6.0 Summary of Human Health and Ecological Risk

6.1 Human Health Risk Assessment

A BLRA was previously prepared for the Durango site (DOE 1995a). Most of the methodology used in that risk assessment followed standard EPA risk assessment protocol (EPA 1989a), though the BLRA did not calculate potential risks for noncarcinogenic constituents. Instead, calculated exposure intakes were compared with a range of contaminant doses associated with various adverse effects. Risks for the former mill tailings and raffinate ponds areas were calculated separately. Data used in that report were collected primarily from 1990 to 1994, although ground water data for the site have been collected since 1982. Since the BLRA was developed, additional data have been collected to more completely characterize the site and to represent more recent site conditions. Updated and revised toxicological data are also available for some site-related constituents. These new data were used to reevaluate COPC identification and assessment of associated risks.

6.1.1 Summary of 1995 BLRA Methodology and Results

The 1995 BLRA identified 23 constituents at the mill tailings area present at levels statistically above background concentrations. This initial list was screened to first eliminate constituents with concentrations within nutritional ranges and then to eliminate contaminants of low toxicity and high dietary ranges. These two steps eliminated four and nine constituents, respectively, resulting in the following COPC list: antimony, cadmium, lead, manganese, molybdenum, selenium, sodium, sulfate, uranium, and vanadium. These contaminants were retained for further risk analysis.

The BLRA identified 28 constituents at the raffinate ponds area at levels statistically above background. After screening to eliminate constituents with low toxicity and high dietary ranges the following COPCs were identified: antimony, arsenic, cadmium, chloride, lead, manganese, molybdenum, selenium, sodium, sulfate, thallium, and uranium.

A number of potential routes of exposure were evaluated: ingestion of ground water as drinking water in a residential setting, dermal contact with ground water while bathing, ingestion of meat and milk from ground-water-fed livestock, ingestion of produce irrigated with contaminated ground water, and ingestion of fish from the Animas River. Results of the exposure assessment indicated intakes for all constituents were negligible from exposure routes other than ingestion of drinking water. Therefore, only exposure through ingestion of ground water as drinking water was retained for more detailed evaluation. Both children and adults were considered as likely receptors.

Calculated exposure intakes were presented along with contaminant intakes associated with a range of adverse health effects. Potential risks associated with exposure to noncarcinogenic constituents were discussed qualitatively or by comparing estimated daily intake values to the acceptable intake levels recommended; carcinogenic risks were quantified and compared to EPA's acceptable risk range of 1×10^{-4} to 1×10^{-6}.

For sulfate, the most sensitive receptor population is infants. Results of the BLRA showed that infants exposed to the levels of sulfate in ground water at the Durango site could experience significant adverse health effects due to diarrhea and dehydration. This risk was estimated to be

more at the raffinate ponds area where almost the entire exposure distribution for sulfate is within the range for severe diarrhea and resulting dehydration.

Exposure intakes for the other noncarcinogenic contaminants in ground water were calculated for the receptors with the highest intake to body weight ratio—children between the ages of 1 and 10. Manganese exposure from ground water consumption may result in the highest unacceptable noncarcinogenic risks. The entire distributions are above the threshold level of mild neurological symptoms and above the EPA acceptable intake levels (reference doses or RfDs) for both the mill tailings and raffinate ponds areas. The RfDs are generally established at levels below known toxicity values to account for uncertainty in toxicity studies and data.

In 1995 other noncarcinogenic contaminants that may result in unacceptable risk included molybdenum, cadmium, selenium, vanadium, and uranium. About 40 percent of the molybdenum intake distribution from contaminated ground water at the mill area was above the acceptable intake level; the estimated exposures at the raffinate ponds area were twice the oral RfD, if ground water were ingested for long periods of time. Cadmium levels at both the mill tailings and raffinate ponds areas might have resulted in mild kidney toxicity. For both areas of concern, selenium likely exceeded the oral RfD; the raffinate ponds area likely had the highest risks. Vanadium was mostly a concern for the mill tailings area; most of the exposure range exceeded the oral RfD. Uranium was of concern for both the mill tailings and raffinate ponds areas. Arsenic, uranium, and antimony concentrations exceeded EPA's acceptable intake levels (RfDs), but were below levels demonstrated to result in adverse health effects. Sodium and selenium concentrations were also typically below the dietary intake range. The original BLRA (DOE 1995a) provides detailed information on toxicity studies and effects.

Carcinogenic risks were calculated for adult exposure. Carcinogenic risks from exposure to uranium and its daughter products exceeded the upper bound of EPA's acceptable risk range of 1×10^{-4} by approximately 1 order of magnitude in the mill tailings area. Risks from uranium at the raffinate ponds area fell within EPA's acceptable range; however, risks from arsenic were greater than the upper bound of acceptable range (4×10^{-3}).

6.1.2 BLRA Update

The original BLRA considered several potential routes of exposure to contaminants and eliminated all but one, ingestion of ground water in a residential setting, as insignificant. Overall concentrations have declined for all COPCs since the BLRA was completed. Therefore, for this BLRA update, it is assumed that any pathway considered insignificant based on the original BLRA is still insignificant; risks will not be recalculated for those pathways. Though not considered a likely scenario, risks are recalculated assuming drinking water in a residential scenario using more recent monitoring data.

Risk calculations presented here follow EPA's *Risk Assessment Guidance for Superfund* (EPA 1989a), which involves determining a point estimate for excess cancer risk from current or potential carcinogenic exposures (risk is equal to lifetime intake times cancer slope factor) and a hazard quotient (HQ) for noncarcinogenic exposures (HQ is equal to exposure intake divided by reference dose). EPA's acceptable carcinogenic risk range is 1×10^{-6} to 1×10^{-4}, which is an excess cancer risk of 1 in 1,000,000 to 1 in 10,000 compared to the general population. Risks exceeding this range are potentially unacceptable. For noncarcinogenic exposures, an HQ exceeding 1 is potentially unacceptable. HQs from multiple contaminants and/or pathways are

often summed to estimate cumulative noncarcinogenic risks; these summed HQs are referred to as a hazard index (HI). An HI greater than 1 also represents potentially unacceptable exposures. Therefore, it is possible for a number of individual contaminants to each have "acceptable" HQs of less than 1, but, when summed, represent a potentially unacceptable cumulative risk. Figure 6–1 provides exposure intake equations and default assumptions used in intake calculations for this BLRA update.

Note that toxicological values used to estimate risks (reference doses and slope factors) are conservative values with uncertainty factors built in to be protective of sensitive populations.

Equations used in calculations

Chemicals: Ingestion from water: Intake (mg/kg-day) = (Cw x IRw x EF x ED)/(BW x AT)

Radionuclides: Ingestion from water: Intake(lifetime in picocuries) = Cw x IRw x EF x ED

Residential Exposure Scenario—Ground Water Ingestion

Where

Cw = contaminant concentration in water, mg/L

IRw = ingestion rate for water (2 liters per day default for adults; 1.5 liters per day children 6-12 years; 0.64 liter per day for infants)

EF = exposure frequency (350 days per year)

ED = exposure duration (30 years for adults, 7 years for children and 1 year for infants for noncarcinogens; 30 years for carcinogens)

BW = body weight (70 kilograms for adults; 38.3 kilograms for children; 4 kilograms for infants)

AT = averaging time (365 days x ED for noncarcinogens; 365 days x 70 years for carcinogens)

Figure 6–1. Exposure Intake and Risk Equations with Default Assumptions

Therefore, risks presented here are reasonable worst-case estimates and are quite likely much higher than those that actually exist.

In this update, which uses point-exposure doses, single values are used for each parameter required in the risk calculations. Calculations to determine contaminant intakes use standard exposure factors (EPA 1989b). The ground water data used to assess risks in this document are from the two rounds of sampling at the site, conducted in June and August 2001. These data were used to give an up-to-date look at the site. Risk calculations performed for ground water use the 95 percent upper confidence level (UCL_{95}) on the mean concentrations to provide reasonable worst-case risk estimates for probable future ground water uses.

The same methodology was used to calculate carcinogenic risks for this BLRA update as was used in the original BLRA (i.e., receptors are adults with exposure averaged over 70 years). For all risk calculations, benchmarks for acceptable contaminant intakes (e.g., reference doses and slope factors) are best available data from standard EPA sources (e.g., Integrated Risk Information System, Region III Risk-Based Concentration Table).

This BLRA update uses the COPC list from the original BLRA as a starting point to evaluate current data for ground water. The constituents listed in the original BLRA for the mill tailings and raffinate ponds areas are listed in Section 6.1.1.

Table 6–1 and Table 6–2 summarize background, current plume, and historical plume data for each COPC in the alluvial ground water associated with the mill tailings area and the raffinate ponds area, respectively. Also included for comparison are the applicable UMTRA ground water standards (if available) and risk-based concentrations (RBCs). The RBC for a given contaminant represents a concentration in drinking water that would be protective of human health provided that

- The residential exposure scenario is appropriate,
- Ingestion of contaminated drinking water is the only exposure pathway,
- The contaminant contributes nearly all the health risk, and
- EPA's risk level of 1×10^{-6} for carcinogens and an HQ of 1 for noncarcinogens is appropriate.

If any of these assumptions is *not* true, contaminant levels at or below RBCs cannot automatically be assumed to be protective. For example, if multiple contaminants are present in drinking water, a single contaminant may be below its RBC but still be a significant contributor to the total risk posed by drinking the water. However, if an RBC is exceeded, it is an indication further evaluation of the contaminant is warranted. RBCs are intended for use in screening-level evaluations.

No standards or benchmarks have been established for sodium based on human-health concerns. The secondary standard of 250 mg/L for sulfate is based on considerations of taste and odor and not on effects to human health. Because of the lack of toxicity data, potential risks from exposure to these two contaminants cannot be quantified. Exposure intakes are calculated for these constituents, but potential adverse effects are considered only qualitatively.

