlands), and aquatic organisms. As the OGF empties into the Clackamas River approximately 3.75 aerial miles and 4.75 river miles downstream from the Site, only points above the confluence are considered targets because of the high flow rate and dilution of the Clackamas River when compared to the OGF.

3.2.2.1 Local Surface Water Use

Plate 1 shows the 1 and 4-mile radius from the Site. There are approximately 250 year round residents within a 4-mile radius, all of whom appear to receive their drinking water from wells. Five campgrounds (Hideaway Lake, Rainbow, Ripplebrook, Lake Harriet, and Shellrock) are located within a 4-mile radius of the Site; however, only two campgrounds are located downstream from the Site (Rainbow and Ripplebrook). The Rainbow campground does not provide drinking water facilities, and the Ripplebrook campground receives drinking water from a surface water right on Pint Creek, a tributary to the OGF. Since the OGF flows through USFS administered land, public access to surface water is not restricted. Surface water uses were not field-verified as part of the SI; surface water in or around the Site most likely is used for recreational purposes such as swimming, camping (washing dishes, cooking), and fishing.

3.2.2.2 Wetlands

Maps outlining designated wetland areas were prepared by the National Wetlands Inventory (NWI), a division of the U.S. Fish and Wildlife Service. Wetlands were identified based on vegetation, visible hydrology, and

geography in accordance with Classification of Wetlands and Deepwater Habitats of the United States (Cowardin et. al., 1979). The following are considered "listed" on the NWI map (USF&W, 1995):

- Areas upstream and downstream of the Site within the channel of the OGF and Sam's Creek are classified as riverine, upperperennial, unconsolidated bottom, permanently flooded (R3UBH).
- Lake Harriet, located upstream of Station OGF-02 and downstream of Station OGF-01, is classified as lacustrine, limnetic, unconsolidated bottom, permanently flooded, impounded (L1UBHH).
- Areas classified as palustrine shrub-scrub, seasonally flooded (PSSC), palustrine emergent, seasonally flooded (PEMC), palustrine forested, seasonally flooded (PFOB), and upland (U) are located approximately 0.5 miles downstream from the Nisbet Mine.
- Areas classified as PSSC, PEMC, and U are located approximately 1.5 miles downstream from the Nisbet Mine.

3.2.2.3 Aquatic Ecological Survey

Aquatic surveys were conducted to assess the potential impacts of the mines on the instream habitat, benthic macroinvertebrate community, and presence of fish species because each may be affected by site-related physical impacts or chemical contamination. Refer to Appendix D for complete Ecological Survey. Seven 300 feet stream reaches were established, with one reach upstream of Lake Harriet, and one each upstream, adjacent, and downstream of the two mine sites. An attempt was made to include both riffle and pool habitat within each reach. Physical habitat quality was quantified for each reach using USEPA Rapid Bioassessment Protocol - Habitat Assessment Field Data Sheets (Barbour 1999). Additional instream characterization was conducted with the Physical Characterization Field Data Sheet (Barbour 1999). The following habitat conditions were noted:

- Habitat scores (172 to 188, out of a possible 200) indicated optimal physical habitat conditions for all Stations. Compared to the other Stations, water volume was significantly higher at Station OGF-01 above the Lake Harriet Dam. Water volume was very low below the dam at Station OGF-02, increased significantly between OGF-02 and OGF-03 due to the inflow of Sam Creek, and steadily increased at each subsequent downstream Station.
- Station OGF-01 (fast/shallow) and OGF-03 (slow/deep) had only one of 4 possible velocity/depth regimes. (See Appendix D). Stations OGF-02 and OGF-04 through OGF-06 had two of the depth regimes with fast/deep and slow/shallow being absent from each reach. Station OGF-07 had three of the four depth regimes with only fast/deep absent.

Overall, other than water volume, instream habitat conditions were optimal from Stations OGF-02 through OGF-07. There were fewer boulders and more cobble and gravel with increasing distance downstream. The stream channel had increasing complexity proceeding downstream primarily due to the increased volume of water.

Sampling of benthic macroinvertebrates was conducted in pool and/or riffle habitat at each of the stream reaches. No pools were present in the vicinity of Station OGF-01 so only a riffle invertebrate sample was collected. No riffles were present in the vicinity of Station OGF-03 so only a pool invertebrate sample was collected. Laboratory enumeration was completed for a minimum of 300 individuals in each sample. Abundance, diversity, and metals tolerance were examined for the invertebrates present in each sample, and were qualitatively compared between Stations. Pool data were only compared to other pool data and riffle data were only compared to other riffle data. The results of the benthic invertebrate investigation in pool habitats show that:

- The abundance of all invertebrates in pools was consistent between OGF-02 and OGF-05 then increased dramatically at Stations OGF-06 and OGF-07. There was no apparent reason for this increase because the habitats at Stations OGF-03 through OGF-06 were very similar. One possible explanation is that the water flow at Stations OGF-06 and OGF-07 is more consistent than at the upstream Stations and that the invertebrate samples from the upstream Stations were collected from areas that were not always inundated. This possibility

could not be verified during the investigation. The abundance as a percent of all invertebrates was consistent with habitat quality across all Stations.

- Ephemeroptera, Plecoptera, and Trichoptera (EPT) species were dominant at Stations OGF-02 and OGF-07, whereas Diptera species were dominant at all other Stations. This is likely due to the smaller pools that contained less fine-grained sediment at Stations OGF-02 and OGF-07.
- The diversity of functional feeding groups and species diversity in pool samples were very consistent across all Stations.
- The metals tolerance index increased slightly at Station OGF-03 and OGF-04, which were adjacent to the Kiggins Mine. This slight change could suggest some slight chemical effect adjacent to the mine, but this is not an obvious conclusion given the similarity in invertebrate abundance and diversity between the Stations.

These results suggest little or no difference in invertebrate populations between pool Stations upstream, adjacent to and downstream of the mines. The reason for the increased abundance adjacent to the Nisbet Mine is not clear, but the consistency in species diversity across all Stations does not suggest a mine-related cause.

The results of the benthic invertebrate investigation in riffle habitats show that:

- The abundance of all invertebrates and the pollution/habitat-sensitive EPT species showed very similar patterns. This included a decrease at Station OGF-04 followed by a large increase at Station OGF-05, and then a decrease at Station OGF-06. The percent abundance shows a clear trend of increasing EPT species and decreasing Diptera species suggesting improved water flow and/or improved riffle conditions (which are preferred by EPT species), with increasing distance downstream.
- The diversity of functional feeding groups and species diversity in riffle samples were both remarkably similar across all Stations.
- The metals tolerance did not change significantly across Stations.

These results suggest minimal or no noticeable impacts to benthic invertebrate populations inhabiting riffle habitats downstream of the mines.

Riffle EPT taxa metrics are likely representative of instream water quality (versus sediment quality). Thus, the benthic invertebrate survey results from riffle habitats suggest that there is little or no evidence of impacts to surface water quality downstream of the mine sites. Pool habitats are more likely representative of sediment quality, which may reflect longer-term influences within the river. Overall, there is no clear evidence of mine-related impacts to pool invertebrates. There are however slight suggestions (such as metals tolerance index increases), of potential mine-related impacts at Stations OGF-03 and OGF-04.

The presence of fish was documented by visual observation during the ecological survey. Several 2 to 6-inch fish were noted in pools at Stations OGF-05 and OGF-06. These were most likely resident cutthroat trout that have been washed over the Lake Harriet Dam during high flow events or power generator shutdowns. The waterfall downstream of Station OGF-07 is a natural barrier to anadromous fish. Therefore, no rare, threatened, or endangered (RTE) fish are present within the vicinity of the mines.

3.2.3 Site Inspection Analytical Results

This section presents the surface water, pore water, and stream sediment analytical results for the SI conducted at the Site. Sample locations are shown on Figure 3, analytical results are tabulated in Tables 1, 2 and 3; the original laboratory reports are available in the USFS Project File. Photographs of selected sampling locations are included in Appendix B. Changes to the sampling program were made during the field event after discussion and concurrence with the USFS representative. A complete report of the quality assurance / quality control (QA/QC) procedures and results is available in the USFS Project File. Field activities were conducted from September 16 through 19, 2003; the reader is referred to the FOP (CES, 2003) for sampling procedure and protocols.

A total of 14 water samples (7 surface water and 7 pore-water) and 7 sediment samples were collected from pool substations in the OGF during the SI field activities (Figure 3). Laboratory analyses and field parameters include the following for each of the media sampled:

- Surface Water Laboratory – Total recoverable metals for the 23 Target Analyte List (TAL); arsenic speciation (III and V); chromium speciation (III and VI); methyl mercury; hardness as calcium carbonate ($CaCO_3$); total dissolved solids (TDS); total suspended solids (TSS); total organic carbon; and sulfate.
- Pore Water Laboratory – Dissolved metals for the 23 TAL; dissolved arsenic speciation (III and V); dissolved chromium speciation (III and VI); methyl mercury; hardness as $CaCO_3$; TDS; TSS; and sulfate.
- Surface Water and Pore Water Field Parameters - pH, temperature, conductivity, dissolved oxygen (DO), oxygen reduction potential (Eh), and flow rate.
- Sediment – Total metals for the 23 TAL; methyl mercury; arsenic and chromium speciation; and grain size.

Surface water, pore water, and sediment results are summarized in the following:

- Surface water wet chemistry results are summarized as follows: conductivity ranged from 60 to 104 microsiemans (uS); hardness as $CaCO_3$ ranged from 26 to 52 milligrams per liter (mg/L); TDS ranged from 50 to 80 mg/L; TSS were only detected above the method detection limit (MDL) in one sample at 6 mg/L; total organic carbon ranged from below the MDL to 2 mg/L; and sulfate was not detected above the MDL of 10 mg/L.
- Pore water wet chemistry results are summarized as follows: conductivity ranged from 68 to 244 uS; hardness as $CaCO_3$ ranged from 32 to 141 mg/L; TDS ranged from 60 to 160 mg/L; TSS ranged from blow MDL to 104 mg/L; and sulfate was detected above the MDL of 10 mg/L in only one sample at 30 mg/L in OGF-PW-6.
- Surface water field parameters ranges included: temperature (7.7 to 11.0 ^{o}C); pH (7.4 to 8.38 su); conductivity (30 to 74 uS); DO (8.5 to 9.1 mg/L); and Eh (32 to 96 millivolts [mv]).
- Pore water field parameters ranges included: temperature (8.4 to 11.6 ^{o}C), pH (7.3 to 9.06 su), conductivity (40 to 156 uS), DO (0 to 6.8 mg/L), and Eh (-123 to 64.2 mv).
- The sediment grain size was between 85% and 100% silt and sand, with minor amounts of clay in all samples.
- Results of the metals analyses for surface water, pore water, and sediment are discussed in the following table and presented in Tables 1, 2, and 3, respectively.

Summary of Surface Water, Pore Water, and Sediment Metals Results

SAMPLE TYPE	TABLE / SAMPLE ID	METALS EXCEEDING ONE OR MORE COMPARISON CRITERIA	TRENDS OBSERVED AND COMMENTS
Surface Water	**Table 1**	**Total Recoverable metals (ug/L)**	**All criteria listed below are Ecological**
Upstream from Kiggins and Lake Harriet (background)	OGF-SW-1	Arsenic (0.2)	
Upstream from Kiggins, below Lake Harriet (background)	OGF-SW-2	Arsenic V (3.71) and arsenic (3.7)	Highest arsenic (V and total) concentration detected in surface water.
Adjacent to Kiggins, near Fall Vein	OGF-SW-3	Arsenic (2.8) and mercury (0.013)	Mercury detected slightly above lowest criteria of 0.012 ug/L, and arsenic lower than highest background.
Adjacent to Kiggins	OGF-SW-4	Arsenic (2.7)	Arsenic lower than highest background.
Downstream from Kiggins, upstream from Nisbet	OGF-SW-5	Arsenic (1.9)	Arsenic lower than highest background.
Adjacent to Nisbet	OGF-SW-6	Arsenic (2.1) and zinc (50)	Arsenic lower than highest background, and zinc slightly above lowest criteria (30 ug/L).
Downstream from Nisbet	OGF-SW-7	Arsenic (2.6)	Arsenic lower than highest background.
Kiggins unnamed stream, upstream (background)	KM-SW-1	Aluminum (230)	Aluminum detected above applicable criteria (87 ug/L).
Kiggins unnamed stream, ponded area	KM-SW-2	Aluminum (420), arsenic (1.0) and mercury (0.0308)	Aluminum detected above both background and applicable criteria of 87 ug/L, arsenic lower than highest background, and mercury highest detected in surface water.

Summary of Surface Water, Pore Water, and Sediment Metals Results (cont.)

SAMPLE TYPE	TABLE / SAMPLE ID	METALS EXCEEDING ONE OR MORE COMPARISON CRITERIA	TRENDS OBSERVED AND COMMENTS
Pore Water	**Table 2**	**Dissolved metals (ug/L)**	**All criteria listed below are Ecological**
Upstream from Kiggins and Lake Harriet (background)	OGF-PW-1	Iron (1,970) and manganese (385)	Iron and manganese detected above lowest criteria (158 and 120 ug/L, respectively).
Upstream from Kiggins, below Lake Harriet (background)	OGF-PW-2	Arsenic V (3.543) and zinc (40)	Arsenic V and zinc detected slightly above lowest criteria (3.1 and 30 ug/L, respectively).
Adjacent to Kiggins, near Fall Vein	OGF-PW-3	Zinc (40)	Zinc slightly above lowest criteria (30 ug/L) and same as background sample.
Adjacent to Kiggins	OGF-PW-4	Mercury (0.0472) and zinc (40)	Mercury exceeded one criteria (0.012 ug/L), and zinc was only slightly above the lowest criteria (30 ug/L) and same as background sample.
Downstream from Kiggins, upstream from Nisbet	OGF-PW-5	Arsenic V (3.55), manganese (164) and zinc (40)	Arsenic V slightly above highest background sample, manganese lower than highest background, and zinc slightly above the lowest criteria (30 ug/L) and same as background sample.
Adjacent to Nisbet	OGF-PW-6	Arsenic V (20.45) and mercury (0.222)	Arsenic V and mercury were the highest detected in pore water.
Downstream from Nisbet	OGF-PW-7	Copper (4) and zinc (50)	Copper exceeds lowest criteria (0.23 ug/L), and zinc slightly above the lowest criteria (30 ug/L) and background sample.
Sediment	**Table 3**	**Total Metals (mg/kg)**	**All criteria listed are Ecological**
Upstream from Kiggins and Lake Harriet (background)	OGF-SS-1	Mercury (1.56) and nickel (87)	
Upstream from Kiggins, below Lake Harriet (background)	OGF-SS-2	Arsenic (16.4), cadmium (0.88), chromium (83), copper (63), manganese (1,120), mercury (14.7) and nickel (88)	
Adjacent to Kiggins, near Fall Vein	OGF-SS-3	Arsenic (32), cadmium (0.98), chromium (68), copper (57), mercury (10.9) and nickel (66)	Arsenic greater than background and criteria (sample collected adjacent to Fall Vein); cadmium similar to background; chromium, copper, mercury, and nickel all below highest background.
Adjacent to Kiggins	OGF-SS-4	Arsenic (10.9), cadmium (0.87), chromium (74), copper (56), mercury (2.1) and nickel (85)	All metals below highest background.
Downstream from Kiggins, upstream from Nisbet	OGF-SS-5	Arsenic (11.5), cadmium (0.83), chromium (76), copper (60), manganese (1,160), mercury (4.71) and nickel (87)	Manganese slightly above lowest criteria (1,100 mg/kg) and highest background; remaining metals below highest background.
Adjacent to Nisbet	OGF-SS-6	Arsenic (11.3), cadmium (0.87), chromium (73), copper (57), mercury (4.5) and nickel (79)	All metals below highest background.
Downstream from Nisbet	OGF-SS-7	Arsenic III (11.89), arsenic (43.6), cadmium (0.85), chromium (57), copper (53), mercury (21.8) and nickel (62)	Arsenic (III and total) and mercury greater than background and lowest criteria, remanding metals below highest background.
Kiggins unnamed stream, ponded area	KM-SS-2	Arsenic (24.7), cadmium (1.01), chromium (110), copper (51), mercury (13) and nickel (75)	Arsenic, cadmium, and chromium all above highest background (however, sample collected from Kiggins unnamed stream), remainder of metals below background

3.2.4 Surface Water Exposure Pathway Summary

Based on the information presented in this section, metals (primarily arsenic and mercury) have been released into the OGF from the Site, and appear to have slightly impacted stream sediments, surface water and pore-water. However, arsenic and mercury concentrations in samples collected above the Site (Station OGF-02) and near the Fall Vein (Station OGF-03) were higher than several of the applicable comparison criteria and higher than many of the samples collected adjacent and downstream of the Site. This indicates that another likely source of metals is above the Site or from the Fall Vein, and raises questions as to the actual degree of impact caused by the Site. The OGF below the waterfall is documented habitat for anadromous fish, which are possibly being affected by metal concentrations in the OGF. Although, the OGF and the surface water pathway appears to be impacted by metal sources other than the Site, the surface water pathway is considered complete and further assessment is warranted.

3.3 Soil Exposure Pathway

3.3.1 Targets

3.3.1.1 Local Use

There are no onsite workers or persons living within 200 feet of the Site. Public use of the Site and vicinity is most likely minimal, though public access records are not maintained**.** Access is currently not restricted by fencing, nor were any "No Trespassing" signs noted during the SI. In general, land uses in this area are limited to timber harvesting, firewood cutting, recreation (hiking, fishing, camping, hunting, etc.) and some minerals prospecting.

3.3.1.2 Terrestrial Ecological Survey

Terrestrial habitats and animals that are present, or likely to be present, at and surrounding the site were primarily documented during the ecological survey and via review of USFS and power generation permitting documents. Lists of endangered, threatened, or sensitive plants and animals known to be present in the vicinity of the site were obtained from the Oregon Natural Heritage Information Center (ONHIC) and the USFS.

Six distinct plant communities were observed on, and adjacent to, the mine sites. These included:

- Mature western hemlock forest over a majority of the on- and offsite area.
- Early seral stage coniferous forest at the Kiggins Mine.
- Riparian forest along banks of Oak Grove Fork.
- Shrub habitat at the Kiggins Mine.
- Mixed deciduous /coniferous forest located on steep slopes above the adits on both mines.
- Palustrine emergent wetland at Kiggins Mine.

The dominant habitat type at the Nisbet Mine was mature coniferous forest with small components of riparian and disturbed forest habitat. The dominant habitat type at the Kiggins Mine was mixed successional forest that included early seral stage coniferous forest, mixed forest, and riparian forest and small components of emergent wetland and shrub habitat. A lack of riparian vegetation at the Nisbet Mine may be due to erosion in the vicinity of the retort, scouring during floods, or other factors. Difference in the vegetative cover and diversity of the mixed forest between the disturbed riparian forest at the Nisbet Mine and undisturbed riparian forest at the Kiggins Mine could be caused by ongoing erosion in the vicinity of the Nisbet Mine. Also, the patchy and disturbed nature of the habitats present at the Kiggins Mine could be due to elevated contamination levels or the apparently frequent human disturbance on this mine.

Flies, mayflies, numerous rough-skinned newts, numerous red-legged frogs, a Pacific giant salamander, winter wrens, black-capped chickadees, dark-eyed juncos, pine-siskins, robins, Stellar's jays, and Douglas tree squirrels were the primary invertebrate and wildlife species identified at or in the vicinity of the Site. Very few game trails were present on the Site but black-tailed deer and Roosevelt elk are expected to inhabit the vicinity. Many other species are possibly found at and in the vicinity of the site.

The ONHIC has documentation of two rare plants occurring in the vicinity of the Kiggins and Nisbet Mines; neither of which were observed during the survey. The U.S. Fish and Wildlife Service (USFWS), Oregon Department of Agriculture (ODA), and the USFS have identified 65 plant species that may occur in the vicinity of the mines that are listed as rare, threatened, or endangered. Twenty-three of these species are USFS "survey & manage" plant species that, although they are not listed as threatened or sensitive, the USFS manages and protects from ground-disturbing activities. None of the plant species listed as rare, threatened, endangered, or under USFS management were observed during the site visit. If a removal action is

necessary, a field survey for early blooming USFS survey and manage species may be needed prior to any ground disturbance activity.

The ONHIC lists the vicinity of the mines as spotted owl habitat areas. State and federally threatened bald eagles were noted as being present within the vicinity but are not expected in close proximity to the site. Habitat exists at the site for harlequin duck, which are USFS sensitive species. However, harlequin ducks have not been documented on the reach of the OGF near the mines. Townsend's big-eared bats are listed by the ONHIC as present in the vicinity of the Site. The actual location of these sightings were not provided and the last observation was listed as 1994. A USFS biologist (Berganimi 2004) indicated that improvements were made to the mines to accommodate bats. Bats were noted at the Nisbet Mine in the Oak Grove Watershed Analysis (USFS 1996). In addition, the open adits at the Kiggins Mine provide habitat that may be used by bats. The wolverine (*Gulo gulo*), Baird's shrew (*Sorex bairdii*), Pacific fringe-tailed bat (*Myotis thysanodes*), and fisher (*Martes pennanti*) are listed by the USFS as sensitive species, and habitat exists for these species surrounding the mines.

Overall, a relatively large number of wildlife species were documented at the Site. This is somewhat unusual given the limited extent of the ecological surveys and likely represents the quality and relatively undisturbed nature of the habitat surrounding the mines. In addition, the varied foraging preferences represented by the documented species shows that the species inhabiting the area surrounding the mines are diverse and suggest that other species are likely to be present, but were not noted. Of the terrestrial invertebrates and wildlife documented or likely to inhabit the Site, those inhabiting the small plateau surrounding the Kiggins Mine are likely to be the species most highly exposed to site-related contamination. Insectivorous species that may forage frequently on invertebrates within this area and amphibians or fish inhabiting the river and its shoreline in the vicinity of the Site may also be exposed to site-related contamination, if present in the river.

3.3.2 Previous Investigations

In 2002, the USFS performed an APA, which consisted of collecting several samples from waste rock piles at the Site (USFS, 2002). The purpose of this investigation was to determine whether or not there is a potential for a release of contaminants to the environment and/or to human health, and whether further site characterization is warranted. A Niton XRF 700 Series, using *in situ* field screening methods, was utilized to help in the preliminary screening of the Site. Antimony, arsenic and nickel were detected at concentrations exceeding the EPA Region IX Industrial PRGs

3.3.3 Site Inspection Analytical Results

The following sections present the background soil, waste rock, and vegetation tissue analytical results for the Site. Sample locations for soils, waste rock and tissue samples are shown on Figure 1, 2, and 3. Analytical results for background soils are tabulated in Table 4 and waste source material in Tables 5 and 6. Vegetation tissue results are tabulated in Table 7. The complete laboratory analytical results and a discussion of QA/QC procedures and results are available in the USFS Project File. A total of three background soil samples, 16 waste source samples, and six vegetation samples (three co-located with background soil samples and three co-located with waste rock samples) were collected around the Site. Laboratory analysis includes the following for each of the media sampled:

- Background Soil - Total metals for the 23 TAL; arsenic and chromium speciation; and pH.
- Waste Rock - Total metals for the 23 TAL; methyl mercury; arsenic and chromium speciation; total sulfur, acid based accounting (ABAs), synthetic precipitation leaching procedure (SPLP), and pH.
- Plant Tissue - Total metals for the 23 TAL.

3.3.3.1 Background Soil, Site Soil, and Waste Source Analytical Results

Background soil samples were collected from three locations upgradient of the Site to provide representative chemistry of undisturbed areas around the Site (Figure 3). BGS-1 was collected below FR 4631 and generally above the Nisbet Mine; BGS-2 was collected above FR 4631 and approximately mid-way between the mines; and BGS-3 was collected below FR 4631 and west of Sam Creek, generally above the Kiggins Mine. Laboratory results are summarized in Table 4, with the mean concentrations for selected metals listed in the following table:

Mean Concentrations of Selected Metals in Background Soils (Results in mg/kg)

As	Cd	Cr	Cu	Hg	Ni	Sb	Se	Th	V	Zn
91.0	0.2	60.0	48.3	8.23	55.7	0.37	0.2	0.73	119.7	75.3

Note: As = arsenic; Cd = cadmium; Cr = chromium; Cu = copper; Fe = iron Hg = mercury; Ni = nickel; Sb = antimony; Se = selenium; Th = thallium; V = vanadium; and Zn = zinc

A total of 16 waste rock, waste material, burnt ore/tailings, and soil samples were collected and submitted for laboratory analysis during the SI field activities, 7 from the Kiggins Mine, 7 from the Nisbet Mine, and 1 from the "powderhouse" at Kiggins Mine (KM-PH-1). In addition, one waste material sample was collected from a small open drum at the Kiggins Mine (KM-B1) and submitted for analyses. As outlined in the SOW, the USFS requested that samples be collected at various depths at each sampling location, including from native soil beneath the piles. However, because the Site is located on the south side of the OGF, heavy equipment (i.e., drill rig or backhoe) could not be used. Therefore, CES attempted to penetrate the piles using a stainless steel hand auger and/or shovel, but due to the density and size of the waste rock, CES was only able to penetrate the waste rock piles at depths of 2 feet BGS or less.

The following table presents the mean concentrations of selected metals in waste source samples and the enrichment value relative to mean concentrations in background soils. As the table shows, antimony, arsenic, cadmium, mercury, and thallium are the metals that are most enriched when compared to background soils, this is also consistent with the information presented above.

Mean Concentrations of Selected Metals in Waste Rock / Waste Materal Samples as Compared to Background Soil Concentrations (Results in mg/kg)

	As	Cd	Cr	Cu	Hg	Ni	Sb	Se	Th	V	Zn
Mean Background	91.0	0.2	60.0	48.3	8.23	55.7	0.37	0.2	0.73	119.7	75.3
Mean Waste Source	1,402	0.74	19.0	24.7	3,039	14.0	7.6	0.33	6.8	137.1	97.0
Enrichment Value	***15x***	***3.7x***	*0.3x*	*0.5x*	***370x***	*0.3x*	***21x***	***1.7x***	***9.3x***	***1.2x***	***1.3x***

Note: The enrichment value is equal to the number of times ("x") the site soils are greater or less than the background soils (i.e. the mean concentration of antimony in waste rock is 21 times greater than background soils). Values greater than 1 times the background are bolded.

Background soil, Site soil, and waste source laboratory analytical results are summarized in the following:

- Background soil pH ranged from 5.5 to 6.0 su; Site soil and waste source pH ranged from 5.4 to 9.6 su.
- ABAs were analyzed on nine waste source samples, acid base potential (ABP) ranged from 18 to 430 t $CaCO_3$/Kt (ABP units are presented as tons of calcium carbonate needed to neutralize a kiloton of waste). ABP is the result of the acid neutralizing potential (ANP) minus the acid generating potential (AGP). A negative ABP indicates that the acid generating potential is greater than the acid neutralization potential, and thus the material has the potential to produce acid rock drainage (ARD). Based on this, the waste rock at the Site does not have the potential to produce ARD.
- Total sulfur in the nine waste source samples analyzed ranged from 0.02% to 2.4%.
- Nine of the 16 waste source samples were submitted for SPLP analyses for the eight Resource Conservation Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). There are no applicable standards for SPLP; however, the results can be compared to RCRA TCLP (toxicity characteristic leaching procedure) disposal limits. None of the samples had SPLP results in excess of the TCLP standard (Table 6) and all were several orders of magnitude below the disposal limits.

- The volume of waste source piles was estimated by measuring the base of the pile, height and slopes of sides and with the use of AutoCAD. Based on these calculations, the total volume of waste rock and material is estimated at 750 CY at the Kiggins Mine and 100 CY at the Nisbet Mine.
- Results of the metals analyses are discussed in the following table.

