Stibnite Gold Project EIS Appendix M

Public Health and Safety - Calculation of Site-Specific Recreational **Risk-based Screening Levels f**or Soil

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Calculation of Site-Specific Recreational RBSLs for Soil

Recreational risk-based screening levels (RBSLs) were derived for the metals of primary concern in soil tailings at the Project site: arsenic, antimony, and mercury. The RBSLs take into account the limited exposures associated with most recreational activities and are considered site-specific screening levels based on the anticipated future land use at the Site. The yearly recreational exposure frequency is assumed to be16 days/year, based on the assumption that individuals are unlikely to spend more time at an individual site on an annual basis. This value is based on the Payette National Forest (PNF) camping stay limit for individual campground sites. The exposure duration assumed for recreational visitors, 26 years, is the default exposure duration recommended by EPA for residents (EPA 2014). It was further assumed that two years of the exposure occur as a child (4 to 6 years old) and 24 years as an adult (> 6 years of age). The remainder of the exposure parameters included in the RBSL calculations are based on EPA's default exposure assumptions for residents (EPA 2014). Table 1 summarizes the exposure parameters used in the recreational RBSL calculations.

The chemical-specific toxicity criteria were obtained from EPA's May 2019 RSL table (EPA 2019) and are summarized on Table 2. For mercury, the toxicity criteria for elemental mercury were applied (rather than the toxicity criteria for salts of mercury). For arsenic, the EPA default relative bioavailability of 60 percent was used in the equations. For the other metals, the EPA default of 100 percent was conservatively used.

Recreational RBSLs were calculated using EPA's methodology and equations for calculation of regional screening levels (RSLs). Detailed calculations are provided as Attachment 1. For noncancer endpoints, a target hazard quotient (THQ) of 1 was used. For cancer endpoints, the cumulative lifetime cancer risk of $1x10^{-6}$ (or one-in-a-million) of developing cancer due to lifetime exposure to a chemical, is the National Contingency Plan (NCP) (EPA 1990) point of departure for the analysis of remedial alternatives. The NCP (EPA 1990) specifically states that $1x10^{-6}$ should not be presumed to be the final target risk for hazardous waste sites and that the range of $1x10^{-6}$ to $1x10^{-4}$ represents "generally acceptable risk," with the option given for even $1x10^{-4}$ to be exceeded in some circumstances. A cumulative lifetime risk exceeding $1x10^{-4}$ (1 in 10,000) is the point at which action generally is warranted at a site. Thus, a range of target cancer risk (TCR) of $1x10^{-6}$ to $1x10^{-4}$ was used in the calculation of the recreational RBSL for arsenic, the only chemical evaluated associated with carcinogenic endpoints. Because arsenic is also associated with noncarcinogenic effects, the lowest RBSL based on noncancer effects or carcinogenic effects is selected as the final screening level. Table 3 summarizes the site-specific recreational RBSLs for arsenic, antimony, and mercury.

References:

EPA. (2019). Regional Screening Levels for Chemical Contaminants at Superfund Sites. EPA Office of Superfund. May 2019. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

EPA. (2014). Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. Memorandum from D. Stalcup, Assessment and Remediation Division. OSWER

Directive 9200.1-120. Washington, DC: Office of Superfund Remediation and Technology Innovation. February.

EPA. (1990). National Oil and Hazardous Substance Pollution Contingency Plan; Final Rule. Thursday, March 8, 1990; Volume 55, Number 46.55. FR 866. NCP-R2TA-1-2. March.

Table 1: Summary of Exposure Assumptions

Parameter	Units	Child (4-6 yrs)	Adult (6-30 yrs)	Source
Ingestion Rate of Sediment (IR)	mg/day	200	100	EPA residential default soil ingestion rate (EPA 2014)
Exposure Frequency (EF)	days/year	16	16	PNF camping stay limit for individual campground sites
Exposure Duration (ED)	years	2	24	EPA residential default exposure duration (EPA 2014); assumes children 2 and older would engage in recreational activities
Body Weight (BW)	kg	15	80	EPA residential default body weight for child and adult receptors (EPA 2014)
Averaging Time (noncancer) (ATnc)	days	730	8,760	ED x 365 days per year (EPA 2014)
Averaging Time (cancer) (ATc)	days	25,550	25,550	EPA default life expectancy of 70 years x 365 days per year (EPA 2014)
Surface Area Available for Contact (SA)	cm^2	2,373	6,032	EPA default values for head, hands, forearms, and lower legs (EPA 2014)
Adherence Factor (AF)	mg/cm^2	0.2	0.07	EPA residential default soil adherence (EPA 2014)
Fraction of day for dermal exposures (FC)	unitless	1	1	EPA residential default for soil exposure (EPA 2014)

