7 Summary and Conclusions

This chapter presents a summary of the data collection activities performed at the RDM; the nature and extent of contamination, including comparisons of contaminants to relevant regulatory criteria; the fate and transport of the contaminants that were most widespread at the site and/or most significantly above background values; and the risks posed by contamination to human and ecological receptors.

This chapter also presents conclusions developed from the results of the RI studies. The conclusions are presented in the context of the key study questions developed through the DQO process outlined at the end of Chapter 1 of this document and presented in the Final RI/FS Work Plan (E & E 2011). Finally, this chapter presents preliminary remedial action objectives that will be assessed in the FS.

7.1 Summary

7.1.1 Data Collection Activities

Data collection activities to support the RDM RI/FS were conducted in 2010 and 2011. In 2010, the following data collection activities were conducted:

- Surface soil sampling for XRF field screening to delineate the surface extent of tailings/waste rock and impacted native surface soil.
- Surface soil sample collection for laboratory analyses.
- Surface water and sediment sample collection in Red Devil Creek.
- Shoreline sediment sample collection along the Kuskokwim River.
- Groundwater sample collection from existing monitoring wells.

In addition, in 2010, the USGS conducted a geophysical survey of the site (Burton and Ball 2011), and the BLM collected fish tissue samples from Red Devil Creek and the Kuskokwim River. These two studies are used in the RI to support site characterization findings and conclusions.

In 2011, the following data collection activities were conducted:

- Additional surface soil sampling for XRF field screening to complete the delineation of the surface extent of tailings/waste rock and impacted native surface soil.
- Additional surface soil sample collection for laboratory analysis.

- Surface water sample collection at all 2010 sample stations on Red Devil Creek and three new stations.
- Sediment sample collection at three new sample stations on Red Devil Creek.
- Measurement of stream discharge (flow) at five sites along Red Devil Creek.
- Additional shoreline sampling along the Kuskokwim River.
- Off-shore sediment sampling in the Kuskokwim River.
- Drilling of 72 exploratory soil borings and collection of subsurface soil samples.
- Installation of 26 new monitoring wells and groundwater sample collection from the new and existing monitoring wells.
- Vegetation sample collection.
- Topographic surveying of all monitoring wells and the stream discharge measurement sites on Red Devil Creek.

Chapter 2 provides a detailed summary of these data collection activities.

7.1.2 Nature and Extent of Contamination

Surface Soil

Thirteen inorganic elements, 38 SVOCs, DRO, RRO, and PCBs were detected above background values in the surface soil samples. Table 7-1 provides a summary of the contaminants detected, detected concentration ranges, and applicable surface soil comparison criteria.

Inorganic elements were detected above background values in all general geographic areas of the site. Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. The highest concentrations of these inorganic elements were in the tailings and tailings/waste rock soil types in the Pre-1955 and Post-1955 portions of the Main Processing Area. While these inorganic elements were also detected at concentrations well above background levels in the Surface Mined Area, field observations indicate that tailings/waste rock is not present on the road surfaces in this area. Rather, the inorganic element concentrations are likely attributable to mineralized Kuskokwim-derived soils in this area. In general, the lowest concentrations and the least number of inorganic elements detected above background values were in the native soil types.

Organic compounds were detected above background values throughout the Pre-1955 and Post-1955 portions of the Main Processing Area. Nearly every sample where organic compounds were analyzed had positive detections. The extent of organic compound contamination in surface soil has not been fully delineated.

Table 7-1 Surface Soil Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Surface Soil Comparison Values	
			Value	Basis
Total Inorganic Elements				
Antimony	9 - 16700	mg/kg	3.6	18 AAC 75.340 Table B1 migration to groundwater
Arsenic	29 - 9880	mg/kg	3.9	18 AAC 75.340 Table B1 migration to groundwater
Barium	248 - 1710	mg/kg	1,100	18 AAC 75.340 Table B1 migration to groundwater
Beryllium	0.5 - 1.3	mg/kg	42	18 AAC 75.340 Table B1 migration to groundwater
Cadmium	0.5 - 1.3	mg/kg	5.0	18 AAC 75.340 Table B1 migration to groundwater
Chromium	29 - 101	mg/kg	25	18 AAC 75.340 Table B1 migration to groundwater
Cobalt	11.4 - 38.8	mg/kg	--	--
Copper	23.4 - 139	mg/kg	460	18 AAC 75.340 Table B1 migration to groundwater
Lead	11 - 3090	mg/kg	400	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
Manganese	817 - 4230	mg/kg	--	--
Mercury	1.46 - 1620	mg/kg	1.4	18 AAC 75.340 Table B1 migration to groundwater
Nickel	25 - 97	mg/kg	86	18 AAC 75.340 Table B1 migration to groundwater
Zinc	67 - 386	mg/kg	4,100	18 AAC 75.340 Table B1 migration to groundwater
Semi-Volatile Organic Compounds				
1-Methylnaphthalene	15 J - 74	µg/kg	6,200	18 AAC 75.340 Table B1 migration to groundwater
2-Methylnaphthalene	29 - 200	µg/kg	6,100	18 AAC 75.340 Table B1 migration to groundwater
4-Bromophenyl Phenyl Ether	1.9 J	µg/kg	--	--
4-Methylphenol	4.9 J	µg/kg	1,500	18 AAC 75.340 Table B1 migration to groundwater
Acenaphthene	2.3 J	µg/kg	180,000	18 AAC 75.340 Table B1 migration to groundwater
Acenaphthylene	1.3 J	µg/kg	180,000	18 AAC 75.340 Table B1 migration to groundwater
Anthracene	2 J	µg/kg	3,000,000	18 AAC 75.340 Table B1 migration to groundwater
Benzoic Acid	120 J	µg/kg	410,000	18 AAC 75.340 Table B1 migration to groundwater
Benzyl Alcohol	12 J	µg/kg	--	--
bis(2-Ethylhexyl)phthalate	11 J - 220	µg/kg	13,000	18 AAC 75.340 Table B1 migration to groundwater
Chrysene	16 J - 42	µg/kg	360,000	18 AAC 75.340 Table B1 migration to groundwater
Dibenzofuran	2.4 J - 10 J	µg/kg	11,000	18 AAC 75.340 Table B1 migration to groundwater
Diethyl Phthalate	8 - 140 B	µg/kg	130,000	18 AAC 75.340 Table B1 migration to groundwater

