

**BASELINE HUMAN HEALTH RISK ASSESSMENT
WORK PLAN FOR THE INHALATION PATHWAY
YERINGTON MINE SITE
REVISION 3**

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ACRONYMS AND ABBREVIATIONS

AQM	Air Quality Monitoring	URF	Unit Risk Factor
ARC	Atlantic Richfield Company	VLT	Vat Leach Tailings
ATSDR	Agency for Toxic Substances and Disease Registry	WRCC	Western Regional Climate Center
Cal/EPA	California Environmental Protection Agency		
COPC	Chemical of Potential Concern		
CSM	Conceptual Site Model	mph	Miles per Hour
DSR	Data Summary Report	mg/kg	Milligrams per Kilogram
DOE	Department of Energy	m ³ /min	Cubic Meters Per Minute
EPA	Environmental Protection Agency	mg/m ³	Milligrams Per Cubic Meter
ERPG	Emergency Response Planning Guidelines		
HEAST	Health Effects Assessment Summary Tables	mm	Millimeters
HHRA	Human Health Risk Assessment	pCi	Picocuries
HI	Hazard Index	PM ₁₀	Particulate Matter Less Than 10 Microns in Size
HQ	Hazard Quotient		
IRIS	Integrated Risk Information System	μg/kg	Micrograms per Kilogram of soil
MRL	Minimal Risk Levels	μg/m ³	Micrograms per cubic meter of air
NAAQS	National Ambient Air Quality Standards		
OU	Operable Unit		
OSWER	Office of Solid Waste and Emergency Response		
PRG	Preliminary Remediation Goals		
PPRTV	Provisional Peer-Reviewed Toxicity Values		
QAPP	Quality Assurance Project Plan		
REL	Reference Exposure Level		
RfC	Reference Concentration		
RI/FS	Remedial Investigation and Feasibility Study		
RSL	Regional Screening Level		
Site	Yerington Mine Site		
SOW	Scope of Work		
TEEL	Temporary Emergency Exposure Levels		
TENORM	Technically Enhanced Naturally Occurring Radioactive Materials		
TSP	Total Suspended Particulates		
UCL	Upper Confidence Limits		

SECTION 1.0
INTRODUCTION

Atlantic Richfield Company (ARC) has developed this Baseline Human Health Risk Assessment Work Plan for the Inhalation Pathway (HHRA Work Plan) to determine if the inhalation of dust poses a potential health concern at the boundary of the Yerington Mine Site (Site) under current conditions. The Site is located near the City of Yerington in Lyon County, Nevada. In accordance with risk assessment guidance from the U.S. Environmental Protection Agency (EPA), “baseline” means a risk assessment that assesses the potential risk under current conditions and assumes that these conditions are unchanging in the future (EPA 1989). The concentrations of particulate matter and chemicals in dust measured at the Site boundary used in this HHRA Work Plan are based on air quality data summarized in the *Air Quality Monitoring Program Data Summary Report - Revision 2* dated September 3, 2009 (AQM DSR; Brown and Caldwell, 2009a).

This HHRA Work Plan has been developed as part of the Scope of Work (SOW) attached to the Administrative Order (Order) for Remedial Investigation and Feasibility Study (RI/FS) for the Anaconda/Yerington Mine Site issued by the EPA - Region 9 to ARC on January 12, 2007 (EPA, 2007a). Although not specified in the SOW, ARC has voluntarily prepared this HHRA Work Plan to respond to community concerns regarding potential inhalation exposures. The Site location is shown in Figure 1-1. The operable units (OUs) identified in the Order and attached SOW are depicted in Figure 1-2.

This HHRA Work Plan presents the methodology, standard assumptions and procedures that will be used to evaluate short term or acute health effects as well as long term or chronic health effects (EPA, 1989; 2006; 2009a and Cal/EPA 2003). This HHRA Work Plan includes the following sections:

- Section 2.0. Conceptual Site Model (CSM) describes the Site, topographic features, climate, land use, the nearest populations and an overview of local meteorological conditions.

- Section 3.0. Data Evaluation describes the data set from January 2005 through March 2008 presented in the Air Quality Monitoring Program Data Summary Report (Brown and Caldwell, 2009a), which will be the basis for the HHRA calculations.
- Section 4.0. Chronic (Long Term) HHRA addresses the potential that average concentrations of dust, associated chemicals and radiochemicals could have an effect on health after many years of exposure.
- Section 5.0. Acute (Short Term) HHRA addresses the potential that peak dust concentrations and associated chemicals could have a short term impact on health.
- Section 6.0 Uncertainty Analysis discusses the level of confidence that can be placed in the results of the HHRA.

SECTION 2.0 CONCEPTUAL SITE MODEL

The information presented in this section, based on the *Conceptual Site Model - Revision 3* dated January 30, 2009 (CSM) (Brown and Caldwell et. al., 2009), summarizes the current understanding of the physical features of the Site, known and potential sources of mine-related contamination, known and potential chemical migration pathways, and human populations that may contact mine-related releases.