For the residential ground water pathway evaluated quantitatively in this BLRA update, both children and adults were evaluated as receptors. Children would be more sensitive receptors than adults due to higher intake to body weight ratios. Infants were also evaluated for exposure to sulfate in residential scenarios because they represent the most sensitive receptor population. Carcinogenic risks were calculated only for adults based on the much longer exposure duration and because risks are averaged over a lifetime.

Table 6–1. Durango Mill Tailings Area Alluvial Ground Water Data Summary

Contaminant	FOD[1]	Minimum (mg/L)	Maximum (mg/L)	Mean (mg/L)	UCL_{95} (mg/L)	UMTRA std (mg/L)	RBC (mg/L)
Antimony							0.015N
Background[2]	2/8	< 0.0003	0.0008	< 0.00065			
Current plume[3]	18/18	< 0.0002	0.0008	< 0.0005	0.000665		
Historic Plume[4]	2/8	< 0.003	0.022	< 0.007			
Cadmium						0.01	
Background	2/8	< 0.0003	0.00071	< 0.00046			
Current plume	10/18	< 0.0004	0.037	< 0.0045	0.00863		
Historic Plume	7/14	< 0.001	0.070	< 0.032			
Lead						0.05	
Background	7/8	< 0.0001	0.00081	< 0.0006			
Current plume	13/18	< 0.0001	0.0023	< 0.0006	0.000879		
Historic Plume	1/14	< 0.003	< 0.01	< 0.02			
Manganese							1.7N[7]
Background	8/8	0.126	1.05	0.654			
Current plume	18/18	0.0032	4.31	0.790	1.35		
Historic Plume	12/4	< 0.01	6.7	< 3.2			
Molybdenum						0.1	
Background	0/8	< 0.0003	< 0.0003	< 0.0003			
Current plume	14/18	< 0.003	0.116	0.0150	0.0304		
Historic Plume	9/14	< 0.01	0.21	< 0.10			
Selenium						0.01	0.05[8]
Background	4/8	< 0.0003	0.0148	< 0.057			
Current plume	10/18	< 0.0003	0.123	< 0.0189	0.0336		
Historic Plume	12/14	0.007	0.16	0.065			
Sodium							
Background	8/8	36.8	477	< 223			
Current plume	18/18	129	645	345	427		
Historic Plume	14/14	231	1,200	696			
Sulfate						250[7]	
Background	8/8	122	2,190	1,276			
Current plume	17/17	656	3,510	1,785	2,062		
Historic Plume	12/12	1,540	3,110	2,635			
Uranium						0.044	
Background	8/8	0.00057	0.0286	0.0079			
Current plume	18/18	0.00065	1.97	0.413	0.681		
Historic Plume	13/14	0.12	3.8	1.4			
Vanadium							0.33N
Background	1/8	< 0.0003	0.002	< 0.0005			
Current plume	10/18	< 0.0003	0.324	< 0.0401	0.0856		
Historic Plume	8/14	< 0.01	0.53	< 0.41			

Background wells: 0629, 0857, 0866
Current plume wells: 0612, 0617, 0630, 0631, 0633, 0634, 0635, 0859, and 0863.
[1]Frequency of detection
[2]Current background data collected 6/2001 and 8/2001.
[3]Current plume data collected 6/2001 and 8/2001
[4]Historical data collected 1989 through 1994; wells 0612 and 0617 (DOE 1995a)
[5]N= noncarcingenic risks
[6]C= carcinogenic risks
[7] Secondary drinking water standard
[8]Safe Drinking Water Act Standard

Table 6–2. Durango Raffinate Ponds Area Alluvial Ground Water Data Summary

Contaminant	FOD[1]	Minimum (mg/L)	Maximum (mg/L)	Mean (mg/L)	UCL_{95} (mg/L)	UMTRA std (mg/L)	RBC (mg/L)
Antimony							0.015N
Background[2]	4/13	< 0.0002	0.0008	< 0.000613			
Current plume[3]	21/40	< 0.0002	0.002	< 0.000652	0.000756		
Historic Plume[4]	1/4	< 0.003	0.166	< 0.025			
Arsenic						0.05	0.011N[5]
Background	3/13	< 0.0005	0.0029	< 0.000585			0.000045C[6]
Current plume	3/40	<0.0005	0.00098	< 0.000531	0.000566		
Historic Plume	1/17	< 0.005	0.04	< 0.01			
Cadmium						0.01	
Background	5/13	< 0.0004	0.0011	< 0.000544			
Current plume	25/40	< 0.0004	0.0041	< 0.000873	0.00112		
Historic Plume	3/17	< 0.0001	0.0009	NA			
Chloride							
Background	13/13	22.2	82.8	52.4			
Current plume	40/40	41.2	1,240	486	561		
Historic Plume	15/15	1,100	2,400	2,000			
Lead						0.05	
Background	5/13	< 0.0001	0.0017	< 0.000288			
Current plume	14/40	< 0.0001	0.0075	< 0.000553	0.000965		
Historic Plume	2/17	< 0.002	0.070	< 0.021			
Manganese							1.7N
Background	13/13	0.00037	0.464	0.181			
Current plume	38/40	< 0.0001	6.94	1.04	1.62		
Historic Plume	4/4	4.7	7.3	6.6			
Molybdenum						0.1	
Background	2/13	< 0.003	0.0054	< 0.00327			
Current plume	1/40	< 0.003	0.0042	< 0.00303	0.00309		
Historic Plume	3/17	< 0.01	0.10	< 0.01			
Selenium						0.01	0.05[8]
Background	7/13	< 0.0003	0.087	< 0.0136			
Current plume	21/40	< 0.0003	19.4	< 1.10	2.17		
Historic Plume	4/17	< 0.005	0.08	< 0.05			
Sodium							
Background	13/13	214	722	342			
Current plume	40/40	135	3,140	1,520	1,750		
Historic Plume	4/4	3,500	4,600	4,200			
Sulfate						250[7]	
Background	13/13	1.92	1,660	760			
Current plume	40/40	580	8,240	3,740	4,320		
Historic Plume	9/9	7,310	10,000	8,600			
Thallium							
Background	5/13	< 0.0001	0.0002	< 0.00013			
Current plume	20/40	< 0.0001	0.00025	< 0.000142	0.000156		
Historic Plume	2/5	< 0.005	0.06	< 0.025			
Uranium						0.044	
Background	13/13	0.00014	0.0056	< 0.00211			
Current plume	37/40	0.0001	0.309	< 0.0488	0.0747		
Historic Plume	2/2	0.22	0.35	0.29			

Background wells: 0592, 0599, 0875, 0886, 0903.
Current plume wells: 0597, 0881, 0889, 0596, 0892, 0880, 0887, 0888, 0628, 0902, 0598, 0593, 0882, 0879, 0876, 0878, 0890, 0884, 0594, and 0607.
[1]Frequency of detection.
[2]Current background data collected 6/2001 and 8/2001.
[3]Current plume data collected 6/2001 and 8/2001.
[4]Historical data collected 1989 through 1994; wells 0593, 0602, or 0598 (DOE 1995a).
[5]N= noncarcinogenic risks.
[6]C= carcinogenic risks.
[7] Secondary drinking water standard.
[8]Safe Drinking Water Act
NA = not available

6.1.3 Results

6.1.3.1 Ground Water—Residential: Mill Tailings Area

Results of calculations for ingestion of ground water through residential use are provided in Table 6–3. Noncarcinogenic risks were calculated for both children and adults; risks are slightly higher for children because of their lower body weights. The greatest risks for both children and adults are from exposure to uranium and manganese. The HQ for these contaminants is greater than 1 under the ground water ingestion by children scenario and accounts for about 85 percent of the total risks. Cadmium contributes about 6 percent of the total risk and exceeds the UMTRA standard at one location. The contribution from other contaminants that can be quantified (antimony, molybdenum, selenium, and vanadium) is less than 9 percent. The mean concentration of selenium exceeds the UMTRA standard by nearly a factor of 2 and should be retained as a COPC. From a risk perspective, antimony, molybdenum, and vanadium could probably be eliminated as COPCs, though molybdenum slightly exceeds the UMTRA standards at one location. Carcinogenic risk for uranium exceeds the high end of EPA's acceptable risk range of 1×10^{-4} by a factor of more than 5.

Sodium, sulfate, and lead could not be evaluated quantitatively due to lack of toxicity data. A recent survey by EPA (1999) indicated no adverse affects resulted from exposures to sulfate of 500 mg/L or less in drinking water in any study conducted. Some studies of adult populations showed negligible effects were associated with concentrations up to 1,200 mg/L. Infants are the receptors most sensitive to sulfate exposure. It is likely that sulfate levels present at the mill tailings area (up to 3,510 mg/L) would result in diarrhea and dehydration if ingested by infants on a regular basis.

Intakes of sodium based on concentrations at the mill tailings area are well within typical dietary ranges. The National Research Council recommends that most healthy adults consume at least 500 mg/day and sodium intake be limited to 2,400 mg/day. A Food and Drug Administration publication, *Scouting for Sodium and Other Nutrients Important to Blood Pressure* (FDA 1995) indicates that most adults tend to eat between 4,000 and 6,000 mg of sodium per day. Therefore, levels associated with the mill tailings area, even with a residential scenario, would not be expected to result in significant adverse affects. The level of sodium ingested by children would be less than 700 mg/day and for adults would be less than 900 mg/day.

Considerable information on the health effects of lead has been gathered through decades of medical research and epidemiologic evaluations. More recent evidence indicates negative effects of lead exposure, particularly concerning children's neurobehavioral development, may occur at blood levels so low that a threshold may not exist (EPA 2001).