Table 7-1 Surface Soil Summary Comparison Table

Contaminants	Range of De-	Units	Surface Soil Comparison Values	
Dimethyl Phthalate	160	µg/kg	1,100,000	18 AAC 75.340 Table B1 migration to groundwater
Docosanoic acid	1300 J	µg/kg	--	--
Fluorene	2.5 J - 20	µg/kg	220,000	18 AAC 75.340 Table B1 migration to groundwater
Hexachlorobenzene	1.3 J	µg/kg	47	18 AAC 75.340 Table B1 migration to groundwater
Naphthalene	14 J - 70	µg/kg	20,000	18 AAC 75.340 Table B1 migration to groundwater
Pentachlorophenol	38 J	µg/kg	47	18 AAC 75.340 Table B1 migration to groundwater
Phenanthrene	4.2 J - 48	µg/kg	3,000,000	18 AAC 75.340 Table B1 migration to groundwater
Phenol	4.6 J	µg/kg	68,000	18 AAC 75.340 Table B1 migration to groundwater
Pyrene	2.8 J	µg/kg	1,000,000	18 AAC 75.340 Table B1 migration to groundwater
Sulfur	180 J - 1300 J	µg/kg	--	--
Unknown	140 J - 5300 J	µg/kg	--	--
Unknown Alkane	2000 J - 4000 J	µg/kg	--	--
Unknown Aromatic	79 J - 3100 J	µg/kg	--	--
Unknown Branched Alkane	1500 J	µg/kg	--	--
Unknown Hydrocarbon	96 J - 980 J	µg/kg	--	--
Unknown Organic Acid	87 J - 380 J	µg/kg	--	--
Unknown Sterol	78 J - 5000 J	µg/kg	--	--
Polychlorinated Biphenols				
Aroclor 1260	0.021 J	mg/kg	0.3	18 AAC 75.340 Table B1 migration to groundwater
Diesel and Residual Range Organics				
C10 - C25 DRO	39	mg/kg	250	18 AAC 75.340 Table B2 migration to groundwater
Diesel Range Hydrocarbons	7.1 J - 680 J	mg/kg	--	--
Motor Oil	13 - 7800	mg/kg	--	--
C25 - C36 RRO	420	mg/kg	10,800	18 AAC 75.340 Table B2 migration to groundwater

Key

▨	concentration exceeds comparison criteria
--	Criterion not available
RRO	residual range organics
µg/kg	micrograms per kilogram
DRO	diesel range organics
J	estimated quantity
mg/kg	milligrams per kilogram

Subsurface Soil

Seventeen inorganic elements, 47 SVOCs, DRO, and RRO were detected above background values in the subsurface soil samples. Table 7-2 provides a summary of the contaminants detected, detected concentration ranges, and applicable subsurface soil comparison criteria.

Inorganic elements were detected above background values in all general geographic areas of the site. Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. The highest concentrations of these inorganic elements were in the tailings and tailings/waste rock soil types in the Pre-1955 and Post-1955 portions of the Main Processing Area. In general, the lowest concentrations, and the least number of inorganic elements detected above background values were in the native Red Devil Creek alluvium and Kuskokwim River alluvium soil types.

Organic compounds were detected above background values throughout the Pre-1955 and Post-1955 portions of the Main Processing Area. Organic compounds were detected above background values at depths ranging from 4 to 26 feet bgs. Nearly every sample where organic compounds were analyzed had positive detections. The extent of organic compounds in subsurface soil has not been fully delineated.

Table 7-2 Subsurface Soil Summary Comparison

Contaminants	Range of Detected Concentrations	Units	Surface Soil Comparison Values	
			Value	Basis
Total Inorganic Elements				
Antimony	7.69 - 28900 J	mg/kg	3.6	18 AAC 75.340 Table B1 migration to groundwater
Arsenic	13.3 - 9530 J	mg/kg	3.9	18 AAC 75.340 Table B1 migration to groundwater
Barium	144 J - 1050 J	mg/kg	1,100	18 AAC 75.340 Table B1 migration to groundwater
Beryllium	0.486 - 0.981	mg/kg	42	18 AAC 75.340 Table B1 migration to groundwater
Cadmium	0.621 - 1.32 J	mg/kg	5.0	18 AAC 75.340 Table B1 migration to groundwater
Chromium	24.8 J - 59.6 J	mg/kg	25	18 AAC 75.340 Table B1 migration to groundwater
Cobalt	19.5 - 34.4	mg/kg	--	--
Copper	59.2 J - 139 J	mg/kg	460	18 AAC 75.340 Table B1 migration to groundwater
Lead	14.4 - 396	mg/kg	400	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
Manganese	1290 - 3510	mg/kg	--	--

Table 7-2 Subsurface Soil Summary Comparison

Contaminants	Range of Detected Concentra-	Units	Surface Soil Comparison Values	
Mercury	4.21 J - 6110 J	mg/kg	1.4	18 AAC 75.340 Table B1 migration to groundwater
Nickel	52.4 - 99.1 J	mg/kg	86	18 AAC 75.340 Table B1 migration to groundwater
Selenium	0.54 - 6.07	mg/kg	3.4	18 AAC 75.340 Table B1 migration to groundwater
Silver	0.091 - 0.554 J	mg/kg	11.2	18 AAC 75.340 Table B1 migration to groundwater
Thallium	0.104 - 1.54	mg/kg	1.9	18 AAC 75.340 Table B1 migration to groundwater
Vanadium	38.7 - 44.6 J	mg/kg	3400	18 AAC 75.340 Table B1 migration to groundwater
Zinc	107 - 461 J	mg/kg	4,100	18 AAC 75.340 Table B1 migration to groundwater
Low Level Mercury				
Mercury	306 - 2040000	ng/g	1400000	18 AAC 75.340 Table B1 migration to groundwater
Semi-Volatile Organic Compounds				
.beta.-Sitosterol	160	µg/kg	--	--
.gamma.-Sitosterol	72	µg/kg	--	--
2-Methylnaphthalene	12 - 12000	µg/kg	6100	18 AAC 75.340 Table B1 migration to groundwater
4-Chloroaniline	8	µg/kg	--	--
9-Octadecenamide, (Z)-	650 - 2600	µg/kg	--	--
Acenaphthene	66 - 410	µg/kg	180000	18 AAC 75.340 Table B1 migration to groundwater
Benzo(a)pyrene	9.4	µg/kg	490	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
Benzo(b)fluoranthene	1.3 - 7.2	µg/kg	4900	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
Benzo(g,h,i)perylene	10	µg/kg	1400000	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
Benzo(k)fluoranthene	3.7	µg/kg	49000	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
Benzyl Alcohol	11	µg/kg	--	--
Bis(2-ethylhexyl) Phthalate	10 - 310	µg/kg	13000	18 AAC 75.340 Table B1 migration to groundwater