2.1 Site Location

The Site is located about 0.5 miles west and northwest of the City of Yerington in Mason Valley, within the Walker River watershed (Figure 1-1). Mason Valley includes over 39,000 acres of irrigated land and is one of the most productive agricultural areas in Nevada (Lopes and Smith, 2007). Agriculture has been the principal economic activity in Mason Valley, including hay and grain farming, with some beef and dairy cattle ranching and local onion farming in the area north of the Site. 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 Yerington Paiute Tribe (YPT) Indian Reservation is located approximately 2.5 miles north of the Site. Portions of the Site are owned by the U.S. Bureau of Land Management and by the Arimetco bankruptcy court. ARC does not own any of the land associated with the Site.

2.2 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.

Climate

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 and the localized effects of surface mining operations. Air quality and 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 miles per hour (mph), however, there is a predominant wind direction to the northeast (Brown and Caldwell, 2009a). Additional meteorological information is provided in the quarterly air quality monitoring reports for the Site.

Geologic Setting

The structurally uplifted mountain ranges in the area of the Site, typical of basin-and-range topography, are primarily composed of granitic and volcanic rocks, with minor amounts of metamorphic rocks. In addition to these bedrock types, semi-consolidated to unconsolidated alluvial fan deposits occur along the margins of the mountain block. The Singatse Range, located immediately west of the Site, has been subject to extensive metals mineralization as a result of natural processes. This is 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.

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 in the area of the mine site generally increases from south to north and from west to east, consistent with the development of alluvial fan, transitional, and flood-plain/lacustrine depositional environments away from the Singatse Range front. At the location of the Yerington Pit, the thickness of unconsolidated alluvial sediments is typically a few tens of feet, but may be up to 168 feet thick. In the vicinity of the tailings areas at the northern margin of the Site, the thickness of the alluvium exceeds 600 feet. 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.

2.3 Past Mining Operations

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 mine site were conducted between 1953 and 1978 by ARC's predecessor, The Anaconda Company (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.

Anaconda conducted mining only in the 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. 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. The steps in the mining process were as follows:

- Crushing and Grinding - Ore was crushed prior to leaching or processing in the plant.
- Leaching (Oxide Ore) - Sulfuric acid leach solution was used to leach copper from the ore. Spent ore, known as oxide tailings or vat leach tailings (VLT) was hauled to the oxide tailings or VLT pile (collectively comprising OU-6).
- Cementation/Precipitation (Oxide Ore) - Copper was recovered from the leach solution by precipitating (i.e., “cementing”) the copper using scrap iron. The copper cement was hauled offsite for final smelting to a pure copper product.
- Concentrator (Sulfide Ore) - The finished concentrate was hauled offsite. Residual solutions, containing elevated concentrations of iron and sulfate as well as uranium and other radiochemicals, were conveyed to evaporation ponds (Seitz et al., 1982). Excess pulp present after the floatation separation was disposed in the sulfide tailings.

Sulfuric Acid Production - Sulfuric acid was produced at the Site at the Acid Plant from raw sulfur ore shipped from the Leviathan Mine located in Alpine County, California. The ore was crushed to minus 10 mesh (<2 mm) and then roasted to drive SO₂ gas from the ore, which would then be converted to sulfuric acid. The burned ore or “calcines” were conveyed via the Calcine Ditch to evaporation ponds for disposal.

Other sources of these materials include the Arimetco operation, which is adjacent to the Site. In 1989, Arimetco, Inc. initiated leaching operations at five lined leach pads located around the site 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. 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.

2.4 Current Conditions

Mining and ore beneficiation operations at the Site have ceased and Site mining and processing areas are no longer active (EPA, 2007). Current Site activities include the management of draindown fluids from the Arimetco facilities (heaps and ponds), operation and maintenance of

the pumpback wells and associated evaporation ponds, and Site investigations associated with the RI/FS process. Public access is discouraged through the use of perimeter fencing and warning signs, and Site security is maintained by ARC.

2.5 Potential Dust Sources

Potential sources of dust on the Site include undisturbed and disturbed soils, tailings, overburden and waste rock materials and evaporative residues. Five of the OUs shown in Figure 1-2 are potential sources of dust from the Site, as listed below (the remaining OUs are not considered sources of dust):

- Process Areas (OU-3)
- Evaporation Ponds and Sulfide Tailings (OU-4)
- Waste Rock Areas (OU-5)
- Oxide Tailings Areas (OU-6)
- Arimetco Facilities (OU-8)

The chemicals associated with the dust include metals, other inorganic chemicals such as sulfate, and radiochemicals. The mineralogical characteristics of the ore and waste rock mined from the Yerington open pit, in conjunction with the ore processing activities, have resulted in the occurrence of technically enhanced naturally occurring radioactive materials (TENORM), resulting in the need to analyze for radiochemicals as part of the air quality monitoring (AQM) program.