Summary of Background Soil, Site Soil, and Waste Source Metals Results

Sample Type	Table / Sample ID	Metals Exceeding at Least One Criteria	Metals Exceeding One Criteria and Mean Background	Trends Observed and Comments
Background Soil	**Table 4**	**Total metals (units in mg/kg)**		
Background Soil	BGS-1, BGS-2, and BGS-3	Aluminum, arsenic, barium, chromium, chromium III, cobalt, copper, iron, manganese, mercury, nickel, vanadium, and zinc.	Not Applicable (NA)	NA
Nisbet Mine	**Table 5**	**Total metals (units in mg/kg) / Criteria: Eco = Ecological, HH = Human Health**		
Tailings / Burnt Ore Pile	NM-WR1-1, NM-WR1-2, NM-WR1-3, & NM-WR1-4	Aluminum, antimony, arsenic (III and total), barium, chromium, iron, manganese, mercury (methyl and total), selenium, thallium, vanadium, and zinc.	Antimony (15), arsenic III (20.32), arsenic (1,640), manganese (1,130), methyl mercury (0.0011), mercury (690), selenium (0.56), thallium (7.2), and zinc (88).	Arsenic (III and total) and total mercury are the metals of concern when compared to the lowest comparison criteria (arsenic III = 10-Eco, total arsenic = 1.6-HH, and total mercury = 0.00051-Eco) and mean background concentrations (arsenic III = not analyzed, total arsenic = 91, and total mercury = 8). In general, all other metals were slightly above the mean background concentrations and/or the lowest comparison criteria.
Waste Rock Pile 2	NM-WR2-1	Aluminum, antimony, arsenic, barium, chromium, cobalt, iron, manganese, mercury, thallium, vanadium, and zinc.	Antimony (6), arsenic (4,900), barium (393), iron (67,500), manganese (1,600), mercury (3,300), and thallium (22).	
Waste Rock Pile 3	NM-WR3-1	Aluminum, arsenic (III and total), barium, chromium, cobalt, iron, manganese, mercury, thallium, vanadium, and zinc.	Arsenic III (24.24), arsenic (4,570), barium (513), iron (74,900), manganese (1,210), mercury (1,170), thallium (15), and zinc (88).	
Waste Rock Pile 4	NM-WR4-1	Aluminum, antimony, arsenic (III and total), barium, chromium, cobalt, iron, manganese, mercury (methyl and total), selenium, thallium, vanadium, and zinc.	Antimony (11), arsenic III (11.15), arsenic (2,020), barium (717), iron (60,900), manganese (976), methyl mercury (0.0018), mercury (780), thallium (17), vanadium (165), and zinc (97).	
Kiggins Mine	**Table 5**	**Total metals (units in mg/kg) / Criteria: Eco = Ecological, HH = Human Health**		
Waste Pile 1	KM-WR-5	Aluminum, arsenic, barium, chromium, cobalt, iron, manganese, mercury, selenium, thallium, vanadium, and zinc.	Arsenic (716), cobalt (33), iron (71,500), manganese (1,000), mercury (1,210), selenium (0.36), thallium (4.4), vanadium (189) and zinc (147).	Arsenic and mercury are the metals of concern when compared to the lowest comparison criteria (arsenic = 1.6-HH and mercury = 0.00051-Eco) and mean background concentrations (arsenic = 91 and mercury = 8). In general, all other metals were slightly above the mean background concentrations and/or the lowest comparison criteria.
Waste Pile 2	KM-WR-6	Aluminum, antimony, arsenic, barium, chromium, iron, lead, manganese, mercury, selenium, thallium, vanadium, and zinc.	Antimony (29), arsenic (1,140), lead (119), mercury (1,130), selenium (0.26), and thallium (7.9).	
Waste Pile 3	KM-WR-7	Aluminum, arsenic, chromium, cobalt, iron, lead, manganese, mercury (methyl and total), selenium, thallium, vanadium, and zinc.	Arsenic (184), cobalt (41), iron (135,000), manganese (1,400), methyl mercury (0.0014), mercury (37,100), selenium (0.9), thallium (1.3), vanadium (424), and zinc (164).	
Waste Rock Piles (Misc.)	KM-WR-1 through KM-WR-4	Aluminum, antimony, arsenic, barium, chromium, cobalt, iron, manganese, mercury, selenium, thallium, vanadium, and zinc.	Antimony (6), arsenic (1,140), barium (318), cobalt (44), iron (88,500), manganese (1,190), mercury (1,020), selenium (0.39), thallium (7.7), vanadium (236), and zinc (139).	
Powder House Soil	KM-PH-1	Aluminum, arsenic, barium, chromium, cobalt, iron, lead, manganese, mercury, thallium, vanadium, and zinc.	Arsenic (268), lead (17.7), mercury (103), thallium (2.4), vanadium (129), and zinc (179).	Arsenic and mercury are above the lowest comparison criteria and mean background concentration, but are not as elevated as the waste piles.
Drum Material	KM-B1	Aluminum, arsenic, chromium, iron, lead, manganese, mercury, thallium, vanadium, and zinc.	Lead (30.9), manganese (302), mercury (337), thallium (1.3), and zinc (146).	Content of the drum unknown, but concentrations are not as elevated as waste piles at the Site.

Notes: For multiple samples, the concentration listed is the highest detected concentration in the sample set. Concentrations listed are "total" concentrations, unless indicated (i.e. methyl mercury, arsenic III, etc.)

3.3.3.2 Plant Tissue Analytical Results

Six vegetation samples, co-located with background soil and waste rock samples, were collected around the Site. Laboratory results are presented in Table 7 and shown on Figures 1 and 2 as V-1, V-2, etc. As the waste piles are not well vegetated, a reconnaissance was first performed to determine which species of plant was abundant and widespread enough for the sampling program, and one that would likely be foraged on by ecological receptors. Based on the reconnaissance, vine maple was sampled. No stressed vegetation was observed during the SI field activities. Samples BG-V-1, BG-V-2, and BG-V-3 were collected to represent background plant tissue concentrations at the same location as background soil sample locations (BGS-1, BGS-2, and BGS-3, respectively). Samples KM-WR-V1, KM-WR5-V1, and NM-WR1-V1 were collected to represent waste rock plant tissue concentrations and were co-located with waste rock samples KM-WR-1, KM-WR-5, and NM-WR1-1, respectively.

Comparison criteria do not exist for plant tissue concentrations; however, they do exist for soil concentrations that are used to assess impacts to plant growth and the subsequent exposure to wildlife receptors that forage on plants. These criteria are included under the waste rock discussion. Results indicate that arsenic and mercury plant tissue concentrations were generally higher in vegetation growing on or near waste piles when compared to background. All other metals in plant tissue growing on waste rock were similar or lower than the plant tissue samples collected from background locations.

3.3.4 Soil Exposure Pathway Summary

Metal concentrations in background soils are elevated; 13 metals are present at concentrations exceeding one or more comparison criteria. The following metals were detected in waste source samples at concentrations exceeding both the mean background soil concentration and one or more comparison criteria: arsenic (all forms), barium, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc. Arsenic and mercury concentrations were detected significantly above several comparison criteria and were detected in both background soils and waste rock at the Site. All waste source samples collected from the Site exceeded the EPA Industrial PRG for arsenic (cancer endpoint), and 12 of the 16 samples exceed the EPA Industrial PRG for mercury. The soil exposure pathway is considered complete for both human and ecological receptors, and a release of hazardous substances has been documented in this SI. However, there are currently no residents or workers occupying the Site and the EPA Industrial PRGs are based on a daily exposure of 8 hours per day for 5 days per week. Because of this, the risk of long-term exposure to contaminants by human receptors is low.

On-site vegetation appears to be impacted by activities associated with the Site. Arsenic concentrations in plant tissue samples collected from waste piles ranged up to ten times higher than the concentrations measured in tissue samples collected from background locations. In addition, numerous federal and state rare, threatened and endangered mammals, birds, and herpetiles have potential habitat in the vicinity of the Site. A full list of the species is included in Tables 4, 5, and 6 of the Ecological Survey (Appendix D). Because of the elevated concentrations of arsenic and mercury in plant tissue, and the fact that ecological receptors may feed on vegetation at the Site, the potential exists that ecological receptors could be impacted.

3.4 Air Exposure Pathway

3.4.1 Targets

The target distance for the air pathway has been defined as 1 and 4 miles from the Site. There are no homes within one mile of the Site. The nearest year-round residences are at the Timberlake Job Corp Center, approximately 3 miles west of the Site. The annual prevailing wind direction is to the east-southeast with a north-northwest direction in the summer. Neither the annual nor the summer wind direction is toward the

nearest residences. Sensitive environments, including wetlands, which are located within 4 miles from the Site, are also outlined in Section 3.2.2.

3.4.2 Air Exposure Pathway Summary

Air samples were not collected as part of the field activities. Arsenic, mercury, and other metals were likely released to the air during processing (i.e. crushing, sorting, and roasting). However, processing is currently not occurring at the Site and has not occurred for over 40 years. The most likely air pathway is due to inhalation of particulate matter. As with soil exposure, this pathway is considered complete because arsenic and mercury impacted soil and waste material is concentrated at the surface where human and ecological receptors could be exposed to particulate matter. Because the air pathway is linked to the soil exposure pathway, addressing and/or eliminating the soil exposure pathway will address the air exposure pathway. Therefore, further assessment of the air pathway is not recommended.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Relevant conclusions and recommendations are presented below.

Groundwater Pathway

- Groundwater is used for drinking water within 4 miles of the Site from two wells located downstream of the Site. However, the nearest downgradient well is over 1 mile west of the Site and both are located north of the OGF and topographically at a higher elevation. Therefore, it is unlikely that groundwater flowing from the Site would impact either well. Based on this, the groundwater pathway appears to be incomplete and no further assessment is warranted.

Surface Water Pathway

- Metals (primarily arsenic and mercury) have been released into the OGF from the Site, and appear to have slightly impacted stream sediments, surface water, and pore-water. However, arsenic and mercury concentrations in surface water, pore water, and sediment samples collected above the Site (OGF-02) and adjacent to the Fall Vein (OGF-03) were higher than several of the applicable comparison criteria. This indicates a likely source of metals to the OGF above the Site or from the Fall Vein, and raises questions as to the actual degree of impact caused by the Site. However, elevated concentrations of arsenic and mercury in samples from Station OGF-07 indicate that the Site may have some contribution to water quality. Although the surface water pathway appears to be in part impacted by metal sources other than the Site, the surface water pathway is complete and further assessment is warranted.

- The OGF below the waterfall (located approximately 0.5 miles downstream of the Nisbet Mine) is a potential habitat for anadromous fish.

- These results suggest little or no difference in invertebrate populations between pool Stations upstream, adjacent to and downstream of the Site. The reason for the increased abundance adjacent to the Nisbet Mine is not clear, but the consistency in species diversity across all Stations does not suggest a mine-related cause. In addition, results suggest minimal or no noticeable impacts to benthic invertebrate populations inhabiting riffle habitats adjacent and downstream of the Site.

Soil Pathway

- The waste piles contain elevated concentrations of metals (arsenic and mercury), which exceeded numerous comparison criteria (both human and ecological). All waste source samples collected exceed the EPA Industrial PRG for arsenic (cancer endpoint); and mercury concentrations exceed the EPA Industrial PRG in 12 of the 16 samples. Numerous federal and state rare, threatened and endangered mammals, birds, and herpetiles have potential habitat in the vicinity of the Site. Based on this information, the soil exposure pathway is

considered complete for both human and ecological receptors, and a release of hazardous substances has been documented in this SI.

- Onsite vegetation appears to be impacted by mining activities associated with the Site. The concentrations of arsenic in plant tissue samples collected from waste piles range from two to over ten times higher than the concentrations measured in tissue samples collected from background locations. Because of this, and the fact that ecological receptors may feed on vegetation at the Site, the potential exists, albeit low, that ecological receptors could be impacted.

Air Pathway

- The most likely air pathway is due to inhalation of particulate matter. As with soil exposure, this pathway is considered complete because arsenic and mercury impacted soil and waste material is concentrated at the surface where human and ecological receptors could be exposed to particulate matter. However, addressing and/or eliminating the soil exposure pathway will likely render the air exposure pathway incomplete. Therefore, further assessment of the air pathway is not recommended.

Based on the information gathered as part of the SI and presented in this report, CES recommends performing a streamlined Engineering Evaluation / Cost Analysis (EECA) at the Kiggins and Nisbet Mine. As part of the streamlined EECA, a risk assessment should be performed to assess the human and ecological impacts, establish removal cleanup standards, and assess if a removal action are warranted.

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TABLES

Table 1. Surface Water Analytical Results
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample I.D.	Sample Date	Pool (P) or Riffle (R)	Aluminum, TR	Antimony, TR	Arsenic III, Total	Arsenic V, Total	Arsenic Inorganic, Total	Arsenic Total, Total	Barium, TR	Beryllium, TR	Cadmium, TR	Calcium, TR	Chromium III, Total	Chromium VI, Total	Chromium, TR	Cobalt, TR	Copper, TR	Iron, TR	Lead, TR	Magnesium, TR	Manganese, TR	Mercury, Total	Mercury, methyl	Nickel, TR	Potassium, TR	Selenium, TR	Silver, TR	Sodium, TR	Thallium, TR	Vanadium, TR	Zinc, TR
			Results in ug/L																												
OGF-SW-1	9/19/2003	P	40B	<0.2	0.020 B	0.105	**0.125**	**0.2B**	<3	<2	<0.1	6,400	<10	<10	<10	<10	<0.5	120	<0.1	2,400	24B	0.000402	<0.00007	<10	600B	<0.1	<0.05	3100	<0.05	<5	20B
OGF-SW-2	9/18/2003	P	<30	<0.2	0.032	**3.708**	**3.74**	**3.7**	<3	<2	<0.1	10,200	<10	<10	<10	<10	<0.5	<10	<0.1	3,100	<5	0.00242	<0.00007	<10	700B	<0.1	<0.05	3400	<0.05	<5	10B
OGF-SW-3	9/17/2003	P	60B	<0.2	0.041	2.769	**2.81**	**2.8**	<3	<2	<0.1	10,300	<10	<10	<10	<10	<0.5	100	<0.1	3,600	9B	**0.013**	<0.00007	<10	500B	<0.1	<0.05	3500	<0.05	<5	10B
OGF-SW-4	9/18/2003	P	30B	<0.2	0.057	2.633	**2.69**	**2.7**	<3	<2	<0.1	10,500	<10	<10	<10	<10	<0.5	20B	<0.1	3,500	<5	0.00414	<0.00007	<10	600B	<0.1	<0.05	3400	<0.05	<5	10B
OGF-SW-5	9/17/2003	P	30B	<0.2	0.047	1.983	**2.03**	**1.9**	<3	<2	<0.1	10,600	<10	<10	<10	<10	<0.5	10B	<0.1	3,400	<5	0.00284	<0.00007	<10	500B	<0.1	<0.05	3400	<0.05	<5	20B
OGF-SW-6	9/17/2003	P	<30	<0.2	0.051	1.889	**1.94**	**2.1**	<3	<2	<0.1	10,900	<10	<10	<10	<10	<0.5	20B	<0.1	3,400	<5	0.00439	<0.00007	<10	400B	<0.1	<0.05	3400	<0.05	<5	**50**
OGF-SW-7	9/17/2003	P	<30	<0.2	0.058	2.892	**2.95**	**2.6**	<3	<2	<0.1	11,100	<10	<10	<10	<10	<0.5	20B	<0.1	3,400	<5	0.00257	<0.00007	<10	400B	<0.1	<0.05	3400	<0.05	<5	20B
KM-SW-1	9/18/2003	P	**230**	<0.2	< 0.007	0.039	**0.039**	<0.1	<3	<2	<0.1	10,700	<10	<10	<10	<10	<0.5	330	<0.1	5,800	53	0.00822	<0.00007	<10	300B	<0.1	<0.05	4100	<0.05	<5	10B
KM-SW-2	9/18/2003	P	**420**	<0.2	0.065	0.692	**0.757**	**1.0**	4B	<2	<0.1	11,300	<10	<10	<10	<10	<0.5	340	<0.1	5,900	15B	**0.0308**	<0.00007	<10	400B	<0.1	<0.05	4100	<0.05	<5	10B
Standards, corrected for hardness where applicable (used 41 mg/L average for surface water samples)																															
Oregon - Aquatic Life [1]			87	1600	150	48	150	150	4	5.3	0.56	116,000	99.7	11	NS	23	5.5	1000	1.02	82,000	120	0.012	NS	74.2	53,000	5	0.12	680,000	40	20	49.8
Oregon - Human Health [2]			NS	5.6	NS	NS	0.0022	0.0022	1000	0.0068	10	NS	0.17	50	NS	NS	1,300	300	50	NS	50	0.144	NS	13.4	NS	10	50	NS	0.24	NS	7,400
EPA - Aquatic Life [3]			87	NS	150	150	150	150	4	0.66	0.15	NS	48.3	11	NS	23	4.54	1000	1.11	NS	120	0.77	NS	24.6	NS	5	0.36	NS	12	20	57.1
EPA - Human Health [4]			NS	5.6	NS	NS	0.018	0.018	1000	4	5	NS	NS	NS	100	NS	1,300	300	15	NS	50	50	NS	610	NS	170	NS	NS	1.7	NS	7,400
ORNL - Surface Water PRGs [5]			87	30	190	3.1	NS	NS	4	0.66	0.15	116,000	44	2	NS	23	0.23	158	0.66	82,000	120	0.23	0.0026	160	53,000	0.39	0.36	680,000	9	20	30

Sample I.D.	Sample Date	Pool (P) or Riffle (R)	Flow Rate (9/18/03) in cubic feet per second	Temperature (Field)	pH (Field)	Conductivity (Field)	Conductivity @ 25C (Lab)	Dissolved Oxygen (Field)	Oxygen Reduction Potential (Field)	Hardness as CaCO3	Residue, Filterable (TDS) @180	Residue, Non-Filterable (TSS) @105 C	Total Organic Carbon	Sulfate
			cfs	^{o}C	su	uS	uS	mg/L	mV	mg/L	mg/L	mg/L	mg/L	mg/L
OGF-SW-1P	9/19/2003	P	176	7.7	7.4	30	60	9.1	43	26	50	<5	1B	<10
OGF-SW-2P	9/18/2003	P	5.9	10.0	7.97	47	86	8.8	90.2	38	50	<5	<1	<10
OGF-SW-3P	9/17/2003	P	22.9	12.3	7.24	74	87	8.9	37.8	41	60	<5	2B	<10
OGF-SW-4P	9/18/2003	P	23.0	9.8	7.45	48	85	9.1	32	41	50	<5	2B	<10
OGF-SW-5P	9/17/2003	P	16.0	11.0	7.92	46	84	9.1	55.2	41	60	<5	2B	<10
OGF-SW-6P	9/17/2003	P	23.5	10.8	7.77	45	84	8.6	96.0	41	60	<5	2B	<10
OGF-SW-7P	9/17/2003	P	36.3	11.0	8.38	45	88	9.1	35.5	42	70	<5	1B	<10
KM-SW-1	9/18/2003	R	0.02	10.8	6.69	61	101	8.5	33.3	51	80	<5	NM	<10
KM-SW-2	9/18/2003	P	0.01	10.8	7.76	61	104	8.6	59.3	52	70	6B	NM	<10

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, and Brooks Rand in Portland, OR.
TR = Total Recoverable Metals, Chromium III was calculated by subtracting Chromium VI from Total Chromium
mg/L = milligrams per liter
ug/L = micrograms per liter
su = standard units
uS = micro siemans
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard
Bolded values indicate that the value exceeds one or more standard
Italic values indicate that the MDL exceeds the lowest standard
NM - Not Measured
NC - Not Collected

STANDARD NOTES:
1 - State of Oregon Ambient Water Quality Criteria for Protection of Aquatic Life, lowest of the following:
1a. Current ODEQ Fresh Water Quality Criteria, Protection of Aquatic Life
1b. Level II Ecological Screening Level Values
2 - State of Oregon Water Quality Criteria for Protection of Human Health, Water and Fish Ingestion, lowest of the following:
3 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002), corrected to total recoverable metals (where applicable)
If none existed, used Tier II secondary chronic values (ORNL, 1996)
4 - EPA recommended ambient water quality criteria for protection of human consumption of water and fish (EPA, 2002)
5 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996).

Table 2. Pore Water Analytical Results
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample I.D.	Sample Date	Pool (P) or Riffle (R)	Aluminum, Diss.	Antimony, Diss.	Arsenic III, Diss.	Arsenic V, Diss.	Arsenic Inorganic, Diss.	Arsenic Total, Diss.	Barium, Diss.	Beryllium, Diss.	Cadmium, Diss.	Calcium, Diss.	Chromium III, Diss.	Chromium VI, Diss.	Chromium, Diss.	Cobalt, Diss.	Copper, Diss.	Iron, Diss.	Lead, Diss.	Magnesium, Diss.	Manganese, Diss.	Mercury, Diss.	Mercury, methyl	Nickel, Diss.	Potassium, Diss.	Selenium, Diss.	Silver, Diss.	Sodium, Diss.	Thallium, Diss.	Vanadium, Diss.	Zinc, Diss.
			Results in ug/L																												
OGF-PW-1	9/19/2003	P	<30	<0.2	0.041	0.232	0.273	0.5B	<3	<2	<0.1	7,700	<10	<10	<10	<10	<0.5	**1,970**	<0.1	3200	**385**	0.00103	0.00018B	<10	900B	<0.1	<0.05	3300	<0.05	<5	20B
OGF-PW-2	9/18/2003	P	50B	<0.2	0.027	**3.543**	3.57	3.5	<3	<2	<0.1	11,000	<10	<10	<10	<10	<0.5	70	0.3B	3300	9B	0.00634	<0.00007	<10	700B	<0.1	<0.05	3900	<0.05	<5	**40B**
OGF-PW-3	9/17/2003	P	50B	<0.2	0.064	2.606	2.67	3.1	<3	<2	<0.1	11,100	<10	<10	<10	<10	<0.5	50B	<0.1	3400	7B	0.00464	0.000177B	<10	600B	<0.1	<0.05	3800	<0.05	<5	**40B**
OGF-PW-4	9/18/2003	P	40B	<0.2	0.098	1.682	1.78	1.4	<3	<2	<0.1	11,000	<10	<10	<10	<10	<0.5	50B	0.4B	3900	10B	**0.0473**	0.000144	<10	800B	<0.1	<0.05	3800	<0.05	<5	**40B**
OGF-PW-5	9/17/2003	P	60B	<0.2	5.680	**3.55**	9.23	11.1	3B	<2	<0.1	13,100	<10	<10	<10	<10	<0.5	200	<0.1	4400	**164**	0.0054	0.000130B	<10	800B	<0.1	<0.05	3700	<0.05	<5	**40B**
OGF-PW-6	9/17/2003	P	<30	<0.7B	0.555	**20.445**	21.0	24.1	3B	<2	<0.1	45,800	<10	<10	<10	<10	<0.5	20B	<0.1	4000	<5	**0.222**	0.000201B	<10	800B	<0.1	<0.05	4700	<0.05	<5	20B
OGF-PW-7	9/17/2003	P	<30	<0.2	0.033	2.607	2.64	2.8	3B	<2	<0.1	11,300	<10	<10	<10	<10	**4**	<10	0.1B	3600	<5	0.00625	<0.00007	<10	600B	<0.1	<0.05	3900	<0.05	<5	**50B**
Standards, corrected for hardness where applicable (used 55 mg/L as average in pore water samples)																															
Oregon - Aquatic Life [1]			87	1600	150	48	150	150	4	5.3	0.71	116,000	126.9	11	NS	23	7.1	1000	1.48	82,000	120	0.012	NS	95.1	53,000	5	0.12	680,000	40	20	63.9
EPA - Aquatic Life [2]			87	NS	150	150.0	150	150	4	0.66	0.17	NS	52.8	11	NS	23	5.6	1000	1.50	NS	120	0.77	NS	31.5	NS	5	0.36	NS	12	20	72.2
ORNL - Surface Water PRGs [3]			87	30	190	3.1	NS	NS	4	0.66	0.15	116,000	44	2	NS	23	0.23	158	0.66	82,000	120	0.23	0.0026	160	53,000	0.39	0.36	680,000	9	20	30

Sample I.D.	Sample Date	Pool (P) or Riffle (R)	Temperature (Field)	pH (Field)	Conductivity (Field)	Conductivity @ 25C (Lab)	Dissolved Oxygen (Field)	Oxygen Reduction Potential (Field)	Hardness as CaCO3	Residue, Filterable (TDS) @180	Residue, Non- Filterable @105 C	Sulfate
			°C	su	uS	uS	mg/L	mV	mg/L	mg/L	mg/L	mg/L
OGF-PW-1	9/19/03	P	8.4	8.5	40	68	0	-90.3	32	60	<5	<10
OGF-PW-2	9/18/03	P	10.0	7.3	46	85	6.8	6.7	41	60	38	<10
OGF-PW-3	9/17/03	P	10.7	6.8	46	89	5.6	64.2	42	70	12	<10
OGF-PW-4	9/18/03	P	10.0	9.03	72	86	3.2	47	44	60	8	<10
OGF-PW-5	9/17/03	P	11.6	8.45	52	99	2.6	-123	51	100	8	<10
OGF-PW-6	9/17/03	P	11.3	8.04	156	244	0	-65	131	160	8	30
OGF-PW-7	9/17/03	P	11.0	7.3	57	86	5.0	53.3	43	70	104	<10

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, and Brooks Rand in Portland, OR.
Diss. = Dissolved Metals, Chromium III was calculated by subtracting Chromium VI from Total Chromium
mg/L = milligrams per liter
ug/L = micrograms per liter
su = standard units
uS = micro siemans
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NS = No Standard
NA = Not Analyzed
NC = Not Collected
Bolded values indicate that the value exceeds one or more standard
Italic values indicate that the MDL exceeds the lowest standard

STANDARD NOTES:
1 - State of Oregon Ambient Water Quality Criteria for Protection of Aquatic Life, lowest of the following:
1a. Current ODEQ Fresh Water Quality Criteria, Protection of Aquatic Life
1b. Level II Ecological Screening Level Values
2 - EPA recommended chronic ambient water quality criteria for freshwater aquatic life used (EPA, 2002), expressed as dissolved metals
If none existed, used Tier II secondary chronic values (ORNL, 1996)
3 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996).

