CONCEPTUAL SITE MODEL FOR THE YERINGTON MINE SITE, LYON COUNTY, NEVADA

(Revision 3)

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ACRONYMS AND ABBREVIATIONS

AQM	Air Quality Monitoring
ARC	Atlantic Richfield Company
Arimetco	Armetco Incorporated
BLM	Bureau of Land Management
CSM	Conceptual Site Model
DSR	Data Summary Report
DTSC	California Department of Toxic Substances Control.
EPA	Environmental Protection Agency
HDPE	High-Density Polyethylene
HFA	Hydrogeologic Framework Assessment North of the Anaconda Mine Site
HHRA	Human Health Risk Assessment
NAAQS	National Ambient Air Quality Standards
NDEP	Nevada Division of Environmental Protection
NDOW	Nevada Division of Wildlife
O&M	Operations and Maintenance
Order	Administrative Order
OU	Operable Unit
PWS	Pumpback Well System
QAPP	Quality Assurance Project Plan
SHSP	Site Health and Safety Plan
Site	Yerington Mine Site
SLERA	Screening-Level Ecological Risk Assessment
SOW	Scope of Work
SSLS	Soil-Screening Levels
SVLs	Soil Level Values
SWMA	Stillwater Wildlife Management Area
SX/EW	Solvent Extraction/Electrowinning
TDS	Total Dissolved Solids
TENORM	Technically Enhanced Naturally Occurring Radioactive Materials
TRVs	Toxicity Reference Values
TSP	Total Suspended Particulates
VLT	Vat Leach Tailings
YPT	Yerington Paiute Tribe

amsl	above mean sea level
bgs	below ground surface
g/l	grams per liter
gpm	gallons per minute
mg/kg	milligrams /kilogram
mrem/year	millirem per year
pCi/g	picocurie
PM_{10}	particulate matter less than 10 microns
ppb	parts per billion
µg/m	micrograms per cubic meter

SECTION 1.0
INTRODUCTION

The Atlantic Richfield Company ("ARC") has prepared this conceptual site model (CSM - Revision 3) pursuant to the Administrative Order ("Order") for Remedial Investigation and Feasibility Study issued by the U.S. Environmental Protection Agency - Region 9 ("EPA") to ARC for the Yerington Mine Site ("Site"). The Order (EPA Docket No. 9-2007-0005) was issued to ARC on January 12, 2007. The location of the Site is depicted in Figure 1-1. This CSM update supercedes the CSM (Revision 2) submitted to EPA on August 29, 2008 (Brown and Caldwell and Integral), and incorporates additional modifications, clarification and information requested by EPA in the comment letter dated January 5, 2009. ARC and EPA recognize that CSM development is an iterative process that will require periodic revisions as new information becomes available as a result of future remedial investigations for operable units ("OUs") at the Site. The following OUs were identified in the Order and attached Scope of Work ("SOW"), as shown in Figure 1-2:

- Site-Wide Groundwater (OU-1)
- Pit Lake (OU-2)
- Process Areas (OU-3)
- Evaporation Ponds and Sulfide Tailings (OU-4)
- Waste Rock Areas (OU-5)
- Oxide Tailings Areas (OU-6)
- Wabuska Drain (OU-7)
- Arimetco Facilities (OU-8)

CSM objectives include: 1) summarize current understanding of the physical features of the Site including known and potential sources of mine-related contamination; 2) describe known and potential chemical migration pathways, and human and ecological populations that may contact mine-related contamination; and 3) remain current with new Site information and updates to the Site Quality Assurance Project Plan (e.g., "QAPP" - Revision 4 dated November 12, 2008).

Human health and ecological models presented in this CSM share a common basis (e.g., physical setting, operations history, known and hypothesized chemical release and transport pathways, and current and potential future land uses). The CSM elements related to exposure media, exposure routes, and populations of concern are used to develop exposure scenarios, which may be discussed further in the human health risk assessment ("HHRA") and screening-level ecological risk assessment ("SLERA") components for each OU. Relevant Site-wide information is presented in Sections 1.1 through 1.5, which provides the basis for the human health and ecological models including specific human health and ecological exposure media, routes of exposure, and populations of potential concern.

1.1 Site Location

The Site is located about 0.5 mile west and northwest of the City of Yerington in Lyon County, Nevada (Figure 1-1). Subsequent to small-scale copper mining in the 1860s and early 1900s, large-scale mining, milling and leaching operations for oxide and sulfide copper ores extracted from the open-pit mine in the southern portion of the Site (Figure 1-2) were conducted between 1953 and 1978 by ARC's predecessor, The Anaconda Company ("Anaconda"). Additional mining from the MacArthur Mine, located about two miles northwest of the Site, and leaching of copper ores at the Site were conducted in the 1990s by Armetco Incorporated ("Arimetco"). Annotated historic aerial photographs for the Site are provided in Appendix A.

The Site is located in Mason Valley within the Walker River watershed. Mason Valley, which includes over 39,000 acres of irrigated land, is one of the most productive agricultural areas in the state (Lopes and Smith 2007). In contrast to sporadic mining operations in the area, agriculture has been the long-term principal economic activity in Mason Valley (i.e., hay and grain farming, with some beef and dairy cattle ranching, and local onion farming). Irrigation water is provided from surface water diversions from the Walker River and from groundwater.

The Walker River flows northerly and northeasterly between the Site and the town of Yerington (the river is within a quarter-mile of the southern portion of the site). The Paiute Tribe Indian Reservation is located approximately 2.5 miles north of the site (Figure 1-1).

1.2 Physical Setting

The physical setting of the Site is within the Basin and Range physiographic province, which is part of the Great Basin sagebrush-steppe ecosystem. Mason Valley occupies a structural graben (i.e., down-dropped faulted basin) immediately east of the Singatse Range, an uplifted mountain block. Vegetative communities in the area vary from relatively dense associations along the Walker River immediately east of the Site to sparse brush found on the alluvial fans derived from Singatse Range, immediately west of the Site. Mining and ore processing activities at the Site have resulted in modifications to the natural, pre-mining topography, including a large open pit (occupied by a pit lake), waste rock and leached ore piles, and evaporation and tailings ponds. These surface disturbances and other Site-related elements, are depicted in Figure 1-2.

Climate and Air Quality

The Site is located in a high desert environment characterized by an arid climate. Monthly average temperatures range from the low 30s °F in December to the mid 70s °F in July. Annual average rainfall for the town of Yerington is only 5.3 inches per year, with lowest rainfall occurring between July and September (WRCC 2007a). Sporadic thunderstorms may occur throughout the year and past storms have resulted in rain events of up to approximately 2 inches in a single day (WRCC, 2007b).

Wind speed and direction at the Site are variable due, in part, to the heterogeneous natural topography (i.e., micro-climates) and the localized effects of surface mining operations. Meteorological data collected since 2002 indicate that wind direction is variable at the Site with no quadrant representing over 50 percent of the total measurements. When wind speeds are above 15 mph, however, there is a predominant wind direction to the northeast (Brown and Caldwell 2008a).

ARC performed meteorological and air quality monitoring ("AQM") at the Site during an approximate three-year program (i.e., January 2005 through March 2008). The AQM program began on January 28, 2005 at six locations (AM-1 through AM-6) located around the perimeter of the Site, as shown in Figure 1-3. Initial monitoring was performed using high volume air samplers for particulate matter less than 10 microns ("PM_{10}") and total suspended particulates ("TSP"). High volume sampling of particulates and chemicals (metals and radiochemicals) was conducted every sixth day according to the National Ambient Air Quality Standards ("NAAQS") monitoring schedule.

On July 4, 2006, the AQM program was revised to: 1) operate only the PM_{10} high volume air samplers at AM-1, AM-3 and AM-6, and the TSP high volume air sampler at AM-6; and 2) reduce the number of analytes. In February 2007, the AQM program was again revised to: 1) add continuous particulate monitors at AM-1, AM-3 and AM-6; 2) add an automatic sampler at AM-6 that collected particulate matter for further analysis during 'dust events'; 3) terminate high volume TSP sampling at AM-6; and 4) add meteorological monitoring at AM-1 and AM-3. The continuous particulate monitors at AM-1, AM-3 and AM-6 were shut down and left in place on April 1, 2008 based on ARC's request and subsequent approval by EPA. The following information was provided in the *Air Quality Monitoring Program Data Summary Report* ("AQM DSR") dated May 29, 2008 (Brown and Caldwell, 2008a):

<u>Meteorological Data</u>

- Wind speed at the Site was observed to be light to moderate with 85 percent of measurements less than 10 miles per hour (mph). A maximum wind speed of 53 mph was recorded during the program (June 5, 2007), but wind speeds in excess of 20 mph occur infrequently (i.e., four percent of measurements exceeded 20 mph). EPA literature (e.g., EPA, 1995) indicates that wind speeds greater than 20 mph are needed for continual particulate emissions from material storage areas (i.e., tailing and waste rock piles, and other surface materials at the Site).
- Wind direction at the Site was variable, but a predominant wind direction to the northeast develops when wind speeds are greater than 10 mph.

Particulate Data

- A variety of potential dust emission sources occur in the vicinity of the Site, including wind blown Site emissions, dust emissions from other mine sites, agricultural activities, and paved and unpaved road emission sources. The emission rates from these sources are variable and can be functions of ambient wind speed, precipitation, agricultural production levels, vehicular traffic patterns, and other variables. In addition, more widespread or regional conditions affect the occurrence of wind-blown dust at the Site.
- Mean values for the 24-hour PM_{10} concentrations at the six monitoring stations ranged from 8 to 14 $\mu g/m^3$, which are low relative to the PM_{10} National Ambient Air Quality Standard ("NAAQS"; annual mean of 50 $\mu g/m^3$; note that the PM_{10} annual NAAQS has been revoked, but still can be used as a benchmark for mean PM_{10} concentrations).
- Approximately 98 percent of all 24-hour PM_{10} measurements were at or below 35 $\mu g/m^3$, which is also low relative to the PM_{10} NAAQS (24-hour averages of 150 $\mu g/m^3$). The maximum 24-hour PM_{10} concentration of 202 $\mu g/m^3$ occurred at AM-6 on June 5, 2007, during a 'dust event', the only value that exceeded the 24-hour PM_{10} NAAQS during the approximate three-year AQM program.
- Hourly PM_{10} concentrations ranged from 0 to 1,200 $\mu g/m^3$. Approximately 98 percent of all hourly PM_{10} measurements were at or below 50 $\mu g/m^3$. The maximum hourly concentrations occurred on June 5, 2007 during a 'dust event'.
- A plot of hourly PM_{10} concentrations versus wind direction at AM-6 (Figure 1-4) indicates that elevated PM_{10} concentrations occur with a variety of wind directions, both from the Site as well as from other locations. This indicates that a variety of on-Site and off-Site (background) dust sources are observed at the monitoring stations.
- The 24-hour PM_{10} concentrations correlated poorly with daily average wind speeds (R^2 between 0.05 and 0.51) at all monitoring locations, indicating that other emission sources may be impacting the monitoring stations, and that other factors beside daily average wind speed effect the generation of dust emissions from Site and background sources.
- Hourly PM_{10} concentrations also correlated poorly with hourly wind speeds (R^2 between 0.13 and 0.27) at all monitoring locations. However, correlations improve (R^2 between 0.54 and 0.71) for hourly PM_{10} concentration data at wind speeds greater than 20 mph, indicating the contribution of wind-erosion emissions to PM_{10} concentrations (relative to other emission processes) as the wind speeds increase.
- The 24-hour PM_{10} concentration data for monitoring days with no precipitation for 25 days prior (representing extended periods of dry surface conditions) also showed improved correlations between PM_{10} concentration with wind speed (R^2 between 0.36 and 0.85), indicating that extended periods of dry weather are significant factors with respect to dust emissions from the Site and background sources.

Chemical Data

- A total of 14 metals (aluminum, beryllium, cadmium, calcium, copper, iron, lead, magnesium, manganese, mercury, silver, vanadium, and zinc) were consistently detected on 24-hour high volume PM_{10} and TSP filters. Seven metals were detected less consistently (in less than 11 percent of the samples): arsenic, barium, chromium, cobalt, molybdenum, selenium, and sodium.
- Gross alpha was detected at a frequency of 50 percent on 24-hour high volume PM_{10} and TSP filters and gross beta was detected on nearly all filters. Radium and thorium isotopes were detected less consistently (between 1 and 23 percent). Uranium isotopes were either not detected or infrequently detected (less than 4 percent).
- The potential effect of measured chemical concentrations at the air monitors will be evaluated in a baseline human health risk assessment for the inhalation pathway.

'Dust Events'

- Based on visual observations by local residents, 'dust events' in the vicinity of the Site had been reported to occur over short time intervals (one to several hours duration) when high, gusty winds generate significant amounts of airborne dust. For 'significant dust events', Site sources and other background sources appear to contribute about equally to wind-blown dust in the area. On average, approximately five 'dust events' per year were observed at the Site over the approximate three-year monitoring program. The primary mechanism for dust emissions is wind erosion.
- Residents who live adjacent to the Site reported four 'dust events' in 2005 and 7 events in 2006. Peak 15-minute wind speeds during these events ranged from 5 to 49 mph. The 24-hour high volume samplers captured five of the 11 observed 'dust events', and 24-hour PM_{10} concentrations ranged from 4 to 38 $\mu g/m^3$.
- In 2007, five 'dust events' were observed based on the continuous PM_{10} monitor data (using an hourly particulate concentration criterion of 300 $\mu g/m^3$ at AM-6 to define a 'dust event'). The 'dust events' were observed to last between two and four hours.
- Numerous 'dust events' occurred during high winds, but periods of high winds did not always result in 'dust events'. This condition indicates that other factors (e.g., lack of precipitation and time of year) beside high wind speeds effect the generation of dust emissions from Site and background sources, and the potential for a 'dust event'.
- The highest measured 24-hour PM_{10}, aluminum, arsenic, copper, manganese, thorium-228, and thorium-230 concentrations for the AQM program occurred during a June 5, 2007 'dust event'. Site and regional meteorological data for this day suggest that an unusual combination of high winds during the event (above 50 mph), and extended dry conditions before the event, caused the 'dust event'.

Upwind/Downwind Evaluation

- An evaluation of upwind/downwind conditions was performed to assess what metals and radiochemicals contained in surface materials at the Site may have migrated off-Site, and in what concentrations. The difference in concentration between downwind and upwind monitoring stations represents the contribution of Site emissions to the total downwind concentration. These analyses were performed for both the short-term 'dust event' data, as well as for 1-hour and 24-hour averages from the entire data set (which represents long-term or annual average conditions) for the approximate three-year AQM program.
- The upwind/downwind analysis of the June 5, 2007 short-term 'dust event' indicated that during the event, 1) background and Site emission sources contributed about equally to measured downwind concentrations of PM_{10}, aluminum, cadmium, nickel, and sulfate; 2) Site sources contributed most of the measured downwind concentrations of arsenic, cobalt, copper and radiochemicals; and 3) background sources contributed most of the measured concentrations of manganese.
- The statistical analysis of hourly PM_{10} data indicated that, for the majority of the cases analyzed, PM_{10} downwind concentrations were higher than upwind concentrations. Site PM_{10} emissions, on average, represent a 15 to 49 percent increase compared to upwind PM_{10} concentrations. Site PM_{10} emissions have migrated off-Site and, on average, contribute approximately 13 to 33 percent of the total downwind PM_{10} concentrations (background sources contribute the remaining amounts)
- A statistical analysis of hourly PM_{10} upwind/downwind data was performed to evaluate relative Site contributions at wind speeds greater than 20 mph. The PM_{10} contribution to downwind concentrations from the Site increases up to 51 percent for these wind speeds, indicating background and Site emission sources contributed about equally to measured downwind concentrations of PM_{10}. With respect to upwind PM_{10} concentrations, the Site PM_{10} contribution represents an approximate 103 percent increase when wind speeds exceed 20 mph. This finding was consistent with the upwind/downwind analysis of PM_{10} concentrations for the June 5, 2007 'dust event'.
- The statistical analysis of 24-hour PM_{10} and chemical data showed that downwind concentrations are statistically higher than upwind for the following analytes: aluminum, copper, and PM_{10}. However, the median differences (i.e., Site contributions) for these analytes are relatively low when compared to the downwind concentrations. For winds blowing to the northeast quadrant, Site emissions of PM_{10}, aluminum, and copper migrated off-Site and, on average, contributed to the measured downwind concentrations of these analytes by approximately 18, 29 and 33 percent, respectively (background sources contribute the remaining amounts). The PM_{10} contribution percentage was within the range observed from the hourly PM_{10} analysis.
- For the 24 hour PM_{10} and chemical data sets that were not statistically significant, the median differences (i.e., Site contributions) for all analytes were very low when compared to the corresponding downwind concentrations, ranging from -14 percent (i.e., upwind greater than downwind) to 14 percent. This range indicates that these other analytes did not migrate off-Site in any appreciable amounts.

ARC presented the following key conclusions in the AQM DSR:

- The collected data met the criteria in EPA's *Air/Superfund National Technical Guidance Study Series: Volume IV – Guidance for Ambient Air Monitoring at Superfund Sites* (EPA-451/R-93-007, 1993) for air pathway assessments, and the quality control and quality assurance goals listed in the AQM Work Plan. Over 35,000 data points were collected over the approximate three-year monitoring period.
- The upwind/downwind evaluation indicated that, during peak short-term periods: 1) background and Site emission sources contributed about equally to measured downwind concentrations of PM_{10}, aluminum, cadmium, nickel, and sulfate; and 2) Site emissions contributed most of the measured downwind concentrations of arsenic, cobalt, copper and radiochemicals. For long-term average periods, the analysis concluded that emissions of PM_{10}, aluminum, and copper migrated off-Site and, on average, contributed to the measured downwind concentrations by approximately 18, 29 and 33 percent, respectively (background sources contribute the remaining amounts). The long-term analysis also concluded that other analytes did not migrate off-Site in any appreciable amounts.
- Ten 'dust events', including the extreme event on June 5, 2007, were monitored and characterized for their frequencies, durations, and peak air concentrations of PM10 and other chemicals.
- Meteorological data collected to date were sufficient for air dispersion modeling of Site emissions at potential off-Site receptors (the extrapolation of the fence line monitoring data to off-Site receptor points).

Based on these conclusions, ARC recommended that a baseline human health risk assessment for the inhalation pathway be performed for off-Site receptors that would incorporate AQM data and the results of air dispersion modeling, and developed the *Draft Baseline Human Health Risk Assessment Work Plan for the Inhalation Pathway, Yerington Mine Site* (HHRA Work Plan) dated June 19, 2008 (Brown and Caldwell et. al., 2008c). This *Human Health Risk Assessment Work Plan* described the approach to address potential acute and chronic human health risks associated with the inhalation of dust sourced from the Site, and from other local or more remote upwind sources. Based on EPA comments received on January 5, 2009 for the AQM DSR and the HHRA Work Plan, revised versions of these two documents are anticipated to be submitted to EPA by March 4, 2009.