Table 7-2 Subsurface Soil Summary Comparison

Contaminants	Range of Detected Concentra-	Units	Surface Soil Comparison Values	
Chrysene	2.9 - 4.4	µg/kg	360000	18 AAC 75.340 Table B1 migration to groundwater
Cyclopropane, 1-pentyl-2-propyl-	820	µg/kg	--	--
Decane, 4-methyl-	870	µg/kg	--	--
Dibenz(a,h)anthracene	7.8	µg/kg	--	--
Dibenzofuran	57 - 58	µg/kg	11000	18 AAC 75.340 Table B1 migration to groundwater
Diethyl Phthalate	1.7	µg/kg	130000	18 AAC 75.340 Table B1 migration to groundwater
Docosanoic acid	230	µg/kg	--	--
Dodecane	730	µg/kg	--	--
Dodecane, 2,6,11-trimethyl-	1100	µg/kg	--	--
Fluorene	1.7 - 1200	µg/kg	220000	18 AAC 75.340 Table B1 migration to groundwater
Heptadecane	3700 - 5700	µg/kg	--	--
Heptadecane, 2,6,10,15-tetramethyl-	1000	µg/kg	--	--
Heptadecane, 2,6-dimethyl-	3300	µg/kg	--	--
Heptylcyclohexane	3900	µg/kg	--	--
Hexadecane, 2,6,10,14-tetramethyl-	1700	µg/kg	--	--
Hexadecanoic acid, butyl ester	66 - 110	µg/kg	--	--
Indeno(1,2,3-cd)pyrene	11	µg/kg	--	--
Naphthalene	8.3 - 3500	µg/kg	20000	18 AAC 75.340 Table B1 migration to groundwater
N-Nitrosodiphenylamine	1.8	µg/kg	15000	18 AAC 75.340 Table B1 migration to groundwater
Nonadecane	1400	µg/kg	--	--
Octadecane	2400 - 11000	µg/kg	--	--
Octadecanoic acid, butyl ester	92	µg/kg	--	--
Octane, 3,6-dimethyl-	3100	µg/kg	--	--
Oleic Acid	130	µg/kg	--	--
Pentadecane, 2,6,10,14-tetramethyl	1300 - 56000	µg/kg	--	--
Pentadecane, 2,6,10-trimethyl-	6400	µg/kg	--	--
Phenanthrene	2.3 - 980	µg/kg	3000000	18 AAC 75.340 Table B1 migration to groundwater
Pyrene	1.7 - 1.8	µg/kg	1000000	18 AAC 75.340 Table B1 migration to groundwater

Table 7-2 Subsurface Soil Summary Comparison

Contaminants	Range of Detected Concentra-	Units	Surface Soil Comparison Values	
Tetradecane	1500 - 83000	µg/kg	--	--
Tricosane, 2-methyl-	60	µg/kg	--	--
Tridecane	60 - 73000	µg/kg	--	--
Undecane	1300 - 15000	µg/kg	--	--
Undecane, 2,6-dimethyl-	540 - 7900	µg/kg	--	--
Undecane, 2-methyl-	210	µg/kg	--	--
Unknown	68 - 16000	µg/kg	--	--
Unknown Alkane	76 - 100000	µg/kg	--	--
Unknown Branched Alkane	60 - 71000	µg/kg	--	--
Unknown Branched Alkene	2900	µg/kg	--	--
Unknown Branched Naphthalene	4600	µg/kg	--	--
Unknown branched undecane	1300	µg/kg	--	--
Unknown Carboxylic Acid	110	µg/kg	--	--
Unknown Cyclic Hydrocarbon	9100	µg/kg	--	--
Unknown Substituted Aromatic	230	µg/kg	--	--
Z-1,6-Undecadiene	1300	µg/kg	--	--
Diesel and Residual Range Organics				
C10 - C25 DRO	2.7 - 7300	mg/kg	6000	18 AAC 75.340 Table B1 Under 40 inch zone direct contact
C25 - C36 RRO	6.8 - 1400	mg/kg	7500	18 AAC 75.340 Table B1 Under 40 inch zone direct contact

Key

▨	concentration exceeds comparison criteria
--	Criterion not available
µg/kg	micrograms per kilograms
DRO	Diesel range organics
J	estimated quantity
mg/kg	milligrams per kilograms
ng/kg	nanograms per kilograms
RRO	Residual range organics

Groundwater

Seventeen inorganic elements (including both total and dissolved analyses), methylmercury, three SVOCs, DRO, gasoline range organics, and RRO were detected above background values in the Red Devil Mine groundwater samples. Table 7-3 provides a summary of the contaminants detected, detected concentration ranges, and applicable groundwater comparison criteria.

Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. Concentrations of total and dissolved antimony and arsenic are highest in the Post-1955 Main Processing Area. Elevated concentrations of total mercury do not display an obvious spatial trend. Concentrations of total antimony are below background values in areas upgradient from the Main Processing Area.

Methylmercury was detected above the background value at nine of the monitoring wells. All monitoring wells with concentrations of methylmercury above the background value were in the Main Processing Area. The extent of methylmercury contamination in groundwater appears to be confined to the Main Processing Area.

In 2010 and 2011, organic compounds were detected in almost all of the groundwater samples submitted for SVOCs, GRO, DRO, and RRO analyses. Only groundwater at monitoring well MW18 did not contain organic compounds analyzed. The extent of organic compounds in groundwater has not been fully delineated.