In addition to dust from the Site, there are other anthropogenic (man-made) sources of these chemicals in Mason Valley including other mine sites (e.g., the Bluestone Mine, located southwest of the Site), agricultural fields and dirt roads as well as natural sources from undisturbed soil. These sources, which occur all around the Site and other sources located outside of Mason Valley, have been observed to contribute to dust in the air around of the Site.

The revised AQM DSR - Revision 2 (Brown and Caldwell, 2009a) provides an assessment of relative contributions to airborne dust from the Site and from other off-Site (i.e., background) sources, which often represent regional dust events.

An example of the relationship between dust events in the area of the Site and regional (i.e., State-wide) dust events is depicted in Figure 14 of the revised AQM DSR, and reproduced as Figure 2-1 in this HHRA Work Plan. As illustrated in Figure 2-1, the excellent correlation between Site PM₁₀ data (particulate matter less than 10 microns in size from upwind and downwind AQM stations) and the PM₁₀ data from the Linda air quality monitoring station (located near Pahrump, Nevada; ndep.nv.gov/baqp/monitoring/pahrumpmonitor2) indicates: 1) Site data are very similar to regional background data; and 2) the importance of incorporating background air quality information into the HHRA, particularly for the assessment of acute health effects that may result from dust events.

2.6 Adjacent Residential Areas

No residential areas are located on the Site, and the closest off-site residential areas include residences on Luzier Lane which are less than one hundred yards away from the northern property boundary of the Site, residences along Locust Drive and north on Sunset Hills Drive (Sunset Hills residential area), a trailer park east of the eastern Site boundary and the community of Weed Heights (Figure 1-1). Other resident populations include the City of Yerington (about 0.5 miles to the east and southeast of the Site), the YPT Reservation (located about 2.5 miles north of the Site) and the YPT Colony (located adjacent to the City of Yerington).

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. The population density is lower to the north and west of the Site, although new residential development is occurring to the north (ATSDR 2006). Members of the Yerington Paiute Tribe include approximately 175 members living east

of the Site in the Colony and approximately 400 members living on the reservation north of the Site (ATSDR, 2006). Commercial and industrial businesses operate in Weed Heights, the City of Yerington, and along Highway 95A between the Site and the City of Yerington.

SECTION 3.0 DATA EVALUATION

The AQM DSR (Brown and Caldwell, 2009a) describes monitoring locations and methods, the number of analytes, and the results of the approximate three-year AQM program. All analytical data were verified and validated in accordance with the revised Draft Site-Wide Quality Assurance Project Plan (QAPP; Revision 5; Environmental Standards, Inc. and Brown and Caldwell, 2009). This section of the HHRA Work Plan describes the data used in the risk assessment. All chemicals and radiochemicals summarized in the AQM DSR will be considered in the risk assessment.

3.1 Laboratory Analytical Data

Samples sent to the laboratory for analysis include measurements of dust including PM₁₀ and total suspended particulates (TSP). Both PM₁₀ and TSP samples were analyzed for chemicals and radiochemicals. Samples for PM₁₀, TSP, chemicals and radiochemicals were collected over a 24-hour period every six days. These high volume air samples were collected at high flow rates (e.g., 1.13 cubic meters per minute [m^3/min]) over a 24-hour period (midnight to midnight), which resulted in a large volume of ambient air (e.g., 1,630 cubic meters). High volume data generated during the AQM program consisted of gravimetric analysis of PM₁₀ and TSP filters, and laboratory analyses of chemicals and radiochemicals present on PM₁₀ and TSP filters.

High volume air sampling was conducted on the National Ambient Air Quality Standards (NAAQS) schedule for PM₁₀, which specifies sampling every six days. Data from 187 sampling events at six locations for PM₁₀, TSP, 21 chemicals and 10 radiochemicals result in a total of 32,175 results from 2005 to 2007. In September 2007, three sample locations and some analytes were eliminated from the AQM program because these locations resulted in duplicative results and some analytes were rarely reported. Starting in September 2007, over 4,000 data points were collected from the remaining three AQM locations for nine chemicals and five radiochemicals.

Two types of samples were collected to represent peak concentrations of dust over a shorter time period as follows:

- **Hourly (Continuous)** - PM₁₀ (dust less than 10 microns in size) samples were collected hourly at three monitoring stations (AM-1, AM-3 and AM-6) since February 2007 resulting in over 20,000 data points.
- **Dust Event Data** – starting in February 2007, data were collected during peak wind or dust events. Samples for chemicals and radiochemicals were collected on an hourly basis at AM6 whenever the PM₁₀ exceeded 300 micrograms per cubic meter of air (µg/m³). These data are limited to five sampling events, as only 17 of 8,760 hours had air with concentrations exceeding 300 µg/m³ since February 2007.

Statistical summaries of the data that will be included in the baseline risk assessment are presented in Table 3-1 for TSP and associated metals and sulfate; for PM₁₀ and associated metals and sulfate in Table 3-2; for radiochemicals in TSP sampling in Table 3-3; and for radiochemicals in PM₁₀ sampling in Table 3-4. Acute (short-term) and chronic (long-term) human health screening levels are included on these tables. In general, most of the metals without published chronic screening levels are either required nutrients (e.g., calcium, magnesium and sodium) or do not exhibit toxicity at levels typically found in air.