General Geologic and Hydrogeologic Setting

As described above, the Mason Valley occupies a structural basin surrounded by uplifted mountain ranges in an area that is typical of basin-and-range topography. The mountain blocks are primarily composed of granitic, metamorphic, and volcanic rocks with minor amounts of semiconsolidated to unconsolidated alluvial fan deposits. The Singatse Range has been subject to extensive metals mineralization, as evidenced by the large copper porphyry ore deposit at the Site, other surface mines and prospects, and mineralized bedrock in the subsurface underlying the Site. Proffett and Dilles (1984) published a geologic map of the Yerington District that describes these features.

Unconsolidated alluvial deposits derived by erosion of the uplifted mountain block of the Singatse Range and alluvial materials deposited by the Walker River fill the structural basin occupied by Mason Valley in the vicinity of the Site. The thickness of alluvium at the Site increases from south to north and from west to east. This geometry is consistent with the alluvial fan, transitional, and flood-plain/lacustrine depositional environments that developed east and north of the Singatse Range. At the Yerington Pit, the thickness of unconsolidated alluvium varies from a few tens of feet up to about 170 feet thick. At the northern margin of the Site, the thickness of the alluvium exceeds 600 feet. As described below, bedrock outcrops associated with a structural spur of the Singatse Range borders the Site along the eastern margin of the Sulfide Tailings area. The alluvial deposits consist of clastic sediments ranging in size from clay to cobbles. Relatively coarse-grained alluvial fan (fine sand) and fluvial (coarse sand to cobble) deposits comprise the major aquifer materials and serve as the principal sources of water for domestic wells and high-capacity irrigation wells in the area.

Conceptually, the degree of metals mineralization and associated hydrothermal alteration haloes in the bedrock serves to influence the background concentrations of chemicals in the topographically down-gradient alluvial fan materials west of, and underlying the Site. The chemical content of the bedrock and alluvial materials also influence the chemistry of groundwater that flows through these materials. The potential for pressurized bedrock underlying saturated alluvium in the area of the Site may also exist, which could result in localized occurrences of vertical upward gradients along rang-front faults, which could also influence the chemical characteristics of the alluvial aquifer. A more detailed description of the hydrogeologic conceptual model is summarized below, and is presented in Appendix B. Pending EPA's review of the *Second-Step Hydrogeologic Framework Assessment Data Summary Report* dated October 15, 2008 (Brown and Caldwell, 2008d) and direction, Appendix B may need to be updated prior to the next CSM revision.

Background Soils Characterization

Brown and Caldwell (2008b) developed background concentration limits for use in remedial investigations at the Site, and associated human health and ecological risk assessments, from two alluvial fan soil types that occur beneath the Site. As shown in Figure 1- 5, two sub-areas (A-1 and A-2) were identified based on topography and mapped differences between variably mineralized bedrock lithologic source types. Sub-area A1 consists of fan materials derived predominantly from rhyolite as flow tuffs. Sub-area A2 consists of fan materials derived predominantly from rhyolite as flow tuffs and mineralized granitic rocks, and to a lesser extent, andesitic lava flows and limestone.

The statistically-derived background concentration limits determined for the two sub-areas located west of the Site are summarized in Table 1-1. Because of a laboratory oversight identified in December 2008, the background concentration limits for the majority of parameters presented in Table 1-1 will have to be re-calculated to account for the moisture content of the sampled soils. ARC anticipates that an updated *Background Soils Data Summary Report* (Revision 2) will be submitted to EPA in March 2009.

Background soils data: 1) provide the basis for a comparison of Site soils to determine areas impacted by historic mine operations; 2) support the development of remedial guidelines to manage impacted site materials (i.e., impacted soils, tailings, waste rock, evaporation pond residues, etc.); and 3) support future risk assessment activities for the Site. Figure 1-6 depicts the Site OUs, the two background soils types currently identified for use in the Site RI/FS, and soil types mapped by the U.S. Soil Conservation Service ("SCS", 1984).

Table 1-1. Summary of Background Concentration Limits

Constituent	Units	Sub-Area A-1	Sub-area A-2
Aluminum	(mg/kg)	15,629	23,391
Antimony	(mg/kg)	0.88	0.88
Arsenic	(mg/kg)	12	16
Barium	(mg/kg)	161	282
Beryllium	(mg/kg)	0.96	1.1
Boron	(mg/kg)	22	20
Cadmium	(mg/kg)	0.30	0.30
Calcium	(mg/kg)	21,814	43,901
Chromium	(mg/kg)	11	18
Cobalt	(mg/kg)	11	14
Copper	(mg/kg)	55	297
Iron	(mg/kg)	18,741	26,533
Lead	(mg/kg)	10	11
Magnesium	(mg/kg)	6,009	9,388
Manganese	(mg/kg)	505	671
Mercury	(mg/kg)	0.030	0.047
Molybdenum	(mg/kg)	1.6	5.1
Nickel	(mg/kg)	11	17
Potassium	(mg/kg)	3,223	4,818
Radium-226	(pCi/g)	2.03	2.42
Radium-228	(pCi/g)	2.23	2.11
Selenium	(mg/kg)	0.75	0.83
Silver	(mg/kg)	0.50	0.50
Sodium	(mg/kg)	1,993	2,190
Thallium	(mg/kg)	0.59	0.55
Thorium	(mg/kg)	14.6	19.1
Uranium	(mg/kg)	2.9	4.1
Vanadium	(mg/kg)	54	62
Zinc	(mg/kg)	58	58

Sub-area A1 alluvial fan materials and associated soil types appear to underlie the inactive Anaconda evaporation ponds (a portion of OU-4) and the majority of the oxide tailings area (OU-5). Sub-area A2 alluvial fan materials and associated soil types appear to underlie the Process Areas (OU-2) and Waste Rock Areas (OU-6) of the Site, and occur within the western portion of the Yerington Pit and pit lake (OU-3). Other background soil types will need to be identified for the sulfide tailings portion of OU-4 and the Wabuska Drain (OU-7). Because of their occurrence within various portions of the Site, Arimetco Facilities (OU-8) appear to overlie both background (A-1 and A-2) types.

Conceptual Hydrogeologic Model

The conceptual hydrogeologic model for the Site was developed and refined based on previous groundwater investigations in the area of the Site, and the groundwater characterization activities conducted for the first phase of investigations pursuant to the *Hydrogeologic Framework Assessment North of the Anaconda Mine Site* ("HFA"); Brown and Caldwell, 2005b). These elements were: 1) summarized in the *Interim Hydrogeologic Framework Assessment Data Summary Report* (Brown and Caldwell 2006); 2) presented in the *Draft Remedial Investigation Work Plan for Site-Wide Groundwater (OU-1), Yerington Mine Site* (Brown and Caldwell and Integral 2007a), the *Draft Process Areas (OU-3) Remedial Investigation Work Plan, Yerington Mine Site* (Brown and Caldwell and Integral 2007b) and the *Draft Remedial Investigation Work Plan for Yerington Pit Lake (OU-2), Yerington Mine Site* (Brown and Caldwell and Integral 2007c); and 3) summarized in the *Second-Step Hydrogeologic Framework Assessment Data Summary Report* dated October 15, 2008 (Brown and Caldwell 2008d). The conceptual model elements presented in the documents listed under (1) and (2) above are provided as Appendix B of this CSM. As described above, pending EPA's review of the *Second-Step Hydrogeologic Framework Assessment Data Summary Report*, Appendix B may need to be updated prior to the next CSM revision.

Recharge to bedrock groundwater beneath the Site from the Singatse Range results from the percolation of precipitation and runoff through the fractured bedrock. Recharge to alluvial groundwater beneath the Site occurs as a result of direct percolation of meteoric water (as precipitation and runoff) through the alluvial fan materials. Recharge from direct precipitation on the valley floor is considered to be negligible based on previous reports authored by Huxel (1969) and Sietz et. al. (1982). Huxel (1969) estimated the following recharge percentages to the

Mason Valley hydrographic basin: 1) 3 percent from precipitation that falls on the surrounding mountain ranges; 2) 97 percent from the river and associated agricultural diversions; and 3) less than 0.1 percent from direct precipitation on the valley floor.

Along the southern margin of the Site, recharge to the alluvium and bedrock groundwater flow systems occurs predominantly from the adjacent Walker River. As the river flows to the northeast, past the City of Yerington, a spur of the Singatse Range likely impedes recharge from the Walker River to the alluvium underlying the northern half of the mine site. This hydraulic boundary condition is inferred from the observed alluvial aquifer head elevations on either side of the spur, although there is insufficient data to quantify this condition. Recharge from the Campbell Ditch immediately east of the "Singatse Spur" to the alluvial aquifer is also likely impeded by the occurrence of the observed bedrock outcrops (i.e., the "Groundhog Hills"). Anticipated effects are different head elevations on either side of the "Singatse Spur", and the influence of fracture flow through the bedrock on groundwater chemical conditions in the alluvial aquifer.

Beneath the mine, groundwater flows toward the northwest, based on measurements obtained from numerous monitoring wells located within and around the Site. Toward the northern margin of the mine, recharge from the agricultural area creates a groundwater mound that strongly influences the groundwater flow regime. In this area, groundwater flows radially away from the center of the mound. For example, the flow direction at the north end of the mine site, in the area of the pumpback wells, is from east to west (away from the center of the mound).

An active groundwater pumpback system comprising 11 wells is located near the north perimeter of the Site. The pumpback system is designed to extract shallow groundwater from approximately 40 to 60 feet below ground surface. Mine-related groundwater in the capture zone areas of the 11 wells is pumped and conveyed to a 23-acre lined evaporation pond system. Operation of the pumpback well system locally affects groundwater flow directions and gradients. The hydraulic relationship between the pumpback system wells and the nearby irrigation well and groundwater mound are to be evaluated as part of the *"Draft Site-Wide*

Groundwater RI Work Plan" (Brown and Caldwell and Integral 2007a). Percolation from irrigated agricultural fields immediately north of the mine site is hypothesized to be the dominant source of groundwater recharge in the area north of the Site.

The hydraulic relationship between the shallow, intermediate and deep hydrostratigraphic zones in the alluvial aquifer north of the mine site is affected locally by: 1) agricultural practices involving extraction of groundwater, presumably from the deep hydrostratigraphic zone, and application of irrigation water on agricultural fields resulting in a groundwater mound; 2) extraction of shallow groundwater by the pumpback well system; and 3) low-permeability layers, where present. Head differences in shallow, intermediate, and deep wells located immediately north of the mine indicate a downward vertical gradient. The magnitude of the vertical gradient is conceptualized to vary seasonally in response to climate conditions, agricultural practices, pumpback well operations, and regional groundwater conditions. Historic groundwater extraction by Anaconda in the area north of the mine site in the 1960s and 1970s for water supply purposes locally affected the groundwater flow regime at that time.

Potential migration paths for mine-related groundwater are hypothesized to be: 1) along an approximately 5,000-foot wide flow path between the irrigation mound and the potential boundary condition imposed by the bedrock of the Singatse Range, and 2) vertical redistribution and mixing resulting from agricultural operations within the mound area. Although some degree of resistance to vertical flow exists within the alluvial aquifer, created by the depositional layering of sedimentary deposits and the occurrence of low-permeability layers, some downward migration of mine-related groundwater is likely to have occurred as a result of historic operations at the Site and the influence of agricultural irrigation practices immediately north of the Site.

Groundwater quality beneath the Process Areas of the Site appears to have been locally impacted by process solutions and operations, as presented in the *Data Summary Report for Process Areas Groundwater Conditions* (Brown and Caldwell 2005a). The geochemical signature of mine-related groundwater varies, but appears to reflect elevated concentrations of metals, radiochemicals, sulfate and total dissolved solids (TDS").

1.3 Past Mining Operations and Current Conditions

Copper in the Yerington district was initially discovered in the 1860s, with large-scale exploration of the porphyry copper system occurring in the early 1900s when the area was organized into a mining district by Empire-Nevada Copper Mining and Smelting Co. Mining, milling, and leaching operations for oxide and sulfide copper ores from an open-pit in the southern portion of the Site were conducted between 1953 and 1978 by ARC's predecessor, Anaconda. Once Anaconda divested itself of the Site, subsequent operators (e.g., Arimetco) used some of the buildings for operational support; the Anaconda-constructed processing components remained inactive during this period. Surface mine units, which generally coincide with the Site OUs, are shown in Figure 1-2.

During mining operations, make-up water for milling and other Site uses beyond what was supplied from pit dewatering operations, was obtained from large-capacity production wells constructed in the alluvial aquifer immediately north of the Site (two of these wells are currently used for agricultural irrigation purposes immediately north of the Site). Improved understanding of the effect of these wells on past and present groundwater conditions is planned to be evaluated pursuant to the *"Draft Site-Wide Groundwater RI Work Plan"* dated November 16, 2007 (Brown and Caldwell, 2007a), which is currently under review by EPA.

Select available historic aerial photos of the Site are provided in Appendix A as a means of documenting the period prior to mining by Anaconda, Site operational conditions during the Anaconda operational period from 1953 through 1978, and the post large-scale mining period. The following timeline summarizes significant operating and related activities at the Site:

1907 Yerington deposit was discovered by Empire-Nevada Copper Mining and Smelting.

1941 Anaconda acquired the property and conducted exploration drilling and ore body delineation.

1951 Construction of the Weed Heights housing community.

1952 Mining activities began with stripping of alluvial overburden and waste rock. Process Areas components were constructed including the Vat Leach tanks, Solution Storage tanks, Cementation/Iron Launder tanks, Acid Plant, Crushing Plant, and most of the support facilities (e.g. Administration, Truck Shop, and Maintenance Buildings).

1953 The open pit excavation reached the ore body, and the first oxide ore was delivered to the leaching plant. The Unlined Evaporation Pond was constructed and used for the management of process waste water (i.e., spent solutions) generated by the oxide vat leaching process. The waste rock area south of the pit was designated as the main location for alluvial overburden and waste rock. Several smaller waste rock piles were developed north of the pit including the W-3 stockpile (low-grade oxide ore) and S-23 stockpile (low-grade sulfide ore).

1955 The Calcine Tails Ponds (Finger Pond #5) was constructed to contain dust precipitates generated from the Acid Plant, and transported to the pond in a slurry using spent solution from the oxide leaching process.

1961 The Sulfide Concentrator Plant was constructed at the north end of the Process Areas and began processing sulfide ore. The initial sulfide tailings dam was constructed near the middle of the current Sulfide Tailings area to limit the accumulation of tails to the southern half of the area.

1965 Dump leaching of the W-3 stockpile began using low-concentration sulfuric acid percolated onto the stockpile and collected in a small collection pond located on the east side of the dump. Two parallel pipelines were installed to transport: 1) raw acid solution from the Acid Plant to the W-3 Dump Leach; and 2) pregnant leachate solution from the collection pond to the cementation tanks in the Process Areas.

1967 The sulfide concentrator in the Process Areas was expanded to double its capacity.

1968 A new sulfide tailings dam was constructed to allow the impoundment to expand into its current configuration (the expansion included the northern half and an additional half mile east towards Highway 95A), which doubled its size.

1974 The Lined Evaporation Ponds and the Lined Finger Ponds (Finger Ponds 1-4) were constructed and put into service. The southern portion of the Sulfide Tailings area was subdivided into numerous shallow evaporation ponds for the purpose of providing additional storage capacity and evaporation surface area for the spent solutions from the oxide leaching process.

1977 ARC acquired the Site from Anaconda.

1978-79 ARC shut down all mining and processing operations, and sold its holdings to Don Tibbals. ARC commenced post-closure activities including placing VLT capping material on the northern half of the Sulfide Tailings area and on the Calcine Tails Pond (Finger Pond #5) and dismantling and removing some plant equipment including all crushing equipment and the Sulfide Concentrator Plant.

1982-88 Tibbals leased the Site to CopperTek for reprocessing oxide tailings using heap leaching and solvent extraction/electrowinning (“SX/EW”) methods. Tibbals also leased building space in the Process Areas to Unison for refurbishing electrical transformers (a more detailed description of the Unison operation is provided in Appendix C).

1986 The Weed Heights Sewage Lagoons were installed at their current location in the southwest corner of the Lined Evaporation Ponds. ARC installed the first group of

Pumpback Wells (PW-1 through PW-5) and a single unlined evaporation pond in the location of the current pumpback well system ("PWS") Evaporation Ponds to evaporate pumped groundwater around the east perimeter of the Lined Evaporation Ponds.

1988 Tibbals sold the Site to Arimetco, who took over all existing heap leaching and processing facilities.

1989-97 Arimetco constructed five heap leach pads and the SX/EW plant at various Site locations, and re-leached Anaconda spent ore from the W-3 low-grade stockpile and the oxide tailings. In addition, Arimetco started to mine ore and waste materials from the MacArthur Mine, located several miles northwest of the Site, for on-Site leaching.

1997 Arimetco filed for bankruptcy protection, but continued to operate existing leach pads and processing plant.

1998 ARC installed six additional Pumpback Wells (PW-6 through PW-11) and modified the evaporation ponds by partitioning into three cells and adding clay liners.

1999 Arimetco abandoned operations and the Site. NDEP assumed control of the Site under their emergency management program to control the drain down of process solutions from the heap leach pads to prevent overflow and to operate and maintain the PWS.

2000 NDEP closed and capped the partially constructed Arimetco pond immediately north of the VLT Pond to mitigate the red dust issue.

2000-01 ARC upgraded the liner systems in the middle and south PWS Evaporation Ponds by installing 60-mil high-density polyethylene ("HDPE") over the top of the existing clay liners. The north cell remains lined with the clay liner installed in 1998.

2001 NDEP capped the thumb (largest finger) pond north of the VLT pond area to mitigate the red dust issue.

2001 NDEP capped three additional areas to mitigate the red dust issue.

2003 NDEP Site Drum and Plant fluids removal included salts and lead-contaminated piping from the Arimetco Plant site.

2005 EPA assumed regulatory oversight responsibilities for the Site.

2006 EPA capped the sulfide tailings for dust mitigation and removed inactive transformers.

2006 EPA constructed a new 4-acre evaporation pond, bypassed the Mega Pond, and relined the North Slot pond

2007 EPA removed the Bathtub Pond, and modified the associated piping.

2007 EPA issued the Order to ARC to begin the RI/FS process.

2008 EPA conducted the following removal actions: 1) removed the Mega Pond, two Raffinate Ponds and the Plant Feed Pond; 2) relined the Phase One pond, repaired the VLT pond, and upgraded a number of ditches that surround the Arimetco heap leach pads; 3) removed two organic traps from the Arimetco Plant site; 4) excavated kerosene contaminated soils from the Arimetco Plant area, and constructed a land farm on the Slot heap for soil remediation.

The following description of Site operations includes volumes and concentrations of materials, which varied over time throughout the mine life of the Anaconda operation. Therefore, the descriptions of Anaconda's mining and processing activities are of a general nature and the cited processing numbers (gallons per minute, tonnages, etc.) are approximate.