6.1.3.2 Ground Water—Residential: Raffinate Ponds Area

The plume at the raffinate ponds area was defined by the wells in which at least one of several key constituents exceeded the maximum concentration in background wells (Table 6–4). Based on this plume, estimated risks for ingestion of ground water at the raffinate area were calculated and are listed in Table 6–5. The greatest noncarcinogenic risks occur from selenium, which accounts for approximately 87 percent of the total risk. Other important

Table 6–3. Intake/Risk Calculation Spreadsheet (ground water ingestion pathway)

Durango Mill Tailings Area- Residential Exposure

Noncarcinogens—Ground Water Ingestion Only (children)

Contaminant	Cw[a]	Irw	EF	ED	BW	AT	Intake	RfD[b]	HQ
Antimony	0.000665	1.5	350	7	38.3	2555	0.00002	0.0004	0.062
Cadmium	0.0086	1.5	350	7	38.3	2555	0.00032	0.0005	0.646
Lead	0.000879	1.5	350	7	38.3	2555	0.00003	NA	NA
Manganese	1.35	1.5	350	7	38.3	2555	0.05070	0.047	1.079
Molybdenum	0.0304	1.5	350	7	38.3	2555	0.00114	0.005	0.228
Selenium	0.0336	1.5	350	7	38.3	2555	0.00126	0.005	0.252
Sodium	427	1.5	350	7	38.3	2555	16.03598	NA	NA
Sulfate	2062	1.5	350	7	38.3	2555	77.43839	NA	NA
infants	2062	0.64	350	1	4	365	316.36164	NA	NA
Uranium	0.681	1.5	350	7	38.3	2555	0.02557	0.003	8.525
Vanadium	0.0856	1.5	350	7	38.3	2555	0.00321	0.007	0.459
								HI=	11.252

Noncarcinogens—Ground Water Ingestion Only (adults)

Contaminant	Cw	Irw	EF	ED	BW	AT	Intake	RfD[b]	HQ
Antimony	0.000665	2	350	30	70	10950	0.00002	0.0004	0.046
Cadmium	0.0086	2	350	30	70	10950	0.00024	0.0005	0.471
Lead	0.000879	2	350	30	70	10950	0.00002	NA	NA
Manganese	1.35	2	350	30	70	10950	0.03699	0.047	0.787
Molybdenum	0.0304	2	350	30	70	10950	0.00083	0.005	0.167
Selenium	0.0336	2	350	30	70	10950	0.00092	0.005	0.184
Sodium	427	2	350	30	70	10950	11.69863	NA	NA
Sulfate	2062	2	350	30	70	10950	56.49315	NA	NA
Uranium	0.681	2	350	30	70	10950	0.01866	0.003	6.219
Vanadium	0.0856	2	350	30	70	10950	0.00235	0.007	0.335
								HI =	7.737

Carcinogens—Ground Water Ingestion Only (adults)

Contaminant	Cw	Irw	EF	ED	BW	AT	Intake	SF	Risk
U-234+238[b]	467	2	350	30	na	na	9.81E+06	5.32E-11	5.22E-04
								Total risk	5.22E-04

[a]Water concentrations used are UCL_{95}
[b]Assumes equilibrium; 1 mg = 686 pCi; slope factor is average of U-234 and U-238
NA - Not available
na - Not applicable

Table 6–4. Raffinate Ponds Area Wells Included as Part of the Plume for the Risk Evaluation

Exceeds Maximum Background Concentration[a]					
Well No.	**Sulfate**	**Manganese**	**Cadmium**	**Selenium**	**Uranium**
0597	✔				
0881	✔				
0889	✔				
0596	✔				✔
0892	✔	✔			✔
0880	✔	✔		✔	✔
0887	✔				
0888	✔				
0628	✔			✔	✔
0902	✔				
0598	✔	✔			✔
0593	✔	✔			
0882	✔	✔			
0879	✔	✔	✔	✔	✔
0876	✔				
0878	✔				
0890	✔				
0884	✔		✔	✔	
0594					✔
0607				✔	

[a]Background wells are defined as wells 0903, 0875, 0592, 0599, and 0886. Maximum concentrations (mg/L) in these wells in August 2001 were as follows: sulfate 1,660; manganese 0.464; cadmium 0.001; selenium 0.087; and uranium 0.0056.

contributors to the quantifiable risks are manganese and uranium; these two contaminants and selenium account for nearly 99 percent of the noncarcinogenic risks. Noncarcinogenic risks from antimony, arsenic, cadmium, and molybdenum contribute less than 2 percent of the total risk, and these compounds should be eliminated as noncarcinogenic COPCs. Although risks from thallium could not be quantified, recent plume data indicate concentrations are indistinguishable from background. Mean concentrations have dropped by over two orders of magnitude from the historical plume data, in large part because of a significant improvement in the detection limit. Because thallium concentrations in the plume are similar to or less than background concentrations, thallium should be eliminated as a COPC.

Other noncarcinogenic COPCs that could not be quantified should be retained since their concentrations are all elevated above background and may result in negative health impacts. Of these compounds, sulfate is of particular concern because it is found at levels known to result in diarrhea and dehydration if ingested on a regular basis.

Two carcinogenic COPCs were identified: uranium and arsenic. Uranium risks are at the upper end of EPA's acceptable risk range and should be retained as a COPC. Although arsenic concentrations are also within the risk range, the risk is caused by the high toxicity coupled with the higher detection limit for arsenic (i.e., concentrations of arsenic at the detection limit result in carcinogenic risks within the risk range). In addition, arsenic concentrations in background wells are greater than those in the plume wells. Concentrations in the plume have decreased by over two orders of magnitude since the data for the original BLRA were gathered. For these reasons, arsenic should be eliminated as a COPC.

Table 6–5. Intake/Risk Calculation Spreadsheet (ground water ingestion pathway)

Durango Raffinate Ponds Area—Residential Exposure									
Noncarcinogens—Ground Water Ingestion Only (children)									
Contaminant	**Cw[a]**	**Irw**	**EF**	**ED**	**BW**	**AT**	**Intake**	**RfD[b]**	**HQ**
Antimony	0.000756	1.5	350	7	38.3	2555	0.00003	0.0004	0.071
Arsenic	0.00056	1.5	350	7	38.3	2555	0.00002	0.0003	0.070
Cadmium	0.00112	1.5	350	7	38.3	2555	0.00004	0.0005	0.084
Chloride	561	1.5	350	7	38.3	2555	21.06835	NA	NA
Lead	0.000965	1.5	350	7	38.3	2555	0.00004	NA	NA
Manganese	1.62	1.5	350	7	38.3	2555	0.06084	0.047	1.294
Molybdenum	0.00309	1.5	350	7	38.3	2555	0.00012	0.005	0.023
Selenium	2.17	1.5	350	7	38.3	2555	0.08149	0.005	16.299
Sodium	1750	1.5	350	7	38.3	2555	65.72123	NA	NA
Sulfate	4320	1.5	350	7	38.3	2555	162.23756	NA	NA
Infants	4320	0.64	350	1	4	365	662.79452	NA	NA
Thallium	0.000156	1.5	350	7	38.3	2555	0.00001	NA	NA
Uranium	0.0747	1.5	350	7	38.3	2555	0.00281	0.003	0.935
								HI=	18.777
Noncarcinogens—Ground Water Ingestion Only (adults)									
Antimony	0.000675	2	350	30	70	10950	0.00002	0.0004	0.046
Arsenic	0.00056	2	350	30	70	10950	0.00002	0.0003	0.051
Cadmium	0.00112	2	350	30	70	10950	0.00003	0.0005	0.061
Chloride	561	2	350	30	70	10950	15.36986	NA	NA
Lead	0.000965	2	350	30	70	10950	0.00003	NA	NA
Manganese	1.62	2	350	30	70	10950	0.04438	0.047	0.944
Molybdenum	0.00309	2	350	30	70	10950	0.00008	0.005	0.017
Selenium	2.17	2	350	30	70	10950	0.05945	0.005	11.890
Sodium	1750	2	350	30	70	10950	47.94521	NA	NA
Sulfate	4320	2	350	30	70	10950	118.35616	NA	NA
Thallium	0.000156	2	350	30	70	10950	0.000004	NA	NA
Uranium	0.0747	2	350	30	70	10950	0.00205	0.003	0.682
								HI =	13.693
								Total risk	6.72E-05

Table 6–5 (continued). Intake/Risk Calculation Spreadsheet (ground water ingestion pathway)

Durango Raffinate Ponds Area—Residential Exposure									
Carcinogens—Ground Water Ingestion Only (children)									
Contaminant	**Cw[a]**	**Irw**	**EF**	**ED**	**BW**	**AT**	**Intake**	**RfD[b]**	**HQ**
Arsenic	0.000566	2	350	30	70	25550	6.6458E-06	1.5	9.97E-06
U234+238[b]	51	2	350	30	na	na	1.08E+06	5.32E-11	5.73E-05
								Total risk	6.72E-05

[a]Water concentrations used are UCL_{95}
[b]Assumes equilibrium; 1 mg = 686 pCi; slope factor is average of U-234 and U-238
NA - Not available
na - Not applicable

With the exception of selenium, all other contaminants have exhibited decreasing concentrations since the original BLRA data were obtained. Selenium has shown significant increases in several on-site wells (up to two orders of magnitude), most likely because of a change in oxidation/reduction conditions. These increasing selenium concentrations have become the major risk driver for the raffinate ponds area.

6.1.3.3 Uncertainty in the BLRA

There are many sources of uncertainty associated with the results from any risk assessment. These include limited site characterization, uncertainty of future land use, and uncertainty in toxicity values used. Generally, because of the conservative nature of assumptions used in calculating risks, risks are most often overestimated for any given exposure scenario. Some of the sources of uncertainty specific to this BLRA update are listed below along with their overall effect on estimates of site-related risks.