Table 3. Sediment Analytical Results
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample ID	Sample Date	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Total Inorganic	Arsenic - Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Chromium, III Total	Chromium, VI Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Mercury, methyl	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
		mg/kg																												
OGF-SS-1	9/19/2003	37,100	<0.1	0.009B	1.472	1.472	2.95	91.2	<0.2	0.17 B	8,120	**46**	<42	<4	27	28	42,100	2.91	16400	501	**1.56**	0.0004	**87**	420	0.10 B	0.82	1,280	<0.03	104	63
OGF-SS-2	9/18/2003	72,000	<0.1	0.067	14.158	**14.225**	**16.4**	202	<0.2	**0.88**	8,050	**83**	<79	<4	40	**63**	68,000	4.74	14,600	**1,120**	**14.7**	0.0009	**88**	550	0.19B	1.74	770	0.16	140	83
OGF-SS-3	9/17/2003	68,700	0.1B	0.19	18.971	**19.161**	**32**	211	<0.2	**0.98**	8,460	**68**	<62	<6	34	**57**	60,100	7.03	9,780	889	**10.9**	0.001	**66**	660	0.24 B	1.32	510	0.2	129	92
OGF-SS-4	9/18/2003	56,600	<0.1	0.087	9.682	**9.769**	**10.9**	180	<0.2	**0.87**	7,990	**74**	<70	<4	39	**56**	67,100	4.81	16,600	1,010	**2.1**	0.0021	**85**	480	0.14 B	1.49	660	0.11	138	85
OGF-SS-5	9/17/2003	58,400	<0.1	0.049	13.785	**13.834**	**11.5**	182	<0.2	**0.83**	8,170	**76**	<72	<4	40	**60**	69,000	4.42	16,700	**1,160**	**4.71**	0.0006	**87**	540	0.11B	1.36	660	0.11	137	83
OGF-SS-6	9/17/2003	59,100	<0.1	0.062	9.635	**9.697**	**11.3**	180	<0.2	**0.87**	8,070	**73**	<69	<4	36	**57**	63,000	4.65	14,100	987	**4.5**	0.0016	**79**	530	0.14 B	1.39	780	0.11	127	79
OGF-SS-7	9/17/2003	51100	0.4B	**11.893**	49.285	**61.178**	**43.6**	183	<0.2	**0.85**	13,200	**57**	<47	<10	31	**53**	51,200	4.81	11,800	788	**21.8**	0.06	**62**	520	0.46	1.28	540	0.17 B	134	73
KM-SS-2	9/18/2003	67900	0.3B	0.352	5.666	**6.018**	**24.7**	223	0.2B	**1.01**	8,610	**110**	<100	10B	35	**51**	51,700	6.71	5,860	1,090	**13**	0.0045	**75**	500	0.4	1.54	440	0.36	122	82
Standards																														
OR - Freshwater [1]		NS	3	6	NS	NS	NS	NS	NS	0.6	NS	37	NS	NS	NS	36	NS	35	NS	1,100	0.2	NS	18	NS	NS	4.5	NS	NS	NS	123
EPA - Freshwater TEL [2]		NS	NS	NS	NS	5.9	5.9	NS	NS	0.596	NS	37.3	NS	NS	NS	35.7	NS	35	NS	NS	0.174	NS	18	NS	NS	NS	NS	NS	NS	123
EPA - Freshwater PEL [3]		NS	NS	NS	NS	17	17	NS	NS	3.53	NS	90	NS	NS	NS	197	NS	91.3	NS	NS	0.486	NS	35.9	NS	NS	NS	NS	NS	NS	315
ORNL - Freshwater [4]		NS	NS	NS	NS	42	42	NS	NS	4.2	NS	159	NS	NS	NS	77.7	NS	110	NS	NS	0.7	NS	38.5	NS	NS	1.8	NS	NS	NS	270

Sample ID	Sample Date	Texture by Hydrometer			Solids
		Clay	Sand	silt	
		%			
OGF-SS-1	9/19/2003	<0.1	90	10	60.0
OGF-SS-2	9/18/2003	5	62.5	32.5	55.9
OGF-SS-3	9/17/2003	13.3	33.3	53.3	39.6
OGF-SS-4	9/18/2003	2.5	65	32.5	58.6
OGF-SS-5	9/17/2003	2.5	67.5	30	61.5
OGF-SS-6	9/17/2003	5	60	35	56.4
OGF-SS-7	9/17/2003	I	I	I	20.6
KM-SS-2	9/18/2003	10	35	55	31.7

NOTES:
Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO and Brooks Rand in Portland, OR
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
umol/g = micromole per gram
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
Chromium III was calculated by subtracting Chromium VI from Total Chromium
NS = No Standard
I = Insufficient sample volume to obtain valid particle size/texture data

STANDARD NOTES:
1 - State of Oregon, Level II Screening Level Values for Freshwater Sediment (ODEQ, 1998)
2 - EPA Threshold Effects Level (NOAA, 1999)
3 - EPA Probable Effects Level (NOAA, 1999)
4 - ORNL ecological screening level values for freshwater, lowest chronic value used (ORNL, 1996)

Table 4. Background Soil Analytical Results
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample ID	Sample Date	Sample Depth (feet)	pH	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Chromium III, Total	Chromium VI, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total
			su	mg/kg																											
BGS-1	9/16/2003	0.5	5.6	**70,200**	0.3B	R	NC	0.0027	**3.4**	**237**	0.4 B	0.2 B	1,700	**77**	**77**	0.0016 B	**31**	45	**58,100**	9.5	2,590	**920**	**2.2**	**70**	480	0.2 B	0.37	100	0.28 B	**111**	**92**
BGS-2	9/19/2003	0.5	5.5	**74,500**	<0.2	R	NC	0.0009	**3.5**	**327**	0.3 B	0.2 B	3,890	**59**	59	0.0022 B	**31**	**62**	**59,500**	7	6,630	**741**	**0.56**	**54**	710	0.2 B	0.51	300	0.12 B	**126**	**70**
BGS-3	9/19/2003	0.5	6.0	**45,400**	0.6 B	3.2 E-5J	0.149	0.1490	**266**	**182**	<0.2	0.2 B	8,410	**44**	44	<0.0006	**30**	38	**48,500**	6	7,070	**851**	**21.9**	**43**	1,070	0.2 B	0.28 B	230	0.73	**122**	**64**
Mean			5.7	63,367	0.37	NC	NC	0.0509	91.0	249	NC	0.2	4,667	60.0	60	0.0014	31	48.3	55,367	7.5	5,430	837	8.23	55.7	753	0.20	0.44	210	0.73	119.7	75.3
Standards																															
OR - Ecological Receptors (p=plant, i=invertebrate, b =birds, m = mammals)[1]				50p	5p	10p	NS	NS	NS	85b	10p	4p	NS	0.4i	NS	NS	20p	50i	10p	16b	NS	100i	0.1i	30p	NS	1p	2p	NS	1p,m	2p	50p
EPA Indust. PRGs - Human Receptors[2]				100,000	410	NS	NS	NS	260 / 1.6	67,000	1,900	7.4	NS	450	64	64	1,900	41,000	100,000	750	NS	19,000	310	20,000	NS	5,100	5,100	NS	67	7,200	100,000
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant)[3]				NS	21m	NS	NS	NS	37p	NS	NS	29p	NS	5p	NS	NS	32b	61i	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	120i
ORNL - Ecological Receptors[4]				NS	5	NS	NS	9.9	9.9	283	10	4	NS	159	NS	NS	20	60	NS	40.5	NS	NS	0.00051	30	NS	0.21	2	NS	1	2	8.5

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO and Brooks Rand in Portland, OR
mg/kg = milligrams per kilogram
su = standard units
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
J = Estimated Value
NC = Not Calculated
R = Rejected, unusable value
Chromium III was calculated by subtracting Chromium VI from Total Chromium

STANDARD NOTES:
1 - State of Oregon, Level II Ecological Screening Level Values for Soil (ODEQ, 1998)
2 - EPA Region 9 Industrial Preliminary Remediation Goals - (EPA, 2002).
3 - EPA Ecological Soil Screening Levels - Lowest Criteria Listed (EPA, 2000)
4 - ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints August 1997

Table 5. Waste Rock and Waste Material Analytical Results
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample ID	Sample Date	Sample Depth (feet)	pH	Aluminum, Total	Antimony, Total	Arsenic III, Inorganic	Arsenic V, Inorganic	Arsenic, Inorganic	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Calcium, Total	Chromium, Total	Chromium III, Total	Chromium VI, Total	Cobalt, Total	Copper, Total	Iron, Total	Lead, Total	Magnesium, Total	Manganese, Total	Mercury, Total	Mercury, methyl	Nickel, Total	Potassium, Total	Selenium, Total	Silver, Total	Sodium, Total	Thallium, Total	Vanadium, Total	Zinc, Total	Total Sulfur	Total Kjeldahl Nitrogen	ABAs		
																																		Acid Generation Potential	Acid Neutralization Potential	Acid-Base Potential
			su																													%	%	t CaCO3/Kt		
KM-WR-1	9/18/2003	1.0	7.4	**34,500**	1.0B	NA	NA	NA	**418**	**173**	<0.4	0.72	22,200	**34**	<32	<2	**44**	42	**79,100**	7.7	12,300	**751**	**418**	NA	16	1,300	0.18B	0.8	250	**1.72**	**236**	**139**	NA	NA	NA	NA	NA
KM-WR-2	9/18/2003	1.0	6.7	**30,700**	0.7B	NA	NA	NA	**524**	**223**	<0.2	0.92	16,600	**19**	<16	3B	**41**	36	**88,500**	10	11,200	**1,190**	**20.2**	NA	15	1,160	**0.23B**	1.1	810	**1.65**	**191**	**88**	NA	NA	NA	NA	NA
KM-WR-3	9/18/2003	1.0	7.2	**30,300**	**5**	1.142N J	687	**688**	**881**	**217**	<0.2	0.62	77,500	**18**	<18	<0.602	**29**	31	**50,000**	9.1	6,720	**752**	**1,020**	0.0009	17	780	**0.39**	0.7B	590	**7.69**	**131**	**87**	0.14	NA	4B	184	180
KM-WR-4	9/18/2003	1.0	7.4	**24,400**	**6**	NA	NA	NA	**1,140**	**318**	<0.2	0.57	112,000	**14**	<11	<3	**21**	25	**44,600**	5.4	5,460	**646**	**919**	NA	11	670	**0.22B**	0.4B	440	**4.19**	**113**	**74**	NA	NA	NA	NA	NA
KM-WR-5	9/18/2003	1.0	7.1	**32,100**	4B	0.511 J	494	**494**	**716**	**236**	<0.4	2.14	67,300	**30**	<30	<0.542	**33**	30	**71,500**	15.6	8,030	**1,000**	**1210**	0.0003	14	820	**0.36**	1.6	470	**4.35**	**189**	**147**	0.51	NA	16	261	245
KM-WR-6	9/18/2003	1.0	7.3	**15,800**	**29**	1.85J	469	**471**	**1,140**	**226**	<0.2	1.49	188,000	**8**	<8	<0.544	18	26	**37,000**	**119**	2,790	**715**	**1130**	0.0001	7	580	**0.26B**	0.6B	310	**7.91**	**80**	**64**	0.61	NA	19	449	430
KM-WR-7	9/18/2003	1.0	7.3	**39,700**	2	0.316 N,J	191	**191**	**184**	63.6	<1.0	0.83	22,600	**50**	<50	<0.583	**41**	41	**135,000**	**26.9**	10,700	**1,400**	**37,100**	**0.0014**	19	280	**0.9**	0.8	130	**1.32**	**424**	**164**	0.51	NA	16	46	30
NM-WR1-1	9/16/2003	1.0	8.0	**10,900**	**13**	NA	NA	NA	**1,640**	78	<1.0	0.14B	266,000	**7B**	<7	<0.3	10B	11B	**18,100**	2.2B	2,100	**690**	**8**	NA	<6	500B	**0.29B**	<0.3	<200	**4.66**	**60**	**39**	NA	NA	NA	NA	NA
NM-WR1-2	9/16/2003	1.0	9.6	**13,900**	**10**	**14.056 J**	1,283	**1,297**	**1,470**	31	<1.0	0.28B	293,000	**<6**	<5	0.911B	<6	23B	**9,950**	3.4	1,900	**1,310**	**12.9**	**0.0011**	<6	<200	**0.56**	<0.3	<200	**5.57**	**71**	**27**	2.4	NA	75	466	391
NM-WR1-3	9/16/2003	1.0	8.1	**15,700**	**9**	**20.319 J**	905	**925**	**826**	**120**	<0.2	0.56	234,000	**5**	<4	<0.731	12	7	**24,800**	4.5	3,680	**756**	**690**	**0.0011**	4B	660	**0.43**	0.4B	240	**4.86**	**92.2**	**88**	0.08B	NA	3B	356	354
NM-WR1-4	9/16/2003	1.0	9.6	**16,100**	**15**	NA	NA	NA	**1,650**	**180**	<0.4	0.9B	87,000	**12**	<12	<0.3	16	14	**40,100**	4	2,840	**520**	**400**	NA	6	670	<0.5	<0.3	280	**7.24**	**102**	**48**	NA	NA	NA	NA	NA
NM-WR2-1	9/16/2003	1.0	6.6	**35,300**	**6B**	NA	NA	NA	**4,900**	**393**	0.6B	1B	24,100	**10**	<10	<0.3	**31**	21	**67,500**	6	2,500	**1,600**	**3,300**	NA	17	1,490	<1	<0.5	260	**22.3**	**71.8**	**72**	0.07B	NA	2B	38	36
NM-WR3-1	9/16/2003	1.0	6.1	**37,400**	<6	**24.244 J**	5,205	**5,229**	**4,570**	**513**	0.7B	0.33	21,000	**12**	<12	<0.638	**35**	26	**74,900**	5B	3,790	**1,210**	**1,170**	0.00004B	17	2,040	0.20B	<1	340	**14.8**	**92.8**	**88**	0.02B	NA	1B	19	18
NM-WR4-1	9/16/2003	1.0	6.3	**44,100**	**11**	**11.151 J**	2,112	**2,123**	**2,020**	**717**	0.7B	0.51	19,900	**22**	<22	<0.578	**32**	30	**60,900**	5	6,040	**976**	**780**	**0.00183**	16	1,250	**0.31**	0.5B	330	**17.1**	**165**	**97**	0.03B	NA	1B	20	19
KM-PH-1	9/18/2003	0.5	5.4	**23,100**	1.5	NA	NA	NA	**268**	**151**	<0.4	0.5 B	9,820	**26**	<23	<3	**26**	31	**45,800**	**17.7**	7,310	**813**	**103**	NA	23	670	0.2 B	0.22 B	480	**2.42**	**129**	**179**	NA	0.16	NA	NA	NA
KM-B1	9/18/2003	0.5	7.5	**11,400**	0.9	NA	NA	NA	**78.7**	69.8	<0.2	0.3 B	42,000	**12**	<9	<3	11	12	**21,700**	**30.9**	3,690	**302**	**337**	NA	13	880	0.1 B	0.12 B	530	**1.27**	**50.2**	**146**	NA	NA	NA	NA	NA
MEAN				25,963	7.6	9.20	1,418	1,427	1,402	232	0.67	0.74	93939	19	NC	NC	27	25	54341	17.03	5,691	914	3,039	0.00085	14	917	0.33	0.66	390	6.80	137	97	0.49	NC	NC	NC	NC
Standards																																					
OR - Ecological Receptors (p=plant, i=invertebrate, b =birds, m = mammals) [1]				50p	5p	10p	NS	NS	NS	85b	10p	4p	NS	0.4i	NS	NS	20p	50i	10p	16b	NS	100i	0.1i	0.0002p	30p	NS	1p	2p	NS	1p,m	2p	50p	NS	NS	NS	NS	NS
EPA Indust. PRGs - Human Receptors [2]				100,000	410	NS	NS	NS	260 / 1.6	67,000	1,900	7.4	NS	450	64	64	1,900	41,000	100,000	750	NS	19,000	310	NS	20,000	NS	5,100	5,100	NS	67	7,200	100,000	NS	NS	NS	NS	NS
EPA - Ecological Receptors (m=mammal, b=bird, i = invertebrate, p=plant) [3]				NS	21m	NS	NS	NS	37p	NS	NS	29p	NS	5p	NS	NS	32b	61i	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	120i	NS	NS	NS	NS	NS
ORNL - Ecological Receptors [4]				NS	5	NS	NS	9.9	9.9	283	10	4	NS	159	NS	NS	20	60	NS	40.5	NS	NS	0.00051	NS	30	NS	0.21	2	NS	1	2	8.5	NS	NS	NS	NS	NS

NOTES:
Analysis was conductedBy ACZ Laboratories, Inc. in Steamboat Springs, CO.
mg/kg = milligrams per kilogram
t CaCO3/Kt = tons of calcium carbonate needed to neutralize 1000 tons of waste/soil. Negative number indicates lack of $CaCO_3$ positive value indicates excess (no need).
su = standard units
< value = analyte not detected above MDL
B = analyte detectedBetween method detection limit (MDL) and practical quantification limit (PQL)
J = Estimated value
N = Spike recovery not within acceptance criteria
NA = not analyzed
Chromium III was calculated by subtracting Chromium VI from Total Chromium

STANDARD NOTES:
1 - State of Oregon, Level II Ecological Screening Level Values for Soil (ODEQ, 1998)
2 - EPA Region 9 Industrial Preliminary Remediation Goals - (EPA, 2002).
3 - EPA Ecological Soil Screening Levels - Lowest Criteria Listed (EPA, 2000)
4 - ORNL = Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Endpoints August 1997

Table 6. Synthetic Precipitation Leaching Procedure Results for Waste Rock Samples
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample ID	Sample Date	Sample Depth (feet)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
			mg/L							
KM-WR-3	9/18/2003	1.0	<0.04	<0.003	<0.005	<0.01	<0.04	0.0003B	<0.04	<0.005
KM-WR-5	9/18/2003	1.0	<0.04	0.004B	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
KM-WR-6	9/18/2003	1.0	<0.04	<0.003	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
KM-WR-7	9/18/2003	1.0	<0.04	<0.003	<0.005	<0.01	<0.04	0.0047	<0.04	<0.005
NM-WR1-2	9/16/2003	1.0	0.07 B	<0.003	<0.005	<0.01	<0.04	<0.0002	<0.04	<0.005
NM-WR1-3	9/16/2003	1.0	0.55	<0.003	<0.005	<0.01	<0.04	0.0041	<0.04	0.005 B
NM-WR2-1	9/16/2003	1.0	0.23	<0.003	<0.005	<0.01	<0.04	0.0006 B	<0.04	<0.005
NM-WR3-1	9/16/2003	1.0	0.07 B	<0.003	<0.005	<0.01	<0.04	0.0013	<0.04	<0.005
NM-WR4-1	9/16/2003	1.0	0.07 B	0.004 B	<0.005	<0.01	<0.04	0.0021	<0.04	<0.005
Applicable Standards										
RCRA TCLP Disposal Limits			5	100	1	5	5	0.2	1	5

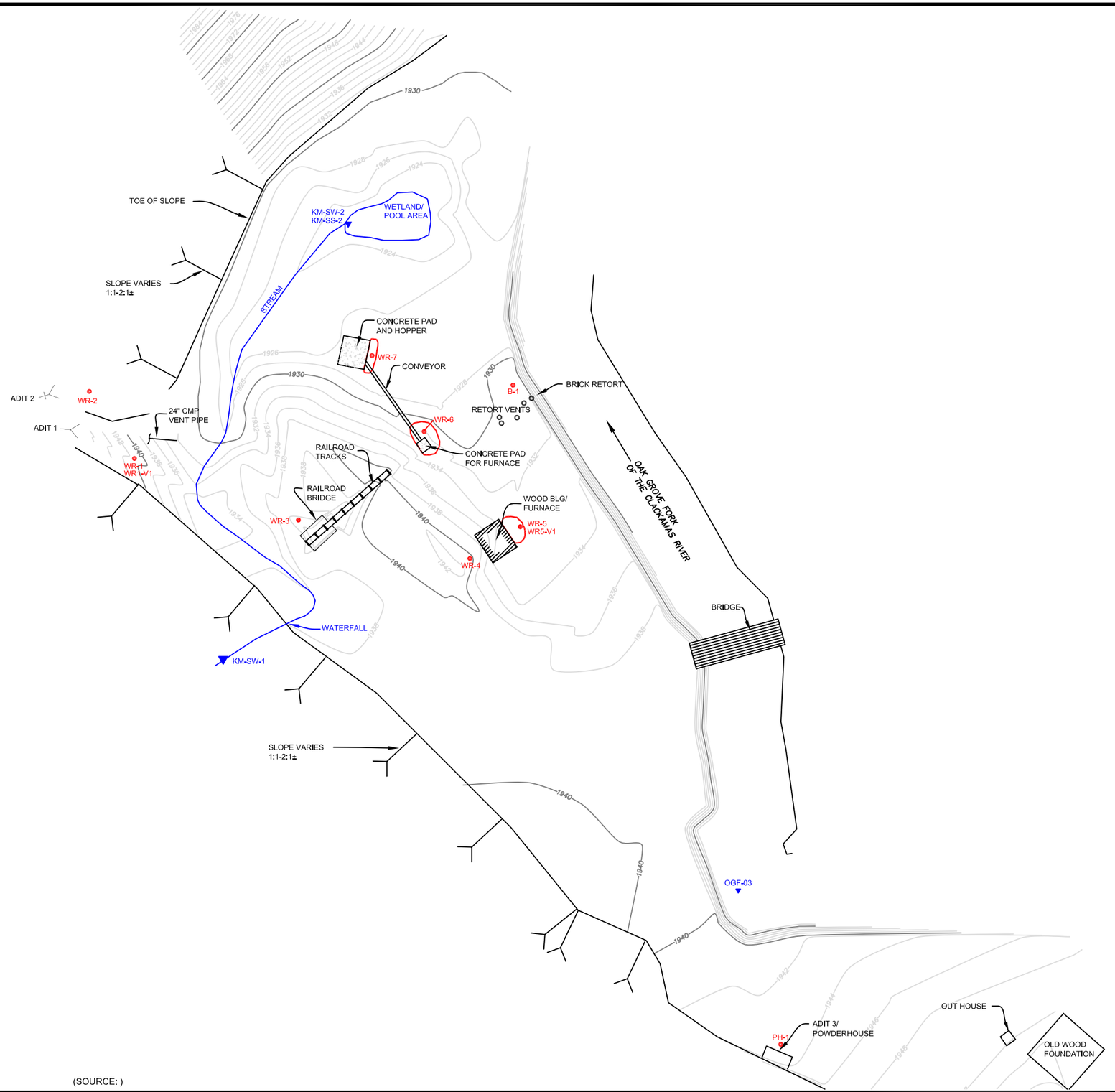
Notes: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO.
mg/L = milligrams per liter
< value = analyte not detected above method detection limit (MDL)
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)

Table 7. Vegetation Analytical Results
Kiggins and Nisbet Mine Site Inspection, Mt. Hood National Forest, Clackamas County, Oregon

Sample ID	Sample Date	Onsite or Background	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Vanadium	Zinc
			mg/kg																						
KM-WR1-V1	09/18/03	On	79	0.2 B	1.03	5.5	<0.2	0.05 B	37,100	<1	<1	3 B	155	0.69	4,170	199	0.6	<1	9,530	0.07 B	<0.5	<30	0.07 B	<0.5	20
KM-WR5-V1	09/18/03	On	62	0.2 B	10.2	2.8	<0.2	0.17 B	18,200	<1	<1	6	189	3.03	3,660	25.0	0.11 B	<1	10,200	<0.05	<0.5	<30	0.06 B	<0.5	259
NM-WR1-V1	09/16/03	On	87	0.2 B	3.28	2.5	<0.2	0.09 B	24,100	<1	<1	4 B	201	0.9	2,700	149	0.2 B	<1	11,100	<0.05	<0.5	<30	0.06 B	<0.5	30
BGV-1	09/19/03	BG	53	0.1 B	0.27 B	54.6	<0.2	0.24 B	21,400	<1	<1	3 B	78	0.52	6,210	522	<0.09	<1	8,380	<0.05	<0.5	<30	<0.03	<0.5	25
BGV-2	09/19/03	BG	55	0.1 B	0.21 B	17.9	<0.2	0.06 B	11,900	<1	<1	5	84	1.07	4,700	308	<0.1	<1	11,000	<0.05	<0.5	<30	<0.03	<0.5	22
BGV-3	09/19/03	BG	143	0.1 B	0.93	13.4	<0.2	0.09 B	15,700	<1	<1	7	250	0.9	4,400	652	<0.09	1B	13,400	<0.05	<0.5	<30	0.04B	<0.5	29

NOTES: Analysis was conducted by ACZ Laboratories, Inc. in Steamboat Springs, CO, per EPA Method 6010/7000 series.
mg/kg = milligrams per kilogram
< value = analyte not detected above MDL
B = analyte detected between method detection limit (MDL) and practical quantification limit (PQL)
NA = not analyzed

FIGURES



EXPLANATION

- OGF-03 - Surface Water Station
- PH-1 - Soil Sample Location
- WR1 - Waste Rock Sample Location
- V-3 - Vegetation Sample Location
- Water Line of Oak Grove Fork (09-17-03)
- 1930 - Major Contour (10 ft. interval)
- Minor Contour (2 ft. interval)
- Waste Pile (WP)
- Adit 1 - Open Adit
- Adit 2 - Collapsed Adit

0 40 FEET
SCALE

(SOURCE:)

Figure 1. Site Layout and Sampling Locations
Kiggins Mine

PROJECT NUMBER: 2323022	KIGGINS - NISBET MINE SITE INSPECTION
DATE: 01/025/04	
DWG BY: DGW / DWG NO: 2323022F1.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company

EXPLANATION

OGF-06 - Surface Water Station

WR1 - Waste Rock Sample Location

V-1 - Vegetation Sample Location

- Water Line of Oak Grove Fork (09-17-03)

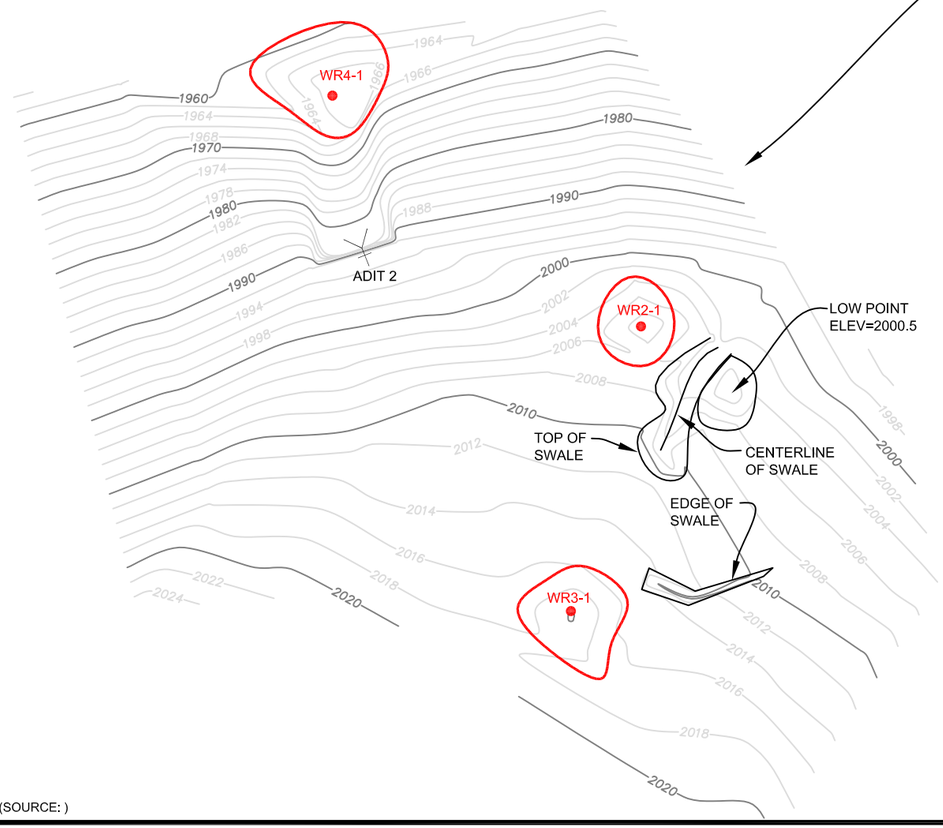
1930 - Major Contour (10 ft. interval)

- Minor Contour (2 ft. interval)

- Waste Pile

Adit 1 - Open Adit

Adit 2 - Collapsed Adit



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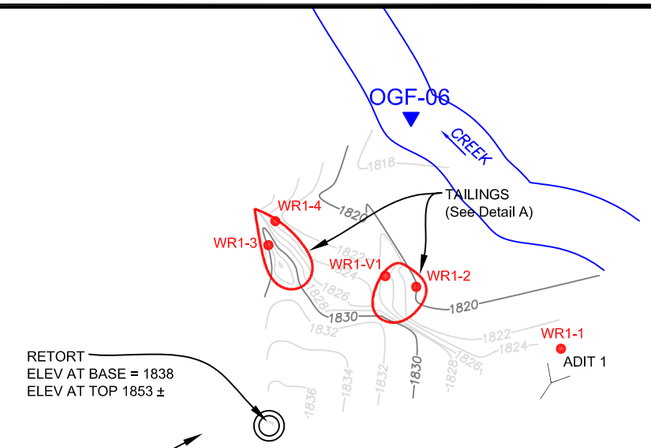