Mining

Anaconda conducted mining only in the main Yerington Pit from the period between 1953 and 1978. Categories of material removed from the pit included: 1) oxide ore; 2) sulfide ore; 3) low-grade dump leach oxide ore; 4) low-grade sulfide ore; and 5) waste rock/overburden. Mining was conducted using electric and diesel shovels, bulldozers, scraper, and 25-ton haul trucks (U.S. Bureau of Mines 1958). By 1972, approximately 70,000 tons per day were mined, including 28,000 tons of oxide and sulfide ore, 28,000 tons low-grade dump leach ore, and 14,000 tons of overburden/waste rock. Mined ore characteristics in 1972 were also described by Skillings (Mining Review 1972) as follows:

- Ore containing >0.3 percent copper was delivered to the primary crusher for plant leaching.
- The overall average grade of oxide ore was 0.55 percent copper, and sulfide ore was 0.6 percent copper.
- Low-grade oxide ore containing 0.2 to 0.3 percent copper was delivered to the W-3 dump leach, located just south of Burch Drive, where it was operated as a heap leach system.
- Low-grade sulfide ore was stockpiled in an area southeast of the Burch Drive bridge, for possible future treatment.

The open pit was mined in 25-foot benches with a 45 degree pit wall slope. Final dimensions of the mined pit are approximately 6,200 feet long, 2,500 feet wide, and 800 feet deep. Groundwater was encountered at approximately 100 to 125 feet below ground surface, and deep wells were installed along the eastern perimeter of the pit to dewater the fractured bedrock as the depth of the pit increased. Water was pumped from these wells at a rate of about 900 gallons per minute (gpm), and the water was used for Weed Heights housing and plant operations (U.S. Bureau of Mines 1958).

Crushing and Grinding

All oxide and sulfide ore was crushed prior to leaching or processing in the plant. Crushing was a two-step process for the oxide ore and a three-step process for sulfide ore. All ore underwent coarse crushing in the Primary Crusher, which was a 54-inch gyratory crusher that reduced the ore to 5 inches or less. Coarse ore exited the crusher onto the No. 1 conveyor and was stored in the oxide and sulfide Coarse Ore Storage. Coarse ore was transported to the Secondary Crusher by the No. 2 conveyor and further reduced in size to 7/16 inch using standard and short-head cone crushers. Fine oxide ore exited the Secondary Crusher through and an underground conveyor (No. 6 conveyor) to the Sample Tower, where a sample was collected for assay and water was sprayed onto the crushed ore to agglomerate fine material as well as control dust (Anaconda Company 1954; U.S. Bureau of Mines 1958).

Sulfide ore underwent additional crushing at the Sulfide Ore Crushing and Stockpile area located at the northwest end of the Vat Leach Tanks. Fine grinding of the sulfide ore to a grain size between 20 and 200 mesh particle size was necessary for use in the floatation process and was accomplished using several rod and ball mills in sequence (Mining Review 1972).

Leaching (Oxide Ore)

Oxide ore was loaded into the Vat Leach Tanks by conveyor and overhead loading bridge with the agglomerated ore from the Secondary Crusher. The ore was bedded into a tank in a manner to prevent segregation and allow uninhibited circulation of leach solutions within the tank. Each tank had a capacity to hold approximately 12,000 dry tons of ore and 800,000 gallons of solution when filled to within 6 inches from the top. The vats operated on a 96-hour (5-day) or 120-hour (6-day) leaching cycle, with an additional 32- to 40-hour wash period, and 24 hours required to excavate and refill. The entire cycle required approximately 8 days; therefore, eight leach vats were installed and used to maximize efficiency (U.S. Bureau of Mines 1958).

Once the ore was bedded into the tanks, sulfuric acid leach solution was added to cover the ore. The initial concentration of acid during this conditioning period was 20 to 30 grams per liter (g/l) which was re-circulated through the tanks for 3 or more hours by drawing it off the bottom and air-lifting it to the top or the tank until the acid content dropped to 0 to 2 g/l. The reinforced-concrete bottoms of the tanks were covered with timbers and cocoa matting as a filter to allow bottom drainage of solutions. Solutions were re-circulated and pumped at a rate of 2,000 gpm. The pregnant solution from the conditioning leach was pumped off to one of the two 286,000-gallon Solution Storage Tanks, and new solution was transferred from the previous vat while acid was added to bring it up to the desired leaching strength of 40 to 60 g/l. This solution was re-circulated and then transferred to the next vat. This cycle continued for four or five leaching periods.

After leaching, the ore underwent three wash cycles, which used primarily discharge water from the Peabody scrubber in the Acid Plant as well as fresh water from the supply well and leach final drain water (Anaconda Company 1954). Approximately 1.4 million gallons of water were used per day for leach wash water. Spent ore, known as oxide tailings or vat leach tailings (VLT) was excavated from the Vat Leach Tanks by a clamshell digger mounted on a rolling overhead gantry crane, which could position over any of the eight tanks. The digger would drop the leached ore into a hopper under which 25-ton end-dump trucks would drive, receive a load, and then haul the waste material to the oxide tailings or VLT pile (collectively comprising OU-6). The average time to excavate one tank was 16 hours at a rate of 40 truckloads per hour.

Cementation/Precipitation (Oxide Ore)

Copper was recovered from the leach solution by precipitating (i.e., "cementing") the copper using scrap iron by means of the following chemical conversion:

$$CuSO_4 + Fe \rightarrow FeSO_4 + Cu$$

The Precipitation Plant was divided into five separate banks or individual cells: 1) Primary, 2) Secondary, 3) Stripping/Settling, 4) Scavenger, and 5) Dump Leach. These banks of cells were operated in the following ways (Anaconda Company 1954; Mining Engineering 1967):

1. *Primary Bank.* 90,000 pounds of new scrap iron were loaded into each cell. Pregnant solution, with a concentration of approximately 15 to 25 g/l copper and 4 to 5 g/l sulfuric acid, was pumped through 4-inch plastic pipes sunk into the concrete bottoms of the launder tanks and percolated upward through the iron, overflowing to a weir box on the northeast side at a rate of 700 to 900 gpm. The overflow solution discharged to the recirculation sump at the northwest end of the precipitation tanks, where it was recirculated back to the secondary bank. Recirculation continued for 4 days, followed by the washing, removal, and drying of the copper cement.
2. *Secondary Bank.* 90,000 pounds of new scrap iron was added to each cell. Recirculation solution discharged from the primary bank was circulated through the iron in the same manner as the primary bank. Solutions were recirculated for 5 days at a pumping rate of 900 to 1,000 gpm and then washed and excavated. Discharge solutions from the secondary bank were sent to the stripping/settling bank.
3. *Stripping/Settling.* This section was operated as pairs of tanks where the stripping tank contained iron and the settling tank did not. Solutions entering the stripping tank came solely from the secondary bank where additional copper was removed from the solutions prior to disposal. Solutions were recirculated through these tanks for approximately 15 days. Final solutions from this area were sent to the Spent Solution Sump and then ultimately returned to the Acid Plant for use as a slurry agent to wash the calcines from the acid plant to the evaporation ponds (Anaconda Company 1954).
4. *Scavenger.* The purpose of the scavenger was to consume unused iron that was removed from the other precipitation banks after washing and separation in a trommel. In general, the residual iron was much finer and the precipitates form a dense mass. At some point, nondigestible residual material was removed from the system and discarded.
5. *Dump Leach Primary and Secondary.* Leach solution from the low-grade dump leach was kept entirely separate from the tank leach solutions so that the process waste water could be reused. The dump leach precipitation operated similarly to the tank leach operation and started in 1965 when dump leaching commenced at Yerington (Mining Engineering 1967). These solutions were recirculated from the dump leach primary to the dump leach secondary through a separate dump leach recirculation sump. Spent solutions were stored in the Dump Leach Surge Pond and were available for reuse in the plant. Areas of reuse have not been determined.

Following the cementation steps described above, all copper cement product was washed in place, excavated by overhead gantry crane with clamshell digger, and then dropped into the trommel hopper located at the southeast end of the precipitation tanks where it was further washed and the unused scrap iron separated from the copper cement. The copper cement was loaded onto hotplates for drying prior to shipment. The hotplates were large flat drying surfaces that were heated underneath by propane gas to dry the material to a moisture content of approximately 12 percent moisture (Mining Review 1972). The copper cement product averaged 83 percent copper, which was hauled by trucks to the Wabuska rail spur and, eventually, to the Anaconda Washoe Smelter in Anaconda, Montana for final smelting to a pure copper product.

Based on the aerial photographs presented in Appendix A of this CSM, leaching of the W-3 low-grade oxide stockpile appears to have been initiated between 1963 and 1965 (to date, written documentation of this operation has not been identified). The 1965 photo indicates that: 1) the rectangular areas of rock darkened by application of the leaching solution; 2) the collection pond located on the east side of the dump; and 3) the installation of the leach solution pipeline from the collection pond to the cementation tanks in the Process Areas. As of 1977, the W-3 dump had been expanded to the north and portions of its south face were excavated, possibly for the construction of an additional leaching operation (i.e., the location of the future Phase IV Slot Heap Leach Pad constructed by Arimetco).

Concentrator (Sulfide Ore)

A froth floatation system was constructed in 1961 for the purpose of processing sulfide ore from the Yerington Pit. Floatation separation is accomplished by mixing very finely ground ore (pulp) with water and a chemical (xanthate) to make the sulfide mineral hydrophobic and then sparging air and a surfactant chemical such as pine oil through the mixture to create a froth. The actual chemicals used in the Yerington concentrator have not been determined. The sulfide minerals in the pulp latch on to the air bubbles in the froth mixture which collects on the surface of the aeration tank in the rougher floatation circuit and are skimmed off as concentrate.

The Yerington concentrator was designed to take this initial concentrate, separate the solids in a 75-foot diameter thickener, and regrind the thickened solids to an even finer pulp size of minus 325 mesh (<44 microns). This reground material was sent through a scavenger floatation circuit, a cleaner circuit, and a recleaner circuit. The final concentrate was thickened in 50-foot diameter thickeners, and the thickened concentrate was dewatered using a vacuum filter and then dried in a 24-foot rotary dryer. The finished concentrate averaged 28 percent copper, which was hauled by trucks to the Wabuska rail spur and, eventually, to the Anaconda Washoe Smelter in Anaconda, Montana for final smelting to a pure copper product (Mining Review, 1972). Residual solutions, containing elevated concentrations of sulfate, metals and radiochemicals were conveyed to evaporation ponds at a rate of about 700 gpm (Seitz et al., 1982).

Seepage from the northernmost tailings pond was collected in a peripheral ditch and recycled along with the liquid fraction of the tailings fluid. During mining and milling operations, the tailings deposition areas and associated evaporation ponds and containment ditches were progressively expanded to the north to accommodate the need for increased tailings capacity. The mineralogical characteristics of the ore and waste rock mined from the Yerington open pit in conjunction with the ore processing activities resulted in the occurrence of technically enhanced naturally occurring radioactive materials ("TENORM").

Excess pulp present after the floatation separation was disposed in the sulfide tailings as a slurry mixture of solids and water. Operation of the concentrator required approximately 3,000 gpm of water, which was obtained from groundwater production wells and recycled water from decanting the sulfide tailings and other plant operations (Mining Review, 1972).

<u>Sulfuric Acid Production</u>

Sulfuric acid was produced at Yerington in the Acid Plant from raw sulfur ore shipped to the Site from the Leviathan Mine located in Alpine County, California. The production of sulfuric acid from sulfur ore can be broken down into five steps: 1) crushing, 2) grinding, 3) roasting, 4) dust precipitation, and 5) contact acid plant. The final product was 93 percent sulfuric acid that was used in the tank leach and the dump leach of the oxide ore. A summary of the steps used in acid production are provided below (Anaconda Company 1954; U.S. Bureau of Mines 1958):

1. *Crushing.* Two stage crushing was completed using a jaw crusher and short-head crusher to reduce the sulfur ore to minus 1 inch.
2. *Grinding.* Rod mills were used to further reduce the ore to minus 10 mesh (<2 mm) for feed to the flousolids roaster.

3. *Roasting.* Fluosolid roasters were used to roast the sulfur ore and drive SO_2 gas from the ore, which would then be converted to sulfuric acid in the subsequent steps. The ore was bedded into an 18-foot wide by 25-foot high reactor lined with insulating and fire brick. The bed of material was maintained at 5 feet and fluidizing air heated by propane was circulated to heat the ore to a temperature of 1,100 ^{o}F to oxidize the sulfur. The burned ore or "calcines" were removed from the bottom of the reactor and disposed of in the evaporation ponds conveyed in the Calcine Ditch using spent solution pumped from cementation to sluice the solids to the ponds.
4. *Dust Precipitation.* Gases leaving the reactor contained 10 to 12 percent SO_2 which were cooled and sent through the Peabody scrubber and Cottrell electrostatic precipitator to remove dust. Precipitates were collected at a rate of about 800 pounds per day and contained 30 to 40 percent selenium with silica. Water from the scrubber was recycled and used as wash water in the leaching vats (U.S. Bureau of Mines 1958). Selenium precipitates were sold and shipped offsite several times per year.
5. *Contact Acid Plant.* The SO_2 gas entered the contact acid plant by going through a primary and secondary converter where the SO_2 was converted to SO_3. The SO_3 gas then went through a heat exchanger and the adsorption tower where it was contacted with 98 percent sulfuric acid, resulting in a diluted 93 percent sulfuric acid product for use in the plant. Approximately 450 tons of 93 percent sulfuric acid was produced per day from 600 tons per day of raw sulfur ore.

Management of Process Waste Solutions and Tailings

Unlined Evaporation Pond. The Unlined Evaporation Pond located on BLM and private land consists of a large northern section (100 acres) and a smaller southern section (4.1 acres). From approximately 1954 to 1961, the entire area of the Sulfide Tailings and the Unlined Evaporation Pond were used as one large area for the storage and evaporation of process water (i.e., spent solutions) discharged from the copper oxide (vat) leaching plant. In 1961, the area was reduced to its current size and continued to operate in the same capacity until operations ended in 1978.

The Unlined Evaporation Pond was constructed on native, unlined soils and is surrounded by berms constructed of crushed VLT materials. The pond bottom was not excavated into the alluvial fan slope and, therefore, becomes deeper towards the northeast (i.e., follows topography). Based on an evaluation done in 1976 by M.J. Bright for Wyoming Minerals Corp. (Bright, 1976), the depth of sediments range from 0.5 to 6 feet deep with an average thickness of 1.77 feet in the large pond cell and 2.88 feet in the small pond cell. The estimated volume of sediment existing in both areas is approximately 310,000 cubic yards. Although no specific chemical data are available, the solutions originated from the vat leaching process and likely contained very high iron concentrations (indicated by the dark red color of the pond solutions in historic photos). The discharged water also likely contained elevated concentrations of other acid-soluble metals (e.g., copper) and radiochemicals. These constituents would have precipitated as sulfate salts as the solutions evaporated, leaving the fine yellow-tinted powdered salt residue currently visible in the Unlined Evaporation Pond.

Lined Evaporation Pond. The Lined Evaporation Pond was used to store and evaporate excess process solutions from the oxide ore beneficiation processes during the period from approximately 1974 through 1978. The pond includes three sub-sections (North, Middle and South), which were lined with a relatively thin asphalt liner. Little is known about the construction and application method for the liner, although it appears to have been applied directly to the native soil or, possibly, a clay sub liner (i.e., without an underlying fabric membrane). The asphalt liner currently appears to have been a mixture of hot asphalt tar mixed with crushed gravel, similar to road paving, and is approximately 0.5 to 1 inch thick. The Lined Evaporation Pond appears to have been constructed as one single lined surface which was subsequently subdivided into the three sections by construction of two graveled roads across the pond liner, as evidenced by no liner material found on the side embankments of the roadways. The northern-most roadway is used for access to the Pumpback Wells, which are drilled through the road and the pond liner to access the shallow aquifer underneath the ponds.

The dividing berms and roads are constructed from VLT materials (half to three-quarter inch size fractions) with some finer grained materials. These materials may allow some movement of surface water between the pond units. The asphalt liner has deteriorated in areas where it has been exposed and shows signs of cracking, peeling and erosion (i.e., underlying soils are locally exposed). The Lined Evaporation Pond was used to evaporate the same waste stream as the Unlined Evaporation Pond (i.e., spent solutions from the oxide leach leaching process). Therefore, the materials in the Lined Evaporation Pond are expected to exhibit similar chemical and physical characteristics as those in the Unlined Evaporation Pond.

Because of the asphalt liner, which impeded infiltration of the processes water into the underlying soils, a greater accumulation of evaporative salts formed as a crust on the surface of the Lined Evaporation Pond relative to the Unlined Evaporation Pond. These salt encrustations appear variegated in color and appear to act as a soil stabilizer, which protects the underlying materials from wind erosion. The solids in the Lined Evaporation Ponds remain saturated throughout much of the year because of the liner and the salt crust, whereas the solids in the Unlined Evaporation Pond tend to dry more quickly.

The Lined Evaporation Pond has a total combined area of approximately 101.3 acres, and is located almost entirely on BLM land (a small portion on the west side is located on private land). The thickness of the pond solids averages 6 to 12 inches, with a maximum measured thickness of approximately 18 inches in select areas. The estimated volume of sediment contained in these ponds is approximately 132,000 cubic yards. Areas of standing water may occur during the approximate six-month wet weather season from December to May and, intermittently, following precipitation events. The January 2002 aerial photograph in Appendix A illustrates the approximate maximum extent of standing water on the pond surface. Water sources consist of direct precipitation and surface water run-on into the pond. The acidic nature of the process solutions causes meteoric water that accumulates as standing water in the pond to be acidic (pH values less than 1.0 standard units).

Finger Ponds. The four western-most Finger Ponds (ponds 1-4) were constructed by Anaconda in approximately 1974, at approximately the same time as the Lined Evaporation Pond. These ponds are all constructed with a minimal cut and fill technique to create a flat bottom, which was subsequently lined with asphalt liner similar in construction and characteristics to the asphalt liner described for the Lined Evaporation Pond. The total potential depth of the ponds is reported to be approximately two feet, with approximately one foot of sediment and salts existing in the ponds (Bright, 1976). Today these ponds contain yellow crystallized precipitate solids and sulfate salts, approximately 2 to 12 inches thick with a hardened surface crust very similar to the material in the Lined Evaporation Ponds. The source of waste material disposed in these ponds was likely spent solution from the oxide leaching process.

Each of these finger ponds were originally 2,500 to 3,000 feet long and approximately 100 to 200 feet wide, and are located west of the Unlined Evaporation Pond. The southern half of these ponds was subsequently covered by Arimetco's Phase IV VLT Heap Leach Pad in 1995. The total surface area of Finger Ponds 1-4 is approximately 17.8 acres and the estimated volume of materials contained within the ponds is 16,240 cubic yards. These ponds are contained wholly on private property. The current condition of the asphalt liner is significantly deteriorated due to exposure to sun and weather, causing crumbling and erosion of the asphalt, as well as physical damage on the south end caused by heavy equipment during the construction of the leach pad.

The Calcine Tails Pond (Finger Pond 5 or Thumb Pond) is the largest and oldest of the Finger Ponds, and was used from approximately 1955 to 1977 to contain the red calcine tails and other dust precipitates created during the roasting of sulfur ore in the production of sulfuric acid at the Acid Plant. At the start of oxide leaching operations in 1954, the Acid Plant generated approximately 300 tons of calcines per day, which were slurried through the concrete lined "calcine ditch" using spent solution pumped from the copper cementation tanks (i.e., iron launders) (Anaconda, 1954). According to Bright (1976), Finger Pond 5 received treated wastewater effluent from the community of Weed Heights for an unspecified time period.