- **Toxicity data and contaminant interactions—**The toxicity values were obtained from EPA's Integrated Risk Information System (IRIS) database and represent the best data available. However, these values are often extrapolated from animal data or from laboratory tests conducted under conditions that differ from those by which actual exposure to environmental contaminants occurs. Most of the studies do not include data on more sensitive populations (e.g., children, the elderly). Uncertainty factors are often applied to these values to account for such circumstances. The RfDs for arsenic and selenium were developed using an uncertainty factor of 3; the RfD for cadmium includes an uncertainty factor of 10. Manganese has an uncertainty factor of 3. Uncertainty factors of 100 and 1,000 were applied in developing the RfDs for vanadium and uranium, respectively. Thus, the actual risks associated with vanadium and uranium are least understood. The application of highly conservative uncertainty factors may overestimate the risks.

- **Chemical interaction—**To get hazard indices and total carcinogenic risks, HQs and risks for all chemicals were simply summed. In reality, certain chemicals can have interactions that are either synergistic or antagonistic. This is not accounted for by summing risks. Lack of data on chemical interaction could either overestimate or underestimate actual risks.

- **Future water and land use—**Risks were calculated assuming future residential use of the site and consumption of ground water as the primary drinking water source. This was assumed as a likely scenario because of the proximity of the site to the city of Durango; however, there are currently no complete exposure pathways to ground water, and the current land ownership (City of Durango and the Animas-La Plata Water Conservancy District) reduce the potential for future residential development. This likely overestimates future risks because residential development of this area would likely include access to municipal water. In addition, risks presented here are overestimates based on exposure to current ground water contamination levels, future concentrations would be lower because of natural flushing. Finally, many of the wells with contaminated ground water yield insufficient water to serve as a primary source of drinking water.

- **Exposure parameters—**Exposure parameters for the residential scenario are default parameters used regularly by EPA. Most of the parameters are based on statistical analyses of population data. Actual exposures vary considerably. Numbers used represent values from the high end of the actual exposure distribution and are therefore conservative estimates.

Because each parameter is set at the high end of its respective distribution, overall risks are probably overestimated.

6.1.4 Human Health Risk Summary

Risk calculations show the only unacceptable exposure pathway is ingestion of ground water as drinking water. Table 6–6 summarizes the COPCs. Results of the risk calculations indicate controls should be put in place to prevent alluvial aquifer use for drinking water until contamination is reduced to acceptable levels.

Table 6–6. List of COPCs for the Durango, Colorado, Site

Mill Tailings Area	Raffinate Ponds Area
Cadmium	Chloride
Lead	Lead
Manganese	Manganese
Selenium	Selenium
Sodium	Sodium
Sulfate	Sulfate
Uranium	Uranium

For the mill tailings area, most of the risk is contributed by uranium and manganese. Cadmium accounts for approximately 6 percent of the total risk and has concentrations in only one well that exceed the standard. Although selenium contributes only 2 percent of the total risk, the UCL_{95} exceeds the MCL by a factor greater than 3. The other constituents combined contribute only about 7 percent of the total risk. Residential carcinogenic and noncarcinogenic risk thresholds are exceeded. Risks could not be calculated quantitatively for sodium, sulfate, and lead, but it appears the most significant potential adverse effect would be associated with infant or child exposure to the sulfate in ground water when used as a drinking water.

For the raffinate ponds area, risks are dominated by selenium with significant quantifiable contributions from manganese and uranium. Although risks could not be quantified, exposure to sulfate in the ground water would result in negative health impacts, particularly for infants.

6.2 Ecological Risk Assessment

6.2.1 Introduction

Ecological risk assessment (ERA) is a process that evaluates the likelihood of adverse ecological effects occurring or may occur in the future as a result of exposure to one or more environmental stressors. A stressor is defined as any physical, chemical, or biological entity that can induce an adverse ecological response. The risk assessment process is outlined in EPA guidance documents, particularly the "Guidelines for Ecological Risk Assessment" (EPA 1998a) and the "Framework for Ecological Risk Assessment" (EPA 1992). The Ecological Risk Assessment for the Durango UMTRA site generally follows this EPA framework and guidance.

The overall goal of this ERA is to identify ecological COPCs (E-COPCs) that can be related to the dispersal of contaminants in ground water and to characterize the potential for adverse effects of these E-COPCs on ecosystems at this site and along the Animas River and its tributaries. In particular, potential effects on special status species and sensitive environments are considered. This assessment is an update and expansion of the BLRA screening-level assessment conducted in

1995 (DOE 1995a). However, it is still primarily a screening assessment to identify E-COPCs and areas for which future monitoring may be necessary. This section summarizes the BLRA findings and evaluates data collected subsequent to the BLRA evaluation. This assessment will also apply data from new studies as well as updated ecological benchmarks and regulatory requirements that have been developed since completion of the BLRA.

Predicting the effects of chemicals on ecological receptors is complicated by the variable interactions and influences within an ecosystem. To a great extent, ecological risk assessment is an emerging science. Little data exist for most chemicals and their effects on ecological receptors. Therefore, attempting to integrate and evaluate individual and synergistic chemical effects with other stressors (predation, drought, disease, etc.) is problematic. Generally, for ecological risks to occur now or in the future there must be a contaminant source, which is assumed to be limited to ground water, and a pathway must exist for exposure of ecological receptors to contaminated ground water. The simplified ecological risk scenario gives a generalized overview of the ecological risk assessment process:

Contamination Source	—	**Release**	—	**Contaminated Media**	—	**Pathway**	—	**Receptor**	—	**Effect**
(Durango mill site)		(Migration into soil and ground water)		(Ground Water, Surface Water, and Sediments)		(Ingestion or Absorption)		(Plants, Wildlife)		(No effect, non-lethal effects, or mortality)

The following sections provide a summary of the BLRA and evaluation of potential risks based on a review of all relevant data, with emphasis on the 2000-2001 data.

6.2.2 Ecological Risk Assessment Process

As shown in Figure 6–2, the framework of the ERA contains three main components: (1) problem formulation, (2) analysis, and (3) risk characterization. The overall goal of the problem formulation is to “set the stage” for the analysis and risk characterization phases of the process. In the problem formulation, the need for a risk assessment is identified and the scope of the problem is defined. Available data are evaluated to identify potential stressors (in this case, the potential stressors are E-COPCs associated with the ground water at the Durango mill site), key ecological receptors, and potential exposure pathways linking the receptors to the stressors. This information is used to develop a site conceptual model and risk hypotheses. Finally, assessment and measurement endpoints are defined for the determination of specific risk to these receptors and the environmental resources they represent. These endpoints are directly tied to overall management goals for the site.

The analysis phase of the ERA includes two concurrent steps—the exposure assessment and the effects characterization. In the exposure assessment, the potential for each receptor to be exposed to each stressor is evaluated and, where possible, quantified. The effects characterization describes the potential for the stressor to adversely affect the receptors exposed to it. Because stressors at the Durango site are chemical, the principal effects to ecological receptors will be toxicological; however, they may also include physical effects, such as those related to radiation.