TAILINGS PILE DETAIL
NTS

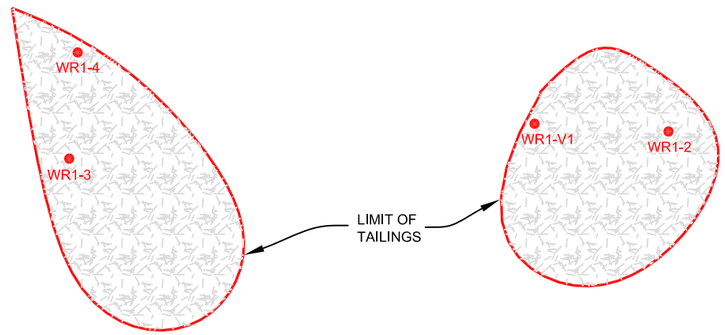
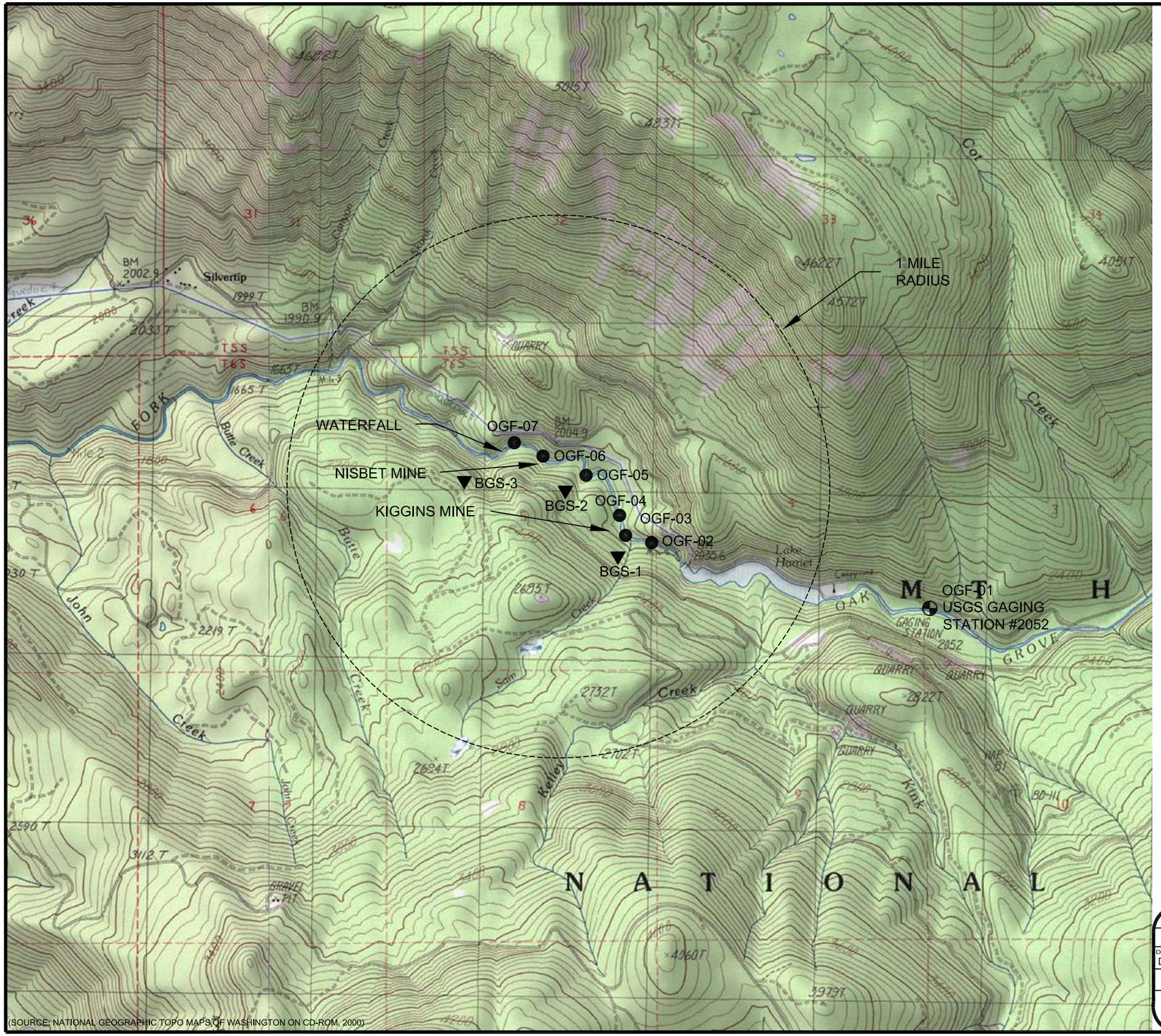


Figure 2. Site Layout and Sampling Locations
Nisbet Mine

0 30 FEET
SCALE

PROJECT NUMBER: 2323022	KIGGINS - NISBET MINE SITE INSPECTION
DATE: 01/025/04	
DWG BY: DGW / DWG NO: 2323022F1.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES A Valmont Industries Company



(SOURCE: NATIONAL GEOGRAPHIC TOPO MAPS OF WASHINGTON ON CD-ROM, 2000)

EXPLANATION

- Radius Surrounding Mine Site
- USGS Gaging Station
- Surface Water Station
- Background Soil Sample

SCALE 1 INCH = 2,000 FEET

1 1/2 0 1 MILE

CONTOUR INTERVAL = 40 FEET

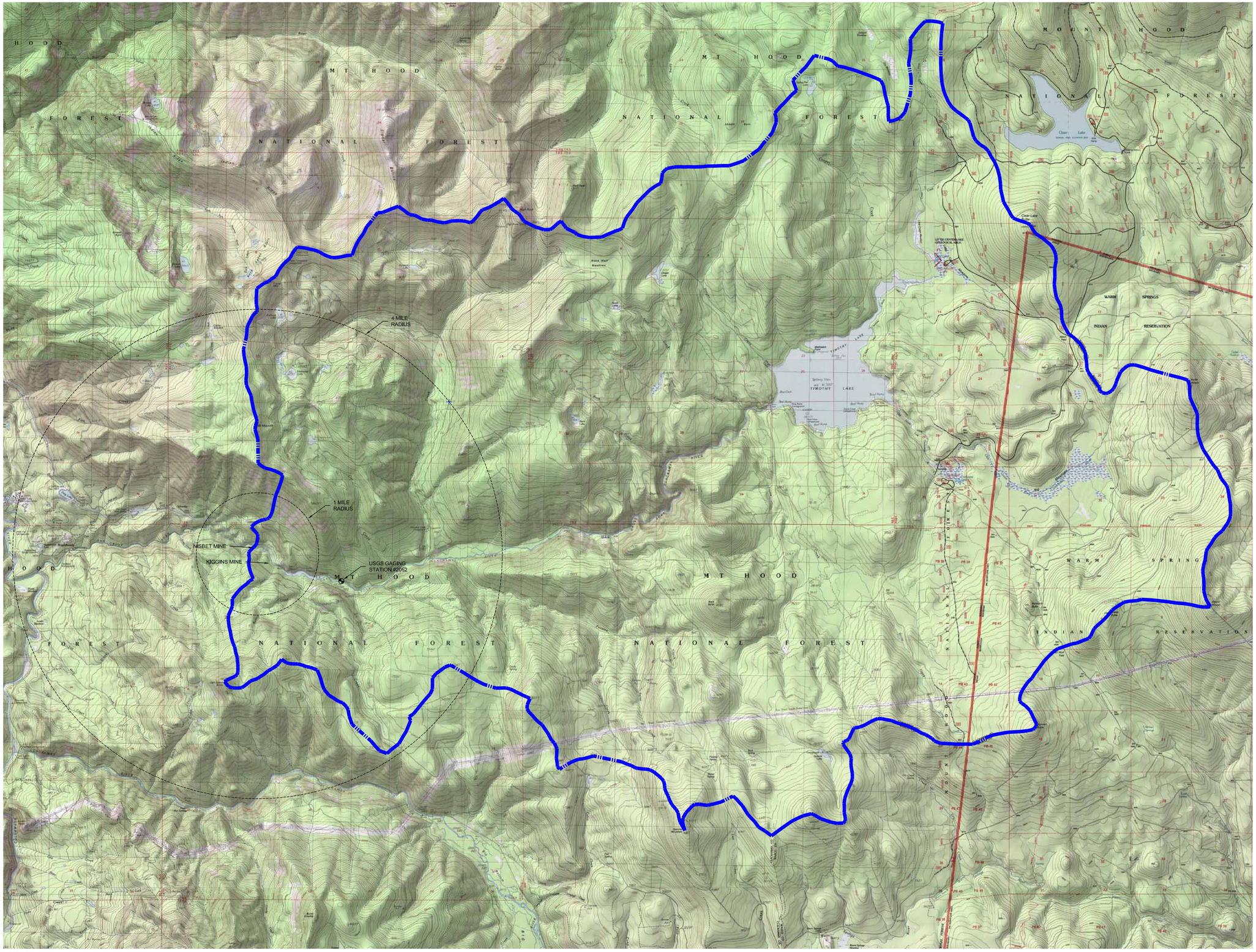
Figure 3. Surface Water Stations

PROJECT NUMBER: 2323022	KIGGINS - NISBET MINE SITE INSPECTION
DATE: 01-31-04	
DWG BY: DGW / DWG NO: 2323022F3.dwg	
PROJECT MANAGER: DGW	
REVISED:	CASCADE EARTH SCIENCES, A Valmont Industries Company

CES CES. Valmont Industries 11/21/2003 2:34 PM 2323008F2.dwg

PLATES

Plate 1. Topographic Map with Estimated Watershed Boundaries and the 1- and 4-mile radii from Site, including Surface Water Stations



EXPLANATION

- Watershed Boundary
- Radius Surrounding Mine Site
- Surface Water Rights - Approximate Location
- Water Well - Approximate Location
- USGS Gaging Station
- Surface Water Station
- Occupied Residence - Approximate Location

N

SCALE 1 INCH = 4,000 FEET

1 0.5 0 1 MILE

CONTOUR INTERVAL = 40 FT.

(SOURCE: NATIONAL GEOGRAPHIC TOPO MAPS OF WASHINGTON ON CD-ROM, 2000)

Plate 1. Oak Grove Fork f the Clackamas River
Watershed Boundary with 1 and 4 mile Radius

PROJECT NUMBER: 2323022	KIGGINS - NISBET MINES SITE INSPECTION
DATE: 01/13/04	
DWG BY: DGW DWG NO: 2323022P1	
PROJECT MANAGER: DGW	
REVISED:	CES CASCADE EARTH SCIENCES A Valmont Industries Company

APPENDICES

Appendix A.

Deviations from the Workplan

CES
Natural Solutions for Water
A VALMONT INDUSTRIES COMPANY

Using natural systems to take the waste out of water

Phone: 509-921-1788 Fax: 509-921-1788
12720 E Nora, Suite A Spokane, WA 99216

December 11, 2003

Mr. Dennis Boles
Winema National Forest
2819 Dahlia
Klamath Falls, Oregon 97601

SUBJECT: CHANGES IN THE KIGGINS AND NISBET MINES SAMPLING AND ANALYSIS PLAN

Dear Dennis:

The following changes were made to the Sampling and Analysis Plan (SAP) for the Kiggins and Nisbet Mines Site Inspection. These changes were made after field observations and after discussions with the USFS to confirm these changes.

- Due to substrate size (i.e. boulders and cobbles), pore-water and sediment samples could not be collected at the "riffle" substations. Because of this, pore-water, surface water and sediment samples could only be collected at the "pool" substations.
- Surface water and pore water samples were not analyzed for pH in the laboratory. This error was made while filling out the chain of custody (COC) forms. By the time the mistake was discovered, the samples were past the hold time. However, pH measurements were recorded in the field, which are more accurate.
- Clay mineralization was planned for all "pool" sediment samples. However, because of the substrate size (i.e., minor amounts of clay) discovered during field activities, this analysis was deemed unnecessary and removed from the analysis list.
- Nine vegetation samples were planned for the field activities (three background, three from the Kiggins Mine, and three from the Nisbet Mine). However, during field activities only a few of the waste piles had vegetation growing from them. Therefore, only three onsite vegetation samples were collected for analysis.

Please contact me at (509) 921-0290 if you have any questions.

Regards,
CASCADE EARTH SCIENCES

Dustin G. Wasley, PE
Managing Engineer

Appendix B.

Photographs

Photograph 1. View to the east from OGF-01

Photograph 2. View to the east from OGF-02

Photograph 3. View to the west from OGF-03

Photograph 4. View to the west of OGF-04

Photograph 5. View to the west from Station OGF-05

Photograph 6. View to the west from OGF-06

Photograph 7. View to the east from OGF-07

Photograph 8 and 9. View of the waterfall, ~200 feet downstream from Station OGF-07

Photograph 10. View to the south of Kiggins Mine powderhouse / Adit 3

Photograph 11. View of tree near the Kiggins Powderhouse with "TNT" carving.

Photograph 12. View to the west of slide over Kiggins Mine powderhouse

Photograph 13. View of the top of Kiggins Mine furnace

Photograph 14. View inside Kiggins Mine Furnace

Photograph 15. View of the Kiggins Mine Furnace, above the Oak Grove Fork

Photograph 16. View of waste drum at Kiggins Mine

Photograph 17. Adit 1 at Kiggins Mine

Photograph 18. Closeup of Adit 1 at the Kiggins Mine

Photograph 19. Closeup of Adit 2 at the Kiggins Mine

Photograph 20. View to the south of Nisbet Mine furnace

Photograph 21. View to the south of waste rock pile # 1 under Nisbet Mine furnace

Photograph 22. View east at Waste Rock Pile 1 at Nisbet Mine

Photograph 23. View west at Waste Rock Pile 1 at the Nisbet Mine

Photograph 24. View of waste rock pile # 2 at Nisbet Mine

Photograph 25. View uphill at Adit 2 from Waste Rock Pile 4 at Nisbet Mine

Photograph 26. View of Adit 1 at the Nisbet Mine

Photograph 27. Closeup of the Oak Grove Vein near the Nisbet Mine

Appendix C.

Mine Maps and Miscellaneous Information

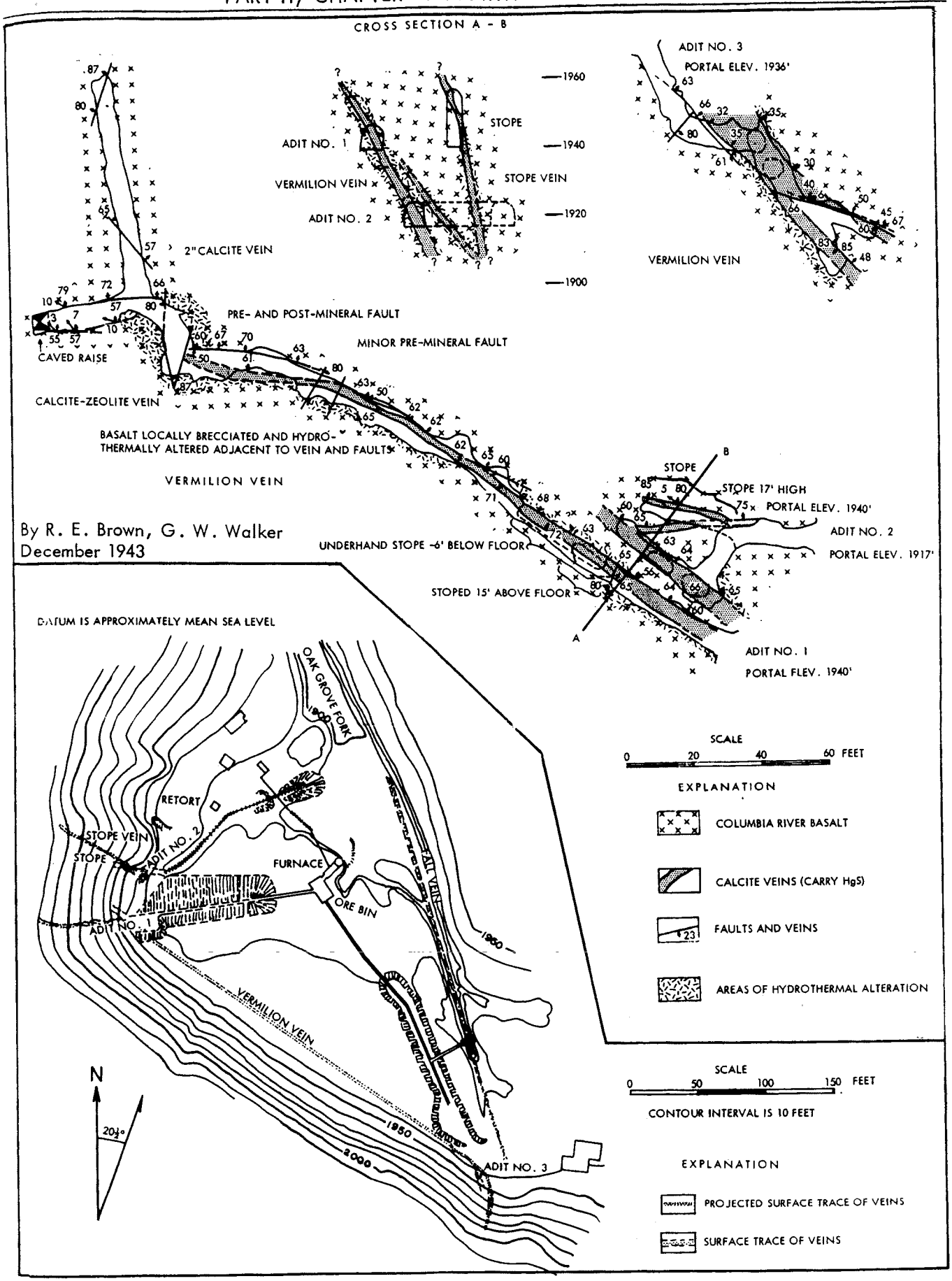


Figure 35. Geology and topography of the Kiggins mine.

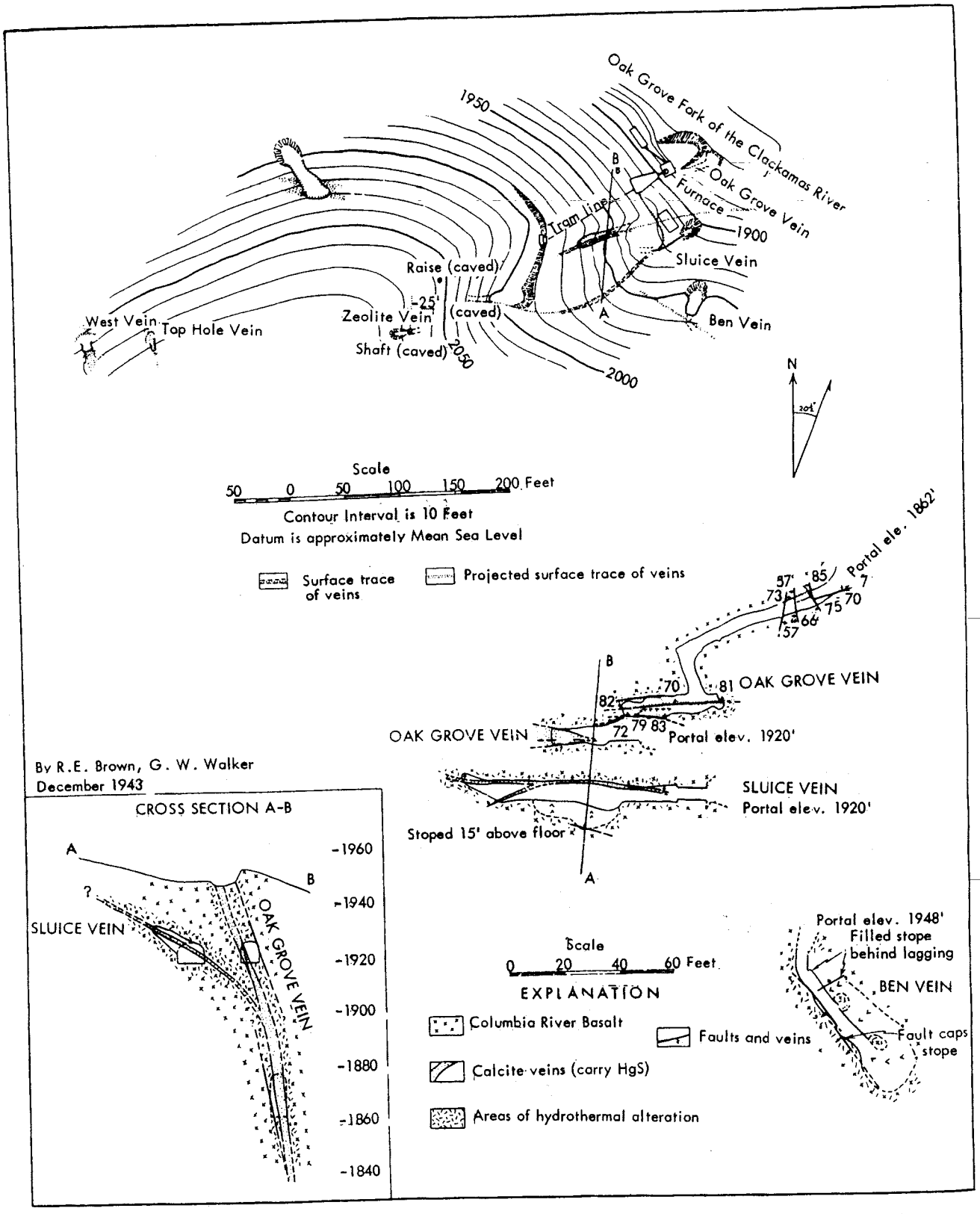


Figure 36. Topography and geology of the Nisbet mine.

Appendix D.

Ecological Survey

1.0 OBJECTIVES

The overall objective of the ecological survey was to document the ecology in close proximity to the abandoned mines and provide a preliminary assessment of the potential for mine-related ecological effects. The specific objectives were:

- Characterize terrestrial and stream habitats and document terrestrial macroinvertebrates, herpetiles (reptiles and amphibians), birds, mammals, fish, and benthic invertebrates that were present, or likely to be present at the Site, including the presence of threatened and endangered species and their habitat.

- Provide an initial characterization of the potential for exposure of ecological receptors to Site-related chemicals and of ecological effects that may occur as a result of this exposure, or as a result of Site-related physical disturbance of the environment.

- Compare benthic invertebrate populations upstream and downstream of the mines.

- Make recommendations regarding the need for further ecological effects assessment at the Site, and, as necessary, suggest possible actions to better understand the potential ecological effects.

Section 2.0 of this report provides the methodology and results of the field surveys. Section 3.0 summarizes the ecological survey results and the potential for Site-related ecological effects. Recommendations are made regarding the need for, and approach to, further ecological assessment. References are provided in Section 4.0.

2.0 RESULTS

2.1 TERRESTRIAL ENVIRONMENT

2.1.1 PLANT COMMUNITIES/HABITAT

The list of RTE plant species documented for the Township 6 South, Range 7 East, Section 4 area was obtained from the ONHIC. In addition, plant species lists and associations for the west Cascades ecoregion were acquired from the ONHIC (ONHP 2001).

At each sample plot, a determination of herbaceous (including weeds), shrub, and tree species was made within a 5-m radius. Plants were identified using *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1990) nomenclature and documented on field forms for each sample plot. Based on the reconnaissance observations, the following 11 survey stations were established:

Kiggins Mine Stations:

- Onsite disturbed shrub
- Onsite palustrine emergent wetland
- Onsite coniferous forest
- Onsite riparian
- Onsite mixed forest

Nisbet Mine Stations:

- Onsite riparian
- Coniferous forest
- Onsite mixed forest

Offsite Stations:

- Offsite riparian
- Two coniferous forest stations.

The plant species documented onsite and likely to be present in the areas surrounding the mine are listed in Table 1. Plant communities observed on and adjacent to the mines are typical for the western hemlock vegetation zone found on Mt. Hood to elevations up to 3,000 ft. (USFS 1990). Seven percent of the Oak Grove watershed is comprised of the western hemlock zone, all located within the lower portion of the river corridor (USFS 1996). In this zone, western hemlock is the dominant tree in those sites that have been undisturbed for hundreds of years. Within both natural and human-induced disturbed areas, Douglas fir is often the dominant tree with western red cedar and western hemlock growing in the understory. The shrub and groundcover layers are often thin to lacking due to shading from the coniferous overstory. Red alder and a lush, diverse groundcover occur in riparian areas.

Six distinct plant communities were observed on, and adjacent to, the mine sites. These included 1) mature coniferous forest over a majority of the onsite and offsite areas, 2) early seral stage coniferous forest at the Kiggins Mine, 3) riparian forest along banks of the OGF at both mines, 4) shrub habitat at the

Kiggins Mine, 5) mixed deciduous/coniferous forest located on steep slopes above the adits on both mines, and 6) palustrine emergent wetland at the Kiggins Mine. The dominant habitat type at the Nisbet Mine was mature coniferous forest with small components of riparian and disturbed forest habitat. The dominant habitat type at Kiggins was mixed successional forest that included early seral stage coniferous forest, mixed forest, and riparian forest and small components of emergent wetland and shrub habitat.

The dominant plant community at the Nisbet Mine and in adjacent habitat surrounding both mines can be characterized as a mature western hemlock (*Tsuga heterophylla*)-dull Oregon grape (*Mahonia nervosa*)/sword fern (*Polystichum munitum*) association (Stations NV-1, NV-4, and NV-6). A fairly closed canopy of western hemlock was observed in this community with an open understory and ground layer of vascular plants, and a lush growth of ground mosses. Other tree species that occur frequently in this association include Douglas fir (*Psuedotsuga menziesii*) and western red cedar (*Thuja plicata*). Shrub and ground layer species that occurred commonly in the open understory varied at each sample station. On the Nisbet Mine site (NV-4), red-stem dogwood (*Cornus sericea*), vine maple (*Acer circinatum*), and lady fern were dominant. At the offsite station at the same elevation as the mine (NV-1), dull Oregon grape, sword fern, and western starflower (*Trientalis latifolia*) were dominant. And at the offsite station approximately 600 ft higher in elevation (NV-6), dull Oregon grape, western hemlock sapling, western red cedar sapling and mountain hemlock (*Tsuga mertensiana*) sapling were dominant. The vegetative cover in each of these areas also varied; areas with a more open tree canopy supported greater percent cover and species diversity in the shrub and ground layers. Mosses in these forests were dominated by stair step moss (*Hylocomium splendens*) with frequently occurring tree moss (*Climacium dendroides*).

Early seral coniferous forest can be characterized as a western red cedar/western hemlock association that was observed in only one relatively small area at the Kiggins Mine located on a waste pile between the middle adit and the OGF (Station KV-3). This plant community is comprised of a densely growing stand of western red cedar and western hemlock. Only a few small, individual plants of sword fern and small patches of stair step moss were observed growing under this closed canopy.

The riparian community is characterized as a red alder (*Alnus rubra*)/big-leaf maple (*Acer macrophyllum*)-vine maple association. This plant community was observed in patches along the banks of the OGF within the study area and sample stations were established onsite at the Kiggins Mine in the Sam Creek/OGF floodplain (KV-4), at the Nisbet Mine by the retort (NV-3), and offsite approximately 300 ft downstream of the Nisbet Mine (NV-2). Red alder trees dominate this plant community, with big-leaf maple trees occurring frequently. While vine maple dominates the understory layer, this open layer is comprised of a variety of species that include red alder saplings, red-stem dogwood, black gooseberry (*Ribes lacustre*), black raspberry (*Rubus leucodermis*), thimbleberry (*Rubus parviflorus*), and coniferous saplings. The ground layer in this association is not dominated by any one species and is comprised of frequently-occurring herbaceous plants including maidenhair fern (*Adiantum pedatum*), lady fern (*Athyrium felix-femina*), fescue (*Festuca* sp.), large-leaved avens (*Geum macrophyllum*), palmate colts foot (*Petasites palmatus*), arrow-leaved groundsel (*Senecio triangularis*), and piggy-back plant (*Tolmiea menziesii*). Mosses were mostly lacking in the riparian areas. The riparian habitat just below the retort at the Nisbet Mine had the least species diversity, with half the number of plant species as the other two sample stations. Riparian habitat at the Kiggins Mine, located in the rubble pile outside the closed adit, had the most diversity in both plant species and structural layering of all three riparian sample stations. The Kiggins Mine riparian station is located in an area that had received a relatively recent input of silt and soil from flooding, while the other two stations are located in areas that tend to get scoured during flooding.

The shrub habitat can be characterized as a thimbleberry/salmonberry (*Rubus spectabilis*) association that was observed in only one small area at the Kiggins Mine just below the main adit (Station KV-1). This plant community is comprised of a thicket dominated by thimbleberry with salmonberry intermixed.