Anaconda (1954) reported that the calcine solids contained 0.9 percent sulfur and the spent solution from the cementation tanks was also acidic. The solids were also likely to be elevated in various metals, including iron and selenium, as it was reported that one step of the acid production process generated fume gas containing 30 to 40 percent selenium (Anaconda, 1954). Historic records indicate that Anaconda collected these selenium precipitates for offsite sale, but it is uncertain whether this was routinely done throughout the life of the operation.

Finger Pond 5 has a containment dike along the northern tip and eastern edge, but otherwise follows natural topographic contours with no bermed containment on the western side. It is unlined with elevated embankments along the north and east (downhill) sides, with no apparent cut on the uphill side, allowing the wastes to fill in above natural topography. The pond was approximately 4,500 feet long by 600 to 1,000 feet wide, as originally constructed, but has since had the southern two thirds covered by the Phase IV VLT Heap Leach Pad. The remainder of the pond covers an area of 68.9 acres, and has been capped with VLT materials so that none of the original pond sediments are readily visible (areas along the edge of pond can be scraped to reveal a fine red powder, and red dust is locally visible on nearby soils and pond sediments). Pond sediment thickness varies from 2 to 6 feet, based on the elevation difference from surrounding topography. If an average thickness of three feet is used, the estimated volume of materials in the remaining exposed pond area is approximately 333,000 cubic yards.

Sulfide Tailings Area. The Sulfide Tailings area is located directly north and northeast of the Process Areas, and occupies a total surface area of approximately 385 acres. The Sulfide Tailings area was constructed in two phases including the original southern tailings dam that was constructed in approximately 1961 and the northern tailings dam that was constructed in 1968. The impoundment embankments were constructed with VLT materials, and the dam appears to have been constructed in lifts to increase the impoundment capacity over time. The elevations of the base and top of the embankments are approximately 4,360 feet amsl and 4,400 feet amsl, respectively, resulting in a height of approximately 40 feet. The estimated volume of tailings material contained in the Sulfide Tailings Pond is approximately 12,425,000 cubic yards. The average thickness of tailings is approximately 20 feet. The ground underlying the tailings material is unlined native soil, which was previously used to evaporate the oxide leach spent solution that was later conveyed to the Unlined and Lined Evaporation Ponds.

Sulfide tailings resulted from the sulfide ore beneficiation process, which operated between 1961 and 1978. The sulfide ore process circuit involved fine crushing and copper sulfide recovery by chemical flotation and lime addition for pH control. The tailings were deposited as a slurry, from which the process water was recycled back to the process or evaporate. A large pumping station at the northwest corner of the Sulfide Tailings area was used to pump excess water back to the Process Areas facility for reuse. The remaining solids (i.e., tailings) consisted of very fine to fine-grained materials (clays, silts and fine sands). During the period between 1972 and 1977, based on the 1977 aerial photo (Appendix A), the southern portion of the Sulfide Tailings area was modified to create smaller discrete cells to serve as process solution ponds for: 1) the recycling of tailings solutions; or 2) the management of spent solutions from the leaching of oxide ores, based on the dark red color of the water resembling the color of the solutions in the Lined and Unlined Evaporation Ponds.

In the late 1980s or early 1990s Arimetco excavated a 500 by 300 foot area of the northern portion of the Sulfide Tailings area to native soil, resulting in an excavation up to 30 feet deep. Arimetco used the clays from this excavation to construct the sub-liner base beneath the heap leach pads. Additional shallow excavations and backhoe pits occur in the northern portion of the Sulfide Tailings by Arimetco were presumably intended to search for other clay borrow areas. Arimetco also excavated a 500 foot long and 20 foot deep trench southwest of the clay borrow pit, which was used as an on-site landfill. The contents and types of wastes discarded in this trench are unknown and have been partially covered. The remaining visible waste appear to be primarily non-hazardous industrial waste and construction materials such as wood pallets, cement bags and office waste (e.g., paper products).

Oxide Tailings Area. Spent oxide ore removed from the Vat Leach tanks after acid leaching for copper recovery is referred to as oxide tailings or Vat Leach Tailings (“VLT”). VLT materials consist of the spent ore remaining after the mined oxide ore was crushed to a nominal 0.75-inch size, leached in sulfuric acid for 5 days, and rinsed with water for two days to remove excess acid. VLT materials were removed from the tanks by clam-shell digger and hauled by truck to the oxide tailings area, where it was stacked and stored as a dry waste. The spent ore consists of quartz monzonite porphyry primarily composed of quartz, feldspar and mica. Anaconda (1954) reported an extraction efficiency of 85 to 90 percent of the copper during leaching, resulting in a residual copper content in the spent ore of 10 to 15 percent of the original copper grade.

The oxide tailings area currently occupies 285 acres immediately north of the Process Areas (Figure 1-2), where the VLT materials were stacked on native ground. Anaconda (1972) estimated the original volume of VLT materials to be approximately 103 million tons, based on a production rate of 4.5 million tons of oxide ore per year for 23 operating years. A portion of the oxide tailings was mined, re-located to newly constructed copper heap leach pads, and processed by Arimetco. VLT materials have also been used in all areas of the Site for road base, capping material, pond embankments and general fill material. The topography of the VLT pile is uneven with numerous terraces of different elevations, most of which are accessible by vehicle.

The following time line, based on the aerial photographs provided in Appendix A, summarize the evaporation ponds and tailings areas used by Anaconda to manage process solids and solutions.

1953 First ore was delivered to the leaching plant, and the initial deposition of oxide (vat leach) tailings occurred north of the Process Areas.

1954 The Unlined Evaporation Pond and the area underlying the Sulfide Tailings was used to manage process solutions generated by vat leaching (the discharge point appears to have been at the southern end of the Sulfide Tailings area and solutions flowed by gravity to collect in the low point in the area of the current Unlined Evaporation Pond). A berm constructed around the sides contained the pond solutions, of which the northern and western sides corresponded with the current margins of the Unlined Evaporation Pond. The sulfide plant was not installed, and no deposition of sulfide tailings occurred.

1961 The sulfide concentrator plant was constructed in the Process Areas and began processing sulfide ore. The tailings dam was likely constructed at this time.

1965 A dam was constructed along the northern and western margins of the current Sulfide Tailings area to limit the accumulation of tails to the southern half of the area (the natural topography of the Groundhog Hills/Singatse Spur constrained the tailings to the east). Light colored "milky" solution visible in the aerial photo indicates the high sediment content in the tailings. The sulfide tailings area was unlined. The northern half of the current sulfide tailings area was used to contain seepage from the southern half and/or was used as an evaporation pond.

The Unlined Evaporation Pond was constructed to its current configuration, with the large pond area to the north and a small triangular pond at the southern tip. A berm was added along the eastern edge to contain pond solutions to the western half. Finger Pond 5 (Calcine Tails Pond), reported to contain the calcine flue dusts from the Acid Plant, was in use along the west and southwest margins of the Unlined Evaporation Pond and the Sulfide Tailings area and contains a dark liquid and sediment.

1967 The sulfide concentrator in the process area reportedly expanded to double its processing capacity in 1967. No significant change is visible from the 1965 photo except that a larger surface area is covered by Sulfide Tailings and the discharge point has been re-located to a southern location. Seepage is visible along the northern tailings dam into the pond area, current covered by the northern portion of the Sulfide Tailings area.

1968 A new sulfide tailings dam has been/is being constructed to the current dimensions seen today, expanding into the northern half and an additional half mile east towards Highway 95A, although it does not appear to be in use as of the date of this photo. No changes have occurred at the Unlined Evaporation Pond or the Finger Pond (1968 Aerial Photo).

1974 The Lined Evaporation Ponds and Lined Finger Ponds were constructed.

1977 ARC acquired the Site from Anaconda prior to shutting down mining and processing operations. The expanded northern end of the Sulfide Tailings had been filled to capacity with process water, while the southern half had been modified with a patchwork of Process Solution Ponds. The Unlined Evaporation Pond was unchanged, and the Lined Evaporation Ponds were constructed to contain similar types of waste water. Four additional Finger Evaporation Ponds (Finger Ponds 1-4) were added alongside the original large Finger Pond (Finger Pond 5), which was still in use.

Post-Anaconda Operations

Arimetco, Inc. acquired the property in 1989 and initiated leaching operations at five lined leach pads located around the site (Figure 2), including the rehandling and leaching of previously deposited waste rock north of the pit. Arimetco also constructed and operated an electro-winning plant with associated solution ponds located south of the former mill area (Figure 2). Some Arimetco leach pads and solution ponds were constructed on the pre-existing Anaconda processing and tailings areas, including the oxide tailings areas, the W-3 dump leach, and the sulfuric acid plant.

Arimetco ceased mining new ore and leaching operations in November 1998 and continued to recover copper from the heaps until November 1999. Since the end of mining and leaching operations by Arimetco in 1999 to the present, the management of heap draindown solutions by recirculation and evaporation has been performed the State of Nevada and ARC. Beginning in 1986, ARC has managed mine-related groundwater by installing and operating a pumpback well system and three lined evaporation ponds located along the northern margin of the Site.

Current On-Site Physical and Chemical Hazards

The following Site conditions, listed by OU and for the Site in general, have been identified as posing potential hazards:

Process Areas

- Unprotected tanks and building foundations/basements create a falling hazard.
- Dilapidated buildings create an overhead hazard of potentially loose or unstable building materials.
- Partially dismantled buildings/equipment and general debris create walking and tripping hazards such as uneven ground, exposed sharp metal edges, or nails.
- Asbestos containing building materials may create an inhalation hazard if the asbestos becomes friable and airborne.
- Building surfaces painted with lead-based paints may create an inhalation or ingestion hazard.
- Containers, soils or building materials may contain or be contaminated by unidentified chemicals creating inhalation or skin exposure hazards.
- Soils and/or process equipment may be contaminated with radiological materials creating radiation exposure or inhalation hazards.

Pit Lake

- Deep water in Pit Lake creates a drowning potential.
- Potentially unstable pit highwalls can result in rocks and loose soil falling from above or roadways/benches collapsing underneath workers.
- Unprotected highwalls create a potential falling hazard.

Evaporation Ponds/Sulfide Tailings

- Standing water in PWS Ponds creates a drowning hazard.
- Rainwater that may accumulate in the inactive Lined and Unlined Evaporation Ponds may become acidified resulting in corrosive hazard when contacted with skin and eyes.
- Moist or saturated sediments in ponds may be slippery or unstable creating a walking/working surface hazard.
- Dust blowing from ponds may create an inhalation hazard or may reduce visibility when working in the area.
- The Weed Heights Sewage Ponds are a biological hazard with potential exposure to e. coli and fecal colliform bacteria.

Oxide Tailings (VLT) and Waste Rock Areas

- Undercut margins created when the piles were re-mined creates potentially unstable surfaces, which could collapse as well as potential driving hazards where vehicles could drive over an unprotected edge.

Arimetco Facilities

- Acidic heap draindown fluids and direct precipitation may accumulate in ditches and ponds, resulting in corrosive hazard when contacted with skin and eyes.
- Moist or saturated sediments in ditches and ponds may be slippery or unstable creating a walking/working surface hazard.

General Hazards (all areas)

- Biological hazards from contact with wildlife (e.g. spiders, snakes, rodents).
- Windblown dust can irritate eyes and throat.
- Heat and cold stress caused by weather conditions, work tasks, or PPE requirements.
- Contact with live electrical lines or buried utilities.

Measures taken by ARC to ensure site security and safety include: 1) the Site is secured by 14 miles of mixed fencing including non-climbable, barbed-wire and chain-link fence; 2) security is managed by two full time site workers who have been trained to specifically identify, mitigate or work around existing physical hazards; and 3) current Site workers are managed by a comprehensive Site Health and Safety Plan ("SHSP") to ensure that appropriate safety measures are taken for any physical or chemical hazards. BLM has restricted access to the property for public use due to such hazards, and both ARC and BLM have posted the appropriate signage on the perimeter fence and on the Site.

ARC has maintained all roads on the Site to eliminate hazardous driving conditions and can restrict driving if inclement weather creates temporary road hazards and poor driving conditions. All flammable or explosive chemicals that may represent an acute hazard have been previously removed by NDEP and EPA. Potential physical hazards associated with uneven terrain, steep slopes, dilapidated buildings, and various structures and equipment remaining from past operations are addressed for all on-Site visitors during the safety meeting and Site orientation provided to all visitors to the Site.

1.4 Human Population Areas

No residential areas are located on the Site. Figure 1-1 indicates that the closest off-Site residential areas include the community of Weed Heights, Locust Lane, portions of the City of Yerington and the adjacent Yerington Paiute Tribe ("YPT") Colony, development north of Luzier Lane and in the Sunset Hills area. Other off-Site resident populations include the YPT Reservation approximately 2.5 miles north of the Site. Approximately 2,880 people (1,200 households) and 5,730 people (2,700 households) live within 1 and 3 miles, respectively, of the Site boundary (ATSDR 2006; U.S. Census Bureau, 2000). Most of these people live in the City of Yerington, with lower populations on 1- to 5-acre parcels located north and west of the Site (e.g., Sunset Hills and Locust Lane residential areas, respectively) Slightly higher density residential development is currently occurring north of the Site (ATSDR, 2006). Members of the YPT include approximately 175 members living east of the Site in the Yerington Colony and approximately 400 members living on the reservation north of the Site (ATSDR, 2006). Commercial and industrial businesses operate in the community of Weed Heights, the City of Yerington, and along Highway 95A between the Site and the City of Yerington.

1.5 Site Ecological Conditions

This section discusses habitats and species likely present at the Site and its surrounding environment. A preliminary overview of local ecological conditions is presented, recognizing that no qualitative or quantitative habitat surveys or vegetative surveys are known to have been conducted at the Site.

1.5.1 Habitats

Terrestrial Habitats

The terrestrial ecosystem in the vicinity of the Site is characterized by an arid sagebrush-steppe vegetative community that is dominated by sagebrush and other low-lying woody vegetation (Table 1-2), interspersed with a variety of forbs and grasses. Both livestock and wildlife preference for grasses contributes to the domination of vegetation in this system by sagebrush and other shrubs (Anonymous 2001; Ricketts et al. 1999).

Vegetation has been removed or buried in the course of mining activities, including the creation of mining waste piles, roads, and buildings. Many remaining areas on the Site have been disturbed to some degree but may still retain areas of sandy soil interspersed with vegetation typical of the sagebrush-steppe vegetative mix of shrubs, forbs, and grasses described above.

Anthropogenic activities on the Site have generated topographic heterogeneity, particularly the large piles of tailings and waste rock piles. These prominent features could be used as vantage points for predators surveying the surrounding area, and steep-sloped piles may potentially be used by nesting birds (e.g., swallows). Buildings in the Process Areas of the Site, particularly if rarely used, offer additional nesting opportunities for wildlife. Process fluid conduits and other structures could serve as coyote or kit fox dens.

Table 1-2. Woody Vegetation of the Great Basin Shrub-Steppe Ecosystem

Species	Min. Elevation (ft)	Max. Elevation (ft)
Rubber (gray) Rabbitbrush	0	10,000
Green Rabbitbrush	0	10,000
Four-winged Saltbush	0	8,500
Greasewood	0	7,000
Red Osier Dogwood	0	9,000
Greenleaf Manzanita	0	9,500
Wild Rose	0	9,000
Winterfat	0	8,000
Snowberry	0	10,000
Ephedra	2,500	6,000
Blue Yucca	2,500	8,000
Utah Juniper	3,000	8,000
Serviceberry	3,000	8,000
Western Chokecherry	3,100	8,000
Bitterbrush	3,100	10,000
Cliffrose	3,500	8,000
Desert sumac	4,000	?
Shadscale	4,000	7,000
Oregon grape	4,000	9,800
Sagebrush	wide range	wide range

Sources:
U.S. National Park Service, 2007; Lloyd, 2007

Aquatic Habitats

The major natural aquatic feature in the vicinity of the Site is the Walker River, which flows north-northeast between the Site and the town of Yerington, and flows within a quarter mile of the Site at its southeastern end. Although riparian systems comprise an extremely small fraction of the Great Basin region, they are critical centers of biodiversity (i.e., more than 75 percent of the species in the region are strongly associated with riparian vegetation; Brussard and Dobkin, 2006).

The Walker River is typical of a Great Basin riparian system, as it is dominated by woody plants such as cottonwood, birch and willows. Saltbush may be abundant if riverbank soil is saline (Anonymous, 2001). The riparian corridor of the Walker River is likely a strong attractant for both resident and migrating wildlife in an arid landscape, as it provides vegetative cover, water and aquatic habitat. The proximity of the Site to the Walker River likely increases Site use by wildlife (e.g., migratory birds initially attracted by the river may discover, and come to rest on, the aquatic areas present on the Site).

Anthropogenic activities at the Site have introduced new aquatic areas that could attract wildlife. Examples of these features include the permanent waters of the Pit Lake at the south end of the Site, wastewater treatment ponds, pumpback evaporation ponds, and seasonally available waters (generally December through May) of the lined evaporation ponds at the north end of the Site. These Site features may provide sources of drinking water for wildlife at the Site, resting areas for migratory birds, and a source of emergent vegetation for feeding and cover for both migrating and resident wildlife.

1.5.2 Species

The topographic diversity at the Site and surrounding area provides potential habitat for species that are native to the Great Basin. Plant communities have been discussed in the preceding sections on habitat. Wildlife monitoring (point-count transects and camera trap surveys) at the north end of the Site (evaporation and sewage treatment pond areas) is currently underway.

Invertebrates

Insects including butterflies and moths, true flies, grasshoppers, crickets, beetles, ants, and bees are all common and diverse in the sagebrush-steppe. Other terrestrial invertebrates, including spiders, scorpions, pseudoscorpions, centipedes, and millipedes are also distributed throughout sagebrush-steppe habitat of the Great Basin. Many invertebrates (e.g., ants, beetles and many species of spiders) will spend some or all of their lifecycle using burrows or underground retreats for storing food, nesting, and seeking protection from predation. Insectivorous birds (e.g., swallows, killdeer, flycatchers) and mammals (e.g., shrew) rely on many of these invertebrate taxa for food.

Aquatic insects including blackfly, caddisfly, and mayfly larvae inhabit streams and other water bodies of the Great Basin, along with other invertebrates, including snails and nematodes. In a sampling effort for water quality and biota in the Walker River near the Walker River Indian Reservation, true bugs (Hemiptera), damselfly (Odonata) and crayfish (Decapoda) were collected (Thodal and Tuttle 1996).

Given the proximity of the Walker River to the Site, and the likelihood of the river to contain several aquatic invertebrate taxa, it is likely that some invertebrates (e.g., those with emergent adult stages) have colonized the pumpback ponds, Pit Lake, and sewage treatment ponds at the Site. Aquatic invertebrates may also colonize the Evaporation Ponds and Sulfide Tailings Ponds during periods of inundation.