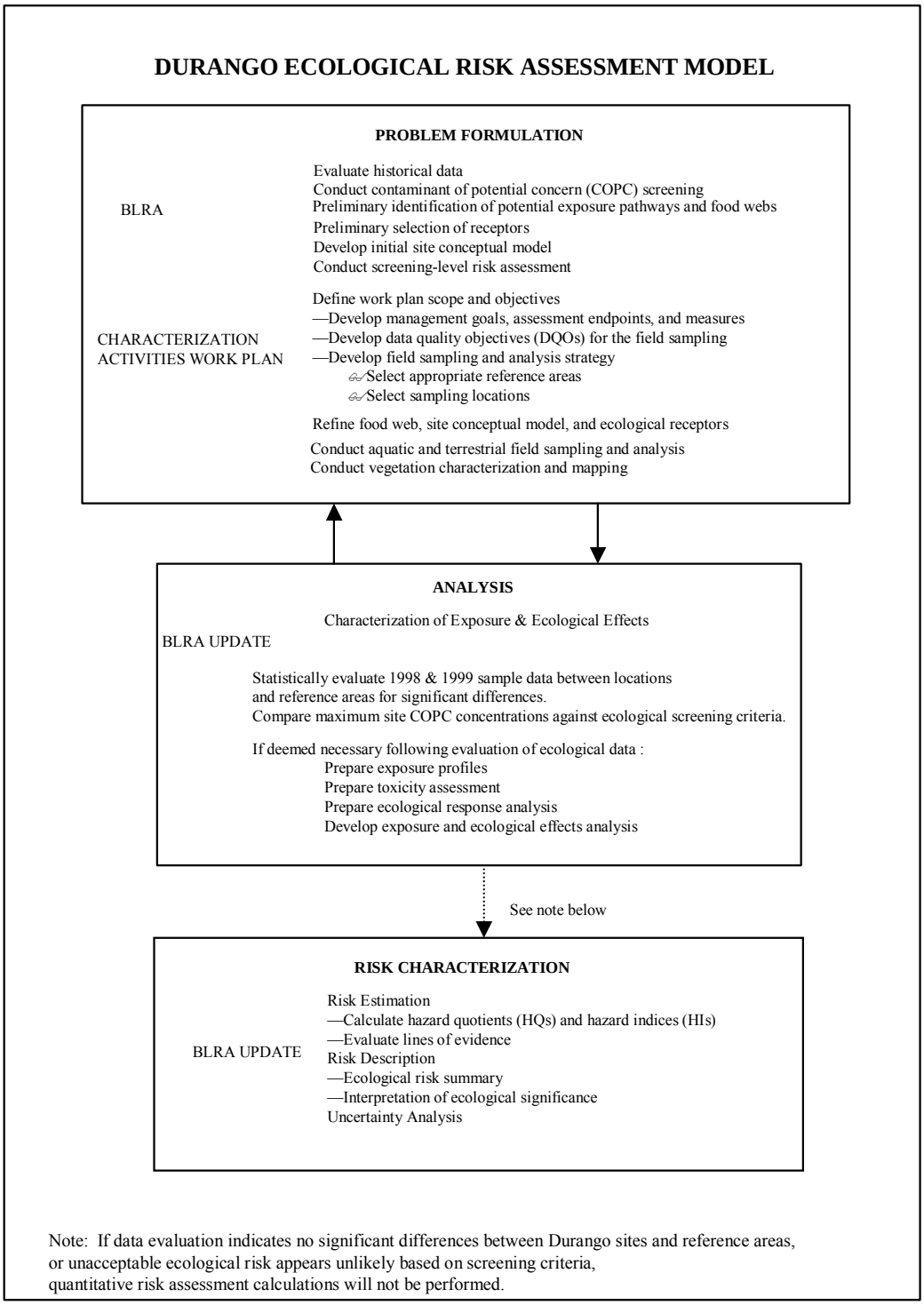

Figure 6–2. Durango Ecological Risk Assessment Model

The risk characterization phase evaluates (either qualitatively or quantitatively) the combined results of the exposure assessment and effects characterization to determine the potential for risk to the receptors due to their exposure to the stressors. A critical aspect of risk characterization is the analysis of uncertainties associated with predictions of potential risk. Typically, uncertainties result from data gaps, which necessitate the incorporation of assumptions into the analysis and risk characterization phases. In general, these assumptions are conservatively biased toward results that will lead to overestimations rather than underestimations of risk. The uncertainty analysis provides an analysis of these assumptions in terms of their potential for introducing significant bias in the risk estimation.

As described in the EPA guidance (EPA 1998a), ecological risk assessment is an iterative process in which the evaluation of potential risks to ecological receptors is refined as additional data are collected to fill data gaps and reduce uncertainties. At the conclusion of each iteration (or "tier") in the process, decisions are made as to whether sufficient data have been collected and analyzed to proceed with risk management actions (if required), or whether additional data should be collected. Such a tiered approach to the ecological risk assessment process began at the Durango site in 1995 by the performance of the screening-level BLRA (DOE 1995a).

Subsequently, additional data have been collected from key environmental media. The ERA presented here incorporates these new data as a refinement and update of the screening-level assessment presented in the BLRA. Sampling of ground water and surface water (from the Animas River) for chemical analysis was conducted between 1999 and 2001 as discussed in Section 4.7, "Ecological Investigation." Samples of sediment were collected and analyzed in November 1993 and January 2001.

Problem Formulation

The problem formulation phase in this ERA is represented in part by information presented in the BLRA (DOE 1995a). The BLRA was based on analytical data collected at the Durango site prior to 1995. These data were reviewed to determine if concentrations of analytes in ground water, surface water, and sediment may pose a potential ecological risk. Information on the geologic setting, ground water hydrology, geochemistry, and habitats of the site were incorporated in the BLRA evaluation. Principal results of the BLRA included an initial screening of chemical analytes as E-COPCs and an assessment of potential risk to biota, including livestock and irrigated crops. The assessment of potential risk, however, was primarily qualitative. The BLRA provided a basis for the preparation of a characterization work plan (DOE 2000b).

Since the completion of the BLRA, additional ground water and surface water samples have been collected on site and at upgradient reference locations. These new analytical data, which include the June 1999 through June 2001 sampling results, are included in this update.

Potentially Affected Habitats and Populations

The ground surfaces of the Durango mill tailings and raffinate ponds areas are highly disturbed from past use and subsequent soil remediation activities. These disturbed areas were reseeded with grasses, including smooth brome, Kentucky bluegrass, western wheatgrass, blue grama, galleta, and saltgrass (DOE 1995a). Along the Animas River, the habitat is mostly an open, rocky shoreline, with only scattered willows, cottonwoods, and boxelders. On the opposite shore, however, are larger trees and thickets of these species (DOE 1995a). Wildlife that use the site

include several species of birds, as well as deer mice, cottontail, deer, and beaver. The cold water of the Animas River in the area of these sites supports trout, which are stocked by the Colorado Division of Wildlife (DOE 1995a). The flora and fauna of the sites as they existed prior to the surface remediation are described in the *Final Environmental Impact Statement, Remedial Actions at the Former Vanadium Corporation of America Uranium Mill Site, Durango, La Plata County, Colorado* (DOE 1985) which documents the results of site-specific biological investigations.

As a result of consultation with the U.S. Fish and Wildlife Service Grand Junction Office (June 27, 2000), three threatened or endangered species have been identified as potentially occurring in the vicinity of the areas. These are the razorback sucker, the Colorado pikeminnow, and southwestern willow flycatcher. Neither the razorback sucker nor the Colorado pikeminnow are likely to occur in the vicinity; however, suitable habitat for the southwestern willow flycatcher occurs along the Animas River, although not close to the site. In addition to these species, bald eagles are known to winter along the Animas River near Durango, but are not known to have nested there in recent history.

Summary of the 1995 Ecological Risk Assessment Results

In the 1995 BLRA (DOE 1995a), analytical data from surface water and sediment samples from Lightner Creek and the Animas River were evaluated for E-COPCs based on comparisons of maximum detected concentrations to background data, when available. As shown in Table 6–7, the BLRA initially identified 31 ground-water-based constituents as possible E-COPCs for further screening and evaluation. Twenty-two of these analytes were detected in surface water and 11 in sediment. Of the 22 analytes detected in surface water, 11 (ammonium, barium, chloride, chromium, copper, fluoride, potassium, sodium, sulfide, tin, and vanadium) did not have corresponding background data. The other 11 had maximum detected concentrations exceeding the background concentrations. For sediment, six analytes (arsenic, iron, lead, nitrate, selenium, and zinc) were detected at concentrations greater than background in samples from the Animas River. One sample designated as sediment (from location 0655) was not included here in the sediment database because it was located above the Animas River water line and had associated evaporite minerals. Sulfate and molybdenum concentrations exceeded the upstream concentrations in this sample, but it is questionable whether this may be due to the concentration of these constituents by surface evaporation.

Although limited media-specific benchmark values and receptor-specific toxicity information were found, results of the screening ecological risk assessment presented in the BLRA indicated the potential for risk to ecological receptors exposed to E-COPCs in the surface water is probably low. For sediment, concentrations of iron, lead, and zinc exceeded benchmark values for sediment quality. Some E-COPCs in ground water, such as arsenic, cadmium, lead, manganese, and selenium, may be taken up by deep-rooted plants and thereby enter the food chain. Although insufficient information was available to assess the potential impact of this pathway, the BLRA concluded that the potential hazard was low due to the limited amount of vegetation covering the sites. Ground water was found to be unsuitable for use in a surface pond due to potential risks to aquatic life.

Table 6–7. Summary of E-COPC in Ground Water, Surface Water, and Sediments from the Baseline Risk Assessment

Constituent	Constituents Detected Above Background in Ground Water at the Mill Tailings Area	Constituents Detected Above Background in Ground Water at the Raffinate Ponds Area	Constituents Detected in the Animas River Surface Water or Sediment
Ammonium	X	X	SW[a]
Antimony	X	X	
Arsenic		X	SD
Barium	X		SW[a]
Cadmium	X	X	(SD)
Calcium	X	X	SW
Chloride	X	X	SW[a]
Chromium		X	SW[a]
Cobalt		X	
Copper		X	SW[a]
Fluoride	X	X	SW[a]
Iron		X	SW, SD
Lead	X	X	SW, (SD)
Magnesium	X	X	SW
Manganese	X	X	SW, (SD)
Molybdenum	X	X	SW, (SD)
Nickel		X	
Nitrate	X		SW, SD
Potassium	X	X	SW[a]
Selenium	X	X	SW, SD
Silica	X	X	
Silver	X		
Sodium	X	X	SW[a]
Strontium	X	X	
Sulfate	X	X	SW, (SD)
Sulfide		X	SW[a]
Thallium		X	
Tin	X	X	SW[a]
Uranium	X	X	SW, (SD)
Vanadium	X	X	SW[a]
Zinc	X	X	SW, SD

[a]Analyte was not measured in upstream (background) samples; therefore, it could not be eliminated as an E-COPC based on background comparison.
SW = Detected in surface water samples from the river
SD = Detected in sediment samples from the river
(SD) indicates that the upstream (background) sediment concentration was greater than the site sample concentrations.

Update of the 1995 E-COPCs

For the current ERA, additional data collected and information received subsequent to the issuance of the BLRA are used to reevaluate the list of E-COPCs and to further assess these constituents for potential ecological risk at the Durango areas. This update to the 1995 BLRA is based on ground

water and surface water data collected between June 1999 and June 2001, and sediment samples collected in November 1993 and January 2001.

Recent ground water data were reevaluated to identify current E-COPCs. Results of this reevaluation are presented in Table 6–8. In this reevaluation, an analyte was identified as an E-COPC if its maximum detected concentration from the site exceeded the maximum upgradient concentration. Constituents that are considered to be essential nutrients (calcium, magnesium, potassium, and sodium) are also excluded as E-COPCs. Sulfate and chloride are anions of low potential toxicity in biota. However, because both sulfate and chloride have State of Colorado water quality standards for the Animas River, they were included for consideration as E-COPCs. Despite the relatively low toxicities of these anions and cations, at high concentrations in water, they can contribute to adverse ecological effects due to high osmotic potentials, and some can affect the use of water by wildlife and livestock by imparting strong tastes to the water. Those types of effects, however, are not addressed in this risk assessment.

As seen in Table 6–8, all nonradiological constituents not excluded as essential nutrients were identified as E-COPCs in ground water at either the mill tailings area or the raffinate ponds area. All were found to be E-COPCs at raffinate ponds area; however, at the mill tailings area, only concentrations of arsenic, cadmium, chloride, chromium, manganese, molybdenum, selenium, sulfate, uranium, vanadium, and zinc exceeded the upper limit of the background range. Of the radionuclides analyzed in ground water, lead-210 and thorium-230 were not detected. Radium-226 was identified as an E-COPC at only the mill tailings area; concentrations of all other radionuclides exceeded background at both areas.