Table 7-3 Red Devil Mine Groundwater Summary

Contaminants	Range of Detected Concentrations	Units	Groundwater Comparison Values	
			Value	Basis
Total Inorganic Elements				
Aluminum	440 - 1460 J	µg/L	--	--
Antimony	1.8 - 13100	µg/L	6	Federal Drinking Water Maximum Contaminant Level
Arsenic	1.3 - 6650	µg/L	10	Federal Drinking Water Maximum Contaminant Level
Barium	41.5 - 365	µg/L	2000	Federal Drinking Water Maximum Contaminant Level
Beryllium	0.019 J - 0.11	µg/L	4	Federal Drinking Water Maximum Contaminant Level
Cadmium	0.018 J - 0.224	µg/L	5	Federal Drinking Water Maximum Contaminant Level
Chromium	6.29 - 10.6	µg/L	100	Federal Drinking Water Maximum Contaminant Level
Cobalt	0.333 - 40.5	µg/L	--	--
Copper	0.53 - 6.29	µg/L	1300	Federal Drinking Water Maximum Contaminant Level
Lead	0.339 - 2.02	µg/L	15	Federal Drinking Water Maximum Contaminant Level
Manganese	62.2 - 7370	µg/L	--	--
Nickel	4.01 - 35.9	µg/L	--	--
Selenium	0.5 J - 5.4	µg/L	50	Federal Drinking Water Maximum Contaminant Level
Silver	0.024 - 0.049 J	µg/L	--	--
Thallium	0.011 J - 0.075	µg/L	2	Federal Drinking Water Maximum Contaminant Level
Vanadium	0.55 - 3.88	µg/L	--	--
Zinc	1.4 - 22	µg/L	--	--
Total Low Level Mercury				
Mercury, Total	1.85 - 56500	ng/L	2000	Federal Drinking Water Maximum Contaminant Level

Table 7-3 Red Devil Mine Groundwater Summary

Contaminants	Range of Detected Concentrations	Units	Groundwater Comparison Values	
			Value	Basis
Dissolved Inorganic Elements				
Aluminum, Dissolved	140 - 140	µg/L	--	--
Antimony, Dissolved	1.64 - 13100	µg/L	6	Federal Drinking Water Maximum Contaminant Level
Arsenic, Dissolved	0.7 - 6660	µg/L	10	Federal Drinking Water Maximum Contaminant Level
Barium, Dissolved	38 - 348	µg/L	2000	Federal Drinking Water Maximum Contaminant Level
Beryllium, Dissolved	0.006 J - 0.041	µg/L	4	Federal Drinking Water Maximum Contaminant Level
Cadmium, Dissolved	0.011 J - 0.229	µg/L	5	Federal Drinking Water Maximum Contaminant Level
Chromium, Dissolved	1.8 - 2.81	µg/L	100	Federal Drinking Water Maximum Contaminant Level
Cobalt, Dissolved	0.037 - 41.5	µg/L	--	--
Copper, Dissolved	0.22 - 1.8	µg/L	1300	Federal Drinking Water Maximum Contaminant Level
Lead, Dissolved	0.009 J - 0.244	µg/L	15	Federal Drinking Water Maximum Contaminant Level
Manganese, Dissolved	0.606 - 7050	µg/L	--	--
Nickel, Dissolved	1.93 - 34.6	µg/L	--	--
Selenium, Dissolved	0.4 J - 4.9	µg/L	50	Federal Drinking Water Maximum Contaminant Level
Silver, Dissolved	0.004 J - 0.013 J	µg/L	--	--
Thallium, Dissolved	0.006 J - 0.059	µg/L	2	Federal Drinking Water Maximum Contaminant Level
Vanadium, Dissolved	0.06 J - 2.03	µg/L	--	--
Zinc, Dissolved	0.5 J - 20.7	µg/L	--	--
Dissolved Low Level Mercury				
Mercury, Dissolved	0.54 J - 2200	ng/L	2000	Federal Drinking Water Maximum Contaminant Level
Methly Mercury				
Methylmercury	0.2 J - 1.71	ng/L	--	--
Semi-Volatile Organic Compounds				
Toluene	0.09 J - 1.8	µg/L	1000	Federal Drinking Water Maximum Contaminant Level
Bis(2-ethylhexyl) Phthalate	5.7 J	µg/L	--	--
Unknown Hydrocarbon	2 J	µg/L	--	--
Gasoline, Diesel and Residual Range Organics				
Diesel Range Organics	14 J - 200 J	µg/L	--	--
Residual Range Organics	42 J - 620 J	µg/L	--	--

Key

▨	concentration exceeds comparison criteria
µg/L	micrograms per liter
J	estimated quantity
ng/L	nanograms per liter

Red Devil Creek Surface Water

Eighteen inorganic elements (including both total and dissolved analyses), methylmercury, and five SVOCs were detected above background values in the Red Devil Creek surface water samples. Table 7-4 provides a summary of the contaminants detected, detected concentration ranges, and applicable surface water comparison criteria.

Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. Total and dissolved concentrations of these three inorganic elements are generally below background values between the reservoir dam and the upper portion of the Main Processing Area. Starting at the upper end of the Main Processing Area, total and dissolved concentrations of antimony, arsenic, and mercury are significantly elevated above background down to the mouth of Red Devil Creek. Methylmercury was generally detected at all sample stations on Red Devil Creek (including near the reservoir dam) and is significantly elevated in the Main Processing Area, particularly at the seep location. All of the SVOCs in Red Devil Creek surface water were detected at concentrations very near their respective method detection limits. The extent of surface water contamination in Red Devil Creek surface water reaches from the reservoir dam area down to the mouth of Red Devil Creek.

Table 7-4 Surface Water Summary Comparison Table

Contaminants	Range of Detected Concentrations		Surface Water Chronic Water Quality Criteria for Aquatic Life	
		Units	Value	Basis
Total Inorganic Elements				
Antimony	1.3 - 184	µg/L	30	Suter and Tsao (1996), Tier II SCV
Arsenic	0.8 - 1030	µg/L	150	ADEC (2008b) and EPA(2008b)
Barium	21.2 - 103	µg/L	4	Suter and Tsao (1996), Tier II SCV
Beryllium	0.009 J	µg/L	0.66	Suter and Tsao (1996), Tier II SCV
Cadmium	0.005 J - 0.006 J	µg/L	0.25	ADEC (2008b) and EPA(2008b)
Chromium	0.15 J - 0.57	µg/L	74	ADEC (2008b) and USEPA(2008)
Cobalt	0.046 - 5.3	µg/L	23	Suter and Tsao (1996), Tier II SCV
Copper	0.28 - 0.71	µg/L	9	ADEC (2008b) and EPA(2008b)
Lead	0.012 J - 0.079	µg/L	2.5	ADEC (2008b) and EPA(2008b)
Manganese	11.8 - 379	µg/L	120	Suter and Tsao (1996), Tier II SCV