Other shrubs were observed in this association, but with minimal percent cover, including red alder sapling, vine maple, sticky currant (*Ribes viscosissum*) and black raspberry. The groundcover layer is nearly bare and includes scattered individuals, many of which are usually associated with disturbed areas. Groundcover species include pearly everlasting (*Anaphalis margaritacea*), bull thistle (*Cirsium vulgare*), Watson's willow-herb (*Epilobium ciliatum*), sweet-scented bedstraw (*Gallium triflorum*), large-leaved avens, oxeye daisy (*Leucanthemum vulgare*), arrow-leaved groundsel, and prickly sow (*Sonchus asper*).

Mixed forest habitat is characterized as a red alder/big-leaf maple/western hemlock-vine maple association. This association was observed at both the Kiggins and Nisbet Mines, but not in the undisturbed areas surrounding the mines. Two types of mixed forest were observed in areas with relatively recent landslide disturbance above adits at each mine (KV-5 and NV-5) and an area showing no recent disturbance at the nearly vertical wall at the Kiggins Mine between the eastern and middle adit. The landslide area at the Nisbet Mine is dominated by young red alder trees with frequently occurring young western hemlock trees. The understory layer is well vegetated and dominated by ocean spray (*Holodiscus discolor*), western hemlock saplings, and thimbleberry, with one Douglas fir sapling observed. The ground layer is dominated by maidenhair fern with a few individuals of sword fern and false Solomon seal (*Smilicina racemosa*). The landslide area at the Kiggins Mine varies from the Nisbet mixed forest association in that it has less tree and shrub cover but much greater ground layer cover. The tree layer is dominated by red alder with infrequently occurring western hemlock. The understory layer, which is mostly lacking, is dominated by vine maple with scattered individuals of red alder saplings, goats beard (*Aruncus dioicus*), Indian plum (*Oemlaria cerasiformis*), and thimbleberry. The groundcover layer is dominated by a lush layer of maidenhair fern, with minor cover of sword fern, arrow-leaved groundsel, Siberian miners-lettuce (*Montia siberica*), fescue species, and piggy-back plant.

The mixed forest habitat along the nearly vertical wall at the Kiggins Mine between the closed adit and middle adit was not formally surveyed as it was not clear whether this area was affected by past mining activities. It is described here as a comparison to the more disturbed mixed forest areas on both mines that are subject to landslides due to steep slopes created from mining activity. This mixed forest habitat is dominated by red alder and big-leaf maple, with western hemlock and Douglas fir intermixed. The understory layer is very dense and is comprised primarily of vine maple, salmonberry, thimbleberry, and dull Oregon grape. Sword fern dominates the dense groundcover layer. In addition to dense vegetative cover, the difference between this mixed forest and the more disturbed mixed forest habitat is the amount of downed wood in this area. Little to no downed wood was observed in the disturbed mixed forest areas.

The wetland habitat is characterized as a lady fern/palmate colts foot association (KV-2), observed only at the Kiggins Mine. The wetland receives hydrology from the small stream flowing through this area and from seeps along the base of the vertical wall between the main and eastern adit. Red alder trees provide some nutrient input into this narrow wetland via leaf litter, although no red alder was growing in the saturated wetland soil regime. In addition to the dominant lady fern and palmate colts foot, maiden hair fern and water parsley (*Oenanthe sarmentosa*) occur frequently in the wetland. Other plants that occur less frequently in the wetland include thimbleberry, kneeling angelica (*Angelica genuflexa*), skunk cabbage (*Lysitchitum americanum*), arrow-leaved groundsel, Cooey's hedgenettle (*Stachys cooleyae*), and piggy-back plant.

The U.S. Fish and Wildlife Service (USFWS) has identified 23 plant species as occurring in the Kiggins/Nisbet Mine vicinity that are listed as endangered, threatened or species of concern in Oregon (Table 2). The Oregon Department of Agriculture (ODA) lists an additional 13 species as endangered, threatened, or candidate species that could potentially occur in this area (Table 2). In addition, Table 3 shows 29 plant species that are listed by the USFS. Most of these USFS plant species are not listed as threatened or sensitive; however, the agency manages and protects them from ground-disturbing

activities. This table shows those managed species that are known to or are likely to occur in the vicinity of the mines (Horvath 2003; Williamson 2003).

The ONHIC has documented the occurrence of cold-water corydalis (*Corydalis aquae-gildae*) upstream of the Kiggins/Nisbet Mine area. Two populations were documented in the vicinity of Peavine Creek and the OGF and just upstream of Harriet Lake. An intensive survey in 2001 for cold-water corydalis in the lower OGF found no plants downstream of the Harriet Lake Dam, although suitable substrate is documented at and downstream from the Nisbet Mine and along the OGF between the two mines (McShane 2003). In addition, a recent study for sensitive plant species and Survey and Manage species (Horvath 2003) documented the occurrence of sensitive plant species along the pipeline, access roads, and indirect recreational areas associated with the Clackamas River hydroelectric project from Timothy Lake to the hydroelectric plant, including the OGF and Harriet Lake. Plants that are likely to occur in the vicinity of the mines include tall bugbane (*Cimicifuga elata*), which occurs near the Oak Grove Pipeline and transmission line associated with the Oak Grove power house. This report also documents the occurrence of cold-water corydalis on the OGF between Stone Creek and Harriet Lake, and along Stone Creek and Peavine Creek, tributaries to the OGF. Three Survey and Manage fungi identified in this area are *Gomphus clavatus*, known to occur approximately ¼ mile from the OGF just below Harriet Lake, and *Helvella elastica* and *Nephroma occultum*, which are known to occur in the riparian areas of the OGF.

None of the listed species, or those species under USFS management, were observed during our Site visit. However, the field surveys were conducted relatively late in the growing season to accommodate access across OGF, and to allow collection of stream invertebrates from the creek. Therefore, plant species that die and/or flower early in the year were unlikely to be discovered by these recent plant surveys. If remediation work is necessary at this Site, field surveys for early blooming listed by the USFWS, ODA, and USFS survey and manage species may be needed prior to any ground disturbance activity.

There was no distinct difference between the onsite and offsite western hemlock association. Any variation in frequency and percent cover of individual species appeared to be more dependent on moisture content of soil, open or closed aspect of the tree canopy, and slope aspect (i.e., steepness, direction facing, and elevation) than to proximity to past mine activity.

The substrate and canopy configuration for each of the three riparian areas varied and must be taken into account when evaluating the effect of past mining activities on these habitats. The offsite riparian area is within an area of barren cobble substrate and is located in a narrow portion of the OGF ravine that limits the amount of daylight this area receives. The Nisbet riparian area receives adequate sunlight and is growing in soil deposited by the creek and by erosion from the steep Nisbet Mine slopes. Both of these areas are subject to scouring during even minor flood events in the OGF. The Kiggins Mine riparian area is also subject to scouring, but only during high flood events and is not expected to be disturbed by scouring as often as the other two areas. In addition, the Kiggins riparian area is growing in rich silt soil delivered by Sam Creek during a large flood event. This area, located in a relatively wide portion of the OGF ravine and receiving the most sun exposure of all three sites, is subject to the most human disturbance from foot travel and informal use as a campsite.

In consideration of all these factors, the Kiggins riparian area has the structural and species diversity that would be expected for the amount of sunlight received, substrate type, and nutrient inputs. It appears that this area is more disturbed by human activities than by past mining activities. The Nisbet Mine area would be expected to also display structural and species diversity, even more so than the offsite riparian area, because of the amount of sunlight it receives, substrate type, and nutrient inputs from the creek. However, this area supports fewer species and has little structural diversity, providing little habitat for wildlife that use the creek. The lack of vegetation in this riparian area may be due to one, or a

combination of, factors including ongoing erosion in the vicinity of the retort, scouring during floods, or elevated concentration of contaminants.

There was a distinct difference between the disturbed mixed forest and the mixed forest habitat on the vertical slope at the Kiggins Mine. The disturbed mixed forest areas by the adits at the Kiggins and Nisbet Mines had a very open canopy with few species represented in all layers (canopy, understory, and ground layer). In contrast, the forest habitat on the vertical slope exhibited a very dense vegetation canopy with a number of species present in the tree and shrub canopy layers. The lower abundance and diversity in the disturbed mixed forest in the vicinity of the adits may be related to ongoing erosion (natural and anthropogenic) and/or elevated concentration of contaminants.

The Kiggins Mine is comprised of relatively diverse habitats that occur in patches, none of which include the mature coniferous forest observed in surrounding areas and at the Nisbet Mine. This appears to be due, at least in part, to the amount of water that flows through the Kiggins Mine area. Sam Creek, seeps from the vertical slope, and a small stream all support more of a riparian community than a coniferous association. However, the patchy and disturbed nature of the habitats present at Kiggins could be due to elevated contamination levels, but is also an indication of human disturbance on this Site as evidenced by the numerous trails running through the area and signs of informal camping.

2.1.2 BIRDS

During the initial Site reconnaissance, one dominant habitat type was identified at each of the mines: successional mixed forest at the Kiggins Mine and mature coniferous forest at the Nisbet Mine. Thus, one bird survey station was established at each mine. Bird Station #1 (BS-01) was established approximately 30 m east of, and 25 m above, the Nisbet Mine at a location where riffles within the OGF were barely audible. Bird Station #2 (BS-02) was located at the Kiggins Mine between the central adit and the bridge. The bird survey stations are shown on Figures 1 and 2, respectively.

Birds identified at the Kiggins Mine included winter wren (*Troglodytes troglodytes*), black-capped chickadee (*Parus atricapillus*), Stellar's jay (*Cyanocitta stelleri*), American robin (*Turdus migratorius*), pine siskin (*Carduelis pinus*), and dark-eyed junco (*Junco hyemalis*). Birds identified at the Nisbet Mine included black-capped chickadee, Stellar's jay, pine siskin, dark-eyed junco, and red-breasted nuthatch (*Sitta canadensis*). During the vegetation, mammal, and stream surveys, additional birds species were noted including an American dipper (*Cinclus mexicanus*), fox sparrows (*Passerella iliaca*), and an unidentified woodpecker. These and other birds likely to be present in the vicinity of the Site are listed in Table 4.

The only RTE bird species listed by the ONHIC for the area within a 3.2-km radius of the Site was the state and federally threatened spotted owl (*Strix occidentalis*). These were noted for areas upstream and downstream of the Site, but spotted owl habitat was also present surrounding the mines. The Site is within critical habitat for the spotted owl. Bald eagles (*Haliatus leucocephalus*) may be present in the region, but are not expected to inhabit the Site vicinity. Habitat exists at the Site for harlequin duck (*Histrionicus histrionicus*), which are USFS Region 6 sensitive species. However, harlequin ducks have not been documented on the reach of the OGF near the mines. The RTE bird species potentially found at the Site are shown in Table 4.

Relatively few birds were documented during the formal bird surveys and during other field activities. This was likely related to several factors. First, the stream noise associated with Gold Creek was audible from the bird survey stations, and may have obscured some bird calls. Second, the habitat was dense forest at both survey stations, which limited the observation distance. Third, the survey periods were

relatively short and conducted at only two portions of the day; additional or longer surveys scattered throughout the day may have identified more birds.

Regardless of the limited nature of the surveys, birds that were observed represented several distinct foraging strategies. Together, these show that species inhabiting the Site are diverse, that the habitat is supporting these species, and that other species are likely to be present but were not noted during our limited survey.

Chemical impacts to upland bird species would be expected only if the birds were picking contaminated food items from, or dust-bathing in, the soil within the waste piles, or otherwise eating insects or fruit that had been exposed to or were rooted in the waste piles. Because the mining-related disturbed areas at the Nisbet Mine were very small (especially in relation to the available surrounding undisturbed habitat), physical impacts to upland bird species would not be expected. The potential area of contamination is larger at the Kiggins Mine, but would likely result in significant exposure only to individual birds that preferentially feed in the successional mixed forest habitat present on the small plateau where ore was processed and in or adjacent to the wetland area downgradient of the adits. The likelihood of effects to upper trophic level species such as the spotted owl due to the transfer of mercury through the food chain is also considered to be low because of the limited number of prey items that may be exposed to Site-related chemicals.

Aquatic bird species such as the dipper may have the highest potential for exposure of birds to chemicals due to the potential distribution of Site-related materials in the OGF. The potential for effects would be related to the nature and extent of contamination in the river.

2.1.3 MAMMALS, HERPETILES, AND TERRESTRIAL INVERTEBRATES

No mammals were documented during the mammal survey. Holes that appeared to be mountain beaver (*Aplodontia rufa*) burrows were noted during the mammal survey and during other field activities at the Site. During the bird surveys, a Douglas tree squirrel (*Tamiasciurus douglasi*) was noted in the trees near station BS-02. No small mammal burrows were noted onsite or offsite, but what appeared to be a drowned Townsend mole (*Scapanus townsendii*) was found alongside the OGF, downstream of the Nisbet Mine. A bobcat was seen crossing Forest Road 4630 within ¼ mile north of the mines. The mammals likely to be present in the vicinity of the Site are listed in Table 5.

The ONHIC lists big-eared bats as present at cinnebar mines in the Site vicinity. The actual location of these sitings were not provided and the last observation was listed as 1994. A USFS biologist (Berganimi, R., 19 January 2004, personal communication) indicated that mines in the vicinity have been improved to accommodate bats. Bats were noted at the Nisbet Mine in the Oak Grove Watershed Analysis (USFS 1996). The open adit at the Kiggins Mine provides habitat that may be used by bats. The wolverine (*Gulo gulo*), Baird's shrew (*Sorex bairdii*), Pacific Fringe-tailed bat (*Myotis thysanodes*), and fisher (*Martes pennanti*) are listed by the USFS as sensitive and habitat exists for these species at the Site. The RTE mammal species observed or expected at the Site are shown in Table 5.

Herpetiles noted in the vicinity of the Site during the field effort included numerous rough-skinned newts (*Taricha granulosa*) and red-legged frogs (*Rana aurora*), and a Pacific giant salamander (*Dicamptodontenebrosus*). The cascade frog (*Rana cascadae*), spotted frog (*Rana pretiosa*), Larch mountain salamander (*Plethodon larselii*), Cascade torrent salamander (*Rhyacotriton cascadae*), Oregon slender salamander (*Batrachoseps wrighti*), and Cope's giant salamander (*Dicamptodon copei*) are USFS sensitive species that may inhabit the Site vicinity. No federal threatened, or endangered herpetiles were listed for the onsite or nearby offsite areas. The herpetiles (including RTE species) observed, expected, or possibly present in the vicinity of the Site are listed in Table 6.

Relatively few sightings or indicators of invertebrates were noted during the survey. Numerous flies (likely Ephemeroptera and Diptera species) were also observed but were not identified. No RTE invertebrate species were observed, but the USFS Survey and Manage or sensitive species listed in Table 6 may inhabit the Site vicinity.

As is generally expected during short-term surveys, relatively few mammals, herpetiles, or invertebrates were documented onsite or offsite. Small and medium-sized mammals such as voles, mice, shrews, marten, and fisher are likely to be present in the forest at or adjacent to the mines, but are unlikely to burrow or forage in the compacted, barren waste piles. Tree squirrels are potentially present onsite, but are unlikely to frequent the nearly barren mine-related waste piles due to the lack of food and cover. Bats such as the Townsend's Big-Eared are likely to use the adits as roosting sites, but are unlikely to be exposed to Site-related chemicals in soil because they forage primarily on flying insects. However, mercury can be transported downstream and through the aquatic food chain, including from sediment and water to aquatic invertebrates and into invertebrate-eating birds. As noted earlier, the potential area of soil contamination appears larger at the Kiggins Mine than at the Nisbet Mine. Of potential concern is the wetland area downgradient of the adits where Site-related chemicals may be concentrated and where some animals may drink or forage. While this is unlikely to result in widespread exposure to wildlife, this could promote mobilization of mercury in the terrestrial food chain.

The abundance of rough-skinned newts and red-legged frogs strongly suggest that the Site provides high quality habitat for amphibians. This is likely related to the stable and slow moving nature of water within the OGF below Harriet. No abnormalities were noted on the newts and frogs that were captured and inspected during the survey. The presence of apparently large populations of amphibians within and adjacent to the river suggests that if Site-related mercury is present within the sediment or surface water, there is a potential for significant chemical exposure and effects. This potential extends to species such as raccoons and fish that forage on amphibians and their eggs.

The terrestrial nature of most reptiles suggests that, similar to most birds and mammals, they have less potential for widespread exposure to Site-related chemicals. The exception to this would be for reptiles (e.g., snakes) that are eating amphibians or other species that are exposed to chemicals in the surface water or sediment of the OGF.

Of the mammals, herpetiles, and invertebrates documented or likely to inhabit the Site, amphibians are likely to be the species exposed the most to Site-related contamination. Species that forage on exposed amphibians or small mammals may be at risk due to the potential for food chain transfer of mercury.

2.2 AQUATIC ENVIRONMENT

2.2.1 HABITAT

The OGF sample station locations are shown on Figure 3. The section of the OGF at Station OGF-01, and from stations OGF-02 to OGF-07 were the only portions of the river or its tributaries that were investigated. Station OGF-01 was upgradient of Harriet Lake and contained a much higher volume of water than the rest of the stations because, except during high flows, the Harriet Lake Dam stops all downstream flow in the OGF and diverts the water through a pipeline to the Three Lynx hydroelectric generator. There was essentially no flow of water at the base of the Harriet Lake Dam and water volume increased with increasing distance downstream from the dam. The river is contained within a relatively steep-walled canyon, and therefore has little or no floodplain within the area of investigation.

Riparian vegetation along the OGF includes a narrow band of mixed young and mature deciduous trees with a densely growing herbaceous layer along the riverbank in some areas, primarily on infrequently

flooded gravel bars and immediately adjacent to the river. Further removed from the bank, the river is surrounded by mature coniferous forest.

Based on a USFS system for identifying stream channel types (Paustian et al. 1992), the channel type for OGF in the Site vicinity is "moderate gradient contained." As such, this portion of the OGF has moderate to high stream power, has variable substrate and bedform, contains a single channel with little off-channel habitat, is entrenched in foothills, and has a gradient between 2 percent and 6 percent. The river substrate in the Site vicinity is predominantly cobble, boulder, and some gravel, with sand and silt in larger pools. The upstream portion of the OGF between Stations OGF-02 and OGF-05 has a slightly steeper gradient than at Station OGF-01 and from Station OGF-05 to Station OGF-07, with a higher percentage of boulders. The higher percentage of boulders is due to the narrow canyon and associated rockfall between the Harriet Lake Dam and Station OGF-02. Large woody debris (LWD) is common and consistent in the portion of the OGF between the dam and the falls. LWD recruitment potential is high at all stations. Channel pattern is good with a sinuous channel and a variety of velocity/depth regimes at most stations. The stream type at Station OGF-01 is similar to the other stations but lacks the bedrock substrate and canyon walls and has a much larger volume of water.

The riffles sampled at Stations OGF-02, OGF-04, and OGF-07 were similar in length (3-5 m), width (2 m), depth (0.1 m) and substrate (cobble and gravel). The riffle at Station OGF-07 river was wider (3 m) and deeper (0.2 m) because of the increased volume of water present at downstream stations. Riffles at Stations OGF-05, OGF-06, and OGF-01 were similar in length (25 m), width (10 m), and depth (0.1 m). The riffles sampled at Station OGF-01 were within a 30-m-wide side channel adjacent to the larger 75-m-wide main river channel. No riffles were present in the vicinity of OGF-03. The riffle substrate at stations OGF-02, OGF-04, OGF-05, OGF-06, and OGF-07 was predominantly boulder and cobble. At Station OGF-01, the substrate was mostly cobble and gravel.

All of the pools were instream except at Station OGF-03. This pool was off-channel at the time of sampling, but receives powerful scouring during high water events. The substrate at Station OGF-03 was primarily a thin layer of silt overlying bedrock. Pools at Stations OGF-04, OGF-05, and OGF-06 were similar to each other in size and each had a silty sand substrate. Pools at Stations OGF-02 and OGF-07 were smaller than the other pools but also had a silty sand substrate. At Station OGF-07, there was a much lower volume of sediment and the sample had to be collected from a depositional area near the shore rather than within the channel. No pool habitat was present in the vicinity of Station OGF-01.

Significant erosional features affecting riparian vegetation or the riverbank were only noticed at the Nisbet Mine. In the vicinity of the Kiggins Mine, the river passes through a short, solid rock, vertical-wall canyon. Thus, there is no visible mine related erosion affecting the river. At the Nisbet Mine, an approximately 3-m diameter ore processing furnace and related silo (retort) were built into the steep slope immediately adjacent to the river. Some furnace wastes are currently situated adjacent to the river and the slope immediately surrounding the retort has eroded, and continues to erode, into the river. During high water events, the river flows around the furnace wastes and along the toe of the eroded hillside. The furnaces wastes are strongly consolidated in the form of an approximately 3-m diameter ball and are unlikely to readily contribute rock or gravel to the stream channel. Erosion from around the retort has been limited but has the potential to erode further.

EPA habitat assessment scores ranged from 172 to 188 out of a possible score of 200. Based on this scoring, instream habitats were rated as optimal at all stations. Stations OGF-02 and OGF-04 scored 172 and 180, respectively. These were lower than downstream stations, due primarily to the low volume of water within the river. Station OGF-01 also scored slightly lower than the three downstream stations because the entire river velocity and depth regime was fast/shallow and lacked slow/deep, slow/shallow,

and fast/deep regimes. These optimal ratings are indicative of the high quality and variety of habitat within the OGF.

Overall, the OGF instream and riparian habitat was very good at all stations. The waterfall downstream of Station OGF-07 and the Harriet Lake Dam upstream of Station OGF-02 both present impassable barriers for the upstream migration of anadromous fishes. The dam also limits the downstream migration of gravel, nutrients, and LWD. However, the well-established riparian and surrounding habitat, and the low, but consistent flow of water within the Site vicinity have produced an apparently stable and productive aquatic environment.

2.2.2 INVERTEBRATES

Invertebrate samples were collected at seven stations. No pool habitat was present at Station OGF-01 so a pool invertebrate sample was not collected from this station. No riffle habitat was present at Station OGF-03 so a riffle invertebrate sample was not collected from this station. The enumeration results for pool samples are considered more likely to be predictive of potential chemical effects because the pools represent depositional areas where sediment-bound Site-related chemicals would settle to the creek bottom and result in the exposure of benthic invertebrates to the chemicals. Whereas, the enumeration results for riffle samples were considered more likely to be predictive of potential physical effects because Site-related gravel and cobble-sized rock may be deposited in the riffle areas.

Pool Samples

Within the six pool samples, the total number of invertebrates was 432 at Station OGF-02, 312 at OGF-03, 478 at OGF-04, 329 at OGF-05, and then increased dramatically to 1,545 and 1,599 at Stations OGF-06 and OGF-07, respectively (see Figure 4). As shown on Figure 4, the number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) was 142 at Station OGF-02, decreased to less than 25 at Stations OGF-03, OGF-04, and OGF-05, then increased to 132 and then 732 at Stations OGF-06 and OGF-07. The higher numbers of EPT at Stations OGF-02 and OGF-07 and overall higher abundance (for all taxa) at Station OGF-07 are coincident with the two smallest pools, closest to riffle habitat, and with the least amount of sand and silt. This type of habitat is expected to have a higher percentage of EPT than the other stations. The higher overall abundance at Station OGF-06 is the result of both higher numbers of individuals and more species present. This increase in abundance is not readily explained by the present data. Figure 5 presents the community composition in pool habitats based on the percent of dominant invertebrate taxa. This figure shows that, similar to Figure 4, Stations OGF-02 and OGF-07 have the highest percentage of EPT species, which are more common in riffles than in pools. This also is likely due to the limited amount of typical pool substrate at these two stations. Figure 5 also shows that the taxonomic order diptera, which are more commonly associated with silty substrate, are much more prevalent, make up a very consistent percentage of the total taxa at Stations OGF-03 through OGF-06, and that each have well-developed pool habitat and a silty substrate. Figure 5 also shows that the diptera order is dominated by chironomid species. Figure 6 shows that the predominant foraging methods of the species present in the pool samples are gathering and predation, with a balanced and consistent number of scrapers, filterers, and shredders. The increased number of gatherers and reduced number of predators at Stations OGF-03, OGF-04, OGF-05, and OGF-06 also reflect substrate conditions in the pools. Figure 7 shows that the number of species (i.e., species diversity) at pool stations is relatively consistent across all stations for all species combined with a slight decrease in the number of EPT and in the number of non-chironomidae/non-oligochaete at the middle stations. These decreases are likely to be related to the higher amounts of coarse substrate at Stations OGF-02 and OGF-07 compared to other stations. The Shannon-Weaver Index presented on Figure 8 reflects this relatively consistent species diversity shown on Figure 7. However, the metals tolerance index shown on Figure 8 correlates to the number of species that are tolerant of metals contamination and this index increased between Stations OGF-02 and OGF-03,

stayed at the higher level at OGF-04, and then decreased at each subsequent downstream station. This suggested a possible increase in metals-tolerant species at the two pools adjacent to the Kiggins Mine.

Overall, the data presented on Figures 4 through 8 suggest a relatively consistent overall abundance and diversity of aquatic invertebrates within pools in the portion of the OGF downstream of Harriet Lake. There may be a slight indication of some metals toxicity at Stations OGF-03 and OGF-04. However, as noted earlier, the pool habitat at Station OGF-03 was poor because of the scouring to bedrock that occurs at each high water event. The sediment layer over bedrock is also very thin at this station. These factors likely disallow the development of a well-established invertebrate community at Station OGF-03. In addition, the diversity of invertebrates at Station OGF-04 does not appear to differ from Stations OGF-05, OGF-06, or OGF-07. The increased invertebrate abundance at Station OGF-06 (adjacent to the Nisbet Mine) could not be readily explained from the current data. Given the habitat and species abundance and diversity data, no mine-related impacts on aquatic invertebrates are obvious in pool habitats.

Riffle Samples

Within the six riffle samples, the number of invertebrates was 1,412 at Station OGF-02, increased to 1,887 at Station OGF-03, decreased to 678 at Station OGF-04, increased to 2,292 at Station OGF-05, and then decreased to 1,289 and then to 1,194 at Stations OGF-06 and OGF-07, respectively (Figure 9). No riffle was present at Station OGF-03. As shown on Figure 10, the EPT taxa make up a majority of taxa identified at all stations except Station OGF-01 (above Harriet Lake), where bivalves were the dominant taxa. Bivalves are often more common in larger rivers (Hafele and Hinton 1996) such as that above the lake. The number of all invertebrates and the number of EPT taxa increased from Station OGF-01 to OGF-02, decreased at OGF-03, increased to a high at Station OGF-04, and then decreased at both Stations OGF-06, and OGF-07. Because the stream character is distinctly different above Harriet Lake at Station OGF-01 than the other stations (due to the much higher water volume and wider, more uniform channel), comparisons are difficult between Station OGF-01 and the other stations. The decrease in abundance between Stations OGF-03 and OGF-04 is likely due to the presence of more boulders and less of the preferred cobble and gravel habitat at OGF-04. The difference between Stations OGF-02 and OGF-05 is likely due to the increased volume of water and cobble. The decrease in abundance between Stations OGF-05 and OGF-06 is not readily obvious because the habitat and stream characteristics were very similar at these two stations. There were essentially no differences in invertebrate abundance between the two downstream stations.

Figures 11 and 12 both show a remarkable similarity in invertebrate foraging methods and species diversity across all the stations. This is consistent with changing abundance related primarily to increased riffle habitat quality and quantity with increasing distance downstream from the dam, but signifying the healthy presence of diverse invertebrate taxa at all stations, including upstream of Harriet Lake. Figure 13 displays a summary of biological indices pertinent to the Site and riffle habitats, which also indicate consistent species diversity (Shannon-Weaver Index) across all the stations and a lack of any apparent impacts due to mine-related metals contamination (Metals Tolerance Index) within the stream.

2.2.3 FISH

A USFS district fisheries biologist (Berganimi, R., 19 January 2004, personal communication) was contacted to determine fish species likely to inhabit the OGF. The presence of fish was also determined visually during the stream habitat and invertebrate investigation, and by several stealthy perpendicular approaches to the stream with careful visual examination for fish movement.