None of the maximum concentrations of metals for either TSP or PM₁₀ exceed the acute screening levels. The maximum concentrations of arsenic, chromium, cobalt, manganese and nickel and the radiochemicals in PM₁₀ exceed the chronic screening levels. The presence of concentrations above the screening level does not indicate a health concern but only that further evaluation in a risk assessment is warranted. These data will be completely evaluated for potential health effects in the acute and chronic risk assessments.

Another consideration is that these parameters are also present in ambient or background air due to natural sources as well as other sources related to man's activities. Section 4.4.3 explains that only three parameters (PM₁₀, aluminum and copper) had concentrations with statistically higher concentrations in the downwind samples that could be related to releases from the Site.

3.2 Meteorological Data

Meteorological parameters were measured during the entire AQM program to support the interpretation of laboratory analytical results including wind speed and direction, precipitation, and relative humidity data, barometric pressure and temperature data, solar radiation, 2-m/10-m delta temperature. Meteorological data were collected from January 2005 through December 2006 at AM-6, and from February 2007 through March 2008 at AM-1, AM-3 and AM-6.

SECTION 4.0

CHRONIC (LONG TERM) HUMAN HEALTH RISK ASSESSMENT

A baseline chronic HHRA evaluates the potential that inhalation of chemicals and radiochemicals in the air pose a concern to human health over the long term (i.e., a person's lifetime). The formal risk assessment process consists of the following five steps:

- Data Evaluation - discusses the data that are available for inclusion in the HHRA.
- Exposure Assessment - presents the receptors and exposure pathways and explains how exposure is estimated.
- Toxicity Assessment - presents the toxicity factors used to estimate the potential health effects associated with each dose.
- Risk Characterization - shows how the information in the Exposure and Toxicity Assessments is combined to estimate the potential for adverse health effects.
- Uncertainty Analysis - discusses the level of confidence that can be placed in the results of the HHRA.

4.1 Data Evaluation

The chronic HHRA will include all of the analytical results from the 24-hour (high volume) PM₁₀ samples for chemicals and radiochemicals as chemicals of potential concern for chronic risk (chronic COPCs).

4.2 Exposure Assessment

The exposure assessment evaluates, the concentrations in the air at the points of exposure which are the air monitoring stations. The exposure pathways considered in this HHRA are presented on Figure 4-1.

4.2.1 Receptor Analysis

The HHRA assumes that a hypothetical resident lives at each of the monitoring stations.

4.2.2 Exposure Concentrations

Exposure point concentrations will be calculated for each air monitoring station as well as for all stations combined. For chronic risk, EPA guidance recommends using an average concentration most representative of the long term exposure (i.e., 30 years). Because it is not possible to know the true average, EPA guidance recommends using an upper confidence limit (UCL) of the average concentration.

An exposure concentration will be calculated for each air monitoring station using EPA's ProUCL software, Version 4.00.04 (EPA, 2009b). ProUCL calculates UCLs for a range of distributions of the data and recommends the most appropriate UCL based on the best fit to a distribution. If the recommended UCL exceeds the maximum concentration detected, ProUCL recommends that the maximum concentration be used to represent the exposure concentration (EPA 1989).

4.2.3 Daily Intake Concentration for Chemicals

Daily intake concentration used to calculate exposure for chemicals is the time-weighted average concentration with units of milligrams per cubic meters of air (mg/m^3). The exposure concentration is adjusted to reflect the amount of time that a resident is exposed (EPA 2009a). Using standard EPA assumptions for residential exposure, residents are assumed to breathe the outdoor air 24 hours per day for 350 days per year for 30 years (EPA 2009c). The equation for calculating intake for chemicals is shown below:

$$IC = (C \times EF \times ED) / (AT)$$

where

<i>IC</i>	=	intake concentration (mg/m^3) for chemicals
<i>C</i>	=	exposure point concentration (milligrams per cubic meter of air)
<i>EF</i>	=	exposure frequency (days per year)
<i>ED</i>	=	exposure duration (years)
<i>AT</i>	=	averaging time (days)

4.2.4 Intake for Radiochemicals

Radiochemical intake is calculated in terms of the amount of radioactivity and has units of inhaled picocuries (pCi). The equation for calculating intake for radiochemicals is:

$$I = (C \times IR \times EF \times ED)$$

where

<i>I</i>	=	intake (pCi) for radiochemicals
<i>C</i>	=	exposure point concentration (pCi per cubic meter of air)
<i>IR</i>	=	inhalation rate (cubic meters of air per day)
<i>EF</i>	=	exposure frequency (days per year)
<i>ED</i>	=	exposure duration (years)

4.3 Toxicity Assessment

The toxicity assessment identifies toxicity values which describe the relationship between the daily intake and the potential for a health effect. Toxicological effects fall into two categories: 1) effects that could potentially cause cancer (carcinogens); and 2) effects that could cause other types of adverse health effects (noncarcinogens).