Table 7-4 Surface Water Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Surface Water Chronic Water Quality Criteria for Aquatic Life	
			Value	Basis
Nickel	0.36 - 19.2	µg/L	52	ADEC (2008b) and EPA(2008b)
Silver	0.008 J - 0.012 J	µg/L	3.2	ADEC (2008b) and EPA(2008b)
Thallium	0.007 J	µg/L	12	Suter and Tsao (1996), Tier II SCV
Zinc	0.3 J - 2.1	µg/L	118	ADEC (2008b)
Total Low Level Mercury				
Mercury, Total	2.33 - 385	ng/L	770	ADEC (2008b) and EPA(2008b)
Dissolved Inorganic Elements				
Aluminum, Dissolved	3.5 J - 19.7 J	µg/L	87	ADEC (2008b) and EPA(2008b)
Antimony, Dissolved	1.2 - 184	µg/L	30	Suter and Tsao (1996), Tier II SCV
Arsenic, Dissolved	0.8 - 857	µg/L	150	ADEC (2008b) and EPA(2008b)
Barium, Dissolved	20.7 - 99.5	µg/L	4	Suter and Tsao (1996), Tier II SCV
Beryllium, Dissolved	0.012 J	µg/L	0.66	Suter and Tsao (1996), Tier II SCV
Chromium, Dissolved	0.11 J - 0.39	µg/L	74	ADEC (2008b) and EPA(2008b)
Cobalt, Dissolved	0.042 - 4.9	µg/L	23	Suter and Tsao (1996), Tier II SCV
Copper, Dissolved	0.15 - 0.5	µg/L	9	ADEC (2008b) and EPA(2008b)
Lead, Dissolved	0.005 J - 0.037	µg/L	2.5	ADEC (2008b) and EPA(2008b)
Manganese, Dissolved	8.2 - 380	µg/L	120	Suter and Tsao (1996), Tier II SCV
Nickel, Dissolved	0.32 - 17	µg/L	52	ADEC (2008b) and EPA(2008b)
Selenium, Dissolved	0.3 J - 0.6 J	µg/L	5	ADEC (2008b) and EPA(2008b)
Silver, Dissolved	0.009 J	µg/L	3.2	ADEC (2008b) and EPA(2008b)
Vanadium, Dissolved	0.07 J - 0.14 J	µg/L	20	Suter and Tsao (1996), Tier II SCV
Zinc, Dissolved	0.3 J - 1	µg/L	118	ADEC (2008b)
Dissolved Low Level Mercury				
Mercury, Dissolved	1.92 - 16.4	ng/L	770	ADEC (2008b) and EPA(2008b)
Methylmercury				

Table 7-4 Surface Water Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Surface Water Chronic Water Quality Criteria for Aquatic Life	
			Value	Basis
Methylmercury	0.08 J - 0.62	ng/L	0.0028	Suter and Tsao (1996), Tier II SCV
Semi-Volatile Organic Compounds				
1-Methylnaphthalene	1.5	µg/L	--	--
2-Methylnaphthalene	1.2 J	µg/L	--	--
2-Methylnaphthalene	1.5	µg/L	--	--
Naphthalene	0.68 J	µg/L	12	Suter and Tsao (1996), Tier II SCV
Unknown Hydrocarbon	2 J - 3 J	µg/L	--	--

Key

▨	concentration exceeds comparison criteria
µg/L	micrograms per liter
J	estimated quantity
ng/L	nanograms per liter
SCV	secondary chronic value

Red Devil Creek Sediment

Thirteen inorganic elements, methylmercury, and 12 SVOCs were detected above background values in the Red Devil Creek sediment samples. Table 7-5 provides a summary of the contaminants detected, detected concentration ranges, and applicable sediment comparison criteria.

Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. These three inorganic elements are significantly elevated above background in the Main Processing Area down to the mouth of Red Devil Creek. The seep in the Main Processing Area is the location of several of the highest concentrations of inorganic elements detected in the Red Devil Creek drainage. Methylmercury was detected in nearly all the samples. All of the SVOCs in Red Devil Creek sediments were detected at concentrations very near their respective method detection limits. The extent of sediment contamination in Red Devil Creek sediment reaches from the reservoir dam area down to the mouth of Red Devil Creek.

Table 7-5 Red Devil Creek Sediment Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Sediment Screening Levels	
			Value	Basis
Total Inorganic Elements				
Antimony	1590 J - 4060 J	mg/kg	2.9	MacDonald et al. (1999). PAETA, WA
Arsenic	1890 - 130000	mg/kg	9.8	MacDonald et al. (2000). TEC.
Barium	278 - 1990	mg/kg	--	--
Beryllium	0.6 - 0.9	mg/kg	--	--
Cadmium	0.317 J	mg/kg	0.99	MacDonald et al. (2000). TEC.

Table 7-5 Red Devil Creek Sediment Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Sediment Screening Levels	
			Value	Basis
Chromium	25 - 47.4 J	mg/kg	43.4	MacDonald et al. (2000). TEC.
Cobalt	12.5 - 50	mg/kg	50	MacDonald et al. (1999). Criterion, Ontario.
Copper	23.4 - 58.2 J	mg/kg	31.6	MacDonald et al. (2000). TEC.
Lead	11 - 14	mg/kg	35.8	MacDonald et al. (2000). TEC.
Manganese	784 - 2610	mg/kg	460	MacDonald et al. (1999). LEL, B.C.
Mercury	0.232 J - 79 J	mg/kg	0.18	MacDonald et al. (2000). TEC.
Nickel	38 - 240	mg/kg	22.7	MacDonald et al. (2000). TEC.
Selenium	0.33 - 0.62	mg/kg	5	MacDonald et al. (1999). Criterion, B.C.
Thallium	0.043 - 0.297	mg/kg	--	--
Vanadium	37.9 - 39.3	mg/kg	--	--
Zinc	83 - 120	mg/kg	121	MacDonald et al. (2000). TEC.
Methylmercury				
Methylmercury	0.1 J - 7.02	ng/g	--	--
Semi-volatile Organic Compounds				
.gamma.-Sitosterol	230 J - 390 J	µg/kg	--	--
Benzo(b)fluoranthene	1.5 J	µg/kg	27	MacDonald et al (1999). TEL *Hyalella* 28-day test.
Benzoic Acid	220	µg/kg	--	--
Benzyl Alcohol	3.1 J	µg/kg	52	Buchman (2008). AET, marine bivalve.
Diethyl Phthalate	1.7 J	µg/kg	320	MacDonald et al. (1999). Chronic EqP threshold.
Di-n-butyl Phthalate	9 J	µg/kg	42	MacDonald et al. (1999). PAETA, *Hyalella*, WA.
Docosanoic acid	190 J - 710 J	µg/kg	--	--
Heptacosane	270 J	µg/kg	--	--
Pentachlorophenol (PCP)	22 J	µg/kg	40	MacDonald et al. (1999). Ecotoxicological value.
Phenanthrene	1.9 J - 2.1 J	µg/kg	204	MacDonald et al. (2000). TEC.
Phenol	4.1 J	µg/kg	48	MacDonald et al. (1999). PAETA, *Hyalella* , WA
Unknown	180 J - 700 J	µg/kg	--	--
Unknown Alkane	99 J	µg/kg	--	--
Unknown Alkene	240 J	µg/kg	--	--
Unknown Carboxylic Acid	130 J - 370 J	µg/kg	--	--