Because of the barrier falls downstream, no anadromous fish are present within the Site vicinity. The most common fish species within the Site vicinity is resident cutthroat trout (*Oncorhynchus Clarki*).

These may be westslope or coastal cutthroat trout that have been planted in the river, streams, and lakes upstream from the Site. Brook trout (*Salvelinus fontinalis*), rainbow trout (*Salmo gairdneri*), and brown trout (*Salmo trutta*) have also been released upstream of the Site and may have been transported to the vicinity of the mines during periods of water flow over the Harriet Lake Dam.

Potential spawning and rearing areas exist within the OGF in the Site vicinity. The trout may move up and downstream between the dam and the barrier falls, but generally will reside in the larger pools downgradient of Station OGF-03 and are likely be carried below the falls during periods of high flow. Given the limited suitable fish habitat present in the Site vicinity below the dam, very few fish are expected to inhabit this portion of the OGF and population level effects on the released fish are unlikely.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 CONCLUSIONS

The Site is within an area that is relatively undisturbed by human activities (except from informal recreational use) and good quality terrestrial and instream habitats are present at, and surrounding, the Site. Mining activities in the early 1900s involved physical disturbances to the natural environment. Although mining activities halted decades ago, physical disturbances are still obvious, particularly the waste pile along the OGF shoreline at the Nisbet Mine and the upland plateau at the Kiggins Mine. The only apparent and potential areas of chemical effect for terrestrial plants, invertebrates, and wildlife are on or near the waste piles at each mine and the wetland area downgradient from the adits at the Kiggins Mine. Given the relatively small area of the waste piles, the potential for terrestrial ecological effects is likely limited to species such as plants, invertebrates, small mammals, and song/perching birds that have small home ranges and are regularly exposed to, or rooted in, the waste piles.

Mining wastes were likely introduced to the OGF during past mining activities and to a limited extent continue to slide into the creek. This contribution appears to have had little physical or chemical effect on the instream habitat quality in the vicinity of the Site. The high-energy water flow within the channel and during Harriet Lake Dam overflow events likely results in the transport of most fine-grained particles (smaller sand, silt, or clay) to depositional areas downstream of the Site, and likely downstream of the barrier waterfall. The predominant low flow would result in the slow transport of any dissolved Site-related contaminants downstream to the Clackamas River.

Based on stream invertebrate enumeration results, the only apparent potential instream effects were noted in pools at Stations OGF-03 and OGF-04. However, physical habitat characteristics may account for the species and metals tolerance differences compared to other sampling stations. Given the depositional nature of pool habitat, potential effects to invertebrates in pools are more likely related to chemicals attached to fined-grained materials than to Site-related physical changes in substrate.

The RTE species inhibiting the Site or its vicinity include black petaltail, cold-water corydalis, spotted owls, western big-eared bats, and red-legged frogs. No anadromous fish are present in the vicinty of the Site. Overall, no aquatic ecological effects were readily apparent in aquatic habitats. There is a slight potential for mine-related contaminants to result in an increased metals tolerance index at Stations OGF-03 and OGF-04. Terrestrial ecological effects are only expected on plants or other sedentary individual animals that may reside or forage on, or in the vicinity of, the waste piles for a large proportion of their lives.

3.2 RECOMMENDATIONS

Terrestrial ecological risk-based screening should be conducted to identify potential risks to terrestrial ecological receptor types and determine contaminants of potential ecological concern (COPECs) in soil. If concentrations of mine-related chemicals in sediment at Stations OGF-03 and OGF-0-04 exceed upstream concentrations, then a benthic ecological risk-based screening should be conducted at these two sample locations. Any identified COPECs in soil or sediment should be examined with regard to their potential for bioaccumulation in terrestrial and aquatic food chains. If some COPECs have a significant potential to bioaccumulate, Site-specific exposure modeling may be necessary to quantify potential ecological risks to upper trophic level species. The calculated ecological risks for both lower and upper trophic level species can then be used to more clearly define the need for further characterization of the extent of contamination or for ecologically-driven remedial action.

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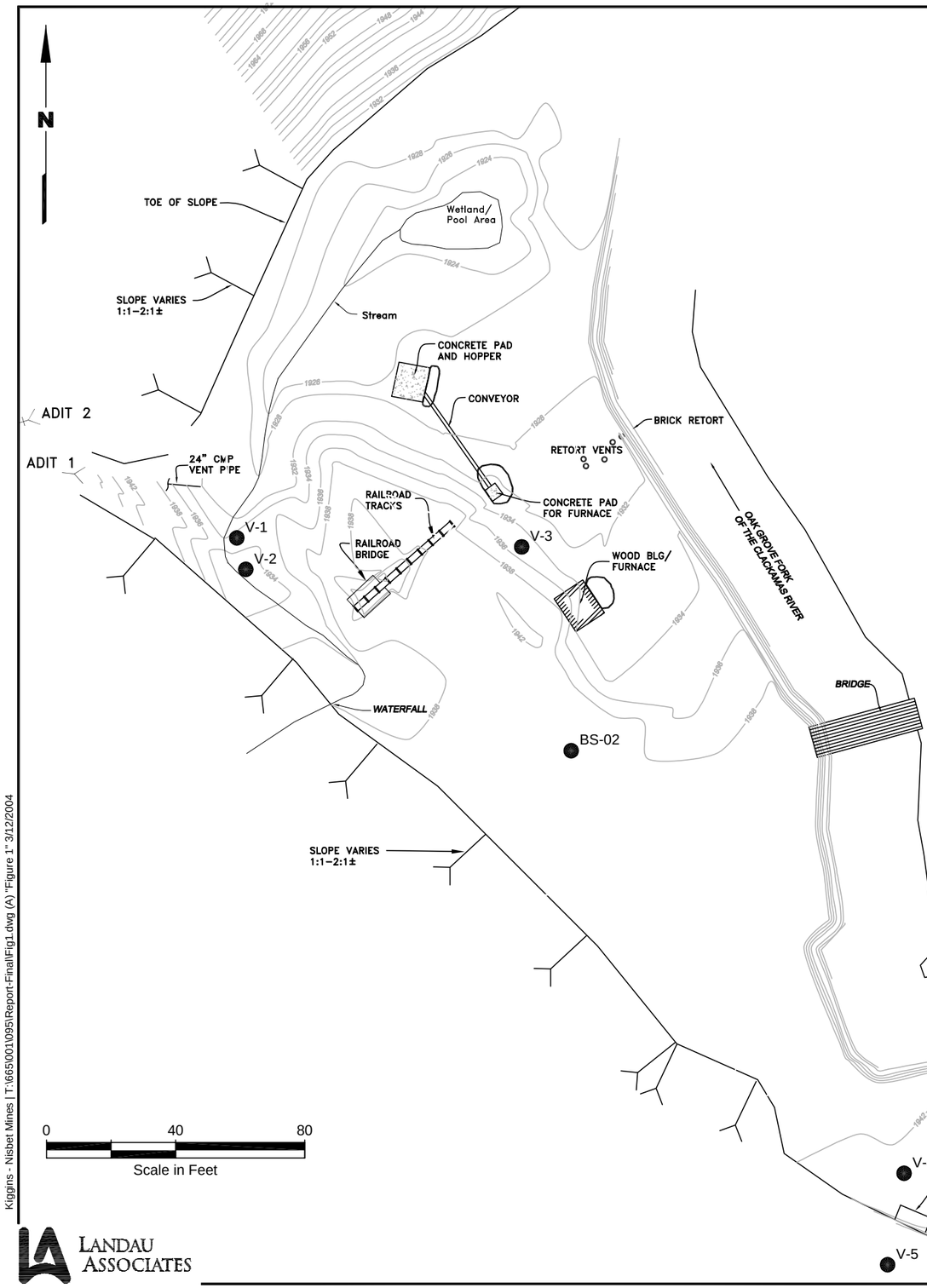

Legend

- V-3 — Vegetation Sample Location
- BS-01 — Bird Survey Location
- Water Line of Gold Creek (07/08/03)
- Major Contour (10 ft. interval)
- Minor Contour (2 ft. interval)
- Waste Rock Pile
- Adit 1 — Open Adit
- Adit 2 — Collapsed Adit

Base map source: Cascade Earth Sciences 2004

LANDAU ASSOCIATES

Kiggins - Nisbet Mines Estacada, Oregon	**Site Layout and Sampling Locations - Kiggins Mine**	Figure 1

Kiggins - Nisbet Mines | T:\665\001\095\Report-Final\Fig1.dwg (A) "Figure 1" 3/12/2004

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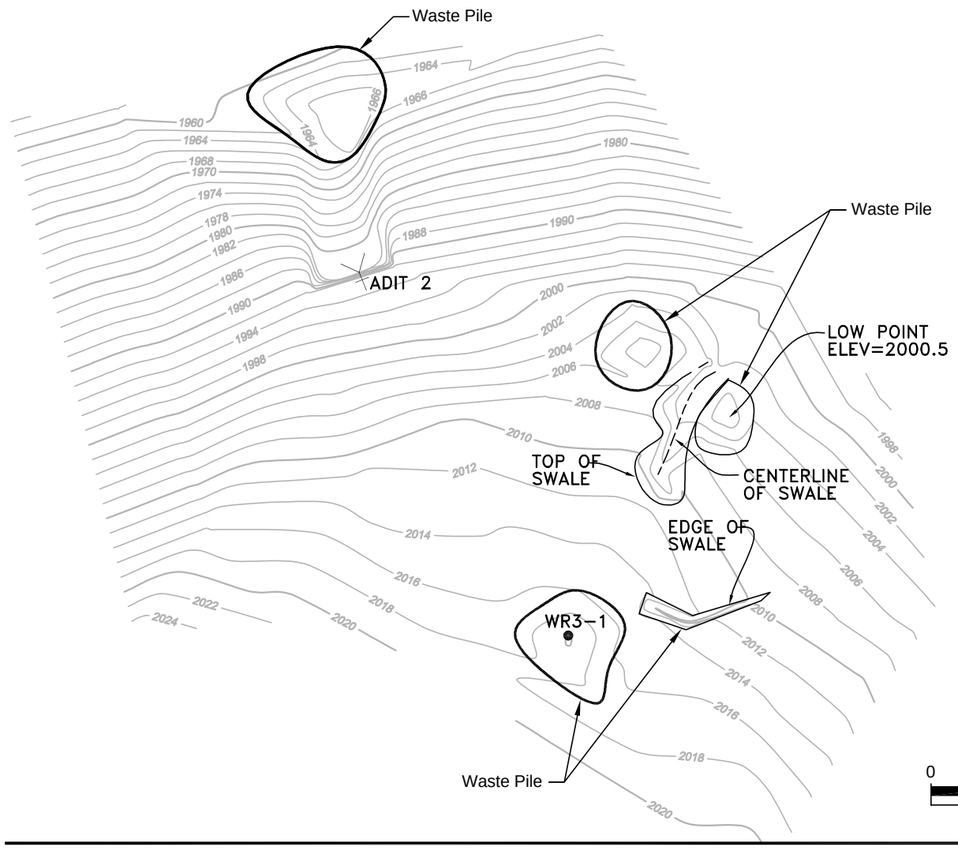
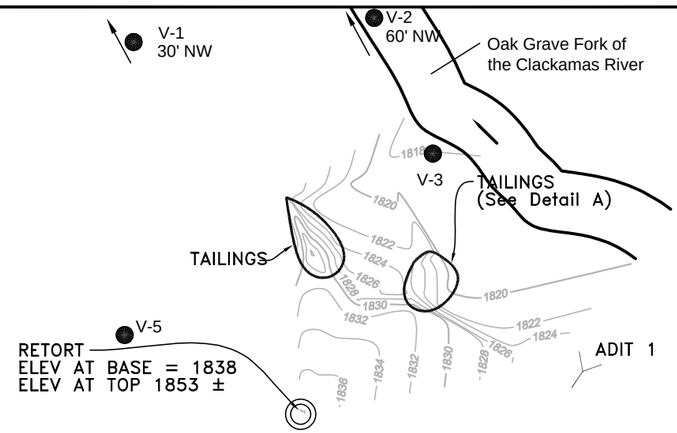
Legend

- V-6 — Vegetation Sample Location
- BS-01 — Bird Survey Location
- Water Line of Gold Creek (07/08/03)
- 1930 — Major Contour (10 ft. interval)
- Minor Contour (2 ft. interval)
- Waste Rock Pile
- Adit 1 — Open Adit
- Adit 2 — Collapsed Adit





BS-01

V-4

V-6

0 30 60

Scale in Feet

Base map source: Cascade Earth Sciences 2004

Kiggins - Nisbet Mines | T:\665\001\095\Report-Final\Fig2.dwg (A) "Figure 2" 3/12/2004

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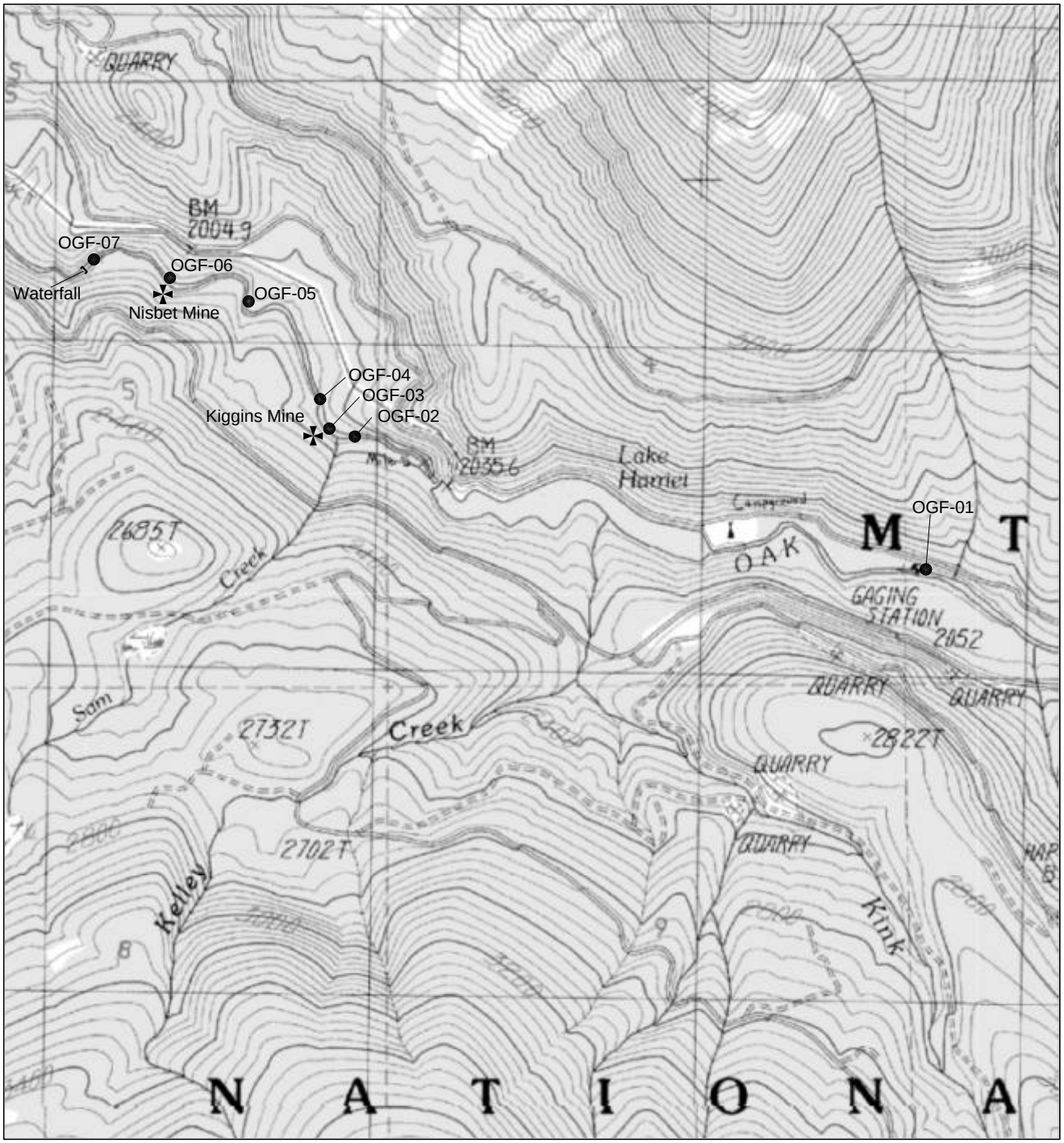
Kiggins - Nisbet Mines Estacada, Oregon	**Site Layout and Sampling Locations - Nisbet Mine**	Figure **2**



Not to Scale

Legend

OGF-01 ● Oak Grove Fork Aquatic Sampling Stations

Kiggins - Nisbet Mines | T:\665\001\095\Report-Final\Fig3.dwg (A) "Figure 3" 3/12/2004

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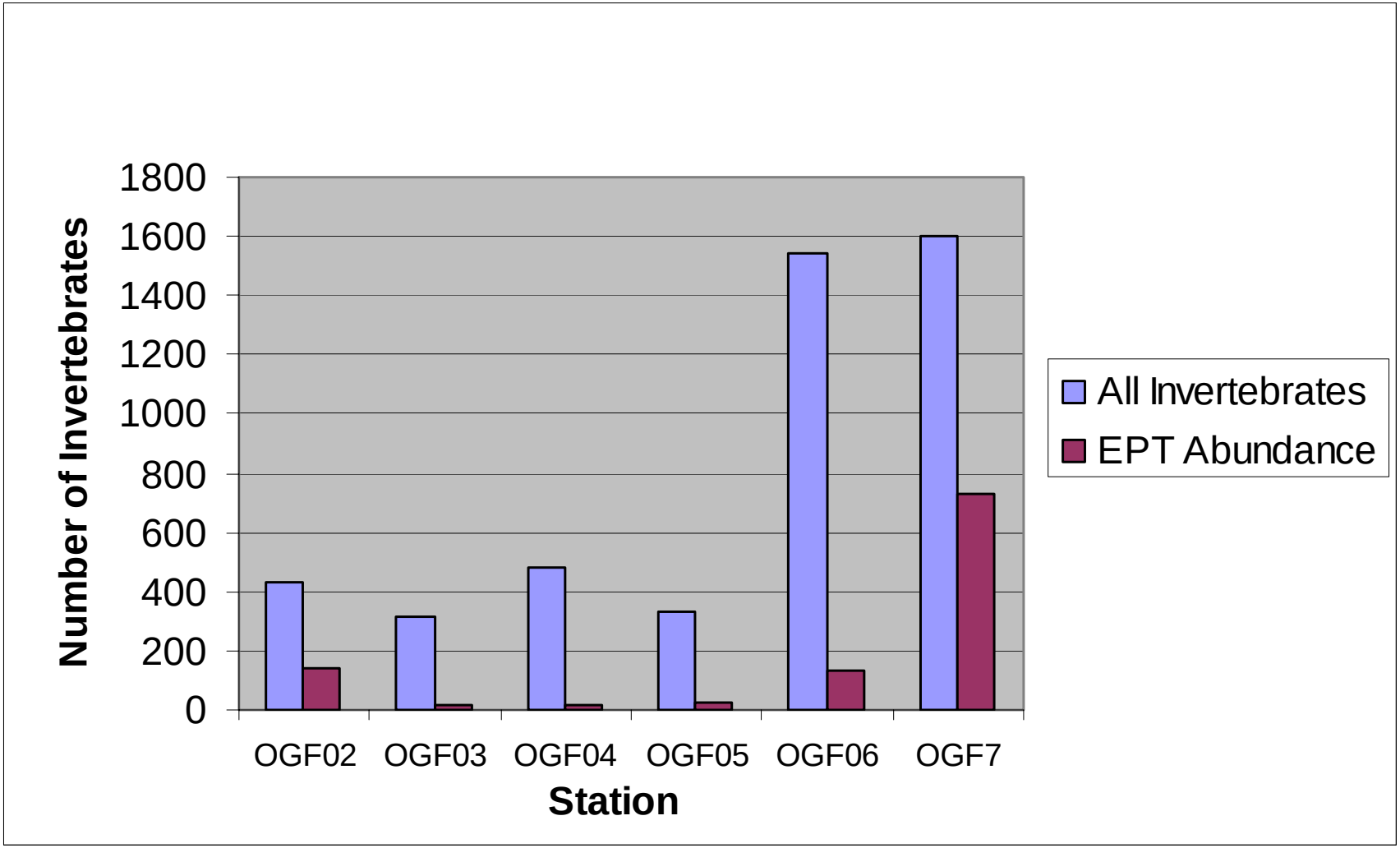
Kiggins - Nisbet Mines Estacada, Oregon	**Aquatic Sampling Stations**	Figure 3

Source: S:\SHAREDOC\K-N Figures.xls Fig 5 Pool Abundance



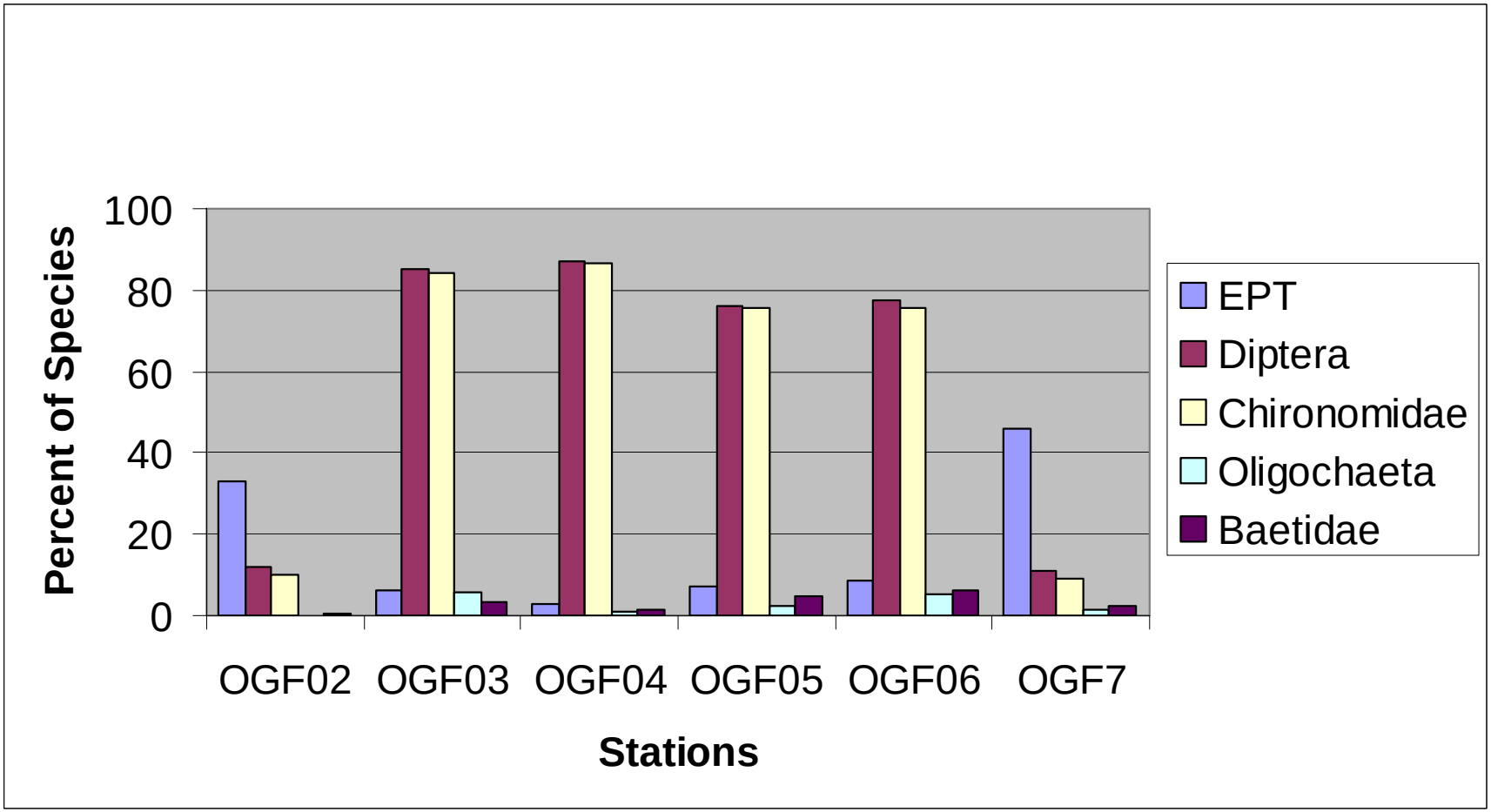
LANDAU ASSOCIATES

Kiggins-Nisbet Mines
Estacada, Oregon

Invertebrate Abundance in Pool Habitats

Figure
4

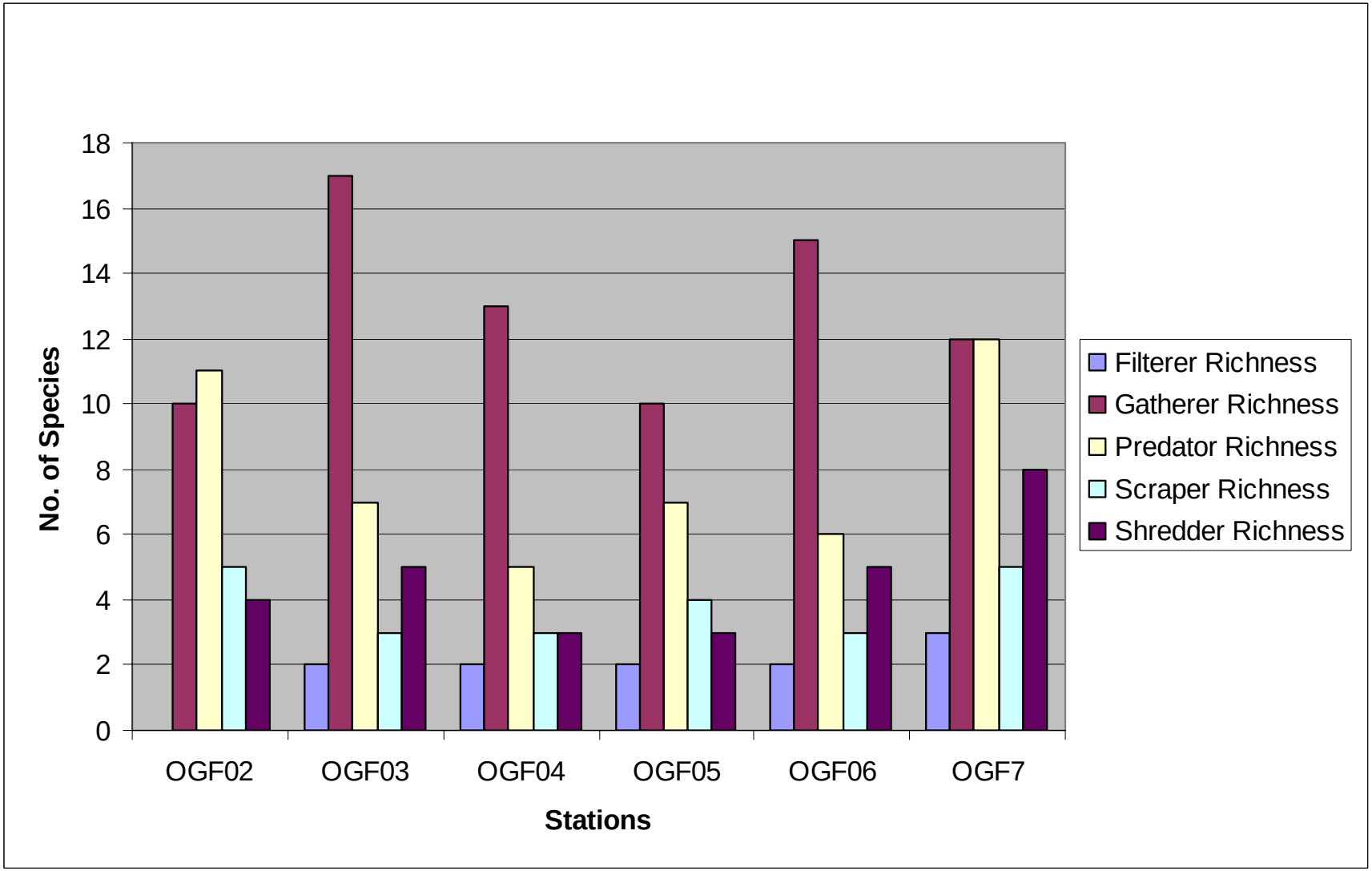
Source: S:\SHAREDOC\K-N Figures.xls Fig 6 Percent Pool Abundance