Reptiles and Amphibians

Several species of snakes and lizards potentially live on or near the Site (Table 1-3), and several unidentified reptile species have been observed on Site. Amphibians are relatively rare in the arid ecosystem of the Great Basin, but at least three species could occur on or near the Site.

Table 1-3. Reptiles and Amphibians that may Occur in the Area of the Site
Reptiles
Snakes
California king snake
Coachwhip
Common garter snake
Great Basin gopher snake
Great Basin rattlesnake
Long-nosed snake
Night snake
Rubber boa
Striped whipsnake
Western ground snake
Western patch-nosed snake
Western terrestrial garter snake
Western yellow-bellied racer
Lizards
Desert horned toad
Desert spiny lizard
Great Basin (Western) skink
Great Basin collared lizard
Leopard lizard
Long-nosed leopard lizard
Northern sagebrush lizard
Side-blotched lizard
Western fence lizard
Western whiptail
Zebra-tailed lizard
Amphibians
Frogs
Pacific tree frog
Toads
Western toad
Great Basin spadefoot toad

Sources:
DCNR-NHP (2007), Sharpe et al. (2007)

Birds

Approximately 270 species occur in the vicinity of the Site, based on a compilation for the Carson City area and the Stillwater Wildlife Management Area ("SWMA") located approximately 40 miles from Yerington (Table 1-4; seasonal abundances are for the SWMA). The Nevada Division of Wildlife ("NDOW") identified 174 bird species present in the lower

Walker River Basin (Thodal and Tuttle, 1996). Shorebirds and waterfowl documented on the Site include killdeer, gulls, dabbling ducks (including cinnamon teal, mallards, and shovelers), diving ducks (e.g., common goldeneyes), and other waterbirds (e.g., American coots and eared grebes). A variety of herbivorous and insectivorous passerines have been documented at ponds on the Site (footnoted in Table 1-4) including sage and white-crowned sparrows, yellow-headed blackbirds (potential nesting pairs documented; Mattison, 2007; pers. comm.), Say's phoebes and barn swallows (Integral, 2008). Raptors (e.g., American kestrels, red-tailed hawks, merlins, owls and turkey vultures) have been documented at the Site (Integral, 2008).

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Loons				
Common Loon	r	-	r	-
Arctic Loon				
Grebes				
Horned Grebe	r	-	r	-
Eared Grebe*	c	c	c	-
Western Grebe*	c	o	c	o
Pied-billed Grebe*	u	u	u	o
Pelicans and Cormorants				
American White Pelican	c	a	a	r
Double-crested Cormorant +	u	u	u	r
Brown Pelican				
Heron, Bitterns, Egrets, and Ibises				
Great Blue Heron*	c	c	c	u
Great Egret*	c	u	c	o
Green-backed Heron				
Black-crowned Night-Heron*	c	a	c	u
Common Egret				
Snowy Egret*	c	a	c	-
Flamingo				
Least Bittern	r	r	r	-
American Bittern*	r	o	r	-
White-faced Ibis* +	u	c	u	r
Wood Ibis				

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas - Continued

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Swans, Geese, and Ducks				
Tundra Swan	c	-	u	a
Canada Goose* (3 races) +	c	c	c	a
Black Brant				
Greater White-Fronted Goose	-	-	o	o
Snow Goose	c	-	c	u
Blue Goose				
Ross' Goose	o	-	o	-
Fulvous Whistling-duck				
Mallard* +	a	a	a	c
Gadwall*	a	a	a	u
Northern Pintail*	a	c	a	u
Cinnamon Teal* +	a	a	c	o
Green-winged Teal*	a	u	a	u
Blue-winged Teal*	o	o	-	-
Eurasian Wigeon				
American Wigeon*	c	o	a	u
Northern Shoveler*	a	c	a	u
Wood Duck*	u	u	u	-
Redhead* +	a	a	a	o
Ring-necked Duck +	u	-	u	-
Canvasback*	c	o	a	u
Lesser Scaup	u	-	u	u
Common Goldeneye	u	-	u	u
Barrow's Goldeneye				
Bufflehead	c	-	u	c
Long-tailed Duck (Oldsquaw)				
Greater Scaup	o	-	o	o
Harlequin Duck				
White-winged Scoter				
Surf Scoter	-	-	o	o
Ruddy Duck* +	a	c	a	u
Hooded Merganser	o	-	o	o
Common Merganser	c	-	u	c
Red-breasted Merganser	r	-	r	r

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas – Continued

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Vultures and Hawks				
Turkey Vulture +	u	u	u	-
Northern Goshawk	r	r	-	-
Sharp-shinned Hawk	a	r	-	o
Cooper's Hawk	o	-	-	o
Red-tailed Hawk* +	c	u	c	u
Swainson's Hawk*	o	u	o	-
Rough-legged Hawk	u	-	u	c
Ferruginous Hawk	r	-	-	r
Northern Harrier* +	c	c	c	a
Osprey				
Prairie Falcon	o	-	o	u
Peregrine Falcon				
Merlin +				
American Kestrel +	c	c	c	c
Golden Eagle	u	o	u	u
Bald Eagle#	o	-	-	u
Grouse, Quail, Pheasants, and Partridges				
Blue Grouse				
Sage Grouse				
California Quail* +	u	c	c	u
Mountain Quail				
Ring-necked Pheasant*	u	u	u	u
Chukar*	c	c	c	c
Gray Partridge				
Wild Turkey				
Cranes				
Greater Sandhill Crane	o	-	o	o
Rails, Gallinules, and Coots				
Sora*	u	c	c	o
Virginia Rail*	u	c	c	o
Common Gallinule*	r	o	r	r
American Coot* +	a	a	a	c
Semipalmated Plover	o	-	o	-
Snowy Plover*	o	u	o	-
Killdeer* +	a	a	c	o

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas – Continued

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Plovers, Snipe, and Sandpipers				
Semipalmated Plover	o	-	o	-
Snowy Plover*	o	u	o	-
Killdeer* +	a	a	c	o
Black-bellied Plover	o	-	o	-
Mountain Plover	-	-	r	-
Ruddy Turnstove				
Common Snipe	u	o	u	o
Long-billed Curlew*	u	u	u	r
Spotted Sandpiper*	u	o	u	r
Solitary Sandpiper	o	-	o	-
Willet	o	o	o	-
Greater Yellowlegs	u	o	u	o
Lesser Yellowlegs +	o	r	o	r
Knot				
Baird's Sandpiper				
Least Sandpiper	a	u	a	-
Dunlin	o	-	o	-
Long-billed Dowitcher	c	o	a	-
Short-billed Dowitcher				
Stilt Sandpiper				
Western Sandpiper	c	a	a	o
Sanderling	r	-	r	-
Marbled Godwit	o	u	u	o
American Avocet +	c	a	a	o
Black-necked Stilt*	c	a	u	-
Wilson's Phalarope* +	a	c	a	-
Northern Phalarope	c	c	c	-
Gulls, Terns, and Murrelet				
Herring Gull				
California Gull	c	c	o	r
Ring-billed Gull	u	u	u	o
Bonaparte's Gull	r	r	r	-
Forster's Tern*	u	a	o	-
Caspian Tern	o	o	-	-
Black Tern*	o	o	-	-
Ancient Murrelet				

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas – Continued

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Pigeons and Doves				
Band-tailed Pigeon				
Rock Dove +				
Mourning Dove* +	u	c	c	o
Common Ground-dove				
Owls				
Barn Owl	c	c	c	c
Western Screech-Owl*	u	u	u	u
Great Horned Owl* +	c	c	c	c
Northern Pygmy-owl				
Northern Saw-whet Owl	-	-	-	r
Short-eared Owl*	o	r	u	c
Long-eared Owl*	o	r	r	o
Burrowing Owl*	u	u	o	-
Goatsuckers				
Common Poorwill +				
Common Nighthawk	u	c	u	-
Swifts and Hummingbirds				
White-throated Swift				
Black Swift				
Vaux's Swift	r	-	-	-
Black-chinned Hummingbird				
Broad-tailed Hummingbird				
Rufous Hummingbird	-	u	-	-
Calliope Hummingbird				
Costa's Hummingbird				
Kingfishers				
Belted Kingfisher	o	r	o	o
Woodpeckers				
Northern Flicker*	c	c	c	c
Downy Woodpecker*	-	-	u	u
Lewis' Woodpecker	r	r	o	-
Hairy Woodpecker	-	-	-	r
White-headed Woodpecker				
Yellow-bellied Sapsucker				
Williamson's Sapsucker				
Black-backed Woodpecker				

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas – Continued

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Flycatchers				
Western Kingbird +	c	a	c	-
Eastern Kingbird				
Ash-throated Flycatcher	o	o	-	-
Cassin's Kingbird				
Western Flycatcher				
Willow Flycatcher, western species				
Hammond's Flycatcher				
Dusky Flycatcher				
Say's Phoebe* +	u	u	o	O
Western Wood-Pewee	u	u	u	-
Black Phoebe	o	-	r	R
Olive-sided Flycatcher	r	r	-	-
Gray Flycatcher				
Larks and Swallows				
Horned Lark +	a	c	a	C
Violet-green Swallow	u	u	u	-
Tree Swallow	c	u	u	-
Northern Rough-winged Swallow* +	u	o	u	-
Barn Swallow* +	c	a	u	-
Cliff Swallow*	u	a	u	-
Bank Swallow +				
Purple Martin				
Jays, Magpies, and Crows				
Scrub Jay	o	-	o	-
Pinyon Jay	r	-	r	-
Stellar's Jay				
American Crow	r	r	r	R
Common Raven +	u	c	c	U
Black-billed Magpie	c	c	c	C
Clark's Nutcracker				
Titmice, Bushtits, and Nuthatches				
Mountain Chickadee	-	-	-	O
Bushtit*	o	o	o	R
Plain Titmouse				
Pygmy Nuthatch				
White-breasted Nuthatch				

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas – Continued

Species	Seasonal Abundance			
	Spring	Summer	Fall	Winter
Titmice, Bushtits, and Nuthatches				
Red-breasted Nuthatch	o	r	o	-
Brown Creeper				
Wrens				
American Dipper				
Winter Wren				
Bewick's Wren*	u	u	u	R
Rock Wren				
Canyon Wren				
Marsh Wren*	c	a	c	U
House Wren				
Mockingbirds and Thrashers				
Northern Mockingbird	r	r	r	-
Sage Thrasher* +	o	o	u	-
Thrushes, Bluebirds, and Solitaires				
American Robin +	u	u	u	O
Townsend's Solitaire	o	o	o	R
Swainson's Thrush				
Western Bluebird	r	-	r	R
Mountain Bluebird	r	-	r	R
Varied Thrush	-	-	o	-
Hermit Thrush				
Kinglets, Gnatcatchers, and Pipits				
Blue-gray Gnatcatcher				
Ruby-crowned Kinglet	o	-	o	O
Golden-crowned Kinglet	-	-	r	-
Water Pipit	o	-	u	U
American Pipit				
Waxwings, Shrikes, and Starlings				
Cedar Waxwing	r	-	r	-
Bohemian Waxwing	-	-	u	-
Loggerhead Shrike*	a	c	a	C
Northern Shrike	-	-	-	U
Phainopepla				
European Starling* +	c	u	c	C

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas - Continued				
Species	**Seasonal Abundance**			
	Spring	**Summer**	**Fall**	**Winter**
Vireos and Warblers				
Solitary Vireo				
Hutton's Vireo				
Warbling Vireo	o	-	o	-
Orange-crowned Warbler	o	-	r	R
Yellow Warbler	u	c	u	-
Townsend's Warbler				
Prothonotary Warbler				
Yellow-rumped Warbler	u	-	o	O
Black-throated Gray Warbler				
Hermit Warbler				
Yellow-breasted Chat*	r	o	r	-
MacGillivray's Warbler	o	-	o	-
Common Yellowthroat*	o	o	o	-
Wilson's Warbler				
Weaver Finches				
House Sparrow* +	u	u	u	U
Meadowlarks, Blackbirds, and Orioles				
Ovenbird				
Western Meadowlark +	a	c	a	C
Yellow-headed Blackbird* +	c	a	o	O
Red-winged Blackbird* +	c	c	c	C
Brewer's Blackbird* +	c	c	c	C
Northern Oriole*	u	u	o	-
Brown-headed Cowbird*	u	u	u	-
Common Grackle				
Scott's Oriole				
Tanagers, Finches, Grosbeaks, and Sparrows				
Western Tanager	u	o	o	-
Black-headed Grosbeak*	o	o	-	-
Evening Grosbeak	u	o	o	-
Lazuli Bunting	o	u	-	-
Blue Grosbeak	o	o	-	-
Lesser Goldfinch				
American Goldfinch	u	-	u	-
Rosy (Gray-crowned and Black) Finch				
Red Crossbill				

Table 1-4. Birds that may Occur in the Carson City and Stillwater Wildlife Management Areas - Continued				
Species	**Seasonal Abundance**			
	Spring	**Summer**	**Fall**	**Winter**
Tanagers, Finches, Grosbeaks, and Sparrows				
Green-tailed Towhee	o	-	-	-
Spotted Towhee (Rufous-sided Towhee)	r	-	r	R
Cassin's Finch				
House Finch*	u	u	u	O
Pine Grosbeak				
Common Redpoll				
Pine Siskin	o	o	-	-
Savannah Sparrow*	u	u	u	U
Vesper Sparrow				
Lark Sparrow	u	u	-	-
Black-throated Sparrow	o	o	o	O
Sage Sparrow +	u	o	o	U
Dark-eyed Junco +	o	-	o	U
Tree Sparrow				
Chipping Sparrow	o	o	-	-
Brewer's Sparrow	o	o	-	-
Harris' Sparrow				
Golden-crowned Sparrow				
Lincoln's Sparrow				
Swamp Sparrow				
Lapland Longspur				
White-crowned Sparrow +	c	-	u	A
Fox Sparrow				
Song Sparrow*	c	c	u	O

Notes:
a - abundant, occurs in large numbers
c - common, occurs regularly in moderate numbers
u - uncommon, occurs regularly in small numbers
o - occasional, a few noted each year
r - rare, a few noted, but not each year
* - nests locally
# - threatened or endangered species
+ -observed in Evaporation Pond wildlife study (Integral 2008)
Sources:
USGS (2007); Nevada Department of Conservation and Natural Resources (2007)

Mammals

The sagebrush-steppe habitat of the Great Basin is home to more than 40 species of mammals (Table 1-5). Grazers such as mule deer and pronghorn antelope use a variety of the broad range of grasses, forbs, shrubs, and woody plants of the sagebrush-steppe habitat. Herbivores, including pocket gophers, rabbits, and voles, are primary consumers of a variety of above and below-ground plant stems, roots, leaves, and seeds. Insectivorous mammals of the area include shrews and bat species. More omnivorous small mammals including squirrels, kangaroo rats, and several species of mice feed on a wide variety of vegetation and arthropods.

Several mammals of the sagebrush-steppe ecosystem use burrowing as a means of thermoregulation, protection from predation, and/or foraging. Burrow depths of these species range from shallow depressions of a few inches in the soil made by jackrabbits to depths of 1.5 to 6 feet for pocket gophers and 8 feet for badgers (DTSC, 1998). Almost all of the above mammals may be potential food sources for mammalian Site predators. Bobcats, coyotes, and foxes are all top predators in this ecosystem, and all have been either observed or are likely to occur in this area. Skunks and badgers are present in the sagebrush-steppe habitat of the Great Basin as scavengers and predators, primarily of small mammals such as voles and mice.

Table 1-5. List of Mammals that may Occur in the Great Basin Area

Species	Max. Burrow Depth (in)
Ungulates	
Pronghorn Antelope	n/a
Mule Deer	n/a
Carnivores	
Mountain Lion	n/a
Coyote	up to 91[1]
Bobcat	n/a
Black bear	n/a
Kit Fox	up to 91[1]
Red Fox	120[1,2]
Gray Fox	ND[1]
Western Spotted Skunk	ND[1]
American Badger	up to 91

Table 1-5. List of Mammals that may Occur in the Great Basin Area – Continued	
Species	**Max. Burrow Depth (in)**
Lagomorphs	
Pygmy Rabbit	n/a
Desert Cottontail	6 to 10
Black-tailed Jackrabbit	1 to 5
Rodents: Omnivores	
Great Basin Ground Squirrel	up to 36
Golden-mantled Ground Squirrel	~18
White-tailed Antelope Squirrel	n/a
Least Chipmunk	20 to 40
Rodents: Omnivores - Continued	
Cliff Chipmunk	n/a
Great Basin Pocket Mouse	n/a
Little Pocket Mouse	20 to 26
Ord's Kangaroo Rat	ND
Chisel-toothed Kangaroo Rat	ND
Merriam's Kangaroo Rat	13
American Deer Mouse	n/a
Canyon Mouse	n/a
Pinon Mouse	n/a
Northern Grasshopper Mouse	n/a
Desert Woodrat	n/a
House Mouse	n/a
Norway Rat	n/a
Rodents: Herbivores	
Northern Pocket Gopher	4-18 inches, with some parts as deep as 5-6 feet
Botta's Pocket Gopher	4-18 inches, with some parts as deep as 5-6 feet
Townsend's Pocket Gopher	4-18 inches, with some parts as deep as 5-6 feet
Long-tailed Vole	n/a
Sagebrush Vole	n/a
Insectivores	
Merriam's Shrew	ND[3]
Bats	
California Myotis	n/a
Western Small-footed Myotis	n/a
Fringed Myotis	n/a
Western Pipistrelle	n/a
Townsend's Big-eared Bat	n/a
Pallid Bat	n/a
Brazilian Free-tailed Bat	n/a

Notes:
[1]Kit fox, red fox, gray fox, western spotted skunk, and coyote tend to use and/or enlarge burrows constructed by other animals including ground squirrels and badgers.
[2]Red fox burrows may be up to 10 m (390 in) long and descend to 3 m (120 in) below ground surface.
[3]Shrews are not primarily fossorial, but they may opportunistically use the burrows of other rodents.
n/a = not applicable because the species is not fossorial.
ND = May burrow or adopt burrows of other species but burrow depths specific to this species were not found.
Sources: Reid (2006); DTSC (1998)

Threatened and Endangered Species

Five federally threatened/endangered plants and 19 state listed plant species are identified by the State of Nevada's Natural Heritage Program; none of the range maps of these species overlaps with the area of the Site (Nevada Department of Conservation and Natural Resources 2007). Five plant species of concern were listed by Thodal and Tuttle (1996) as occurring in the Walker River basin: Eastwood's milkvetch (*Asclepias eastwoodiana*), Masonia mountain jewelflower (*Streptanthus oliganthus*), Mono phacelia (*Phacelia monoensis*), Nevada dune beardtongue (*Penstemon arenarius*); Nevada oryctes (*Oryctes nevadensis*). The bald eagle occurs seasonally in small numbers throughout the area, but there is little if any suitable habitat for this species at the Site. The Site is located north of the estimated breeding range of the federally listed Southwestern willow flycatcher (*Empidonax trailii extimus*) (USFWS 1995); the western subspecies of willow flycatcher (*Empidonax trailii brewsterii*) is potentially found in the Site area, but this subspecies of willow flycatcher is not a listed species.