Key

▨	concentration exceeds comparison criteria
--	Criterion not available
µg/kg	micrograms per kilogram
B.C.	British Columbia, Canada
ERM	Effects range median
J	estimated quantity
mg/kg	milligrams per kilogram
ng/kg	nanograms per kilogram

Table 7-5 Red Devil Creek Sediment Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Sediment Screening Levels	
			Value	Basis

PAETA	Probable apparent effect threshold approach
TEC	Threshold effect concentration
WA	Washington State

Kuskokwim River Sediment

Seventeen inorganic elements and methylmercury were detected above background values in the Kuskokwim River sediment samples. Table 7-6 provides a summary of the contaminants detected, detected concentration ranges, and applicable sediment comparison criteria.

Of the inorganic elements detected, antimony, arsenic, and mercury concentrations were the most highly elevated above background values. Arsenic and methylmercury results display a concentration gradient in the sediment samples, with concentrations decreasing with distance downstream of the mouth of Red Devil Creek. The downstream extent of sediment contamination was not fully delineated during RI sampling in 2010 and 2011.

Table 7-6 Kuskokwim River Sediment Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Sediment Screening Levels	
			Value	Basis
Total Inorganic Elements				
Antimony	2.1 - 1420 J	mg/kg	2.9	MacDonald et al. (1999). PAETA, WA
Arsenic	17.5 J - 1790	mg/kg	9.8	MacDonald et al. (2000). TEC.
Barium	179 J - 398	mg/kg	--	--
Beryllium	0.501 - 0.8	mg/kg	--	--
Cadmium	0.657 - 0.663 J	mg/kg	0.99	MacDonald et al. (2000). TEC.
Chromium	27.7 J	mg/kg	43.4	MacDonald et al. (2000). TEC.
Cobalt	13.9 - 15.8	mg/kg	50	MacDonald et al. (1999). Criterion, Ontario.
Copper	37.2 J - 87.5 J	mg/kg	31.6	MacDonald et al. (2000). TEC.
Lead	14.1 - 14.8	mg/kg	35.8	MacDonald et al. (2000). TEC.
Manganese	1060 J - 5410	mg/kg	460	MacDonald et al. (1999). LEL, B.C.
Mercury	0.199 J - 119 J	mg/kg	0.18	MacDonald et al. (2000). TEC.
Nickel	48 - 65.1 J	mg/kg	22.7	MacDonald et al. (2000). TEC.
Selenium	0.87 - 2.11	mg/kg	5	MacDonald et al. (1999). Criterion, B.C.
Silver	0.141 - 0.41	mg/kg	3.9	MacDonald et al. (1999). PAETA, WA.

Table 7-6 Kuskokwim River Sediment Summary Comparison Table

Contaminants	Range of Detected Concentrations	Units	Sediment Screening Levels	
			Value	Basis
Thallium	0.12 - 0.653	mg/kg	--	--
Zinc	132 J	mg/kg	121	MacDonald et al. (2000). TEC.
Methylmercury				
Methylmercury	0.15 J - 2.64	ng/g	--	--
Key				
▨	concentration exceeds comparison criteria			
--	Criterion not available			
B.C.	British Columbia, Canada			
ERM	Effects range median			
J	estimated quantity			
mg/kg	milligrams per kilogram			
ng/kg	nanograms per kilogram			
PAETA	Probable apparent effect threshold approach			
TEC	Threshold effect concentration			
WA	Washington State			

Vegetation

Seventeen inorganic elements were detected above background values in the vegetation samples. Methylmercury was detected in one sample, a horsetail pond vegetation sample (11MP84PV).

Of the inorganic elements detected, antimony, arsenic, barium, mercury, and nickel concentrations were the most highly elevated above background values. The horsetail pond vegetation samples contained the highest concentrations of antimony, arsenic, and mercury. The fewest number of contaminants detected above background values were in the blueberry stems and leaves samples.

7.1.3 Fate and Transport of Contaminants

The occurrence of contaminants at the RDM is chiefly dependent on the distribution of mine waste materials, consisting of primarily of tailings, waste rock, and flotation tailings, and also including disturbed soils and sluiced overburden from the surface mined area. The present distribution of these materials is explained by historical mining and ore processing and subsequent modification by surface processes. Migration of contaminants associated with these materials is occurring, as described below.

Surface water has historically played a significant role in distributing tailings and waste rock to their present locations. Tailings/waste rock have historically been disposed of or eroded into Red Devil Creek. These materials have been deposited within and transported down the channel of Red Devil Creek to the Kuskokwim River, where these materials accumulated in a delta. Sluicing of overburden from the surface mined area by sluicing resulted in the Dolly and Rice Sluice deltas in the Kuskokwim River. These materials have migrated downriver to some extent in the Kuskokwim River. Materials that enter Red Devil Creek by erosion and mass wasting have been in the past, and presently are, subject to surface water transport downstream within Red Devil Creek. Materials deposited in the Red Devil Creek delta and sluice deltas may be subject to further erosion and transport.

Contaminants at Red Devil Mine presently are transported primarily by the groundwater and surface water pathways. Migration of contaminants to groundwater occurs principally via leaching from tailings, waste rock, and, to a lesser extent, flotation tailings and other soils. Leached contaminants enter groundwater directly where/when groundwater immerses these source materials, and by leaching and downward transport toward groundwater where groundwater level is beneath the source materials. Contaminants may also enter groundwater as a result of flow through the underground mine workings.