LANDAU ASSOCIATES

Kiggins-Nisbet Mines Estacada, Oregon	**Community Composition in Pool Habitats**	Figure 5

Source: S:\SHAREDOC\K-N Figures.xls Fig 7 Pool FunGrp Diversity



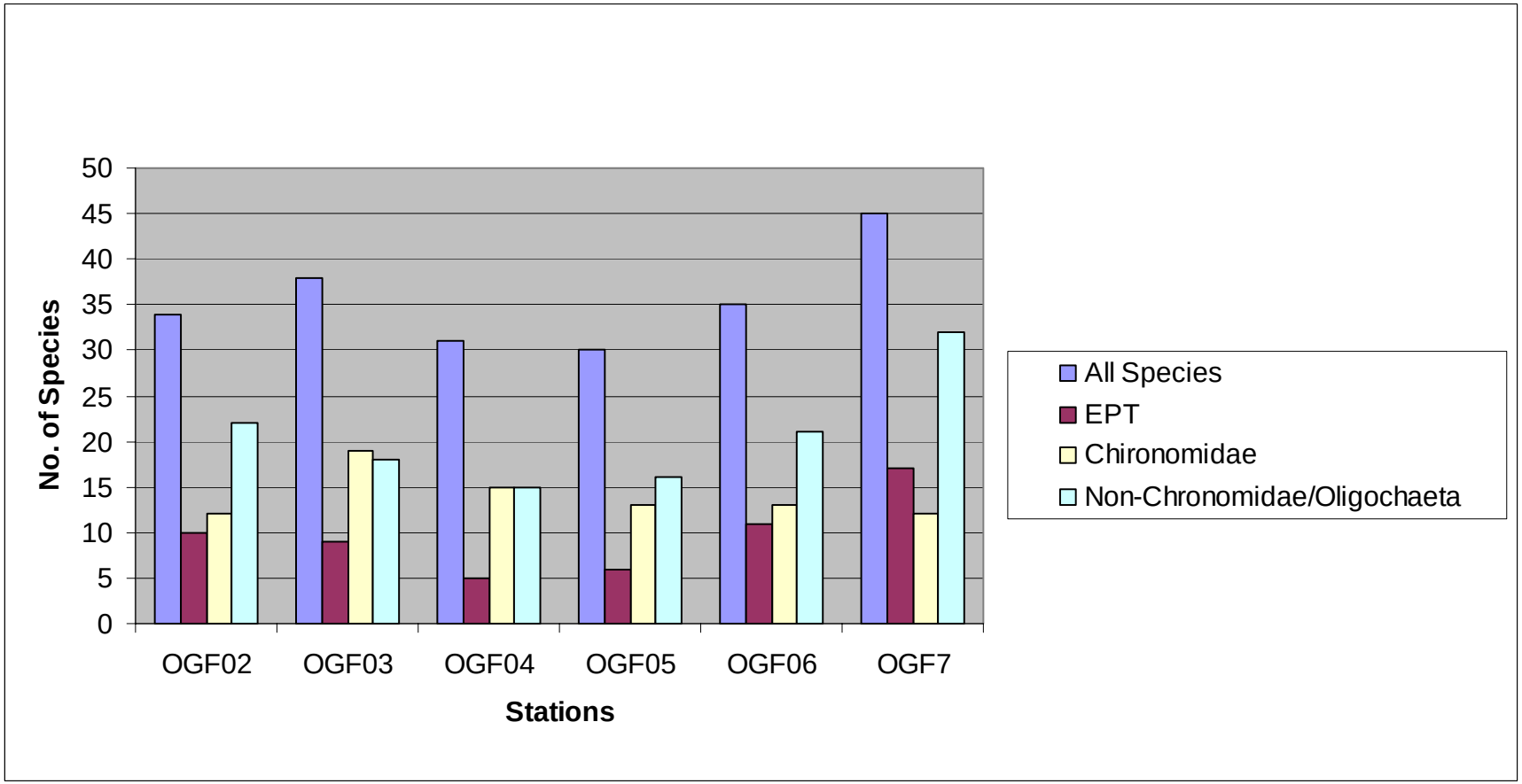
LANDAU ASSOCIATES

Kiggins-Nisbet Mines
Estacada, Oregon

Functional Feeding Group Composition in Pool Habitats

Figure
6

Source: S:\SHAREDOC\K-N Figures.xls Fig 8 Pool Species Diversity



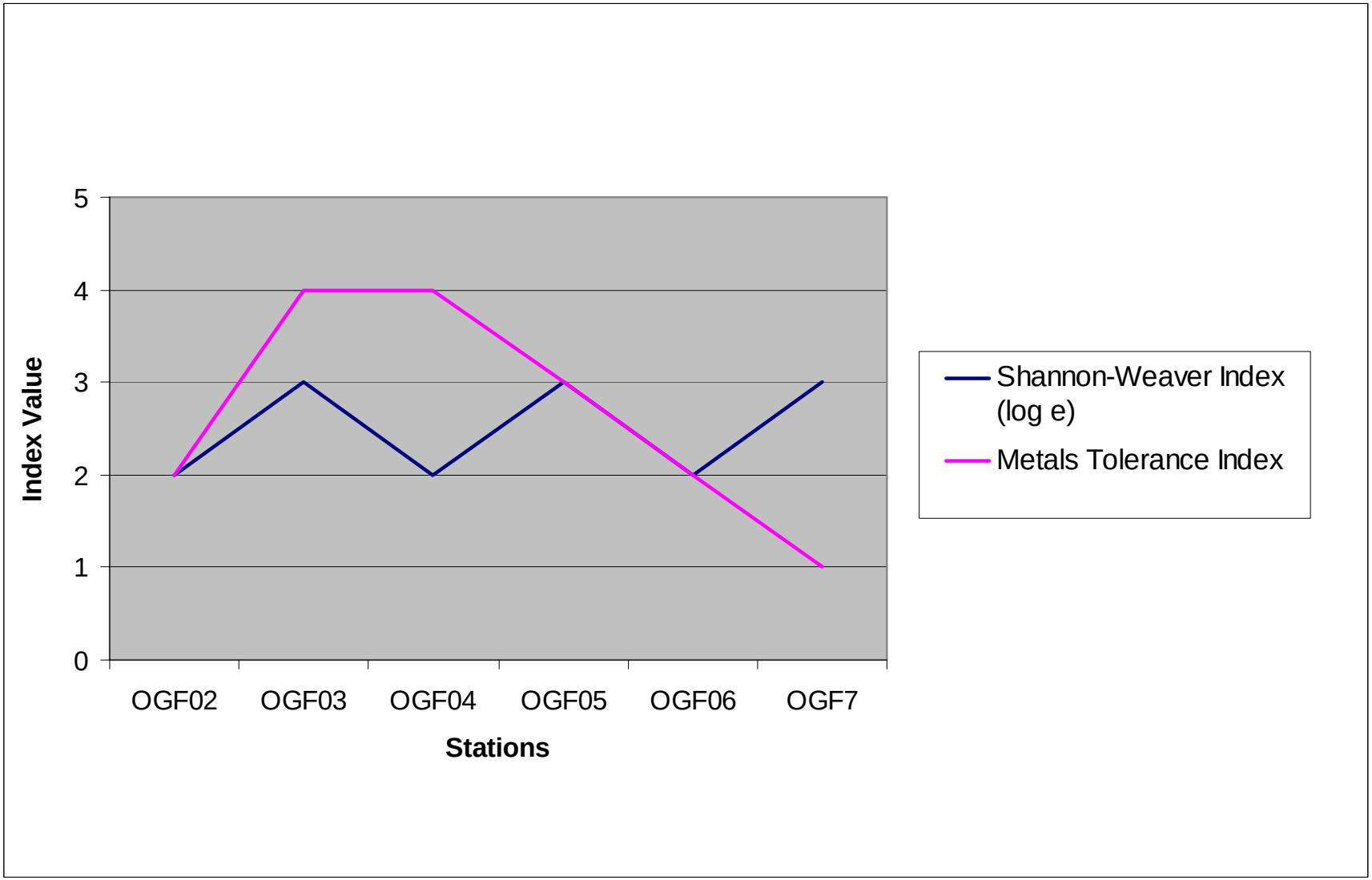
LANDAU ASSOCIATES

Kiggins-Nisbet Mines
Estacada, Oregon

Species Diversity in Pool Habitats

Figure
7

Source: S:\SHAREDOC\K-N Figures.xls Fig 9 Pool Tolerance



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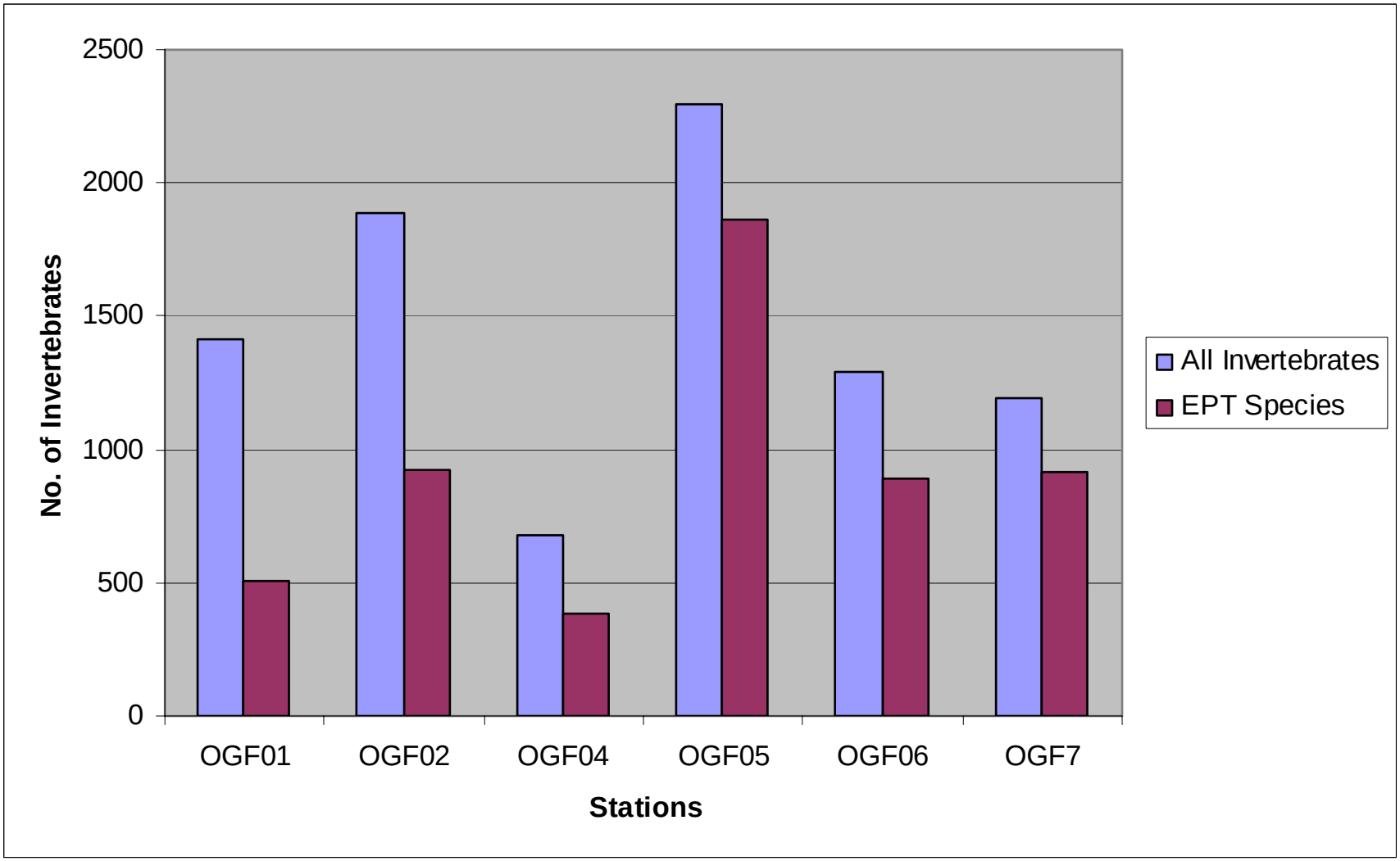
Kiggins-Nisbet Mines
Estacada, Oregon

Biological Indices for Pool Habitats

Figure
8

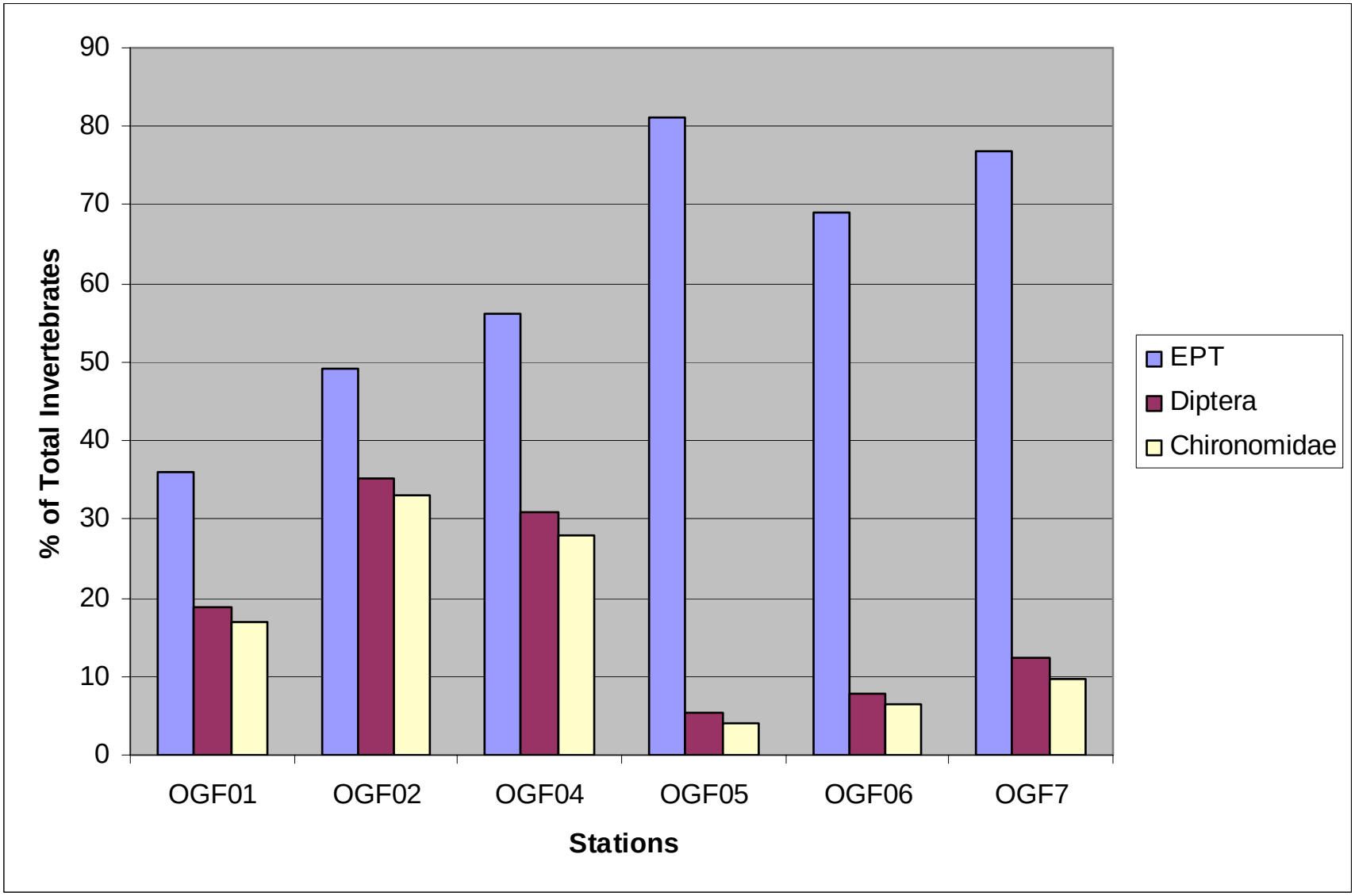
Source: S:\SHAREDOC\K-N Figures.xls Fig 10 Riffle Abundance



LANDAU ASSOCIATES

Kiggins-Nisbet Mines Estacada, Oregon	**Invertebrate Abundance in Riffle Habitats**	Figure 9

Source: S:\SHAREDOC\K-N Figures.xls Fig 11 Riffle Percent Abundance



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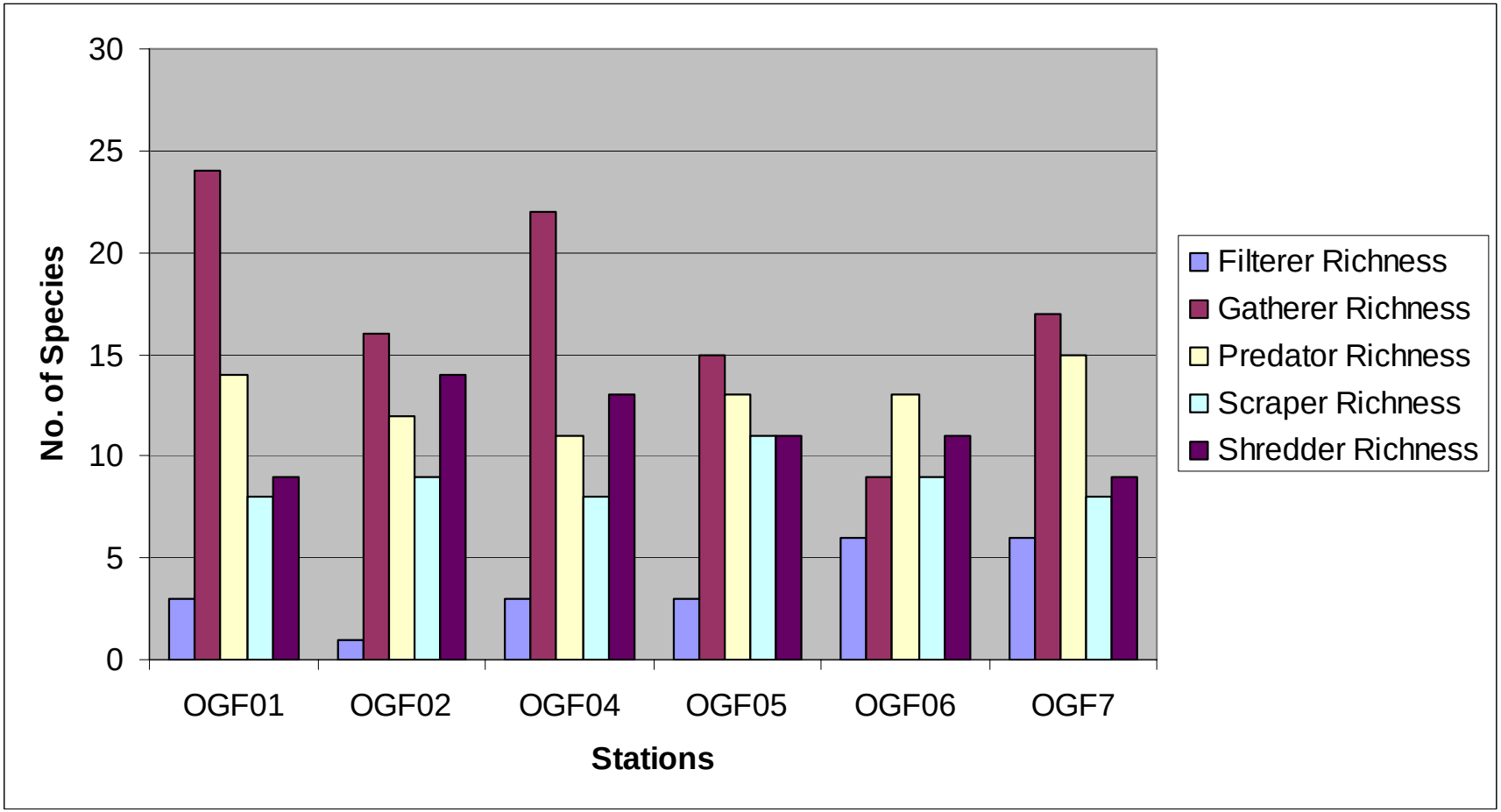
Kiggins-Nisbet Mines
Estacada, Oregon