Table 6–9 presents the E-COPC selection results for surface water in the Animas River and Lightner Creek. For surface water, data from both the mill area (including Lightner Creek) and the raffinate ponds area were combined and evaluated as a single unit. As with the ground water evaluation of E-COPCs, a constituent was considered an E-COPC if its maximum detected concentration exceeded the maximum concentration from the upstream (background) locations (including both the Animas River and Lightner Creek upstream samples). Also as with ground water, the essential nutrients calcium, magnesium, potassium, and sodium, were excluded from the E-COPC selection process due to their low toxicities.

Of the nonradiological analytes, only ammonium, cadmium, calcium, lead, selenium, and sulfate concentrations exceeded the background maximum concentration in surface water. Calcium was excluded as an E-COPC because it is an essential nutrient. Cadmium was also dropped because its maximum value only very slightly exceeded the maximum background value. Maximum concentrations of lead, selenium, and sulfate were also very close to their corresponding background concentrations. In fact, of the 41 data points collected for each of these analytes, only one exceeded the background range for both lead and sulfate and two exceeded the background range for selenium. These results confirm the conclusion in the BLRA that contaminants in ground water have not adversely affected water quality of the Animas River and Lightner Creek.

Of the nine radionuclides analyzed in surface water samples, only lead-210 and radium-228 had maximum values less than the background maximum. However, as with the nonradiological analytes, the maximum concentrations of the other radionuclides were generally close to the background range.

Table 6–8. Summary of Preliminary E-COPCs in Ground Water at the Durango Site Based on Sampling Data from June 1999 through June 2001

Constituent	Maximum Concentration in Ground Water				E-COPC? (Site)	Reason
	Mill Tailings Background	Mill Tailings Area	Raffinate Ponds Background	Raffinate Ponds Area		
Nonradiological Analytes (mg/L)						
Ammonium	2.28	1.33	1.4	**9.08**	DUR02	Exceeds background range
Antimony	<0.0045	<0.002	<0.0014	**0.0022**	DUR02	Exceeds background range
Arsenic	0.0013	**0.0015**	0.0034	**0.0041**	DUR01, DUR02	Exceeds background range
Cadmium	0.00034	**0.0435**	0.00031	**0.0037**	DUR01, DUR02	Exceeds background range
Calcium	583	499	242	**462**	No	Essential nutrient
Chloride	265	**358**	83.6	**1,400**	DUR01, DUR02	Exceeds background range
Chromium	<0.0059	**0.005**	0.0053	**0.0068**	DUR01, DUR02	Exceeds background range
Copper	0.0153	0.0085	0.0069	**0.0518**	DUR02	Exceeds background range
Iron	11.8	6.76	1.71	**9.78**	DUR02	Exceeds background range
Lead	0.0023	0.00043	0.00011	**0.0107**	DUR02	Exceeds background range
Magnesium	254	**451**	216	**455**	No	Essential nutrient
Manganese	1.05	**5.4**	0.58	**7.07**	DUR01, DUR02	Exceeds background range
Molybdenum	0.0057	**0.15**	0.0155	**0.0899**	DUR01, DUR02	Exceeds background range
Nitrate	11.2	7.01	4.99	**50**	DUR02	Exceeds background range
Potassium	8.17	**39.8**	8.85	**73.6**	No	Essential nutrient
Selenium	0.0148	**0.123**	0.0077	**12.3**	DUR01, DUR02	Exceeds background range
Sodium	488	**1,550**	626	**3,520**	No	Essential nutrient
Sulfate	2,160	**3,450**	1,330	**8,530**	DUR01, DUR02	Exceeds background range
Thallium	0.00038	0.0001	<0.00037	**0.00024**	DUR02	Exceeds background range
Uranium	0.0354	**2.12**	0.0321	**0.356**	DUR01, DUR02	Exceeds background range
Vanadium	0.00098	**0.448**	0.00075	**0.0235**	DUR01, DUR02	Exceeds background range
Zinc	0.0265	**2.61**	0.23	**0.464**	DUR01, DUR02	Exceeds background range
Radiological Analytes (pCi/L)						
Gross Alpha	25.93	**1,655**	54.0	**261**	DUR01, DUR02	Exceeds background range
Gross Beta	30.32	**666**	23.7	**161**	DUR01, DUR02	Exceeds background range
Lead-210	<1.47	<1.47	<1.47	<1.5	No	Not detected
Polonium-210	0.09	**0.1**	0.12	**1.12**	DUR01, DUR02	Exceeds background range
Radium-226	0.22	**0.46**	0.7	0.54	DUR01	Exceeds background range
Radium-228	<1.39	**0.7**	0.5	**0.99**	DUR01, DUR02	Exceeds background range
Thorium-230	<2.6	<2.6	<3.1	<2.7	No	Not detected
Uranium-234	14.1	**732**	4.1	**105**	DUR01, DUR02	Exceeds background range
Uranium-238	14.2	**766**	2.6	**111**	DUR01, DUR02	Exceeds background range

Bold text indicates value exceeds the maximum background concentration.
DUR01 = Mill Tailings Area
DUR02 = Raffinate Ponds Area

Table 6–9. Surface Water Constituents Retained for Evaluation Based on Sampling Data from June 1999 through June 2001

Constituent	Maximum Concentration in Surface Water		E-COPC?	Reason
	Background	Durango Site		
Nonradiological Analytes (mg/L)				
Ammonium	0.0456	**0.49**	Yes	Exceeds background range
Antimony	<0.0013	<0.0019	No	Not detected
Arsenic	0.00096	0.0004	No	Within background range
Cadmium	0.00053	**0.00054**	No	Within background range
Calcium	167	**173**	No	Essential nutrient
Chloride	20.9	20.5	No	Within background range
Chromium	0.0111	0.0079	No	Within background range
Copper	0.0063	0.006	No	Within background range
Iron	0.101	0.0637	No	Within background range
Lead	0.00026	**0.00033**	Yes	Exceeds background range
Magnesium	137	135	No	Essential nutrient
Manganese	0.205	0.158	No	Within background range
Molybdenum	0.0019	0.0017	No	Within background range
Nitrate	3.15	2.11	No	Within background range
Potassium	7.08	5.05	No	Essential nutrient
Selenium	0.0026	**0.003**	Yes	Exceeds background range
Sodium	111	85	No	Essential nutrient
Sulfate	793	**809**	Yes	Exceeds background range
Thallium	<0.00037	<0.00044	No	Not detected
Uranium	0.0333	0.031	No	Within background range
Vanadium	0.0017	0.0016	No	Within background range
Zinc	0.0788	0.0691	No	Within background range
Radiological Analytes (pCi/L)				
Gross Alpha	<12.1	**17.9**	Yes	Exceeds background range
Gross Beta	16.1	**16.7**	Yes	Exceeds background range
Lead-210	<1.38	<1.4	No	Not detected
Polonium-210	0.06	**0.08**	Yes	Exceeds background range
Radium-226	0.15	**0.21**	Yes	Exceeds background range
Radium-228	1.1	<1	No	Within background range
Thorium-230	<2.6	**4.1**	Yes	Exceeds background range
Uranium-234	3.6	**5.6**	Yes	Exceeds background range
Uranium-238	4.1	**4.6**	Yes	Exceeds background range

Bold text indicates value exceeds the maximum background concentration.

Data from sample location 0655 were not included with the sediment samples in this analysis because the sample was collected above the water line of the Animas River and was associated with evaporites (DOE 1995a). Six analytes (arsenic, iron, lead, nitrate, selenium, and zinc) were detected in sediments of the site at concentrations greater than background. These analytes were identified as E-COPCs.

A summary of results of the reevaluation of E-COPCs is presented in Table 6–10. These lists of E-COPCs are media-specific and location-specific.

Table 6–10. Summary of E-COPCs at the Durango Sites Based on Analytical Data from June 1999 through June 2001

Ground Water		Surface Water	Sediment
Mill Tailings Area	**Raffinate Ponds Area**		
Arsenic	Ammonium	Ammonium	Arsenic
Cadmium	Antimony	Lead	Iron
Chloride	Arsenic	Selenium	Lead
Chromium	Cadmium	Sulfate	Nitrate
Manganese	Chloride	Gross Alpha	Selenium
Molybdenum	Chromium	Gross Beta	Zinc
Selenium	Copper	Polonium-210	
Sulfate	Iron	Radium-226	
Uranium	Lead	Thorium-230	
Vanadium	Manganese	Uranium-234	
Zinc	Molybdenum	Uranium-238	
Gross Alpha	Nitrate		
Gross Beta	Selenium		
Polonium-210	Sulfate		
Radium-226	Thallium		
Radium-228	Uranium		
Uranium-234	Vanadium		
Uranium-238	Zinc		
	Gross Alpha		
	Gross Beta		
	Polonium-210		
	Radium-228		
	Uranium-234		
	Uranium-238		

6.2.3 Ecological Site Conceptual Model

The conceptual model for an ERA is developed from information about stressors, predicted exposure pathways, and the potential effects of exposure on ecological receptors. Conceptual models consist of two principal components:

- A set of risk hypotheses that provide descriptions of predicted relationships among stressor, exposure, and assessment endpoint response, along with the rationale for their selection.
- A diagram that illustrates the relationships presented in the risk hypotheses.

A complete exposure pathway is the mechanism by which a contaminant in an environmental medium (i.e., the source) can contact an ecological receptor. A complete exposure pathway includes

- Contaminant source,
- Release mechanism that allows contaminants to become mobile or accessible,
- Transport mechanism that moves contaminants away from the release,
- Ecological receptor, and
- Route of exposure (e.g., dermal or direct contact, inhalation, or ingestion).