Tailings and waste rock are leachable and make up the primary source of contaminants to groundwater and surface water. Antimony and arsenic in these materials are relatively more leachable than mercury. This is supported by mercury SSE tests that indicate that most of the mercury in these materials is likely cinnabar, which is minimally soluble. Other materials at the site, including soils disturbed by surface mining activities and sediment, exhibited similar characteristics. Elemental mercury was observed locally in subsurface soils within the pre-1955 and post-1955 Main Processing Areas. Mercury concentrations in groundwater may be locally impacted as a result of this elemental mercury.

Methylmercury is present in surface water, groundwater, and sediment. Methylmercury concentrations in surface water are closely linked to sulfate concentrations, which were considerably higher in water at the seep than in Red Devil Creek. Sediment at the seep, consisting of yellowboy material, had methylmercury concentrations that also were high compared to Red Devil Creek sediment. The highest concentration of methylmercury detected in Kuskokwim River sediment samples was 2.64 ng/g. The rest of the river sediment samples contained methylmercury at concentrations of 1.45 ng/g or less.

In general, arsenate is the dominant arsenic species in all media at the RDM. The fraction of arsenate to total inorganic arsenic made up 80 percent or more of total inorganic arsenic in soil samples. Arsenate was the dominant arsenic species in all Red Devil Creek and Kuskokwim River sediment samples. The proportion of arsenate to total inorganic arsenic ranged from 72 to 90 percent in Red Devil Creek surface water samples. The seep sample, however, was dominated by arsenite. Arsenate made up 95 percent or more of total inorganic arsenic in all but one groundwater sample with total and dissolved arsenic concentrations greater than 37 µg/L.

7.1.4 Baseline Risk Assessment

This section will be presented upon completion of the human health and ecological risk assessments.

7.2 Conclusions

7.2.1 Key Study Questions

This section provides responses, based on the RI's findings, to the key RI study questions developed through the Work Plan DQO process..

Nature and Extent of Contamination

1. **What COPCs, in addition to those identified in previous investigations, exist at and near the site?**
   The COPCs identified at the site include inorganic elements, methylmercury, SVOCs, and petroleum hydrocarbons. While PCBs were detected in one sample, PCBs are not considered a major site contaminant. The detailed list of COPCs is provided in the media-specific summary tables presented in Section 7.1.2.

2. **Do COPC concentrations differ in areas where different ore processing operations were conducted?**
   Yes. The characteristics of tailings, including contaminant concentrations, leachability of metals, texture, and appearance, are different in the Pre-1955 portion of the Main Processing Area, the Post-1955 portion of the Main Processing Area, and the flotation tailings in the settling ponds.

3. **Are COPC reporting limits sufficient to characterize human health and ecological risks?**
   Yes. For surface soil, subsurface soil, and sediment samples, all detection limits were below risk-based screening criteria. For groundwater and surface water samples, detection limits for several analytes exceeded risk-based screening criteria by less than an order of magnitude. However, none of these analytes have been historically found at the site, and none were identified as COPCs in the human health or ecological risk assessments. Therefore, analytical detection limits are deemed sufficient to characterize risk at the site.

4. **Is mercury present in organic forms at the site?**
   Yes. Methylmercury was detected above background values in Red Devil Creek surface water and sediment, Kuskokwim River sediment, groundwater, and vegetation. See the summary tables in Section 7.1.2 for methylmercury concentration ranges in these media.

5. **What is the areal and vertical extent of tailings, flotation tailings, and waste rock?**
   Tailings and waste rock are comingled throughout the site at most locations and are mixed with native alluvium and soil in some areas, most importantly in the channel and delta of Red Devil Creek. The areal extent of tailings/waste rock generally includes the Main Processing

Area down to the mouth of Red Devil Creek. The maximum depth of tailing/waste rock encountered is approximately 24 feet bgs. The flotation tailings are mostly confined to the footprint of the settling ponds and extend to a maximum depth of approximately 8 feet bgs. Material that appears to be flotation tailings was encountered in a soil boring downgradient of Settling Pond #1.

6. **Are soils in the area of former surface exploration and mining a source of COPCs, and are metals in a mobile or bioavailable form?**
   Soils in the area of former surface exploration and mining contain contaminant concentrations above background values. Leaching tests indicate that these contaminants may be mobile. However, arsenic leachability appears to be lower than for tailings/waste rock and flotation tailings based on leach test results,Three samples collected in the area of former surface exploration and mining had arsenic bioavailability results ranging from 3.9 to 43 percent.

7. **Are roads at and to the site a source of COPCs?**
   Roads within the Main Processing Area are surfaced with tailings/waste rock that contains concentrations of inorganic elements above background values. XRF screening of roads outside the Main Processing Area, including the road along the Kuskokwim River, indicated elevated levels of arsenic, antimony, and mercury on the road surface and in soils down-slope of the road at most locations evaluated. Roads in the Surface Mined Area do not appear to be surfaced with tailings/waste rock, except in areas immediately adjacent to the Main Processing Area.

8. **Are the Dolly Sluice and possible Rice Sluice areas sources of COPCs?**
   Yes. Surface soils in the Dolly Sluice and the Rice Sluice contain concentrations of inorganic elements, particularly arsenic and mercury, above background values. Surface and subsurface soil at the Dolly Sluice and Rice Sluice deltas on the Kuskokwim River also contain inorganic element concentrations above background values, particularly antimony, arsenic, and mercury.

9. **What is the nature and extent of contamination in native subsurface soil?**
   Native subsurface soils have been impacted locally by contaminants related to past mining activities and tailings/waste rock disposal. Native soils in some areas of the site contain contaminant concentrations that are believed to be naturally elevated, particularly in the surface mined area.

10. **What is the nature and extent of contamination in groundwater?**
    Groundwater is impacted locally by inorganic contaminants associated with tailings/waste rock, flotation tailings, and organic contaminants associated with petroleum hydrocarbons. Groundwater is also likely impacted by contaminants associated with the underground mine workings. The extent of groundwater contamination includes the Main Processing Area, the Red Devil Creek downstream alluvial area, and the Surface Mined Area.

11. **What is the nature and extent of contamination in aquatic biota?**
    Benthic macroinvertebrate and slimy sculpin tissue samples, collected from Red Devil Creek by the BLM in 2010 and 2011, contained site-related inorganic elements and methylmercury. The ecological risk assessment presented in Section 6.2 summarizes these data and integrates them into estimates of ecological risk.