SECTION 2.0
POTENTIAL SOURCES AND RELEASE MECHANISMS

A number of the OUs described in Section 1.0 represent potential sources of chemicals to the environment. A complete list of chemicals (e.g., metals, radiochemicals, organic compounds related to fuels) for water, soil/sediment, and air that may be evaluated as part of the remedial investigation activities for these OUs is provided below. The updated Site-Wide QAPP (Revision 4, dated August 19, 2008; ESI and Brown and Caldwell, 2007) lists analytical methods and detection limits, which is reproduced in Table 2-1.

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations

Chemicals of Potential Concern	Water	Soil/Sediment	Air
Benzene	X	X	
Bromobenzene	X	X	
Bromochloromethane	X	X	
Bromodichloromethane	X	X	
Bromoform	X	X	
Bromomethane	X	X	
n-Butylbenzene	X	X	
sec-Butylbenzene	X	X	
tert-Butylbenzene	X	X	
Carbon tetrachloride	X	X	
Chlorobenzene	X	X	
Chloroethane	X	X	
2-Chlorotoluene	X	X	
4-Chlorotoluene	X	X	
Chloroform	X	X	
Chloromethane	X	X	
1,2-Dibromo-3-chloropropane	X	X	
Dibromochloromethane	X	X	
1,2-Dibromoethane	X	X	
Dibromomethane	X	X	
1,2-Dichlorobenzene	X	X	
1,3-Dichlorobenzene	X	X	
1,4-Dichlorobenzene	X	X	
Dichlorodifluoromethane	X	X	

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations – Continued

Chemicals of Potential Concern	Water	Soil/Sediment	Air
1,1-Dichloroethane	X	X	
1,2-Dichloroethane	X	X	
1,1-Dichloroethene	X	X	
cis-1,2-Dichloroethene	X	X	
trans-1,2-Dichloroethene	X	X	
1,2-Dichloropropane	X	X	
1,3-Dichloropropane	X	X	
2,2-Dichloropropane	X	X	
1,1-Dichloropropene	X	X	
Ethylbenzene	X	X	
Hexachlorobutadiene	X	X	
Isopropylbenzene	X	X	
p-Isopropyltoluene	X	X	
Methylene chloride	X	X	
Naphthalene	X	X	
n-Propylbenzene	X	X	
Styrene	X	X	
tert-butyl methyl ether	X	X	
1,1,2,2-Tetrachloroethane	X	X	
1,1,2,2-Tetrachloroethene	X	X	
1,1,1,2-Tetrachloroethane	X	X	
Toluene	X	X	
1,2,3-Trichlorobenzene	X	X	
1,2,4-Trichlorobenzene	X	X	
1,1,1-Trichloroethane	X	X	
1,1,2-Trichloroethane	X	X	
Trichloroethene	X	X	
Trichlorofluoromethane	X	X	
1,2,3-Trichloropropane	X	X	
1,2,4-Trimethylbenzene	X	X	
1,3,5-Trimethylbenzene	X	X	
Vinyl chloride	X	X	
Xylene (total)	X	X	
o-Xylene	X	X	
m-Xylene	X	X	
p-Xylene	X	X	
Diesel (C12-C23)-TPH	X	X	
Motor Oil (C23-C40)-TPH	X	X	

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations – Continued

Chemicals of Potential Concern	Water	Soil/Sediment	Air
Gasoline (C4-C12)-TPH	X	X	
2-Chlorophenol	X	X	
4-Chloro-3-methylphenol	X	X	
2,4-Dichlorophenol	X	X	
2,4-Dimethylphenol	X	X	
2,4-Dintrophenol	X	X	
4,6-Dintiro-o-cresol	X	X	
2-Methylphenol	X	X	
3&4-Methylphenol	X	X	
2-Nitrophenol	X	X	
4-Nitrophenol	X	X	
Pentachlorophenol	X	X	
Phenol	X	X	
2,4,5-Trichlorophenol	X	X	
2,4,6-Trichlorophenol	X	X	
Acenaphthene	X	X	
Acenaphthylene	X	X	
Anthracene	X	X	
Benzo(a)anthracene	X	X	
Benzo(a)pyrene	X	X	
Benzo(b)fluoranthene	X	X	
Benzo(g,h,i)perylene	X	X	
Benzo(k)fluoranthene	X	X	
Benzoic acid	X	X	
4-Bromophenyl phenyl ether	X	X	
Butyl benzyl phthalate	X	X	
2-Chloronaphthalene	X	X	
4-Chloroaniline	X	X	
Carbazole	X	X	
Chrysene	X	X	
bis(2-Chloroethoxy)methane	X	X	
bis(2-Chloroethyl)ether	X	X	
bis(2-Chloroisopropyl)ether	X	X	
4-Chlorophenyl phenyl ether	X	X	
2,4-Dintitrotoluene	X	X	
2,6-Dinitrotoluene	X	X	
3,3′-Dichlorobenzidine	X	X	
Dibenzo(a,h)anthracene	X	X	

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations – Continued

Chemicals of Potential Concern	Water	Soil/Sediment	Air
Dibenzofuran	X	X	
1,2-Dichlorobenzene	X	X	
1,3-Dichlorobenzene	X	X	
1,4-Dichlorobenzene	X	X	
di-n-Butyl phthalate	X	X	
di-n-Octyl phthalate	X	X	
Diethyl phthalate	X	X	
Dimethyl phthalate	X	X	
bis(2-Ethylhexyl)phthalate	X	X	
Fluoranthene	X	X	
Fluorene	X	X	
Hexachlorobenzene	X	X	
Hexachlorobutadiene	X	X	
Hexachlorocyclopentadiene	X	X	
Hexachloroethane	X	X	
Indeno(1,2,3-cd)pyrene	X	X	
Isophorone	X	X	
2-Methylnaphthalene	X	X	
2-Nitroaniline	X	X	
3-Nitroaniline	X	X	
4-Nitroaniline	X	X	
Naphthalene	X	X	
Nitrobenzene	X	X	
N-Nitroso-di-n-propylamine	X	X	
N-Nitrosodiphenylamine	X	X	
Phenanthrene	X	X	
Pyrene	X	X	
1,2,4-Trichlorobenzene	X	X	
alpha-BHC	X	X	
beta-BHC	X	X	
gamma-BHC (Lindane)	X	X	
delta-BHC	X	X	
Heptachlor	X	X	
Aldrin	X	X	
Heptachlor epoxide	X	X	
Endosulfan I	X	X	
Dieldrin	X	X	
Endrin aldehyde	X	X	

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations – Continued

Chemicals of Potential Concern	Water	Soil/Sediment	Air
Endrin	X	X	
Endosulfan II	X	X	
4,4′- DDD	X	X	
Endosulfan sulfate	X	X	
4,4′-DDT	X	X	
4,4′-DDE	X	X	
Methoxychlor	X	X	
Endrin ketone	X	X	
alpha-Chlordane	X	X	
gamma-Chlordane	X	X	
Toxaphene	X	X	
Aroclor-1016	X	X	
Aroclor-1221	X	X	
Aroclor-1232	X	X	
Aroclor-1242	X	X	
Aroclor-1248	X	X	
Aroclor-1254	X	X	
Aroclor-1260	X	X	
2,4,5-T	X	X	
2,4-D	X	X	
2,4-DB	X	X	
Dalapon	X	X	
Dichloroprop	X	X	
Dicamba	X	X	
Dinoseb	X	X	
MCPA	X	X	
MCPP	X	X	
Silvex	X	X	
Aluminum	X	X	X
Antimony	X	X	
Arsenic	X	X	X
Barium	X	X	X
Beryllium	X	X	X
Bismuth	X	X	
Boron	X	X	
Cadmium	X	X	X
Calcium	X	X	X
Chromium	X	X	X

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations – Continued

Chemicals of Potential Concern	Water	Soil/Sediment	Air
Cobalt	X	X	X
Copper	X	X	X
Gallium	X		
Iron	X	X	X
Lead	X	X	X
Lithium	X		
Magnesium	X	X	X
Manganese	X	X	X
Mercury	X	X	X
Molybdenum	X	X	X
Nickel	X	X	X
Phosphorus	X		
Potassium	X	X	
Scandium	X		
Selenium	X	X	X
Silicon	X		
Silver	X	X	X
Sodium	X	X	X
Strontium	X		
Thallium	X	X	
Thorium	X	X	
Thorium-232	X		
Thorium-232 Activity	X		
Tin	X		
Titanium	X		
Uranium	X	X	
Uranium Activity	X		
Vanadium	X	X	X
Zinc	X	X	X
Chloride	X		
Fluoride	X		
Nitrate	X		
Nitrite	X		
Nitrate/Nitrite	X		
Sulfate	X		**X**
Phosphate (ortho)	X		
Phosphorus, total	X		
Alkalinity	X		

Table 2-1. Preliminary List of Chemicals Relevant to Site Remedial Investigations – Continued

Chemicals of Potential Concern	Water	Soil/Sediment	Air
Bicarbonate Alkalinity	X		
Carbonate Alkalinity	X		
Hardness as Alkalinity	X		
Hardness	X		
pH	X		
TDS	X		
TOC	X		
TS	X	X	
Gross α	X	X	X
Gross β	X	X	X
Radium-226	X	X	X
Radium-228	X	X	X
Thorium-228	X	X	X
Thorium-230	X	X	X
Thorium-232	X	X	X
Uranium-234	X	X	X
Uranium-235	X	X	X
Uranium-238	X	X	X
TSP			X
PM10			X

Transport mechanisms for chemicals from primary impacted media to secondary and tertiary impacted media are depicted on the schematic diagram for physical and chemical processes (Figure 2-1). Exposure media specific to human health and ecological are described in Sections 3.0 and 4.0, respectively, of this CSM. More detailed descriptions of sources will be provided in each OU-specific remedial investigation work plan.

Chemicals released directly to surface soils or found in tailings as a result of former mining activities may be transported by wind and surface water runoff to other areas of the Site. The presence of natural or artificial physical barriers, such as vegetation or concrete slab foundations, will inhibit or reduce the transport of particles as wind-blown dust. Particulates or fugitive dust that are transported by wind may be deposited and accumulated in downwind areas, including surface soils and surface water bodies (e.g., ponds, pit lake).

Erosion of surface mine units due to surface water runoff (e.g., stormwater or snowmelt events) also may result in transfer and deposition of chemicals in exposed surface soil to other, down-gradient areas. Portions of the Site are subject to stormwater runoff from the alluvial fan developed along the base of the Singatse Range and from local anthropogenic topographic features (e.g., steep slopes in waste rock, heap leach or tailings areas). A limited potential for stormwater to leave the site due to the existence of protective berms or ditches around many of the mine units as well as interior collection areas (e.g., ponds and topographically low areas). Areas that may have minor potential for surface runoff include the south waste rock area, portions of the oxide tailings area on the western margin of the Site, and the sulfide tailings embankment on the northern margin of the Site (evidence of potential stormwater runoff includes visible erosion in the tailings areas and heap leach pads). Accumulated soils or dust may become secondary sources of chemicals to groundwater via leaching and percolation.

Percolation of historic process solutions into the soil column, vadose zone, and groundwater is a potential release mechanism that likely ceased or substantially decreased when mine operations ended, when such solutions evaporated, and/or when surface mine units dried sufficiently to increase moisture storage capacity. Though some recharge may occur during larger precipitation events or melting of winter snows, perched water zones have not been identified during drilling of Site monitoring wells installed at various times beginning in the 1960s through the present.

Geochemical processes (e.g., mobilization and attenuation) may modify the concentration of chemicals in percolating process solutions, soils or unsaturated alluvial materials (i.e., the vadose zone). Horizontal and vertical migration of volatile chemicals (fuel-related compounds and radon) that migrate upwards and are released to ambient air may contribute to attenuation of chemicals in subsurface soil and groundwater. Vapor migration for volatile chemicals in soils and shallow groundwater (EPA, 2002a) is influenced by the chemical and physical properties of soils, and of the volatile chemical species. Zones of capillary reflux are anticipated to occur in the vadose zone immediately beneath the surface, following precipitation and runoff events, and immediately above the water table in the alluvial aquifer.

Groundwater inflows to the Wabuska Drain and the Pit Lake, or recharge from surface mine units and/or the Wabuska Drain to groundwater, may occur (reduced precipitation has lowered the water table in the area of the Site during recent years, which has limited the potential for groundwater inflows into the Wabuska Drain). The Pit Lake is hypothesized to currently function as an evaporative sink. However, water may flow out of, and transport chemicals from, the Pit Lake into: 1) the alluvial groundwater flow system at the current time; and 2) the bedrock flow system when the lake reaches an “equilibrated” state in the future, particularly during seasonal periods of high precipitation. Groundwater inflows to the Pit Lake and the Wabuska Drain may also result in the transport of chemicals from the subsurface environment to surface water, including chemicals in suspended sediments. Sediment and chemical precipitate accumulations also occur in the active PWS ponds and the inactive Anaconda evaporation ponds.

Sources of chemicals to groundwater include historic releases from the Site, past and current agricultural operations, and the flow of groundwater through mineralized bedrock and alluvial materials. The PWS extracts a portion of the groundwater that may migrate off-Site (groundwater flow in this area is affected by agricultural practices immediately north of the Site). The extracted groundwater is pumped and released to lined evaporation ponds, resulting in an accumulation of sediment as the water evaporates. Irrigation wells located to the north and east of the Site pump water from the deep aquifer to provide irrigation of agricultural fields and water for livestock. Groundwater and surface water used to irrigate the fields immediately adjacent to the Site affect off-site groundwater flow directions by the creation of a seasonal mound.

In addition to migration of chemicals from their sources to other media, radiation may exist anywhere radioactive materials are or may accumulate in soils or water. Transport of the material may occur by any of the transport pathways described above. External radiation is limited to materials within the upper 6 inches of soil thickness; radioactive materials found below this level are shielded by the top layer of soil. Geometric attenuation limits the external radiation from materials with no interposed shielding materials to within a few meters (i.e., less than 5 meters and often less than 1 to 2 meters from the source). Radon exhalation into the air and subsequent atmospheric transport also may occur from soils and water containing radium.

The understanding of the fate and transport of mine-related chemicals will evolve through implementation of the OU-specific remedial investigations. This Site-wide CSM will be subsequently updated as additional information is obtained regarding Site sources of chemicals, fate and transport of chemicals, and secondary and tertiary impacted media.

SECTION 3.0
HUMAN HEALTH RECEPTORS AND EXPOSURE ROUTES

This section describes exposure media in which Site-related chemicals may be found, the human receptors that may contact site-related chemicals, and the pathways by which people may contact the chemicals. Transport pathways and impacted media are similar for both the human health and ecological models (e.g., airborne particulates and vapors, soils, sediment, surface water, and groundwater), with slight exceptions for indoor air exposure for humans and variations in soil and sediment contact for ecological receptors. The exposure media, potential exposure routes, and potential receptors of concern for ecological scenarios are discussed in Section 4.0. QAPP-related human health risk assessment information is provided in Appendix D of this CSM.

Sources of chemicals from the Site and release and transport mechanisms for chemicals found or thought to exist on site are discussed in previous sections of this CSM. Figures 3-1 and 3-2 illustrate potential sources, media, transport mechanisms and exposure routes, and human receptors. Exposure media of concern for one or more receptors and may be evaluated in the HHRA process for individual OUs, as applicable, include:

- Surface and subsurface soils (surface soil is defined as soil found from ground surface to 2 feet bgs; subsurface soil is defined as the interval from 2 to 10 feet bgs).
- Tailings.
- Particulates and vapors in outdoor and indoor air.
- Surface water.
- Groundwater.
- Soil or sediment in ephemeral water bodies or conveyances
- Biota (e.g., homegrown produce and livestock, commercial crops, wild game, deep-rooted locally-grown native plants and fish).

The selection of exposure media, receptors, and exposure pathways to be evaluated for each OU-specific HHRA will be based on the nature of data obtained during the remedial investigations for each OU, and discussions with stakeholders.

As described in Section 1.4, approximately 2,880 people (1,200 households) and 5,730 people (2,700 households) live within 1 and 3 miles of the Site, respectively. The majority of the nearby residents live in the City of Yerington, with the remaining population located on nearby parcels in Lyon County. The YPT includes approximately 175 members living east of the Site in the Yerington Colony and approximately 400 members living on the reservation approximately 2.5 miles to the north. Lyon County is developing a revised land use plan, including input from the Mason Valley Environmental Committee (2007), which includes future industrial or commercial reuse at the Site. Current and future land use of the Site is not consistent with, or conducive to, on-Site residential use. Therefore, an on-Site residential scenario is included in this CSM as low probability and potentially incomplete.

Potential pathways of exposure are identified for each of seven receptors:

- Future construction worker.
- Current and future outdoor worker.
- Future indoor worker.
- Off-Site resident.
- Off-Site tribal practitioner of traditional lifeways.
- Trespasser.

EPA (1989) defines a complete exposure pathway as containing the following elements:

- Source and mechanism for release of chemicals.
- Transport or retention medium.
- Point of potential human contact (exposure point) with the affected medium.
- Exposure route at the exposure point.

If any one of these elements is missing, the pathway is not considered complete. In some cases, an exposure pathway may be complete but is not significant because: 1) the exposure may be less than that from another pathway involving the same medium; 2) the magnitude of exposure has low toxicological significance; and/or 3) the probability of exposure is low and potential risks associated with the pathway are not high (EPA 1989). Pathways expected to contribute the most to potential exposures are referred to as "primary" pathways, while those expected to contribute much less on a relative basis are described as "minor" pathways. These designations are preliminary and do not necessarily correspond to pathways that are intended to be evaluated quantitatively versus qualitatively in the human health risk evaluation. Minor and primary exposure routes for each receptor are represented in Figure 3-1 as open and closed circles, respectively. Incomplete exposure routes are represented by two short dash marks. The schematic diagram of the CSM presented as Figure 3-2 shows a simplified version of the chemical transport pathways for the Site. Each of the seven human receptors is depicted on Figure 3-2, along with their corresponding primary and minor exposure routes.

Specific exposure parameters used to quantify intake of mine-related chemicals for each receptor are not provided in this CSM. Memoranda presenting proposed exposure parameters will be prepared and submitted to EPA as interim deliverables prior to initiation of the first OU-specific human health risk assessment ("HHRA").

3.1 Future Construction Worker

It is possible that temporary workers will be used to redevelop the Site in the future. Future workers may include a construction worker who works on site temporarily to perform demolition or construction activities within the Site. These activities may be conducted throughout the Site, wherever existing structures are located for demolition or where future structures and roads may be built. Activities associated with demolition and construction may result in contact with exposure media via the following primary exposure pathways:

- Inhalation of particulates in air.
- Incidental ingestion of, dermal contact with, and external radiation exposure from surface and subsurface soils.

Construction workers are assumed to have potential for direct contact with soil from 0 to 10 feet bgs during demolition and construction activities. This depth is recommended for the Site as the most relevant for activities such as construction (EPA 2002b). While working, the construction worker also may inhale surface soil that has been resuspended and is entrained by the wind or vehicle movement. Construction workers may also contact chemicals via other potentially complete but minor exposure pathways:

- Incidental ingestion of, dermal contact with, and external radiation exposure from tailings.
- Incidental ingestion of, dermal contact with, and external radiation exposure from ephemeral pooled waters and other surface waters and their associated sediments.
- Inhalation of vapors and radon in outdoor air.