Notes:

mg/day = milligrams per day

mg/cm^2 = milligrams per square centimeter

cm^2 = square centimeter

kg = kilogram

Table 2: Chemical Specific Parameters

Chemical	RfC mg/m^3	RfD mg/kg-day	IUR $(ug/m^3)^{-1}$	CF $(mg/kg\text{-}day)^{-1}$	PEF of VF m^3/kg	RBA unitless	ABSd unitless
Arsenic	1.5E-05	3.0E-04	4.3E-03	1.5E+00	1.4E+09	0.6	0.03
Mercury (elemental)	3.0E-04	--	--	--	3.5E+04	1	--
Antimony	--	4.0E-04	--	--	1.4E+09	1	--

Source: EPA May 2019 RSL table (EPA 2019)

Notes:

RfC = inhalation reference concentration

RfD = oral reference dose

IUR = inhalation unit risk

CF = cancer slope factor

PEF = particulate emission factor (to evaluate inhalation exposures of metals in dust)

VF = volatilization factor (to evaluate inhalation exposures of mercury vapor)

RBA = relative bioavailability factor

ABSd = dermal absorption factor from soil (For metals with no ABSd value, the dermal pathway from soil is generally considered insignificant)

mg/m^3 = milligrams per cubic meter

mg/kg-day = milligrams per kilogram-day

ug/m^3 = micrograms per cubic meter

m^3/kg = cubic meters per kilogram

Table 3: Summary of Site-Specific Recreational RBSLs

Metals	Final Risk Based Screening Level[a] mg/kg		
	Optimal THQ=1, TCR=$1x10^{-6}$	**Acceptable** THQ=1, TCR=$1x10^{-5}$	**Do Not Exceed** THQ=1, TCR=$1x10^{-4}$
Arsenic[b]	27	268	763
Mercury[c,d]	240	240	240
Antimony[c]	684	684	684

Notes:

[a]RBSLs are protective of recreational exposures to soil through the ingestion, dermal, and inhalation pathways.

[b]For arsenic, the RBSL is based on carcinogenic effects, except at the TCR of 1×10^{-4} where noncancer effects become the driving health concern.

[c]The RBSLs for mercury and antimony are based on noncarcinogenic effects and are protective of a THQ of 1.

[d] RBSL for elemental mercury exceeds the soil saturation concentration (Csat) of 3.1 mg/kg, an estimate of the concentration at which the soil pore water, pore air, and surface sorption sites are saturated. Above this theoretical threshold concentration, elemental mercury may be present in free-phase within the soil matrix.

THQ = target hazard quotient

TCR = target cancer risk

mg/kg = milligrams per kilogram

Table M-1
Incidental Ingestion of Soil (Reclamation Cover Material)
Future

Exposure Medium: Surface Soil
Exposure Point: Reclamation Cover Material
Receptor Population: Recreational
Receptor Age: Children and Adults

Noncancer RBSL = (THQ x RfD) / (SIFnc x RBA x ABSo)
Cancer RBSL = (TCR) / (SIFc x CSF x RBA x ABSo)

Parameter	Units	Child (4-6)	Adult (6-30)
Chemical Concentration in Soil (C-s)	mg/kg	chem-specific	chem-specific
Ingestion Rate of Soil (IR)	mg/day	200	100
Exposure Frequency (EF)	days/year	16	16
Exposure Duration (ED)	years	2	24
Conversion Factor (CF)	kg/mg	1.00E-06	1.00E-06
Body Weight (BW)	kg	15	80
Averaging Time (noncancer) (ATnc)	days	730	8,760
Averaging Time (cancer) (ATc)	days	25,550	25,550
SIFnc = (IR*EF*ED*CF)/(BW*ATnc)	$(day)^{-1}$	5.84E-07	5.48E-08
IngFadj (Ingestion Adjusted Factor)= (IRch*EDch/BWch)+(IRa*EDa/BWa)	mg-yr/day-kg	56.67	
SIFc = (IngFadj*EF*CF)/ATc	$(day)^{-1}$	3.55E-08	