4.3.1 Toxicity Assessment for Chemicals

For chemicals, the toxicity value for carcinogenic effects is called a unit risk factor (URF) with units of $(\mu\text{g}/\text{m}^3)^{-1}$, and the toxicity value for noncarcinogenic effects is called a reference concentration (RfC) in mg/m^3 . Chemicals that show a potential for both carcinogenic and noncarcinogenic health effects are assigned both unit risk factors and reference concentrations. The hierarchy of human health toxicity values follows OSWER Directive 9285.7-53, issued by EPA's Office of Solid Waste and Emergency Response on December 5, 2003, as augmented in the EPA Regional Screening Levels (EPA, 2009c):

1. EPA's Integrated Risk Information System (IRIS).
2. The Provisional Peer Reviewed Toxicity Values (PPRTVs) derived by EPA's Superfund Health Risk Technical Support Center for the EPA Superfund program.

3. The Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk levels (MRLs).
4. The California Environmental Protection Agency/Office of Environmental Health Hazard Assessment's toxicity values (<http://www.oehha.ca.gov/risk/ChemicalDB/index.asp>).
5. The EPA Superfund program's Health Effects Assessment Summary (HEAST).

Toxicity values from Sources 2 and 5 will be obtained from the table of regional screening levels (RSLs) published by EPA because PPRTVs and values from HEAST are not available to the public (EPA, 2009c). There are chemicals detected in the air samples that do not have either a cancer slope factor or a noncancer reference dose in these sources. For these chemicals, the oral toxicity factor will be used as a surrogate for inhalation toxicity (route-to-route extrapolation).

4.3.2 Toxicity Assessment for Radiochemicals

In accordance with EPA guidance, radiochemicals are only assessed for the potential to increase incidence of cancer. For radiochemicals, the only source of toxicity factors is the Health Effects Assessment Summary Tables for Radionuclides (EPA, 2001).

4.4 Risk Characterization

The final step in any risk assessment is to combine daily intake and toxicity values to calculate potential cancer risks for chemicals and radiochemicals, noncancer health estimates for chemicals, and the evaluation of lead.

4.4.1 Chemical Cancer Risk

Cancer risk represents the probability that exposure to chronic COPCs could result in an increased risk of cancer. Chemical cancer risk is calculated by multiplying the daily intake concentrations times the unit risk factor as follows:

$$\text{Chemical Cancer risk} = \text{daily intake concentration} \times \text{unit risk factor.}$$

4.4.2 Radiochemical Cancer Risk

Radiochemical cancer is calculated by multiplying the intake times the cancer slope factor as follows:

$$\text{Radiochemical cancer risk} = \text{intake for radiochemicals} \times \text{cancer slope factor.}$$

Cancer risk is termed “the probability of increased individual excess cancer.” This means the risk over and above the natural risk of cancer in the general public. The EPA considers cancer risks at or below 1×10^{-6} to be insignificant. The total cancer risks are added across chemicals and radiochemicals to estimate an overall cancer risk. The total cancer risk includes chemicals and radiochemicals that are found at or below background concentrations.

4.4.3 Noncancer Risks for Chemicals and Evaluation of Lead

Noncancer chemical health effects are evaluated based on a hazard quotient (HQ) for individual chemicals. The HQ is the ratio between the daily intake concentration and the reference concentration:

$$\text{Hazard Quotient} = \text{daily intake concentration}/\text{reference concentration}$$

An HQ value of 1 indicates that lifetime exposure has limited potential for causing an adverse effect in sensitive populations, and values of less than 1 can generally be considered acceptable. The sum of chemical-specific HQs is called a hazard index (HI). It is only appropriate to add HQ values for different chemicals if they have the same health effect. Adding HQ values into a single cumulative HI value across chemicals is a preliminary estimate of the highest possible noncancer risk. HI values of less than 1 can generally be considered acceptable. Values greater than 1 are usually given closer attention.

The health effects of lead fall into the noncancer category and are evaluated by comparing the air concentrations to the NAAQS Standard of 0.15 micrograms of lead per cubic meter of air ($\mu\text{g}/\text{m}^3$). An HQ is not calculated for lead and the effects of lead are not considered additive with other chemicals.

4.4.4 Contribution of Background Sources

The AQM DSR (Revision 2; Brown and Caldwell, 2009a) provides an assessment of relative contributions to airborne dust from the Site and from other off-Site sources, based on an analysis of upwind and downwind concentrations. In summary, the statistical analysis presented in Section 6.2 of the AQM DSR (Brown and Caldwell, 2009a) indicated a statistically significant difference between upwind and downwind concentrations for only three parameters (aluminum, copper and PM_{10}). For conditions when the wind direction is to the northeast quadrant, Site emissions contribute to the measured downwind concentrations of PM_{10} , aluminum and copper an average of approximately 18, 29 and 33 percent, respectively (background sources contribute the remaining amounts). For the nine other analytes with results that were not statistically significant, the median differences (i.e., Site contributions) are generally low in comparison to corresponding downwind concentrations, ranging from -14 percent (upwind greater than downwind) to +14 percent (downwind greater than upwind). The statistical analyses indicate that the other parameters do not migrate off-Site in any appreciable amounts.