12. **What are the background concentrations of COPCs in native soils and in groundwater, surface water, sediment, and biota in areas undisturbed by mining activities?**
    Background values for inorganic elements were developed through application of the EPA's ProUCL software for all media and are presented in Section 4.1. Background samples were collected from locations outside of and upgradient of the areas recognized as potentially impacted by mining, ore processing, and waste disposal operations. It should be noted that, although the ore zones that were mined are discrete, localized ore bodies, natural mineralization in the RDM area occurs outside of those areas that were mined, including areas not considered for background evaluation due to their location within the area of potential mine-related impacts. At several such locations, undisturbed native soil that is apparently unaffected by mining impacts exhibits arsenic and mercury concentrations that are up to one or two orders of magnitude higher than the calculated background soil concentrations presented in Chapter 4. Therefore, the background levels presented Chapter 4, particularly soil background levels, are considered to be conservative, and likely underestimate actual background concentrations of inorganic elements associated with local bedrock mineralization.

13. **Are the previous locations of transformers a source of COPCs?**
    The locations where transformers were previously stored onsite were extensively researched through a review of historical photographs and previous waste removal and investigation reports. From this research, 16 soil samples were collected for PCB analysis. One sample (11MP82SS) had a positive detection of Aroclor1260 at a concentration of 0.021J mg/kg, which is less than the State of Alaska PCB soil cleanup level (18 AAC 75.340).

14. What physical and chemical characteristics can be used to define a difference between tailings, waste rock, and native soils at the site?

The following physical and chemical characteristics can be used to define the difference between tailings, waste rock and native soils: contaminant concentrations, metals leachability, and lithologic characteristics, particularly the presence or absence of key minerals or red porous rock/red oxidation rind. These characteristics were used in conjunction with other lines of evidence to define material differences, including historical and recent aerial and land-based photographs, historical and recent topography, historical geologic maps, and historical information on historical mining and ore processing activities to identify and delineate the extent of these materials.

Fate and Transport of Contamination

15. Is contaminated groundwater impacting Red Devil Creek or the Kuskokwim River?

Contaminated groundwater is impacting Red Devil Creek surface water through baseflow and the seep in the Main Processing Area. Groundwater that emerges at the seep and via baseflow in the vicinity of the seep has resulted in the formation of iron oxyhydroxide (yellowboy) which has impacted sediments in Red Devil Creek. The RI results do not provide sufficient evidence to attribute contaminants in Kuskokwim River sediments to groundwater.

16. Have tailings, flotation tailings, waste rock, and/or other site sources impacted sediments, surface water, and aquatic biota in Red Devil Creek?

Yes. Tailings and waste rock are present in the bed and delta of Red Devil Creek. Concentrations of inorganic elements associated with tailings and waste rock, particularly antimony, arsenic, and mercury, were detected above background values in Red Devil Creek surface water, sediment, and aquatic biota. See the summary tables in Section 7.1.2 for contaminant concentration ranges in Red Devil Creek surface water and sediment. Contaminant concentration data for aquatic biota are presented in Section 6.2.

17. Have tailings, flotation tailings, waste rock, and/or other site sources impacted sediments in the Kuskokwim River downriver of the mouth of Red Devil Creek?

Yes. Concentrations of inorganic elements associated with tailings and waste rock were detected above background values in Kuskokwim River sediments. See the summary table in Section 7.1.2 for contaminant concentration ranges in Kuskokwim River sediment.

18. **Have tailings, flotation tailings, waste rock, and/or other site sources impacted native subsurface soils at the site?**
    Yes. See response to question 9.

19. **Has elemental mercury, previously documented in subsurface soil near Monofill #2, mobilized and/or entered groundwater?**
    Groundwater sampled in monitoring well MW-10, immediately downgradient of Monofill #2, contained total mercury at a concentration above the background value. Elemental mercury was observed adhering to clay/silt in a subsurface interval in the MW-10 soil boring However, RI information does not indicate whether the mercury detected in monitoring well MW-10 is attributable to this elemental mercury or leaching from tailings/waste rock.

20. **What is the leaching potential of COPCs in tailings and flotation tailings at the site?**
    Tailings/waste rock and flotation tailings exhibit varying degrees of metals leachability, based on the SPLP and TCLP leaching methods. Metals leaching potential is further evidenced by groundwater impacts that are attributable to leaching from tailings/waste rock and flotation tailings.

21. **What is the fraction of mercury in tailings, flotation tailings, waste rock, and contaminated soil that is available to chemically mobilize?**
    Mercury in waste materials exhibited varying degrees of susceptibility to mobilization. At locations where total mercury was at the highest concentrations, the dominant mercury form is likely cinnabar, which is minimally leachable in water.

22. **Are COPCs in waste rock and impacted soils leachable?**
    Yes. These materials exhibit varying degrees of metals leachability potential. See response to question 20.

23. **What is the fraction of arsenic in soil, sediment, surface water, and groundwater that is bioavailable to humans?**
    The fraction of arsenic in soil that is bioavailable to humans ranges from 2.7 to 68.1 percent at the site and appears to be highly dependent on soil type. The bioavailability of arsenic is discussed in the Uncertainties section of the Human Health Risk Assessment in Section 6.1. The bioavailability of arsenic in sediment, surface water, and groundwater was not measured in RI samples.

24. **Are the underground mine workings influencing the nature, extent, and migration of COPCs in groundwater and surface water?**
    Probably. The exact manner in which the mine workings influence groundwater flow paths, and consequently groundwater and surface water contaminant levels and migration, is not known.

25. **Have site-related contaminants impacted onsite vegetation or wildlife?**
    Site-related contaminants, including inorganic elements and methylmercury, were detected above background values in on-site vegetation. RI field investigations did not include direct measurement of contaminants in tissues of wildlife; therefore, this study question remains unanswered.

Human Health and Ecological Risk

26. **What risks to human health under future residential, subsistence user, and industrial land use scenarios are posed by COPCs at and near the site?**
    This response will be presented upon completion of the human health risk assessment.

27. **What risks to ecological receptors at various trophic levels are posed by COPCs at and near the site?**
    This response will be presented upon completion of the ecological risk assessment.

7.2.2 Preliminary Remedial Action Objectives

This section will be presented upon completion of the human health and ecological risk assessments.