Because stressors at the Durango site are chemical contaminants, the risk hypotheses are considered to be stressor-initiated.

As part of the initial problem formulation in the BLRA, a generalized site conceptual model was developed for the Durango site. That model has since been revised to address current and potential exposure pathways based on all the available data (Figure 6–3). At this site, the movement of contaminated ground water from the mill tailings area and raffinate ponds area is not known to have resulted in surface expressions, such as seeps and springs; however, discharges into the Animas River and possibly Lightner Creek may be occurring at low rates. For this reason, risk hypotheses are developed for these surface water features based on this possible contact.

Risk Hypotheses Based on Current Exposure Scenarios

The following are the risk hypotheses proposed where complete exposure pathways to ecological receptors may exist based on the current site conditions. Contaminants in the near-surface ground water of the site may be taken up by deep roots of phreatophytes. These contaminants may produce phytotoxic effects on the plant and may transport to plant tissues that are accessible to wildlife. Contaminated ground water may be discharging into the Animas River, thereby adversely affecting surface water and sediment quality of the area. Aquatic organisms in direct contact with these media may be affected and may provide a link for bioaccumulation of the contaminants up the food chain. Wildlife could be directly exposed to these contaminants through ingestion of this water and/or food items exposed to the water, and sediment and the incidental ingestion of the sediment.

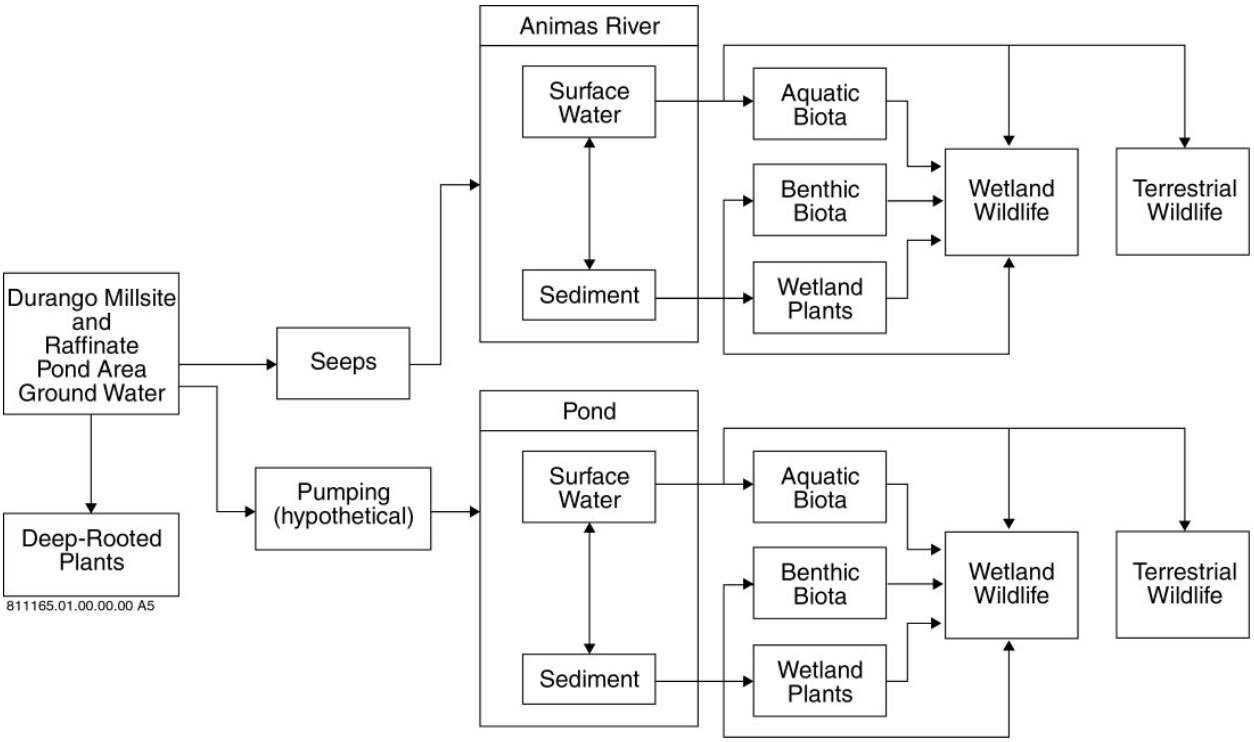

Figure 6–3. Ecological Site Conceptual Model for the Durango UMTRA Site

Risk Hypotheses Based on Hypothetical Future Exposure Scenario

Without institutional controls, ground water could possibly be pumped and used for irrigation, surface ponds, livestock watering, or industrial uses. This practice would create a source for potential ingestion of ground water, direct contact with terrestrial vegetation, and deposition of ground water on the soil. The soil would then represent an additional source medium for ingestion and direct contact.

Ecological Receptors

Ecological receptors that could potentially be exposed to E-COPCs were identified in the BLRA (DOE 1995a) and include mammalian and avian species. Section 6.2.2 summarizes the habitats and populations that may be affected by exposures to E-COPCs at the Durango site. The food web for this site (Figure 6–4) illustrates the significant dietary interactions among and between the wetland and aquatic receptors associated with the Animas River. The food web also depicts the major trophic interactions and shows nutrient flow and transfer of matter and energy through the trophic levels. This food web model was developed from the species lists and consideration of the exposure pathways. The food web diagram was used to portray potential pathways of E-COPCs from the ground water to biota at various trophic levels, with potential receptor species being identified as having potentially complete ecological exposure pathways. These potential receptors are as follows:

The Animas River. The habitat of the river channel is primarily riparian. The potential receptors of these areas include:

- Plants—Wetland and riparian plants that grow along the channel course in direct contact with water and sediments.
- Aquatic receptors—Aquatic receptors include fish, aquatic invertebrates, and aquatic plants that live in direct contact with water and sediments.
- Wetland wildlife—Wetland wildlife may be exposed to E-COPCs along the river as a result of drinking surface water and feeding on the aquatic organisms and wetland plants. Potential receptors include insectivorous birds, such as swallows and flycatchers; shorebirds, such as sandpipers and killdeer; piscivorous birds, such as belted kingfishers and herons; and mammals associated with wetland habitats, including muskrats and raccoons.

As described in Section 6.2.2, potential receptors associated with the Animas River include the endangered southwestern willow flycatcher and the threatened bald eagle. However, neither of the two species of endangered fish discussed in Section 6.2.2 are considered potential receptors at this site.

The River Floodplain and the Uplands. The habitats of the Animas River floodplain and adjacent uplands are primarily terrestrial; however, many of the wildlife receptors that occur in these habitats probably live and feed in close association with the aquatic habitats of the river. These receptors may use the river as a source of drinking water, and may thereby be exposed to E-COPCs. Because the areas of the millsite and raffinate ponds on these upland areas are highly disturbed, little wildlife use of these areas is expected. However, small mammals and birds use the area, and terrestrial predators may sometimes hunt these animals. Larger species, such as deer, probably cross the area while going to and from the river, and may forage in the area on occasion.

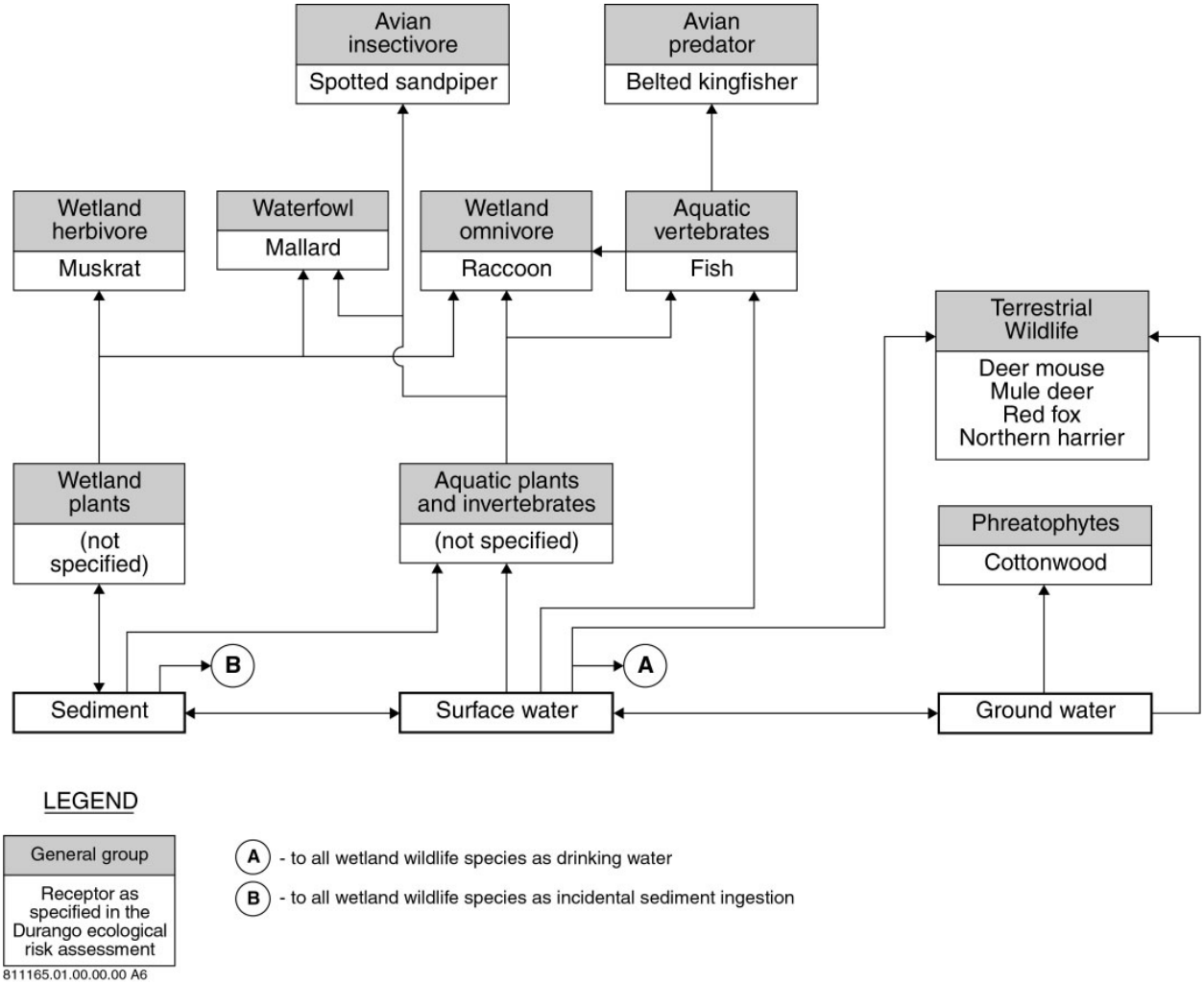

Figure 6–4. Generalized Food Web for Ecological Receptors at the Durango Site.