4.4.5 Evaluation of Arsenic Air Quality Data

Arsenic was detected frequently in background soils (e.g., more than 85 percent of the samples in background soils; *Background Soils Data Summary Report - Revision 1* dated March 9, 2009 (Brown and Caldwell, 2009b) and infrequently in air (e.g., 10 percent or less of the samples as shown on Tables 3-1 and 3-2. The low frequency of detection of arsenic in the air samples can be explained using the average concentrations of arsenic in soil and dust (PM_{10}) in the air, and the laboratory detection limit for the air samples. The average concentration of arsenic in the Process Areas soils is 5.9 milligrams per kilogram (mg/kg; Brown and Caldwell, 2005) and the average concentration of PM_{10} at perimeter air monitoring stations is $10.5 \mu\text{g}/\text{m}^3$ (Brown and Caldwell, 2009a).

Assuming that the PM₁₀ in the air is generated from the soils that occur on the Site, it is possible to calculate the average concentration of arsenic expected in the air as follows:

1. Arsenic concentration in air = arsenic concentration in soil times soil concentration in air (represented by PM₁₀)
2. Arsenic concentration in soil of 5.9 mg/kg is equivalent to 5.9 parts per million or 0.0000059 (g/g or dimensionless)
3. PM₁₀ concentration of 10.5 ug/m³ represents soil concentration in air
4. Arsenic concentration in air = 0.0000059 x 10.5 ug/m³ = 0.000062 ug/m³

Therefore, the estimated average concentration of arsenic in the air, resulting from emissions from the Process Area soils, is 0.000062 µg/m³. The detection limits for arsenic in the air samples ranged from 0.0004 to 0.0013 µg/m³. The PM₁₀ and/or arsenic concentrations in the PM₁₀ would have to be more than 6 times the average before a reportable quantity would be present in the filters. The laboratory analytical method and detection limits, approved by EPA, are sufficiently close to the PRG of 0.00045 µg/m³. The Preliminary Remediation Goals (PRGs) are health-based concentrations that are considered protective for 30 years of exposure. The fact that the detection limits are close to the PRGs means that any arsenic that may be of concern to human health effects would have been detected in the air samples. For the purposes of this HHRA Work Plan, the arsenic data from the air samples are reliable, and appropriate for the intended purpose of estimating risk via the inhalation pathway.

SECTION 5.0

ACUTE (SHORT TERM) HUMAN HEALTH RISK ASSESSMENT

The evaluation of the potential for acute (i.e., short term) health effects due to exposure to higher levels of dust, chemicals and radiochemicals is described in this section. Acute health effects are those that appear during or immediately after a short period of exposure (e.g., a few minutes to a few hours), and are generally temporary in nature (e.g., clearing up after a day or so). Examples of acute health effects include irritation to the lungs or eyes. There are three steps in the HHRA for acute health effects:

- Data Evaluation – the data are compiled and a list of the chemicals of potential concern for acute exposure (acute COPCs) is determined.
- Acute Exposure Guidelines - the exposure concentrations are compared to health-based concentrations that have been developed to be protective for short term exposure.
- Exposure Concentrations – discusses the method used to estimate the appropriate concentration of acute COPCs for comparison to the acute exposure guideline.
- Acute Risk Characterization – presents the comparison of the exposure concentration to the acute exposure guideline.

5.1 Data Evaluation

The acute COPCs include chemicals, PM₁₀, and TSP. All data for the acute COPCs collected as part of the AQM program since 2005 will be included in the acute HHRA. Table 5-1 presents the acute COPCs.

Radiochemicals are not included as acute COPCs because short term exposure has not been associated with acute health effects for radiochemicals, and Federal and State health agencies have not set short term guidelines for exposure to radiochemicals. Acute radiological effects are not evident until radiation doses exceeding 100 rem are received. Doses of this magnitude are: 1) only received from medical procedures, high activity gamma radiation sources, or industrial X-ray machines; and 2) are not easily achievable accidentally via inhalation, ingestion, or any other internal dose pathway. With regard to doses arising from aurally dispersed TENORM at the Site, it would not be possible to inhale sufficient dust to cause an acute effect.