External radiation from surface water and direct contact with these waters is considered a potentially complete but minor pathway. If volatile chemicals and/or radon are present in subsurface soil and migrate upward to outdoor air, workers may inhale the vapors and/or radon while working outside. However, this exposure pathway is considered a minor pathway, because vapors are expected to be dispersed in ambient air.

Depth to groundwater at the northern margin of the Site is 20-30 feet bgs compared with other portions of the Site (e.g., up to 200 feet deep in the Process Areas). Therefore, groundwater is not expected to be contacted directly by workers performing construction activities. The future construction worker is not assumed to work indoors; therefore, inhalation of vapors and radon in indoor air also is considered an incomplete exposure pathway.

3.2 Current and Future Outdoor Worker

Two full-time workers currently employed at the Site assist with pumpback well system operations and maintenance ("O&M"), Site security, and related activities. O&M functions include repairing or changing groundwater pumps, and arranging for subcontractor access to occasionally flush the pipes of the PWS. These activities do not involve disturbance of subsurface soils (e.g., excavating), water or sediment in the ponds, or any other area with known sources of contamination. These workers are appropriately trained in hazardous site operations and their activities are conducted in compliance with the SHSP.

Temporary workers are contracted for short periods of time to perform specific maintenance tasks (e.g., re-grading roads, repairing lines and flushing the pipes in the PWS). These activities may last from one day to two weeks, and involve contractors who are either trained to work on hazardous waste sites, or directly managed by someone who has received such training. Contractor activities do not currently include working with Site wastes or source materials. Based on these contractor activities, contact with subsurface soil (from 2 to 10 feet bgs) and surface water are incomplete exposure routes. Although contact with soil/sediment in the various on-Site ponds would not be expected to occur, this pathway is represented as a minor pathway on Figure 3-1 to represent future remedial activities.

A future outdoor worker also is included in this CSM and represents a post-redevelopment exposure scenario. The future outdoor worker is not assumed to perform intensive earth-moving activities, but could perform lighter intensity work such as building maintenance and skilled or trade labor activities. Some of these activities will bring outdoor workers in contact with soil. Although it is also assumed that a future worker may contact sediment (when dry) and water (when wet) in the Wabuska Drain and evaporation ponds, these exposure routes are expected to be limited. Future workers could also contact chemicals in drinking water if institutional controls are not implemented at the Site to prohibit the installation of on-site drinking water wells at depths where Site-related chemicals are found. Based on these tasks, potential primary exposure pathways for current/future outdoor workers (Figure 3-1) at the Site include:

- Inhalation of particulates in outdoor air.
- Incidental ingestion of, dermal contact with, and external radiation exposure from surface and subsurface soils (combined to account for burrowing animals).
- Ingestion of groundwater as drinking water (future only).

Some exposure pathways that may be considered complete for the current worker are expected to have minimal contributions to total exposures. Potentially complete, but minor pathways, include:

- Incidental ingestion of, dermal contact with, and external radiation exposure from tailings.
- Inhalation of vapors and inhalation of radon in outdoor air.
- Incidental ingestion of, dermal contact with, and external radiation exposure from surface water.
- Dermal contact with and external radiation exposure from groundwater (current only associated with maintenance of the pumpback system).
- Incidental ingestion of, dermal contact with, and external radiation exposure from surface soil/sediment in ephemeral ponds or conveyances.

As previously described, surface soil is defined as soil from 0 to 2 feet bgs (EPA 2002b). For the current worker, surface and subsurface soil will be considered to account for burrowing animals that could bring deeper soil to the surface. Because redevelopment or re-grading activities may result in subsurface soils being brought to the surface, it is assumed that future workers may contact both surface and subsurface soils.

Exposures via dermal contact with surface soil, surface water, sediment, and groundwater water are considered potentially complete but minor pathways due to the low dermal absorption of metals, the primary chemicals found on site. EPA (2004) states that: "volatile chemicals will volatilize from soil on skin, limiting the potential for dermal absorption of volatile chemicals." Contact with groundwater by current workers is limited to short-term, intermittent events during maintenance of the pumpback system. If chemicals in subsurface soil, including radon, volatilize to outdoor air, concentrations are likely to be dispersed in ambient air and would not result in a significant exposure pathway for current workers. Contact with sediment may occur when the Wabuska Drain or evaporation ponds are dry, leaving sediment exposed. However, normal work activities would not involve regular contact with this medium.

Current employees wear dosimeters at all times while working on-Site. To date, the maximum documented radiation exposure to site workers is 12 millirem per year (mrem/year), which is significantly less than OSHA's maximum allowable worker exposure limit of 5,000 mrem/year and most likely represents exposure to background levels of naturally occurring (solar) radiation.

Therefore, current workers are expected to have negligible exposure to external radiation, and conditions for future workers are not expected to differ significantly.

3.3 Future Indoor Worker

Following redevelopment of the Site, future workers also may include commercial office workers who spend all or most of their time indoors. Potentially complete, primary exposure pathways for future indoor workers include:

- Incidental ingestion of surface and subsurface soil as indoor dust (assumes that subsurface soil is brought to the surface during regrading for redevelopment).
- Incidental ingestion of, dermal contact with, and external radiation exposure from surface and subsurface soils (assumes that subsurface soils are brought to the surface during re-grading or redevelopment activities).
- Inhalation of vapors and radon in indoor air.
- Ingestion of groundwater as drinking water.

Although the indoor office worker is not likely to perform outdoor activities and have direct contact with soils, these pathways are included. It is more likely that the indoor worker will contact soil that has been tracked or blown indoors and is present on interior surfaces as dust. If volatile chemicals, including radon, are present in subsurface soil, vapors may infiltrate cracks and spaces in building foundations and migrate to indoor air. Therefore, inhalation of vapors and/or radon in indoor air will be considered a potentially complete, primary exposure pathway for indoor workers. Also, ingestion of groundwater as drinking water is assumed to be a complete primary exposure route in the event that institutional or other controls do not prohibit future installation of an on-site drinking water well. Potentially complete but minor pathways for future indoor workers include:

- Dermal contact with and external radiation from surface and subsurface soil as indoor dust (assumes that subsurface soil is brought to the surface during re-grading for redevelopment).
- Dermal contact with and external radiation from groundwater.
- Inhalation of particulates in outdoor air.

The indoor worker is not expected to perform duties outside, and so contact with exterior exposure media will be limited relative to the outdoor worker and redevelopment worker scenarios. Although possible, inhalation of particulates, vapors, and radon in outdoor air, and contact with groundwater are assumed to be minor exposure pathways.

3.4 Resident

Potential exposure routes for off- and on-Site residents are considered in this section of the CSM. Off-Site residents also include those individuals who practice tribal lifeways, which are discussed in Section 3.5. An on-Site residential exposure scenario is included in this CSM as a low probability occurrence and partially incomplete because of existing land ownership (half the Site is owned by BLM), current Lyon County land use planning and, more importantly, the likelihood that future mining and ore-reprocessing activities will occur at the Site.

Off-Site Resident

As described in Section 1.4, off-Site residents include the human population in the following areas: the community of Weed Heights, Locust Lane, portions of the City of Yerington and the adjacent YPT Colony, development north of Luzier Lane and in the Sunset Hills area. In addition to consideration as off-Site residents, potential exposure pathways specific to traditional tribal lifeways are discussed in Section 3.5.

The City of Yerington provides drinking water to the majority of Yerington residents, and the Willow Creek sub-division located north of the Site, from municipal supply located across the Walker River from the Site. Residents in the community of Weed Heights are supplied water from an on-Site well, constructed in bedrock adjacent to the open pit, which meets all drinking water standards. Residents living directly adjacent to the northwestern boundary of the Site (Locust Lane) and north of the Site (north of Luzier Lane and the Sunset Hills area) are on domestic wells. Currently, off-site residents using domestic wells in areas north and northwest of the Site have the option to receive bottled water if the domestic well water contains total uranium at a concentration of 25 parts per billion (ppb) or greater.

Off-site residents who drink groundwater from domestic wells in areas north and northwest of the Site may contact mine-related groundwater with chemicals sourced from the Site. Contact may occur via direct ingestion of groundwater as drinking water, and through use of water for showering and other household activities (e.g., washing produce). Residents also may use this water for irrigating homegrown produce and watering animals raised for personal consumption. Residents may hunt local game or consume locally grown commercial crops and come into contact with associated soil. In addition, off-Site residents may have contact with wind-blown dust from the Site via inhalation of particulates or incidental ingestion of indoor dust. A Baseline Human Health Risk Assessment Work Plan for the Inhalation Pathway was submitted to EPA on June 19, 2003 to evaluate the potential for acute (short-term) and chronic (lifetime) health effects for chemicals and radiochemicals on off-Site Residents.

Area residents, including YPT members, may contact mine-related groundwater through consumption of homegrown or locally produced commercial crops, livestock or wild game. Potentially complete primary pathways for off-Site residents include:

- Inhalation of particulates in outdoor air.
- Incidental ingestion of indoor dust, including attic dust.
- Ingestion of mine-related groundwater.
- Ingestion of biota (e.g., homegrown produce, livestock, wild game and local commercial crops and associated surface soil irrigated with groundwater containing chemicals sourced from the Site).

Other potentially complete pathways for off-Site residents include:

- Dermal contact with and external radiation from indoor dust.
- Incidental ingestion of, dermal contact with, and external radiation from surface soil (e.g., Wabuska Drain).
- Dermal contact with and external radiation exposure from groundwater.

Although a small percentage of the current Wabuska Drain alignment is located adjacent to the northern portion of the Site (i.e., the sulfide tailings area), the great majority of its alignment is located off-Site. It is anticipated that the relative amount of time spent by residents directly in the Wabuska Drain will be negligible because its intended use is to convey irrigation tail water and, potentially, shallow groundwater (i.e., the drain is not a recreational area). Therefore, contact with surface soil/sediment in the drain is expected to be a minor exposure route.

On-Site Resident

The probability that the Site would be used for residences in the future is very low and the exposure pathways are considered potentially incomplete. However, in theory, a hypothetical future resident could be exposed to mine-related chemical via air, soil, tailings materials, sediment, surface water and biota through ingestion, inhalation, dermal contact and external radiation as noted in Figures 3-1 and 3-2.

3.5 Practitioner of Traditional Tribal Lifeways

A sub-set of the off-Site resident receptor includes members of the Yerington and Walker River Paiute Tribes that practice traditional tribal lifeways. Such practitioners would have the potential for exposure routes that would be supplemental to those of other off-Site receptors. Traditional tribal uses of plants and animals that a practitioner of traditional lifeways would rely on for food and for medicinal purposes, and for materials to make clothing, tools and dwellings are based on the publications listed in Appendix D. Appendix D also includes photographs some of the traditional lifeways activities. ARC views the information presented in Appendix D as a starting point for refining this aspect of the CSM, and anticipates that clarification from tribal members will be necessary to understand the role of traditional tribal lifeways for current tribal members as off-Site residents.

Potential exposure pathways relevant to practitioners of traditional tribal lifeways include: 1) the harvesting and ingestion of native plants (listed in Appendix D) that are irrigated with water impacted from historic Site releases; and 2) the harvesting and ingestion of wild game (i.e, the birds, fish and mammals listed in Appendix D) that consume plants and animals that have been irrigated with, or consumed, mine-related groundwater. Potentially complete primary exposure routes for a practitioner of tribal lifeways, not previously listed in Section 3.4, include:

- Ingestion of mine-related groundwater via collection and use of deep-rooted native plants.
- Ingestion of mine-related groundwater via consumption of wild game that graze on fields irrigated with mine-related groundwater.

Potentially complete minor pathways for practitioners of traditional tribal lifeways include:

- Dermal contact with and external radiation exposure from mine-related groundwater taken up by deep-rooted native plants.
- Contact with and external radiation from irrigation water.
- Incidental ingestion, dermal contact and external radiation exposure to potentially-impacted surface soil that may be present on native plants and wild game.

External radiation exposure from groundwater, irrigation water or surface soil is considered an indirect, minor exposure pathway. Although harvest and use of locally growing crops, livestock, native plants, and wild game are identified as potentially complete and primary exposure pathways due to a higher frequency of contact for tribal members compared to other off-Site residents, the pathways are likely to be minor relative to more direct exposure routes (e.g., inhalation of fugitive dust). Further analysis of these pathways will be considered pending results of conservative screening-level assessments for individual OUs.

3.6 Trespasser

Although access to the Site is currently restricted, unauthorized visitors (i.e., trespassers) are known to unlawfully enter the Site for recreation (e.g., dirt bike riding) or to collect scrap metal and other materials or equipment. While on the Site, trespassers could come into contact with chemicals in air, soil, surface water, and/or sediment. Surface and subsurface soils are combined to account for deeper soils that could be brought to the surface by burrowing animals. The trespasser may also fish and/or hunt game or wild fowl on the Site, or collect native plants for ingestion. The trespasser is not expected to contact groundwater. As such, complete primary exposure pathways for the trespasser scenario include:

- Inhalation of particulates in outdoor air.
- Incidental ingestion of soil (surface and subsurface to account for deeper soils brought to the surface by burrowing animals).
- Ingestion of mine-related surface water via ingestion of wild game, fish, and waterfowl obtained on site.

Trespassers could have minor exposures via the following pathways:

- Dermal contact with, incidental ingestion of, and external radiation from tailings.
- Dermal contact with and external radiation exposure from soil.
- Inhalation of vapors and radon in outdoor air.
- Dermal contact, incidental ingestion of, and external radiation exposure from surface water.
- Dermal contact with, incidental ingestion of, and external radiation exposure from surface soil/sediment in ephemeral ponds or conveyances.

Exposure via inhalation of chemical vapors and radon, and contact with sediment, and surface water are considered potentially complete but minor pathways for the reasons mentioned for the outdoor worker scenario. Exposure to external radiation from on-Site media is considered a potentially complete, primary pathway for other receptor scenarios but is assumed to be minor for the trespasser due to the short period of time and low frequency of visits to the Site.

SECTION 4.0
ECOLOGICAL EXPOSURE ROUTES AND RECEPTORS

Similar to the model for human receptors, this section describes the sources, release and transport mechanisms for chemicals found (or thought to exist) on the Site, pathways and exposure media for potential ecological receptors at the Site. In addition, and consistent with the update QAPP, chemicals that may be sources of exposure to wildlife are discussed this section. For the most part, transport pathways of Site-related chemicals for potential ecological receptors are the same as those for the potential human receptors described in Section 3.0. QAPP-related ecological risk assessment information is provided in Appendix D of this CSM.

4.1 Exposure Media

Potential exposure media for ecological receptors include:

- Air.
- Tailings.
- Surface and subsurface soil (surface soil is defined as soil found from ground surface to 2 feet bgs; subsurface soil is found from 2 to 10 feet bgs).
- Sediment.
- Surface water.
- Groundwater.
- Biota.

Subsurface soil depth is often additionally defined in a site-specific manner based on the likely potential depth to which biological activity occurs (i.e., the lowest depth to which burrowing animals are likely to dig and, therefore, potentially be exposed to chemicals of concern).

4.2 Potential Routes of Ecological Exposure

This section describes, in general terms, the likely routes of exposure of plants and animals to chemicals at the Site. Exposure routes are discussed below and depicted in Figure 4-1.

Inhalation

Inhalation is a potentially complete pathway for terrestrial invertebrates by passive exchange of air, and for vertebrates by breathing in airborne particulates or volatilized chemicals. Because volatile chemicals are not expected to be present in surface soils, inhalation of vapors in outdoor air is not considered to be a complete pathway. Inhalation is generally considered to be a relatively minor pathway for exposure relative to direct ingestion of chemicals of concern by wildlife. For example, EPA (2005) did not use inhalation of soil particles in deriving the national ecological soil-screening levels ("SSLs") because exposure is accounted for by the soil-ingestion route. One exception to the statement that inhalation is generally considered a minor pathway is the potential inhalation of particulates and volatile chemicals in the confined spaces occupied by burrowing animals in subsurface soils (Figure 4-1).

Dermal Contact/Uptake

The dermal system of plants is the outermost cellular structure that covers the surface of the plant (likely locations where this structure may be crossed are the root and foliar structures). Plants can accumulate chemicals through direct deposition on their leaves from particulates in air and, for aquatic plants, from contact with surface water. Plants can also accumulate chemicals through uptake from soil and, for aquatic plants, from sediment via their roots. The former pathway is not expected to be a substantial source of exposure to the plant itself, as the majority of chemical uptake by a plant is accomplished through its root system.

Some woody plants that are characteristic of the sagebrush community have tap roots that are deep enough to contact and take up groundwater. The potential for chemicals to accumulate in plants is affected by the specific properties of the chemical, the physical and chemical properties of the soil, and biophysical properties of the plant. For example, large-molecular-weight chemicals (e.g., dioxins, PCBs) have a low potential to be taken up by the roots of plants.

Many animals are equipped with protective outer coverings that reduce or prevent the absorption of environmental chemicals.[1] For this reason, dermal exposure is usually considered a less important pathway than oral ingestion in accounting for exposure to contaminants (EPA, 2005). In developing soil screening levels, EPA (2005) indicates that conditions likely to increase contact with soil and therefore potential exposure to chemicals include:

- Species with little or no fur or feathers.
- Species that spend long periods of time exposed to soil (i.e., in burrows).
- Where the contaminants of concern may be significantly more toxic via the dermal pathway compared to the oral pathway (e.g., some pesticides).
- Where dermal exposures may be substantially higher compared to oral exposures (i.e., pesticides applied directly to trees or soil surfaces).

Dermal exposure to soils is potentially complete for a variety of ground-dwelling animals, especially for invertebrates that burrow and burrowing mammals (e.g., pocket gopher and shrew) that live predominantly within the soil (Figure 4-1). However, the dermal route of exposure is not considered primary, and will not be quantified for these receptors, because: 1) trace metals have a low potential for dermal uptake or dermal toxicity; and 2) pesticides or other organic compounds that have a high potential for dermal uptake or dermal toxicity are not likely to be present at elevated levels (EPA, 2005). Dermal exposure to sediments is similarly potentially complete for a variety of aquatic and semi-aquatic receptors that regularly contact sediment during foraging and/or nest-building activities.

Similar to soil exposure, the dermal route of exposure is not considered primary and will not be quantified for most receptors. However, there are some cases in which primary exposure are possible because of enhanced opportunities for dermal absorption of chemicals (e.g., unfeathered nestlings). These pathways are discussed in more detail in Section 4.3 (exposure pathways for representative receptors).

[1] For example, the hardened exoskeleton of many invertebrates, the fur of mammals, the feathers of birds, and the scales of reptiles.

Dermal exposure to surface water is considered a potentially complete but minor pathway for terrestrial animals who contact surface water bodies in order to drink. Exposure via direct ingestion (discussed below) is expected to be a much more important pathway for these animals. Exposure to surface water may be a primary pathway for aquatic invertebrates, and aquatic and semi-aquatic avian taxa including waterfowl.