Chemical	RfD-O (mg/kg-d)	CSF-O $(mg/kg-d)^{-1}$	RBA unitless	ABSo unitless
Arsenic (total)	3.0E-04	1.5E+00	6.0E-01	1.0E+00
Mercury (elemental)	--	--	1.0E+00	1.0E+00
Antimony	4.0E-04	--	1.0E+00	1.0E+00

Chemical	Ingestion Soil RBSLs				
	NC - child mg/kg	NC - adult mg/kg	lifetime cancer mg/kg		
	THQ=1	THQ=1	TCR = 1x10-6	TCR = 1x10-5	TCR = 1x10-4
Arsenic (total)	855	9125	31.31	313.11	3131.13
Mercury (elemental)	--	--	--	--	--
Antimony	684	7300	--	--	--

Notes:
ABSo = oral absorption factor
C-s = concentration in soil
CSFo = oral cancer slope factor
kg = kilograms
mg = milligrams
mg/kg-d = milligrams per kilogram per day
mg-yr/day-kg = milligrams per year per day per kilogram
kg/mg = kilograms per milligram
mg/kg = milligrams per kilogram
RBA = relative bioavailability factor
RfDo = oral reference dose
SIF = summary intake factor
TCR = target cancer risk level
THQ = target hazard quotient
RBSL = risk based screening level
nc = noncancer
c = cancer

Table M-2
Dermal Contact with Soil (Reclamation Cover Material)
Future

Exposure Medium: Surface Soil
Exposure Point: Reclamation Cover Material
Receptor Population: Recreational
Receptor Age: Children and Adults

Noncancer Cleanup Level = (THQ x RfD) / (SIFnc x ABSd)
Cancer Cleanup Level = (TCR) / (SIFc x CSF x ABSd)

Parameter	Units	RME	
		Child (4-6)	Adult (6-30)
Chemical Concentration in Soil (C-s)	mg/kg	chem-specific	chem-specific
Exposure Frequency (EF)	days/year	16	16
Exposure Duration (ED)	years	2	24
Surface Area Available for Contact (SA)	cm^2	2,373	6,032
Adherence Factor (AF)	mg/cm^2	0.2	0.07
Fraction of day for dermal exposures (FC)	unitless	1	1
Conversion Factor (CF)	kg/mg	1.0E-06	1.0E-06
Body Weight (BW)	kg	15	80
Averaging Time (noncancer) (ATnc)	days	730	8760
Averaging Time (cancer) (ATc)	days	25550	25550
SIFnc = (EF*ED*SA*AF*FC*CF)/(BW*ATnc)	$(day)^{-1}$	1.39E-06	2.31E-07
DFadj (Dermal Adjusted Factor) = (EDch*SAch*AFch /BWch) +(EDa*SAa*AFa/BWa)	mg-yr/day-kg	189.95	
SIFc = (DFadj*EF*FC*CF)/ATc	$(day)^{-1}$	1.19E-07	

Chemical	RfD-D (mg/kg-d)	CSF-D $(mg/kg-d)^{-1}$	AbsD
Arsenic (total)	3.0E-04	1.5E+00	3.0E-02
Mercury (elemental)	--	--	--
Antimony	6.0E-05	--	--

Chemical	Dermal Soil Risk Based Screening Levels				
	NC - child mg/kg	NC - adult mg/kg	lifetime cancer mg/kg		
	THQ=1	THQ=1	TCR = 1x10-6	TCR = 1x10-5	TCR = 1x10-4
Arsenic (total)	7210	43222	186.82	1868.16	18681.62
Mercury (elemental)	--	--	--	--	--
Antimony	--	--	--	--	--

Notes:
ABSd = dermal absorption
cm^2 = square centimeters
C-s = concentration in soil
CSFd = dermal cancer slope factor
kg = kilograms
kg/mg = kilograms per milligram
mg/cm^2 = milligrams per square centimeter
mg/kg = milligrams per kilogram
mg/kg-d = milligrams per kilogram per day
mg-yr/day-kg = milligrams per year per day per kilogram
RfDd = dermal reference dose
SIF = summary intake factor
TCR = target cancer risk level
THQ = target hazard quotient
yr = year
nc = noncancer
c = cancer
RBSL = risk based screening level