5.2 Acute Exposure Guidelines

The acute exposure guidelines (Table 5-1) used to evaluate the potential for short term health effects are selected from a variety of lists from scientific and regulatory agencies. A hierarchy of lists is based on a recommendation from EPA Region 9 to use guidelines from the California Environmental Protection Agency (Cal/EPA) followed by other reputable sources for COPCs without Cal/EPA guidelines. The following hierarchy would be used for the acute HHRA:

- California EPA's reference exposure levels (RELs), which are available for only five analytes: arsenic, copper, mercury, nickel, and vanadium. Most RELs are based on an exposure time of one hour and define the concentration at which no adverse health effects are expected.
- Emergency response planning guidelines (ERPGs) developed by the American Industrial Hygiene Association. ERPGs are intended to be protective of the general population, and Level II values represent one-hour concentrations at which no irreversible or serious effects are expected to occur that would impair an individual's ability to take protective action.
- Temporary emergency exposure limits (TEELs), from the U.S. Department of Energy, developed for use when no other acute values are available for a given chemical. Level 1 TEELs represent concentrations at which no adverse health effects are expected over a 15-minute exposure time.

5.3 Exposure Concentrations

Exposure concentrations are the COPC concentrations at a receptor's point of exposure. The first step in creating the exposure concentrations will be to determine the 99.7 percent UCL of the data or the maximum concentration, whichever is lower, for each acute COPC. Then the exposure concentrations will be matched to the time-frame of the acute short term guidelines for that chemical. For example, the REL for arsenic is a 4-hour average, and the exposure concentration would be developed that is representative of this time period.

Table 5-1. Health-based Guidelines for Acute (Short term) Inhalation Exposure			
Analyte	Health-Based Guidelines ($\mu\text{g}/\text{m}^3$)	Exposure Time (hour)	Source
Aluminum ^a	10,000	0.25	TEEL-0
Arsenic ^b	0.19	4	CalEPA REL
Barium	500	0.25	TEEL-0
Beryllium	25	1	ERPG-2
Cadmium	5.0	0.25	TEEL-0
Calcium	10,000	0.25	TEEL-0
Chromium, total	1,000	0.25	TEEL-0
Cobalt	100	0.25	TEEL-0
Copper	100	1	CalEPA REL
Iron	1,500	0.25	TEEL-0
Lead	50	0.25	TEEL-0
Magnesium	10,000	0.25	TEEL-0
Manganese	200	0.25	TEEL-0
Mercury ^c	1.8	1	CalEPA REL
Molybdenum	10,000	0.25	TEEL-0
Nickel	6.0	1	CalEPA REL
PM ₁₀ ^d	10,000	0.25	TEEL-0
Selenium	200	0.25	TEEL-0
Silver	10	0.25	TEEL-0
Sodium	500	0.25	TEEL-0
Sulfates	120	1	CalEPA REL
TSP ^d	10,000	0.25	TEEL-0
Vanadium ^e	30	1	CalEPA REL
Zinc	10,000	0.25	TEEL-0

Notes: Cal/EPA REL = California EPA Reference Exposure Levels for 1 or 4 hr maximum concentration, intermittent exposure lasts less than 24 hr and occurs no more than 1 time per month, or no more frequently than every two weeks in a given year.

ERPG = Emergency Response Planning Guidelines; 1-hour exposure developed by American Industrial Hygiene Association.

PM10 – particulate matter less than 10 micron in size.

TEEL-0 = Temporary Emergency Exposure Limits; intended for use until ERPGs are adopted. TEEL-0 is the concentration below which most people will experience no adverse health effects. Concentrations are peak, 15-min time-weighted averages. Revision 23 for Chemicals of Concern (08/2007).

TSP – total suspended particulates.

$\mu\text{g}/\text{m}^3$ – micrograms per cubic meter.

aValue based on aluminum chloride.

bValue based on inorganic compounds.

cValue based on mercury (I) chloride

dValue based on PNOS (particulates not otherwise specified)

eValue based on vanadium pentoxide

The majority of the data for acute COPCs are 24-hour average concentrations and the acute guidelines are based on shorter time intervals ranging from 4 hours to 15 minutes. EPA guidance recommends adjusting 24-hour average data to be representative of an hour by multiplying by a factor ranging from 3 to 5 (EPA, 1992). In addition to using EPA guidance, the acute HHRA will evaluate an absolute worst-case condition by multiplying the 24-hour sample concentration by an appropriate multiplier. For example, to estimate the “worse case” concentration for acute COPCs with TEELs (15 minute exposure), the 24-hour concentrations will be multiplied by 96 (24 hours x four 15 minute increments per hour). This calculation results in an extremely high estimate of the actual concentration because it is assumed that all the dust in the air measured during a 24-hour period occurred within 15 minutes.

5.4 Acute Risk Characterization

To evaluate the potential for an acute risk, the exposure concentrations of each acute COPCs will be compared to the respective health-based acute guideline. Concentrations below the guidelines can be considered safe for short term exposure, and would not likely result in any adverse health effects.

SECTION 6.0 UNCERTAINTY ANALYSIS

Uncertainty associated with the chronic and acute HHRA's will be analyzed using EPA protocols and assumptions to ensure that exposure will not be underestimated. However, there is a level of uncertainty for any risk assessment regarding whether exposure could be overestimated or underestimated. Risk managers take uncertainty into consideration when making decisions on cancer risks within the risk management range (1×10^{-6} to 1×10^{-4}) and hazard values above 1.