Dermal exposure to airborne particulates is a potentially complete but minor pathway for animals. Dermal contact with airborne particulates is expected to occur primarily via contact with surface soil or surface water onto which particulates have settled and is addressed in exposure routes associated with those media.

Direct Ingestion

Direct ingestion of chemicals and absorption via the alimentary canal is an important route of exposure for biota. Invertebrates can ingest soil and sediment directly while burrowing or foraging. Mammals and birds can ingest soil directly while foraging and cleaning their fur or feathers (Beyer et al., 1994). While some terrestrial receptors (e.g., gophers and shrews) derive most if not all of their water from consumed prey, others such as deer and coyote may regularly seek out surface water to drink and may be exposed to chemicals in the surface water medium.

Trophic Transfer

Any animal that eats another organism that contains chemicals of concern has the potential to be exposed to those chemicals of concern. The extent to which trophic transfer occurs is dependent on a number of factors including the exposure of the prey to chemicals of concern, the ability of the prey to bioaccumulate those chemicals, the extent to which those chemicals are partitioned in the tissues of the prey and, in turn, what parts of the prey are eaten by the receptor. Trophic transfer is a viable pathway for trace metals and may be of particular importance for hydrophobic, bioaccumulative chemicals of concern, and for higher trophic-level consumers (e.g., kit fox, coyote, badger) might represent a primary route of exposure. The trophic relationships and feeding guilds[2] expected at the Site, including examples of relevant species for each trophic level, are presented in Figure 4-2.

Radiation Exposure

Internal radiation exposure (dose) may occur as a result of an intake of radiochemicals by any of the inhalation, dermal contact/uptake, direct ingestion, and trophic transfer pathways discussed above. Plants and animals can also receive an external radiation exposure from the materials in the vicinity of the receptor for extended periods of time. Plants may receive both internal and external exposure from radioactive materials in surface soils, and/or in deeper soils comprising the plant's root zone. Internal and external exposure from surface soils may occur for animals that burrow, roost, sleep, or otherwise routinely inhabit an area in close proximity to the soil. Surface waters may be a source of internal and external exposure to aquatic plants and animals, and migrating waterfowl that are in or on the water for significant periods of time.

Preliminary data for Ra 226 and Ra 228 emissions at the Site are well below screening levels that are protective of internal and external radiation (including alpha emitters) in wildlife developed by the U.S Department of Energy (DOE, 2002). Wildlife exposure to internal and external radiation is assumed to be potentially complete, but minor, route of exposure for all media and receptors. However, this assumption will be re-evaluated based on site-specific comparisons of radiochemical activities to DOE Soil Level Values ("SLVs") in the SLERA for each OU.

4.3 Potential Ecological Receptors

The sagebrush-steppe habitat of the Great Basin is home to a diverse assemblage of plants and animals. Tables 1-2 through 1-5 summarize a wide variety of woody and herbaceous plants; a diverse assemblage of invertebrates, reptiles and amphibians that includes hundreds of resident and migratory birds and more than 40 species of mammals. Because it is not feasible to model exposure pathways for the entire diversity of species present at the Site, representatives from

[2] A trophic guild consists of a group of related species or taxa that exploit similar food resources.

similar feeding guilds will be used as surrogates for estimating exposure (birds and mammals with respect to reptiles and the terrestrial life stages of amphibians, and fish with respect to amphibian aquatic life stages, where appropriate). For example, several species of snakes and lizards and a few species of amphibians have been documented in the vicinity of the Site (Table 4-2). However, there is very little available toxicological information to evaluate effects to these classes of receptors. Toxicity reference values ("TRVs") and information needed to build exposure and uptake models are generally not available for these classes of receptors.

Figure 4-1 uses known or expected ecological relationships of flora and fauna at the Site to represent potential pathways and receptors that comprise the various trophic guilds within the biological communities that have the potential to be exposed to chemicals of concern at the Site. It is assumed that terrestrial receptors are expected to be associated with limited areas of the Site that contain vegetation and/or cover. These areas include fringe habitat at the margins of the Site, the margins of permanent water bodies such as the sewage treatment ponds and the Pit Lake, and abandoned or infrequently used man-made structures that may serve as nesting or roosting habitat for some species. Many of these receptors also likely use adjacent off-Site areas including agricultural fields and the Walker River riparian corridor. Aquatic receptors (aquatic plants, invertebrates, waterfowl) are expected to be restricted to seasonal and permanent water features at the Site (e.g., inactive evaporation ponds and pit lake). Examples of how the information presented in Figure 4-1 may be focused on specific areas are shown in Figure 4-3.

Aquatic and Terrestrial Plants: Primary Producers

Plants are separated into aquatic and two terrestrial types because different exposure media and pathways are important for these groups. Aquatic plants include rooted emergent aquatic vegetation, such as cattails present at the margins of the sewage treatment ponds on the Site and macroalgae that may grow in permanently ponded waters on the Site. Complete exposure routes for aquatic plants (Figure 4-1) include:

- Foliar contact with airborne particulates and surface water and root contact with sediment.
- Absorbed radiation[3] via surface water and sediment.

Forbs and grasses are herbaceous annual and perennial plants that are consumed by a variety of herbivorous and omnivorous animals of the sagebrush-steppe habitat. Median rooting depth for forbs and grasses in arid conditions with approximate 125 mm (5 inches) of mean annual precipitation is less than 0.5 m (1.6 foot) of soil (Schenk and Jackson, 2002). Complete exposure routes for terrestrial forbs and grasses (Figure 4-1) include:

- Foliar contact with airborne particulates and root contact with tailings and surface soil[4].
- Absorbed radiation via tailings and surface soil.

Woody plants are perennial plants that continue to add to their aboveground growth in successive years. These plants tend to be somewhat less palatable and therefore less preferred by some herbivores relative to forbs and grasses. This category includes sagebrush, rabbitbrush, bitterbrush and similar woody shrubs, and trees such as willow and cottonwood that grow along the shorelines of aquatic areas at the Site. Several woody plant species of the sage-steppe ecosystem, including bitterbrush, are phreatophytic, or able to obtain some to most of their water needs from groundwater via deep roots.

Complete exposure pathways for woody plants include:

- Foliar contact with airborne particulates and root contact with tailings, surface and subsurface soil, and groundwater.
- Absorbed radiation via tailings, surface soil, subsurface soil, and groundwater.

[3] As discussed in Section 4.2, radiation exposure refers to both internal and external exposure.

[4] To the extent that "flashy water" associated with precipitation transports suspended soil particles or dissolved contaminants, exposure of plants to these contaminants would be mediated by root uptake from the soil matrix and, therefore, is already accounted for in the soil exposure pathway.

Invertebrates: Primary and Secondary Consumers

Invertebrates are separated into aquatic and terrestrial groupings for the ecological model. Aquatic invertebrates spend some or all of their lifecycle in water. Many invertebrates are aquatic as larvae and emerge to become aerial/terrestrial adults, at which point they become available as food to aerial predators such as swallows. The permanent waters of the sewage treatment ponds and the Pit Lake are most likely to contain aquatic invertebrates. However, no studies have been conducted to examine the diversity or abundance of these taxa in the aquatic portions of the Site. Complete exposure pathways for aquatic invertebrates (Figure 4-1) include:

- Inhalation (respiration) of airborne particulates.
- Direct contact with surface water and sediments.
- Ingestion of surface water and sediments incidental to consuming food.
- Trophic transfer by consuming vegetation or prey that may have been exposed via airborne particulates, surface water or sediment.
- Absorbed radiation from surface water and sediment.

Terrestrial invertebrates include taxa that live at the surface (e.g., grasshoppers, many spiders, true flies), and those whose life cycle is spent underground (e.g., some spiders, ants, beetle larvae). Many invertebrates live in the upper few inches of soil below ground, and some species can have much deeper burrows (e.g., several species of ants in the Great Basin-Mojave desert ecosystem have burrows a meter or more in depth; Jensen and Hooten, 2000). Complete exposure pathways for invertebrates (Figure 4-1) include:

- Inhalation (respiration) of airborne particulates.
- Direct contact with airborne particulates, tailings, surface soil, and subsurface soil[5].
- Incidental ingestion of tailings, surface soil and subsurface soil while consuming food.
- Trophic transfer by consuming vegetation or prey that may have been exposed via airborne particulates, tailings, surface soil, subsurface soil and groundwater.
- Absorbed radiation from tailings, surface soil, and subsurface soil.

[5] A complete exposure pathway via subsurface soil is only expected for those species spending some or all of their life cycle below surface soils, as described above.

- Inhalation of particulates/vapors in burrows (invertebrates that live part- or full-time below ground).

Mammals and Birds: Primary Consumers

Potential bird and mammal receptors of concern for the ecological CSM were chosen as representatives of feeding guilds likely to be present at the Site. Primary consumers include birds and mammals that feed primarily on vegetative matter. Feeding guilds include *browsers* and *granivores/herbivores*.

Browsers feed on a range of woody and herbaceous vegetation - mule deer and jackrabbit were chosen to represent this feeding guild. Both species will consume green, leafy vegetation (e.g., forbs and grasses) when available, but will switch to woody plants, particularly in the drier months when forbs and grasses are not as abundant. Jackrabbits do not create deep burrows, but they may create shallow depressions in the first few inches of soil for thermoregulation and cover (Table 4-4). Complete exposure routes for mule deer (Figure 4-1) include:

- Inhalation of airborne particulates.
- Direct contact with airborne particulates, tailings and surface soil.
- Direct ingestion of surface water and incidental ingestion of tailings or surface soil while consuming food.
- Trophic transfer by consuming vegetation that may have been exposed via surface water, tailings, surface soil, subsurface soil, and groundwater.
- Absorbed radiation from surface water, tailings, and surface soil.

Complete exposure pathways for jackrabbit (Figure 4-1) include:

- Inhalation of airborne particulates.
- Direct contact with airborne particulates, tailings, surface soil and surface water.
- Ingestion of drinking water if available. Jackrabbits can obtain much of their water needs through the water available in vegetation (drinking surface water may be needed during drier parts of the year, and this pathway may be complete and primary in OUs that have surface water available during the drier months of summer and fall).
- Incidental ingestion of tailings and surface soil while consuming vegetation.

- Trophic transfer by consuming vegetation that may have been exposed via tailings, surface soil, subsurface soil, and groundwater.
- Absorbed radiation from surface water, tailings, and surface soil.

Granivores/herbivores feed on a combination of herbaceous vegetation, including stems, leaves, and seeds of plants. Two birds and a mammal were chosen to represent vertebrate taxa in this feeding guild.

Chukar, a ground-nesting bird that has been observed on the Site, eats a combination of seeds and herbaceous plants and may seasonally incorporate insects in its diet. Complete exposure pathways for chukar (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings and surface soil.
- Direct ingestion of surface water (chukar may ingest surface water at least seasonally) and incidental ingestion of tailings or surface soil while consuming food (RRCIA, 2007).
- Trophic transfer by consuming vegetation that may have been exposed via tailings, surface soil, and surface water. Because the diet of the chukar is primarily forbs and grasses that are not exposed to subsurface soils (Seattle Audobon Society, 2007), subsurface and groundwater trophic transfer pathways are considered incomplete.
- Absorbed radiation from tailings, surface water, and surface soil.

Canada geese feed on a range of seeds and leafy material from aquatic and terrestrial herbaceous plants and agricultural crops; invertebrates may also occasionally be consumed. Potentially complete pathways for Canada geese (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings, surface soil, surface water, and sediment.
- Direct ingestion of airborne particulates, tailings, surface soil, surface water, and sediment incidental to ingesting food. Geese may incidentally ingest sediment associated with the roots of aquatic vegetation that they pull up during foraging, so this pathway is considered complete.

- Trophic transfer by consuming vegetation that may have been exposed via airborne particulates, tailings, surface water, sediment, and surface soil.
- Absorbed radiation from surface water, tailings, surface soil, and sediment.

Pocket gophers were chosen as a mammalian representative of the granivore/herbivore feeding guild; these small mammals eat a variety of above- and underground plant materials and create burrows that extend from 18 inches to as deep as 6 feet below the surface (Table 4-4). Potentially complete pathways for pocket gophers (Figure 4-1) include:

- Inhalation of airborne particulates.
- Inhalation of vapor/particulates in burrows.
- Direct contact with airborne particulates tailings, surface soil, and subsurface soil.
- Direct ingestion of tailings, surface soil, and subsurface soil incidental to consuming food. Direct ingestion of surface water is considered a potentially complete, but minor, pathway for pocket gophers. The pathway is considered minor because, while it is possible that they could consume surface water if it was available, these arid-environment animals obtain water through their food. These animals have survived, and thrived, for several weeks in captivity with water only available via food provided in the captive diet (Judd and Reichman, 1972; Reichman, 2008).
- Trophic transfer by consuming vegetation that may have been exposed via tailings, surface soil, subsurface soil, and groundwater.
- Absorbed radiation from tailings, surface and subsurface soil, and surface water.

Birds and Mammals: Secondary Consumers

Secondary consumers feed primarily on animal matter. Feeding guilds include *invertivores*, *rodentivores*, and *predators/scavengers*.

Invertivores obtain most of their energy through the consumption of insects and other arthropods. Four birds and one mammal displaying a variety of nesting and feeding strategies were chosen to represent this trophic guild. Mallards are omnivorous feeders with a varied diet that includes a wide range of vegetation and aquatic and terrestrial invertebrates. During the breeding season, mallard females and ducklings rely on animal diets to meet reproductive and early growth needs for protein; mallard diets contain higher proportions of plant material at other times of the year.

Complete exposure pathways for the mallard (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings, surface soil, surface water, and sediment. Although some birds engage in dust-bathing activities, which can increase the possibility of exposure to chemicals in soils, no evidence of dust-bathing activities has been found for mallards (preening and cleaning would primarily be done while in the water).
- Direct ingestion of tailings, surface soil, surface water, and sediment incidental to ingesting prey.
- Trophic transfer by consuming vegetation and invertebrates that may have been exposed via tailings, surface soil, surface water and sediment.
- Absorbed radiation from surface water, tailings, surface soil, and sediment.

Killdeer are primarily upland birds that will also use the shorelines of aquatic habitats to forage on a wide variety of terrestrial invertebrates. Complete exposure pathways for killdeer (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings, surface soil, surface water, and sediment.
- Ingestion of tailings, surface soil, surface water, and sediment incidental to consuming food.
- Trophic transfer by consuming prey that may have been exposed via tailings, surface soil and subsurface soil, surface water, and sediment.
- Absorbed radiation from tailings, surface soil, surface water, and sediment.

Eared grebes spend the majority of their time in contact with surface water and forage by diving to collect invertebrates from the water column and benthos. Complete exposure pathways for eared grebes (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, surface water and sediment. Eared grebe forage primarily in the water column and on invertebrates at the substrate surface. As a result, opportunities for direct contact with sediment are considered limited and this pathway is considered potentially complete but minor.
- Direct ingestion of surface water and sediment incidental to consuming food.
- Trophic transfer by consuming prey that may have been exposed via surface water and sediment.
- Absorbed radiation from surface water and sediment.

Barn swallows focus primarily on aerial insects, including aquatic insects that have emerged from the water as adults. Barn swallows build nests out of soil, sediment and vegetation; nests are primarily found on human-made structures such as eaves of buildings. Complete exposure pathways for barn swallows (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings, surface soil, surface water and sediment as a result of foraging, nest-building and nesting activities. Brief contact with surface water may occur during foraging activities, and surface water may be transported in nesting materials. However, nesting materials generally dry quickly and surface water evaporates, leaving sediment as the primary medium for potential exposure to nestlings. Therefore, the dermal contact with surface water pathway is considered potentially complete but minor relative to contact with soil and sediment.
- Incidental ingestion of tailings, surface soil, surface water, and sediment. Incidental ingestion of surface water, tailings, surface soil and sediment may occur during nest-building activities, and limited surface water ingestion may occur while capturing emergent aquatic insects. Consequently, these pathways are considered primary, but unquantifiable exposure routes.
- Trophic transfer by consuming prey that may have been exposed via surface water, tailings, surface soil and sediment.
- Absorbed radiation from tailings, surface soil, surface water and sediment.

Merriam's shrew is an invertivore that inhabits the sagebrush-steppe habitat of the Great Basin. This small, aggressive mammal is found under cover of vegetation and may use the burrows of other rodents. Shrews are rarely eaten by mammalian predators because they have distasteful scent glands, although snakes and owls may prey on them.

Complete exposure pathways for the shrew (Figure 4-1) include:

- Inhalation of airborne particulates.
- Inhalation of vapors in burrows. Shrews are not primarily fossorial, but they will opportunistically use burrows of other rodents, so this pathway is considered complete but minor.
- Dermal contact with airborne particulates, tailings, surface soil, and subsurface soil.
- Ingestion of tailings, surface soil, and subsurface soil incidental to consuming food. It is unknown whether Merriam's shrew regularly drinks surface water, so this pathway is included as potentially complete but is not quantifiable.
- Trophic transfer by consuming prey that may have been exposed via tailings, surface soil and subsurface soil.
- Absorbed radiation from tailings, surface soil, subsurface soil, and surface water.

Predators: Several top predators, including many raptors, canids, and felids, fall in the category of being primarily predatory; and may also be scavengers and opportunists. A bird and a mammal displaying a variety of nesting and feeding strategies were chosen to represent this feeding trophic guild.

The American kestrel is a small raptor found in open natural, agricultural, suburban, and urban habitats throughout North America. Kestrels prey on a wide variety of animals, including small mammals, reptiles, birds, and large insects. Kestrels nest in tree cavities as well as buildings and in nest boxes. Complete exposure pathways for American Kestrel (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings and surface soil.
- Ingestion of tailings and surface soil incidental to consuming food.

- Trophic transfer by consuming prey that may have been exposed via tailings, surface soil, subsurface soil, surface water and groundwater. The groundwater exposure route is limited to prey that feed on woody plants that may uptake groundwater contaminants, and this route is considered potentially complete for the American Kestrel but minor relative to other exposure routes.
- Absorbed radiation from tailings and surface soil.

The coyote's diet in the Great Basin ecosystem is focused largely around small mammals, but also incorporates a wide range of other foods, including human garbage, carrion, and invertebrates. Complete exposure pathways for the coyote (Figure 4-1) include:

- Inhalation of airborne particulates.
- Dermal contact with airborne particulates, tailings, surface soil, and surface water. Opportunities for direct contact with these media are likely limited to resting periods or when drinking water. Therefore, this pathway is considered a potentially complete but minor exposure route.
- Direct ingestion of surface water and ingestion of tailings and surface soil incidental to consuming food. Ingestion of subsurface soil may occur when specifically digging for and feeding on burrowing prey, so this pathway is considered complete but minor.
- Trophic transfer by consuming prey that may have been exposed via airborne particulates, tailings, surface soil, subsurface soil, surface water and groundwater. The surface water route is limited to prey such as ground-nesting birds that may ingest water, and the groundwater exposure route is limited to prey that feed on woody plants that may uptake groundwater contaminants. These routes are considered potentially complete for the coyote but minor relative to other exposure routes.
- Absorbed radiation from tailings, surface soil, and surface water.

SECTION 5.0
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