Community Composition in Riffle Habitats

Figure
10

Source: S:\SHAREDOC\K-N Figures.xls Fig 12 Riffle FunGrp



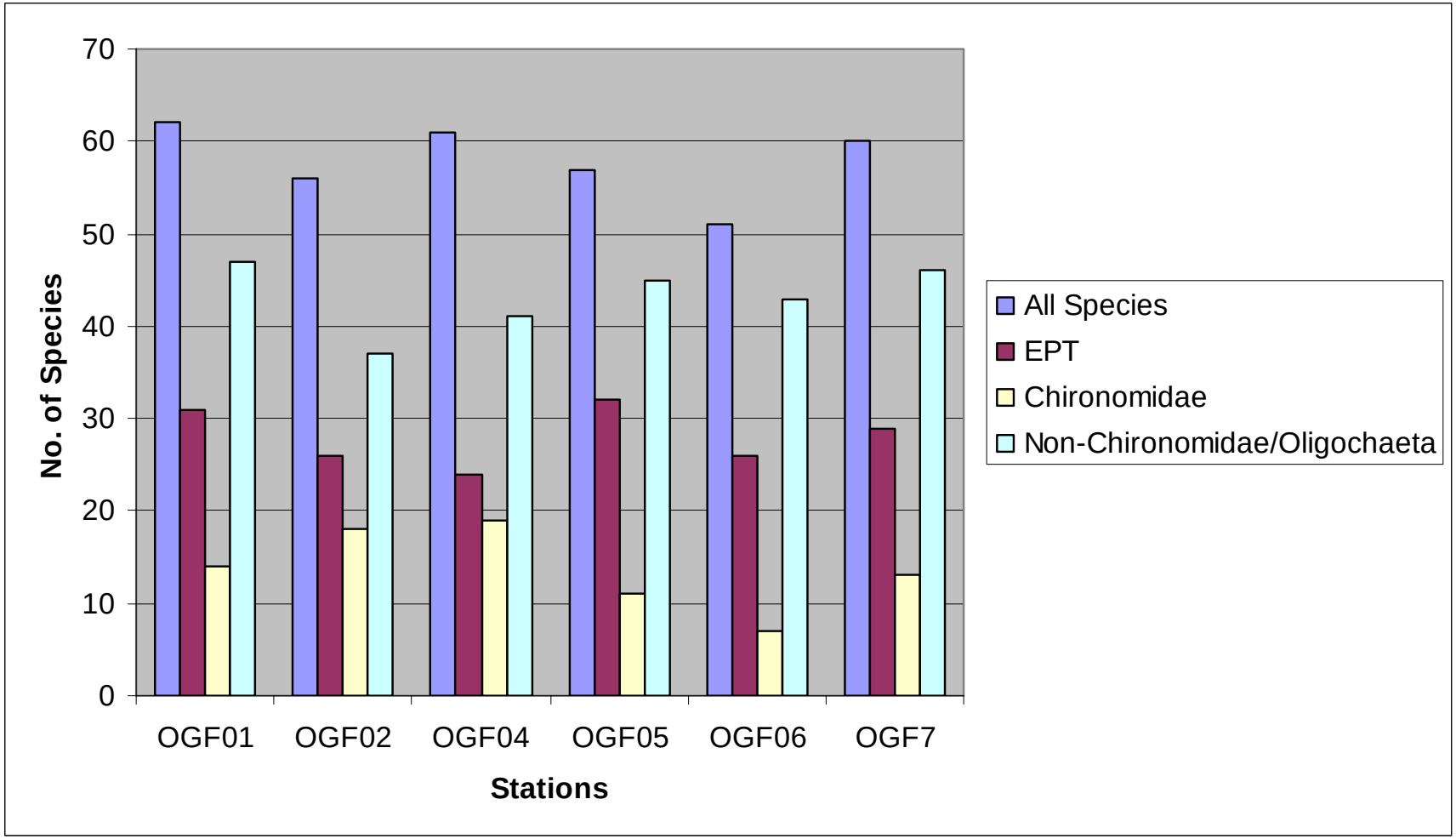
LANDAU ASSOCIATES

Kiggins-Nisbet Mines
Estacada, Oregon

Functional Feeding Group Composition in Riffle Habitats

Figure
11

Source: S:\SHAREDOC\K-N Figures.xls Fig 13 Riffle Diversity



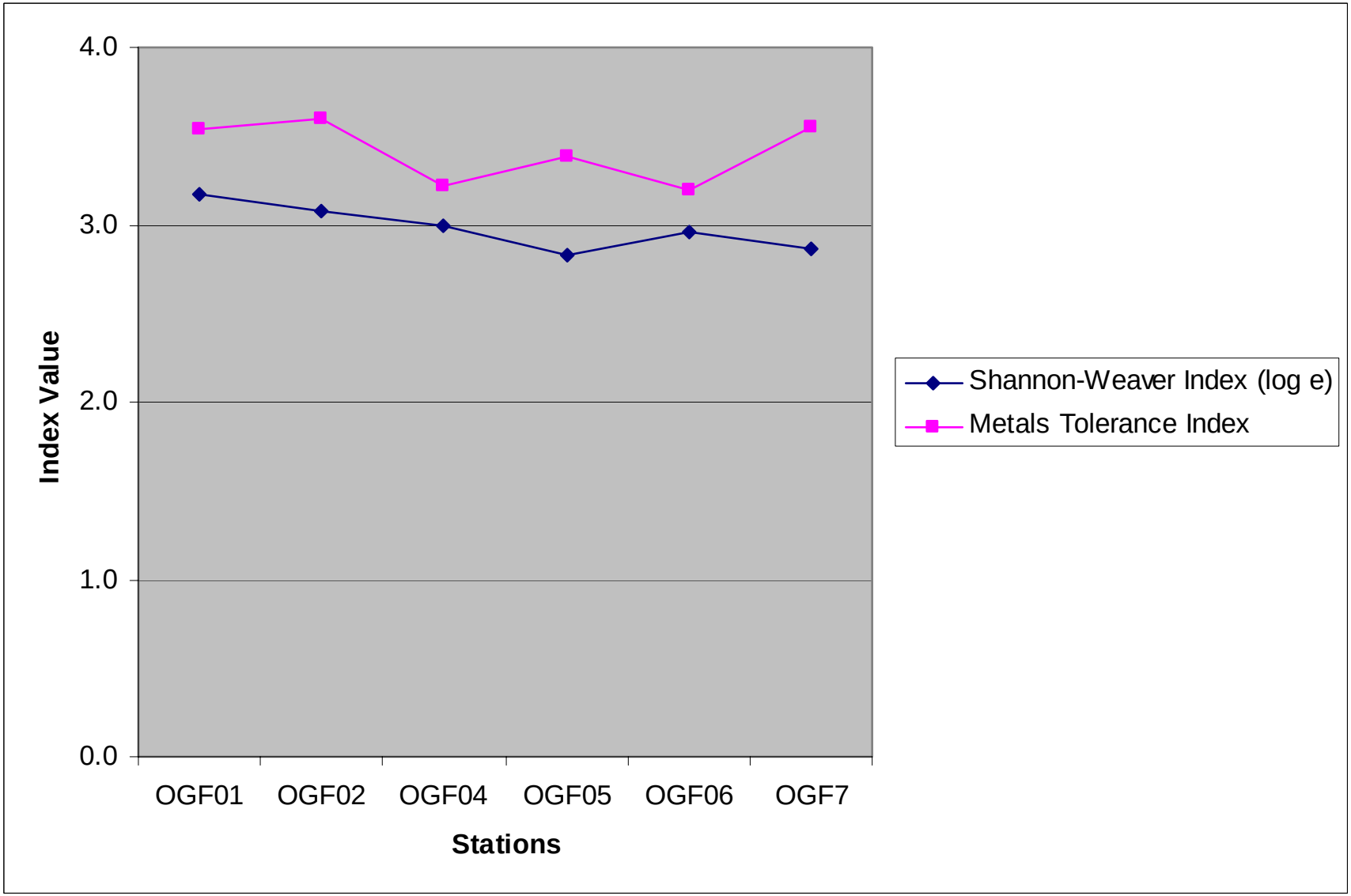
LANDAU ASSOCIATES

Kiggins-Nisbet Mines
Estacada, Oregon

Species Diversity in Riffle Habitats

Figure
12

Source: S:\SHAREDOC\K-N Figures.xls Fig 14 Riffle Tolerance



LANDAU ASSOCIATES

Kiggins-Nisbet Mines
Estacada, Oregon

Biological Indices for Riffle Habitats

Figure
13

TABLE 1
PLANT SPECIES AND PERCENT COVER BY SURVEY STATION
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Location (a):	OS	OF	OF	OS	OS	OS	OF	OS	OS	OS	OS
	Survey Station (b):	NV-4	NV-1	NV-6	KV-3	KV-4	NV-3	NV-2	KV-1	KV-5	NV-5	KV-2
	Habitat Type (c):	CF	CF	CF	CF	R	R	R	S	MF	MF	PEM
	Common Name											
TREES												
Acer macrophyllum	big leaf maple					15		20		25		
Alnus rubra	red alder					55	35	20			30	
Thuja plicata	western redcedar	15	10	25	55							
Pseudotsuga mensiezii	Douglas fir	20	40	20								
Tsuga heterophylla	western hemlock	40	40	50	35					5	15	
SHRUBS												
Acer circinatum	vine maple	10	2			20			<1	10		
Acer macrophyllum	big leaf maple (sapling)							2				
Alnus rubra	red alder (sapling)					2	35	10	2	5		
Aruncus dioicus	goats beard									3		
Cladothamnus pyroliflorus	copperbrush			<1								
Cornus sericea	red-stemmed dogwood					3	5					
Gaultheria shallon	salal	15		5								
Holodiscus discolor	Ocean spray										10	
Mahonia nervosa	dull Oregon grape	1	50	65								
Oemlaria cerasiformis	Indian plum									5		
Pseudotsuga mensiezii	Douglas fir (sapling)							<1			5	
Ribes lacustre	black gooseberry					5						
Ribes viscosissum	sticky currant								<1			
Rosa pisocarpa	squaw currant			3				1				
Rubus armenicus	Himalayan blackberry			1								
Rubus leucodermis	black raspberry					1			2			
Rubus parviflorus	thimbleberry		2			1			20	2	30	4
Rubus spectabilis	salmonberry								8			
Salix lucida	Pacific willow						5					
Thuja plicata	western redcedar (sapling)			25		5	<1					
Tsuga heterophylla	western hemlock (sapling)		5	30		7		<1			15	
Tsuga mertensiana	mountain hemlock (sapling)			10								
Vaccinium parvifolium	red huckleberry	1	5									
GROUNDCOVER												
Achlys triphylla	vanilla leaf			1								
Adenocaulon bicolor	pathfinder			1								
Adiantum pedatum	maidenhair fern					3	5			65	30	10
Anaphalis margaritacea	pearly everlasting								<1			
Angelica genuflexa	kneeling angelica											1
Athyrium felix-femina	lady fern	10					2	2				20
Bromus sp.	brome species					1		1				
Carex deweyana	Dewey's sedge					4						
Cirsium vulgare	bull thistle	2							<1			
Epilbium angustifolium	fireweed							1				
Epilbium ciliatum	Watson's willow-herb						10	1	<1			
Festuca sp.	fescue species	5				2	3	5		2		
Fragaria virginiana	wild strwaberry								2			
Galium triflorum	sweet-scented bedstraw			1				5	<1			
Geum macrophyllum	large leaved avens					5	1		1			
Glyceria sp.	mannagrass species					2						3
Goodyera oblongifolia	rattlesnake plantain			2								
Heuchera micranths	small-flowered alum root			<1								
Leucanthemum vulgare	oxeye daisy					<1			4			
Linnaea borealis	twinflower			4								
Lysitchitum americanum	skunk cabbage											2
Montia siberica	Siberian miners-lettuce							3		1		
Oenanthe sarmentosa	water parsley											10
Osmorhiza chilensis	mountain sweet cicely					5						

TABLE 1
PLANT SPECIES AND PERCENT COVER BY SURVEY STATION
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Location (a):	OS	OF	OF	OS	OS	OS	OF	OS	OS	OS	OS
	Survey Station (b):	NV-4	NV-1	NV-6	KV-3	KV-4	NV-3	NV-2	KV-1	KV-5	NV-5	KV-2
	Habitat Type (c):	CF	CF	CF	CF	R	R	R	S	MF	MF	PEM
	Common Name											
Petasites palmatus	palmate colts foot						2	4	-			30
Plantago major	broad-leaf plantain						4					
Polystichum munitum	sword fern		10	4	1	5				2	6	
Saxifragia nelsoniana	heart-leaved saxifrage							2				
Senecio triangularis	arrow-leaved groundsel					1	2	15	2	<1		<1
Smilicina racemosa	False Solomon seal		4			2					1	
Sonchus asper	prickly sow								<1			
Stachys coolyei	Cooley's hedgenettle							1				1
Tolmeia menziesii	piggyback plant					30		1		2		1
Trientalis latifolia	western starflower		15	1			<1	5				
Trillium ovatum	western trillium			<1								
Viola glabella	yellow wood violet			2								
Viola palustris	marsh violet			<1								
MOSSES												
Bryum Psuedotriquetrum	tall clustered thread moss							20				
Climacium dendroides	tree moss	30										
Hylocomium splendens	stair step moss	60	90	70	1			25		15		
Sphagnum sp.	sphagnum moss species			30								

Notes:

(a) OS = Onsite, OF = Offsite

(b) K = Kiggins mine, N = Nisbet mine, V-1, V-2, etc. refers to the sample station number.

(c) CF = Coniferous Forest, MF = Mixed Forest, R = Riparian, S = Shrub, PEM = Palustrine Emergent Wetland

TABLE 2
SENSITIVE PLANT SPECIES LIST
U.S. FISH AND WILDLIFE SERVICE/OREGON DEPARTMENT OF AGRICULTURE - FEBRUARY 2001
KIGGINS/NISBET MINES
ESTACADA, OREGON
(Source: ONHP 2001)

Species Name	Common Name	Federal Status (a)	State Status (b)
Arabis suffrutescens var. *horizontalis*	Crater lake rockcress	SoC	C
Asarum wagneri	Green-flowered wild ginger		C
Aster curtus	White-topped aster	SoC	LT
Aster vialis	Wayside aster	SoC	LT
Bolandra oregana	Oregon bolandra		C
Botrychium pumicola	Pumice grape-fern		LT
Botrychium crenulatum	Crenulate moonwort	SoC	C
Calochortus umpquaensis	Umpqua mariposa-lily	SoC	LE
Camassia howellii	Howell's camas	SoC	C
Cimicifuga elata	Tall bugbane		C
Cordylanthus maritimus ssp. *palustris*	Salt-marsh bird's-beak		LE
Corydalis aquae-gelidae	Cold-water corydalis		C
Cypripedium fasciculatum	Clustered lady's slipper	SoC	C
Delphinium oreganum	Willamette Valley larkspur		C
Delphinium pavonaceum	Peacock larkspur	SoC	LE
Erigeron decumbens var. *decumbens*	Willamette daisy	LE	LE
Erigeron howellii	Howell's daisy		C
Erigeron oreganus	Oregon daisy	Soc	C
Filipendula occidentalis	Queen-of-the-forest	SoC	C
Frasera umpquaensis	Umpqua swertia		C
Hackelia diffusa var. *diffusa*	Diffuse stickweed		C
Horkelia congesta ssp. *congesta*	Shaggy horkelia	SoC	C
Kalmiopsis fragans	Fragrant kalmiopsis	SoC	
Lathyrus holochlorus	Thin-leaved peavine	SoC	
Limnanthes gracilis var. *gracilis*	Slender meadow-foam		C
Lomatium bradshawii	Bradshaw's lomatium	LE	LE
Lupinus sulphureus ssp. *kincaidii*	Kincaid's lupine	LT	LT
Micorseris laciniata ssp. *detlingii*	Detling's microseris	SoC	
Montia howelii	Howell's montia		C
Penstemon barrettiae	Barrett's penstemon	SoC	C
Perideridia erythrorhiza	Red-root yampa	SoC	C
Plagiobothrys figuratus var. *corallicarpus*	Coral-seeded allocarya	SoC	C
Rorippa columbiae	Columbia cress		C
Sisyrinchium sarmentosum	Pale blue-eyed grass	SoC	C
Sullivantia oregana	Oregon sullivantia	SoC	C

Notes:

C = Candidate Species for listing as threatened or endangered.

LE = Listed Endangered Species

LT = Listed Threated Species

SoC = Federal Species of Concern

TABLE 3
U.S. FOREST SERVICE SURVEY MANAGE LIST - MARCH 2003
KIGGINS/NISBET MINES
ESTACADA, OREGON
(Source: Williamson et al. 2003 and Horvath 2003)

Scientific Name	Common Name	Federal Status (a)	State Status (b)
FUNGI			
Bridgeoporus nobilissimus (Oxyporus nobilissimus)	Fuzzy sandwort		
Gomphus clavatus	pig's ears		
Helvella elastica	no common name		
Polyozellus multiplex	blue chanterelle		
Ramaria celerivirescens	no common name		
Ramaria maculatipes	no common name		
Rhizopogon brunneiniger	no common name		
LICHENS			
Bryoria tortuosa	no common name		
Dendriscocaulon entracatulum	no common name		
Hypogymnia duplicata	Rare leafy lichen		
Loberia linita	Cabbage lungwort		
Nephroma occultum	Paw		
Platismatia lacunosa	crinkled rag		
BRYOPHYTES			
Schistostega pennata	Schistostega		
Tetraphis geniculata	Bent-kneed four-tooth moss		
VASCULAR PLANTS			
Botrychium minganense	Gray moonwort		
Botrychium montanum	Mountain grape-fern		
Carex livida	Pale sedge		
Cimicifuga elata	Tall bugbane		
Coptis trifolia	Three-leaf goldthread		C
Corydalis aquae-gelidae	Cold water corydalis		C
Cypripedium fasciculatum	Clustered lady's slipper	SoC	C
Cypripedium montanum	Mountain lady's slipper		
Erigeron howellii	Howell's daisy		C
Howellia aquatilis	Howellia	LT	
Lycopodium complanatum	Ground cedar		
Ophioglossum pusillum	Adder's tongue		
Sisyrinchium sarmentosum	Pale blue-eyed grass	SoC	C
Wolfia columbiana	Columbia water-meal		

Notes:

C = Candidate Species for listing as threatened or endangered.

LE = Listed Endangered Species

LT = Listed Threated Species

SoC = Federal Species of Concern

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Common Name	Federal Status	Oregon State Status	Forest Service Sensitive or Survey and Manage Species	Observed/ Expected
Corvus brachyrhynchos	American Crow				E
Cinclus mexicanus	American Dipper				O
Calypte anna	Anna's Hummingbird				P
Haliaeetus leucocephalus	**Bald Eagle**	**FT**			**P**
Riparia riparia	Bank Swallow				P
Strix varia	Barred Owl				E
Megaceryle alcyon	Belted Kingfisher				E
Thryomanes bewickii	Bewick's Wren				E
Leucosticte atrata	Black Rosy Finch				E
Picoides arcticus	**Black-backed Woodpecker**		**Critical**		**P**
Parus atricapillus	Black-capped Chickadee				O
Archilochus alexandri	Black-Chinned hummingbird				E
Pheucticus melanocephalus	Black-headed Grosbeak				E
Dendroica nigrescens	Black-throated Gray Warbler				P
Dendragapus obscurus	Blue Grouse				E
Cyanocitta cristata	Blue Jay				E
Bombycilla garrula	Bohemian Waxwing				P
Parus hudsonicus	Boreal Chickadee				E
Aegolius funereus	Boreal Owl				E
Euphagus cyanocephalus	Brewer's Blackbird				E
Spizella breweri	Brewer's Sparrow				E
Certhia familiaris	Brown Creeper				E
Molothrus ater	Brown-headed Cowbird				E
Icterus bullockii	Bullocks Oriole				E
Psaltriparus minimus	Bushtit				P
Stellula calliope	Calliope Hummingbird				P
Carpodacus cassinii	Cassin's Finch				E
Bombycilla cedrorum	Cedar Waxwing				E
Parus rufescens	Chestnut-backed Chickadee				E
Nucifraga columbiana	Clark's Nutcracker				E
Petrochelidon pyrrhonota	Cliff Swallow				E
Chordeiles minor	Common Nighthawk				E
Corvus corax	Common Raven				E
Carduelis flammea (Acanthis flammea)	Common Redpoll				E
Geothlypis trichas	Common Yellowthroat				E
Accipiter cooperii	Cooper's Hawk				E
Empidonax occidentalis	Cordilleran Flycatcher				P
Junco hyemalis	Dark-eyed Junco (Slate-colored)				E
Picoides pubescens (Dendrocopos pubescens)	Downy Woodpecker				E
Empidonax oberholseri	Dusky Flycatcher (Wright's Flycatcher)				E
Tyrannus tyrannus	Eastern Kingbird				E
Hesperiphona vespertina	Evening Grosbeak				E
Buteo regalis	**Ferruginous Hawk**	**FCo**	**Critical**		**E**
Passerella iliaca	Fox Sparrow				E
Regulus satrapa	Golden-crowned Kinglet				E
Zonotrichia atricapilla	Golden-crowned Sparrow				E
Accipiter gentilis	Goshawk	FCo			E
Dumetella carolinensis	Gray Catbird				E
Empidonax wrightii	**Gray Flycatcher**			**X**	**P**
Perisoreus canadensis	Gray Jay				E
Perdix perdix	Gray Partridge (Hungarian Partridge)				E
Leucosticte tephrocotis	Gray-crowned Rosy Finch				E
Ardea herodias	Great Blue Heron				E
Strix nebulosa	**Great Gray Owl**		**Vulnerable**	**X**	**E**
Bubo virginianus	Great Horned Owl				E
Pipilo chlorurus	Green-tailed Towhee				P
Falco rusticolus	Gyrfalcon				E
Picoides villosus (Dendrocopos villosus)	Hairy Woodpecker				E
Empidonax hammondii	Hammond's Flycatcher				E
Histrionicus histrionicus	**Harlequin Duck**	**FCo**		**X**	**E**

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Common Name	Federal Status	Oregon State Status	Forest Service Sensitive or Survey and Manage Species	Observed/ Expected
Zonotrichia querula	Harris' Sparrow				E
Surnia ulula	Hawk Owl				E
Catharus guttatus (Hylochichla guttata)	Hermit Thrush				E
Dendroica occidentalis	Hermit Warbler				E
Carduelis hornemanni (Acanthis hornemanni)	Hoary Redpoll				E
Carpodacus mexicanus	House Finch				E
Troglodytes aedon	House Wren				E
Vireo huttoni	Hutton's Vireo				P
Chondestes grammacus	Lark Sparrow				E
Passerina amoena	Lazuli Bunting				E
Empidonax minimus	Least Flycatcher				E
Carduelis psaltria	Lesser Goldfinch				P
Melanerpes lewis (Asyndesmus lewis)	**Lewis' Woodpecker**		**Critical**		**E**
Melospiza lincolnii	Lincoln's Sparrow				E
Lanius ludovicianus	Loggerhead Shrike	FCo			E
Asio otus	Long-eared Owl				E
Oporornis tolmiei	MacGillivray's Warbler				E
Falco columbarus	Merlin (Pigeon Hawk)				E
Mimus polyglottos	Mockingbird				P
Sialia currucoides	Mountain Bluebird				E
Parus gambeli	Mountain Chickadee				E
Zenaida macroura (Zenaidura macroura)	Mourning Dove				E
Vermivora ruficapilla	Nashville Warbler				E
Colaptes auratus (Colaptes cafer)	Northern Flicker				E
Accipiter gentilis	**Northern Goshawk**		**Critical**		**P**
Circus cyaneus	Northern Harrier				E
Icterus galbula (Icterus bullockii)	Northern Oriole (Bullock's Oriole)				E
Lanius excubitor	Northern Shrike				P
Corvus caurinus	Northwestern Crow				E
Nuttallornis borealis	Olive-sided Flycatcher	FCo			E
Vermivora celata	Orange-crowned Warbler				E
Pandion haliaetus	Osprey				E
Empidonax difficilis	Pacific-Slope Flycatcher				E
Falco peregrinus	**Peregrine Falcon**	**FCo**		**X**	**P**
Dryocopus pileatus	**Pileated Woodpecker**		**Critical**		**E**
Pinicola enucleator	Pine Grosbeak				E
Carduelis pinus (Spinus pinus)	Pine Siskin				E
Falco mexicanus	Prairie Falcon				E
Carpodacus purpureus	Purple Finch				E
Sitta pygmaea	Pygmy Nuthatch				E
Glaucidium gnoma	Pygmy Owl				E
Loxia curvirostra	Red Crossbill				E
Sitta canadensis	Red-breasted Nuthatch				O
Sphyrapicus ruber	Red-breasted Sapsucker				E
Vireo olivaceus	Red-eyed Vireo				P
Buteo jamaicensis	Red-tailed Hawk				E
Agelaius phoeniceus	Red-winged Blackbird				P
Turdus migratorius	Robin				O
Salpinctes obsoletus	Rock Wren				E
Buteo lagopus	Rough-legged Hawk				E
Stelgidopteryx ruficollis	Rough-winged Swallow				E
Regulus calendula	Ruby-crowned Kinglet				E
Bonasa umbellus	Ruffed Grouse				E
Selasphorus rufus	Rufous Hummingbird				E
Euphagus carolinus	Rusty Blackbird				E
Aegolius acadicus	Saw-whet Owl				E
Otus asio	Screech Owl				E
Accipiter striatus	Sharp-shinned Hawk				E
Vireo solitarius	Solitary Vireo				E
Melospiza melodia	Song Sparrow				E

TABLE 4
BIRD SPECIES POTENTIALLY INHHABITING THE VICINITY OF THE SITE
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Common Name	Federal Status	Oregon State Status	Forest Service Sensitive or Survey and Manage Species	Observed/ Expected
Pipilo erythrophthalmus	Spotted (Rufous-sided) Towhee				E
Strix occidentalis	**Spotted Owl**	**FT**	**ST**	**X**	**E**
Canachites canadensis	Spruce Grouse				E
Sturnus vulgaris	Starling				P
Cyanocitta stelleri	Steller's Jay				O
Buteo swainsoni	**Swainson's Hawk**		**Vulnerable**		**E**
Catharus ustulata (Hylocichla ustulata)	Swainson's Thrush				E
Vermivora peregrina	Tennessee Warbler				E
Picoides tridactylus	**Three-toed Woodpecker**		**Critical**		**E**
Myadestes townsendi	Townsend's Solitaire				E
Dendroica townsendi	Townsend's Warbler				E
Spizella arborea	Tree Sparrow				E
Iridoprocne bicolor	Tree Swallow				E
Meleagris gallopavo	Turkey				P
Cathartes aura	Turkey Vulture				E
Ixoreus naevius	Varied Thrush				E
Chaetura vauxi	Vaux's Swift				E
Pooecetes gramineus	Vesper Sparrow				E
Tachycineta thalassina	Violet-green Swallow				E
Vireo gilvus	Warbling Vireo				P
Sialia mexicana	**Western Bluebird**		**Vulnerable**		**E**
Empidonax difficilis	Western Flycatcher				E
Tyrannus verticalis	Western Kingbird				E
Sturnella neglecta	Western Meadowlark				E
Piranga ludoviciana	Western Tanager				E
Contopus sordidulus	Western Wood Pewee				E
Sitta carolinensis	White-breasted Nuthatch				P
Zonotrichia leucophrys	White-crowned Sparrow				E
Picoides albolarvatus (Dendrocopos albolarvatus)	**White-headed Woodpecker**		**Critical**		**E**
Zonotrichia albicollis	White-throated Sparrow				E
Loxia leucoptera	White-winged Crossbill				E
Sphyrapicus thyroideus	Williamson's Sapsucker				E
Empidonax traillii	Willow Flycatcher (Traill's Flycatcher)	FCo			E
Wilsonia pusilla	Wilson's Warbler				E
Troglodytes troglodytes	Winter Wren				E
Dendroica petechia	Yellow Warbler				E
Sphyrapicus varius	Yellow-bellied Sapsucker				E
Icteria virens	Yellow-breasted Chat				E
Xanthocephalus xanthocephalus	Yellow-headed blackbird				E
Dendroica coronata	Yellow-rumped Warbler				E

Notes:

Bold indicates regulated or managed species observed, expected, or possible at the site.

Blank status indicates no listing was available for the species.

E = Expected at or near the site

FC = Federal Candidate Species

FCo = Federal Species of Concern indicating there is not enough data to assess species status.

FE = Federal Endangered Species

FT = Federal Threatened indicating species is likely to become federally endangered.

O = Observed at or near the site

P = Possibly present at or near the site

ST = State Threatened indicating the species is likely to become state endangered

TABLE 5
MAMMAL SPECIES DOCUMENTED OR EXPECTED AT THE SITE
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Common Name	Federal Status	Oregon State Status	Forest Service Sensitive or Survey and Manage Species	Observed/ Expected
MAMMALS					
Aplodontia rufa	Aplodontia (Mountain Beaver)				O
Sorex bairdii bairdii	**Baird's Shrew**			**X**	**E**
Castor canadensis	Beaver				E
Eptisicus fuscus	**Big Brown Bat**			**X**	**E**
Ursus americanus	Black Bear				E
Odocoileus hemionus columbianus	Black-tailed Deer				E
Lynx rufus	Bobcat				O
Clethrionomys gapperi	Boreal Redback Vole				E
Neotoma cinerea	Busytail Woodrat				E
Myotis californicus	California Myotis				E
Spermophillus sateratus (Citellus sateratus)	Cascade Golden-mantled Ground Squirrel				E
Canis latrans	Coyote				E
Peromyscus maniculatus	Deer Mouse				E
Tamiasciurus douglasi	Douglas Squirrel - Chickaree				O
Sorex obscurus	Dusky Shrew				E
Martes pennanti	**Fisher**	**FCo**	**Critical**	**X**	**E**
Myotis thysanodes	**Fringed Myotis**	**FCo**	**Vulnerable**	**X**	**E**
Spermophilus lateralis	Golden-mantled Ground Squirrel				E
Phenacomys intermedius	Heather Vole				E
Felis concolor	Hoary Bat				E
Myotis keeni	Keen's Myotis				E
Eutamias minimus	Least Chipmunk				E
Myotis lucifugus	**Little Brown Bat**			**X**	**E**
Myotis evotis	**Long-eared Myotis**	**FCo**		**X**	**E**
Myotis volans	**Long-legged Myotis**	**FCo**		**X**	**E**
Microtus longicaudus	Longtail Vole				E
Mustela frenata	Longtail Weasel				E
Lynx canadensis	**Lynx**	**FT**			**P**
Martes americana	**Marten**		**Critical**	**X**	**E**
Sorex cinereus	Masked Shrew				P
Mustela vision	Mink				E
Felis concolor	Mountain Lion (Cougar)				E
Microtus montanus	Mountain Vole				E
Glaucomys sabrinus	Northern Flying Squirrel				E
Sorex palustris	Northern Water Shrew				E
Microtus oregoni	Oregon Vole				E
Myotis thysanodes vespertinus	**Pacific Fringe-tailed Bat**			**X**	**E**
Antozous pallidus	**Pallid Bat**		**Vulnerable**		**E**
Microsorex hoyi	Pgymy Shrew				E
Erethizon dorsatum	Porcupine				E
Procyon lotor	Raccoon				E
Lasiurus borealis	Red Bat				E
Vulpes fulva	Red Fox				P
Aborimus longicaudus	**Red Tree Vole**			**X**	**E**
Lutra canadensis	River Otter				E
Cervus elaphus roosevelti	**Roosevelt Elk**			**X**	**E**
Mustela erminea	Shorttail Weasel (Ermine)				E
Neuotrichus gibbsi	Shrew-mole				E
Lasionycteris noctivagans	**Silver-haired Bat**			**X**	**E**
Myotis leibii	**Small-footed Myotis**	**FCo**			**E**
Spilogale putorius	Spotted Skunk				P
Mephitis mephitis	Striped Skunk				E
Coryhorhinus townsendii	**Townsend's Big-eared Bat**	**FCo**	**Critical**	**X**	**E**
Eutamias townsendi	Townsend's Chipmunk				E
Sorex trowbridgei	Trowbridge's Shrew				E
Sorex vagrans	Vagrant Shrew				E
Microtus richardsoni	Water Vole				E
Sciurus griseus	**Western Gray Squirrel**	**FCo**			**P**
Gulo gulo luteus	**Wolverine**	**FCo**		**X**	**E**
Myotis yumanensis	**Yuma Myotis**	**FCo**			**E**

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Blank status indicates no listing was available for the species.

E = Expected at or near the site

FCo = Federal Species of Concern indicating there is not enough data to assess species status.

FT = Federally Threatened indicating species is likely to become federally endangered.

O = Observed at or near the site

P = Possibly present at or near the site

TABLE 6
HERPETILE SPECIES DOCUMENTED OR EXPECTED AT THE SITE
KIGGINS/NISBET MINES
ESTACADA, OREGON

Scientific Name	Common Name	Federal Status	State Status	Forest Service Sensitive or Survey and Manage Species	Observed/ Expected/ Possible
AMPHIBIANS					
Rhyacotriton cascadae	**Cascade Torrent Salamander**			**X**	**E**
Rana cascadae	**Cascades Frog**		**Critical**	**X**	**P**
Aneides ferreus	**Clouded Salamander**		**Critical**		**P**
Dicamptodon copei	**Cope's Giant Salamander**		**Critical**	**X**	**P**
Plethodon dunni	Dunn's Salamander				E
Ensatina eschscholtzii	Ensatina				E
Plethodon larselii	**Larch Mountain Salamander**		**Vulnerable**	**X**	**P**
Ambystoma macrodactylum	Long-toed Salamander				E
Ambystoma gracile	Northwestern Salamander				E
Batrachoseps wrighti	**Oregon Slender Salamander**		**Critical**	**X**	**E**
Dicamptodon tenebrosus	Pacific Giant Slamander				O
Hyla regilla	Pacific Treefrog				E
Rana aurora	**Red-legged Frog**			**X**	**E**
Taricha granulosa	Rough-skinned Newt				O
Rana pretiosa	**Spotted Frog**	**FC**	**Critical**	**X**	**P**
Ascaphus Truei	**Tailed Frog**	**FCo**	**Vulnerable**		**E**
Bufo boreas	Western Toad	FCo			P
REPTILES					
Charina bottae	Rubber Boa				E
Clemmys marmorata	**Northwestern Pond Turtle**			**X**	**P**
Eumeces Skiltonianus	Western Skink				P
Gerrhonotus coeruleus	Northern Alligator Lizard				E
Diadophis punctatus	Ringneck Snake				E
Thamnophis elegans	Western Garter Snake				P
Thamnophis sirtalis	Common Garter Snake				E
Thamnophis ordinoides	Northwestern Garter Snake				E
INVERTEBRATES (Mollusks)					
Monadenia fidelis minor	**Dalles Sideband**			**X**	**P**
Cryptomastix devia	**Puget oregonium**			**X**	**E**
Cryptomastix henderson	**Columbia oregonium**			**X**	**E**
Deroceras hesperium	**Evening Fieldslug**			**X**	**E**
Pristiloma arcticum crateris	**Crater Lake Tightcoil**			**X**	**E**
Oreobasis spp.	**Basalt Juga**			**X**	**P**
Lyogyrus spp.	**Columbia duskysnail**			**X**	**E**

Notes:

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Blank status indicates no listing was available for the species.

E = Expected at or near the site

FCO = Federal Species of Concern

FC = Federal Candidate Species

O = Observed at or near the site

P = Possibly present at or near the site