When little information exists for a site, or the toxicity of the COPCs, and uncertainty exists concerning exposure, risk managers may tend to assign a target risk at the lower end of the risk management range (e.g., 1×10^{-6}). When there is a higher level of confidence that: 1) the site has been adequately characterized; 2) there is a sufficient understanding of the toxicology of the risk drivers; and 3) exposure has not been underestimated, risk managers may choose a higher target risk level (e.g., 1×10^{-4}) as appropriate for the site. Therefore, it is important to understand the adequacy of the data and any uncertainty associated with exposure or toxicity before making risk management decisions.

SECTION 7.0

REFERENCES

- ATSDR, 2006, *Health Consultation - Yerington Anaconda Mine Site, Yerington, Nevada*. Released for public comment on January 23, 2006. Notice of final report released on September 12, 2006. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Atlanta, GA.
- Brown and Caldwell, 2005, *Data Summary Report for Process Areas Soils Characterization, Yerington Mine Site*. Prepared for the Atlantic Richfield Company. November 1, 2005.
- Brown and Caldwell, 2009a, *Air Quality Monitoring Program Data Summary Report (Revision 2)*, Yerington Mine Site. Prepared for the Atlantic Richfield Company. September 3, 2009.
- Brown and Caldwell, 2009b, *Background Soils Data Summary Report (Revision 1)*, Yerington Mine Site, Lyon County Nevada. Prepared for the Atlantic Richfield Company. March 9, 2009
- Brown and Caldwell, Integral Consulting, Inc., Foxfire Scientific, Inc. 2009, *Conceptual Site Model (Revision 3)*, Yerington Mine Site, Lyon County Nevada.. Prepared for the Atlantic Richfield Company. January 30, 2009.
- Cal/EPA, 2003. *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments*. California Environmental Protection Agency. Office of Environmental Health Assessment. August.
- DOE, 2001. *User's Manual for RESRAD Version 6*. Environmental Assessment Division Argonne National Laboratory US Department of Energy. ANL/EAD-4. July 2001.
- Environmental Standards, Inc. and Brown and Caldwell, 2009, *Quality Assurance Project Plan, (Revision 5)* Yerington Mine Site, Lyon County Nevada. Prepared for the Atlantic Richfield Company. May 20, 2009.
- EPA, 1989, *Risk Assessment Guidance for Superfund (RAGS): Volume 1 – Human Health Evaluation Manual (Part A), Interim Final*. Office of Emergency and Remedial Response, Washington, DC.
- EPA, 1992. *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources*, Revised, EPA 454/R-92-019, October

- EPA, 2001, *Health Effects Assessment Summary Tables: Radionuclide Carcinogenicity Slope Factors*. <http://www.epa.gov/radiation/heat/index.html>. Last Updated March 8, 2006. Office of Radiation and Indoor Air, U.S. Environmental Protection Agency, Washington, DC
- EPA, 2006, *A Preliminary Risk-Based Screening Approach for Air Toxics Monitoring Data Sets, Version 1.2* Air, Pesticides, and Toxics Management Division. U.S. Environmental Protection Agency, Atlanta Georgia. EPA-904-B-06-01. February.
- EPA, 2007a, *Administrative Order for the Remedial Investigation and Feasibility Study, in the Matter of Anaconda/Yerington Mine Site, Yerington, Lyon County, Nevada*. Atlantic Richfield, Respondent. U.S. EPA Region 9, Docket No. 9-2007-0005. Proceeding under Section 106(a) of CERCLA, as amended, 42 USC § 9606(a). Including Attachment A: Scope of Work for the Remedial Investigations / Feasibility Studies Continued Response Action. January.
- EPA, 2009a. *Risk Assessment Guidance for Superfund (RAGS): Volume 1 – Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), Final*. Office of Emergency and Remedial Response, Washington, DC. /EPA-540-R-070-002. OSWER 9285.7-82 January.
- EPA, 2009b, *ProUCL Software Version 4.00.04*. April
- EPA, 2009c, *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. April.
- Lopes, T.J. and J.L. Smith, 2007, *Bathymetry of Walker Lake, West-Central Nevada*. Prepared for the U.S. Department of Interior. Scientific Investigations Report 2007-5012. U.S. Geological Survey.
- Seitz, H.R., A.S. Van Denburgh, and R.J. La Camera, 1982, *Ground-water quality downgradient from copper-ore milling wastes at weed heights, Lyon County, Nevada*. U.S. Geological Survey Open-File Report 80-1217.
- U.S. Census Bureau, 2000, Yerington City, Nevada - Fact Sheet. Accessed on September 28, 2007.
- WRCC, 2007a, Yerington, Nevada (269229): Period NCDC 1971-2000 Monthly Normals. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nv9229>. Western Regional Climate Center.
- WRCC, 2007b, Yerington, Nevada (269229): *Period of Record General Climate Summary - Precipitation*. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?nv9229>. Western Regional Climate Center.