Table M-3
Inhalation of Fugitive Dust (Reclamation Cover Material)
Future

Exposure Medium: Surface Soil
Exposure Point: Reclamation Cover Material
Receptor Population: Recreational
Receptor Age: Children and Adults

Noncancer Cleanup Level = (THQ x RfC x PEF) / (SIFnc)
Cancer Cleanup Level = (TCR x PEF) / (SIFc x IUR)

Parameter	Units	RME	
		Child (4-6)	Adult (6-30)
Chemical Concentration in Soil (C-s)	mg/kg	chem-specific	chem-specific
Exposure Frequency (EF)	days/year	16	16
Exposure Duration (ED)	years	2	24
Exposure Time (ET)	hours/day	24	24
Conversion Factor (CF)	ug/mg	1.0E+03	1.0E+03
Averaging Time (noncancer) (ATnc)	hours	17520	210240
Averaging Time (cancer) (ATc)	hours	613200	613200
SIFnc = (EF*ED*ET)/(ATnc)	unitless	4.38E-02	4.38E-02
SIFc = ([EDc+EDa]*EF*ET*CF)/ATc	ug/mg	1.63E+01	

Chemical	RfC mg/m3	IUR $(ug/m3)^{-1}$	PEF m3/kg
Arsenic (total)	1.5E-05	4.3E-03	1.4E+09
Mercury (elemental)	3.0E-04	--	3.5E+04
Antimony	--	--	1.4E+09

Chemical	Inhalation Soil Screening Levels				
	NC - child	NC - adult	lifetime cancer		
	TH	THQ=1	TCR = 1x10-6	TCR = 1x10-5	TCR = 1x10-4
Arsenic (total)	465151	465151	19416	194159	1941595
Mercury (elemental)	240	240	--	--	--
Antimony	--	--	--	--	--

Notes:
PEF = particulate emission factor
C-s = concentration in soil
IUR - inhalation unit risk
kg = kilograms
ug/mg = micrograms per milligram
mg/cm^2 = milligrams per square centimeter
mg/kg = milligrams per kilogram
mg/m^3 = milligrams per cubic meter
ug/m^3 = micrograms per cubic meter
RfC = inhalation reference concentration
SIF = summary intake factor
TCR = target cancer risk level
THQ = target hazard quotient
yr = year
m^3/kg = cubic meter per kilogram

Table M-4
Summary of Recreational Soil Risk Based Screening Levels

Metals	RBSL NC - child mg/kg THQ=1	RBSL NC - adult mg/kg THQ=1	RBSL lifetime cancer mg/kg TCR = 1x10-6	TCR = 1x10-5	TCR = 1x10-4
Ingestion					
Arsenic	855	9,125	31	313	3,131
Mercury	--	--	--	--	--
Antimony	684	7,300	--	--	--
Dermal					
Arsenic	7,210	43,222	187	1,868	18,682
Mercury	--	--	--	--	--
Antimony	--	--	--	--	--
Inhalation					
Arsenic	465,151	465,151	19,416	194,159	1,941,595
Mercury	240	240	--	--	--
Antimony	--	--	--	--	--
Total[a]					
Arsenic	763	7,414	27	268	2,678
Mercury	240	240	--	--	--
Antimony	684	7,300	--	--	--

Final Risk Based Screening Level[b] (mg/kg)

Metals	Optimal THQ=1, TCR=1x10-6	Acceptable THQ=1, TCR=1x10-5	Do Not Exceed THQ=1, TCR=1x10-4
Arsenic	27	268	763
Mercury	240	240	240
Antimony	684	684	684

Notes:

[a] Total Risk Based Screening Levels (RBSLtot) take into account combined incidental ingestion, inhalation, and dermal contact is calculated using the following formula:

$$\text{RBSLtot} = \frac{1}{\frac{1}{\text{RBSL}_{\text{ing}}} + \frac{1}{\text{RBSL}_{\text{inh}}} + \frac{1}{\text{RBSL}_{\text{derm}}}}$$

[b] Final RBSLs are the lowest of the noncancer- or cancer-based RBSLs at the specified target cancer risk level.

mg/kg = milligrams per kilogram
THQ = target hazard quotient
TCR = target cancer risk
NC = noncancer
RBSL = risk based screening level

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