6.2.3.1 Management Goals and Endpoints

Table 6–11 presents the primary goals for protection of environmental resources with respect to contaminants associated with ground water, and the assessment and measurement endpoints that will be used to evaluate potential risk to these resources in support of achieving these goals.

6.2.4 Analysis

6.2.4.1 Exposure Assessment

Exposure Modeling and Assumptions

Only complete exposure pathways are quantitatively and qualitatively evaluated in an ERA. In this assessment, the following potential exposure pathways were considered for evaluation:

- Surface water ingestion and direct contact
- Sediment ingestion and direct contact
- Dietary ingestion of forage or prey, as appropriate, by receptor

Table 6–11. Management Goals, Assessment Endpoints, and Measurement Endpoints for the Evaluation of Ecological Risks at the Durango Site

Management Goals	Assessment Endpoints	Measurement Endpoints
Maintain the quality of aquatic habitats in the Animas River	Surface water quality of the Animas River	Concentrations of E-COPCs in the surface water of the Animas River meet applicable water quality criteria or equivalent benchmarks for the protection of aquatic life.
	Sediment quality of the Animas River	Concentrations of E-COPCs in the sediment of the Animas River meet applicable sediment quality benchmarks for the protection of benthic organisms.
Maintain habitat quality of the floodplain for the protection of wildlife diversity	Potential for adverse effects on survival and reproduction in wildlife from exposures to E- COPCs in various environmental media of the Animas River floodplain and adjacent uplands	Hazard quotients comparing estimated exposure to toxicity benchmarks for key indicator receptor species are less than unity.
	Ground water quality of the Animas River floodplain	Concentrations of E- COPCs in the ground water of the Animas River floodplain meet benchmarks for the protection of riparian plants.

Contaminants associated with the Durango site are inorganic and are associated with surface water, ground water, and sediments. Estimates of potential exposures to key ecological receptors are based on the dominant pathways from these media for the specific receptor. Exposures in wetland plants are dominated by direct contact with the sediment in which they are rooted. Phreatophytes may be exposed through direct contact with the ground water. Exposures to aquatic organisms (those that live within the water column) and benthic organisms (those that live within the sediment) are dominated by direct contact with the external media (water and sediment) in which they live, but in the cases of aquatic and benthic animals also include the ingestion of food associated with these media. In all of these cases, potential exposure to an E-COPC is based on the concentration of that E-COPC in the media of principal contact.

Exposures in wildlife involve multiple potential pathways that may include ingestion of food, water, and sediment; direct contact and dermal absorption; and inhalation. In this assessment, the inhalation and dermal absorption pathways are assumed to be minor pathways with respect to the combined exposures based on ingestion. Most wildlife of the area have very little and infrequent direct dermal contact with potentially contaminated media due to their protective covers of feathers or fur and their habits and behaviors, such as preening and grooming, and (in the cases of most birds) living principally in trees and shrubs. The E-COPCs are not highly volatile. Therefore, their occurrence in the air is minimal. The assessment of exposures in wildlife through inhalation was considered a minor exposure pathway relative to sediment ingestion. Although both dermal absorption and inhalation will contribute to the overall exposure in these receptors, these contributions are assumed to be included within the conservatisms incorporated in the estimation of exposures through the ingestion pathways.

For the estimation of ingestion-related exposure for wildlife receptors, the E-COPCs are assumed to be 100 percent bioavailable and the receptors are assumed to be exposed only at the selected exposure point concentration, regardless of home range size or seasonal use patterns. The exposure through multiple ingestion pathways is modeled using the methods described in the EPA's *Wildlife Exposure Factors Handbook* (EPA 1993). The basic model for estimating the daily intake of an E-COPC per kilogram of body weight (i.e., the estimated daily dose of the E-COPC) through these ingestion pathways is

$$D_x = \frac{\sum_{k=1}^{m}(C_k \cdot F_k \cdot I_k) + C_s \cdot F_s \cdot I_s + C_w \cdot F_w \cdot I_w}{W}$$

where

D_x is the estimated daily dose (mg/kg-day) of E-COPC *x*,
C_k is the concentration of E-COPC x in the kth food type (mg/kg dry weight),
F_k is the fraction of the kth food type that comes from the site,
I_k is the ingestion rate of the kth food type (kg dry weight/day),
m is the number of food items in the receptor's diet,
C_s is the concentration of E-COPC *x* in the sediment or soil (mg/kg dry weight),
F_s is the fraction of ingested sediment or soil that comes from the site,
I_s is the ingestion rate of sediment or soil (kg dry weight/day),
C_w is the concentration of E-COPC *x* in water (mg/L),
F_w is the fraction of the ingested water that comes from the site,
I_w is the ingestion rate of water (L/day), and
W is the body weight of the receptor (kg wet weight).

F_k, F_s, and F_w are commonly assumed to be the area use factor (the area of the site divided by the home range of the receptor or 1, whichever is smaller) but may also be modified by a seasonal use factor (number of days at the site divided by 365 days per year) if the home range is used for only part of the year. For estimating risk in this assessment, both area use and seasonal use are conservatively assumed to be 100 percent; therefore, F_k, F_s, and F_w are assumed to be 1.

For the purposes of estimating exposure in wildlife, E-COPC concentrations in plants were principally based on empirically derived uptake models (nonlinear or linear) as recommended by Oak Ridge National Laboratory (Bechtel Jacobs Company 1998a). The nonlinear form of the uptake model is

$$C_{plant} = B_0 \cdot C_{soil}^{\ B_1}$$

where

C_{plant} is the concentration of the E-COPC in the plant (mg/kg dry weight),
C_{soil} is the soil concentration of the E-COPC (mg/kg dry weight), and
B_0 and B_1 are empirically derived model parameters for the E-COPC.

In the linear form of this model, B_1 is assumed to be exactly 1 and B_0 becomes a soil-to-plant transfer factor, where

$$C_{plant} = B_0 \cdot C_{soil}$$

In cases where parameters were not available in the Oak Ridge National Laboratory uptake model documents, soil-to-plant transfer factors from other literature sources (e.g., Baes and others 1984) were used in this linear model.

For aquatic prey species (invertebrates and fish), linear uptake models based on bioaccumulation factors (BAFs) were used to estimate concentrations of E-COPCs in tissues. These models are of the form:

$$C_{organism} = BAF \cdot C_{water}$$

where

> $C_{organism}$ is the concentration of the E-COPC in the invertebrate or fish prey species (mg/kg dry weight),
> C_{water} is the concentration of the E-COPC in the water (mg/L), and
> BAF is the bioaccumulation factor for the E-COPC.

BAFs account for all exposure pathways (dermal absorption, uptake through respiratory organs, and ingestion). In contrast, bioconcentration factors (BCFs) account for uptake through pathways other than ingestion. However, for most inorganic constituents, uptake through ingestion is insignificant, and BAFs are considered to be equal to BCFs. Therefore, BCFs are used as BAFs in this assessment when the latter values are not available. Whenever possible, however, BAFs and BCFs specific to either invertebrates or fish were used to model the concentrations in these respective prey types. Data specific to ammonium and nitrate uptake could not be found; however, because of its high biological activity, ammonium was assumed not to accumulate in tissues or be transferred through the food web. Nitrate concentrations in the prey species were assumed to equal its concentration in the surrounding media. Table 6–12 presents the uptake model parameters (B_0, B_1, BAF, and/or BCF values) used in modeling the concentrations of E-COPCs through the food chain at the Durango site.

Key Indicator Receptors

The receptors used to evaluate potential risks were selected based on their potential presence in the habitats of the site, their potential for exposure to E-COPCs in the media at the site, and their potential for conservatively representing potential exposures to a range of other receptors at the site. Receptors for the habitats identified as having potentially complete ecological pathways are discussed in Section 6.2.3.1. The indicator receptors are representative of key links in the food webs associate with these habitats.

These indicator receptors are as follows:

- Terrestrial habitats—deep-rooted plant (phreatophyte), deer mouse (herbivorous), red fox, mule deer, northern harrier

- Wetland habitats—wetland plant, muskrat, raccoon, mallard, spotted sandpiper, belted kingfisher

- Aquatic habitats—aquatic and benthic organisms

Table 6–12. Uptake Model Parameters and Bioaccumulation Factors for E-COPC

Ecological Contaminant of Potential Concern	Plant Uptake Model Parameters		Bioaccumulation Factors	
	B_0	B_1	Invertebrates	Fish
Ammonium	0.0[a]	1.0	0.0[a]	0.0[a]
Antimony	0.20[b]	1.0[c]	10[d]	1.0[d]
Arsenic	0.136[e]	0.564[e]	73.0[f]	17.0[g]
Cadmium	0.621[e]	0.546[e]	3,460[f]	12,400[g]
Chloride	70[b]	1.0[c]	1.0[h]	1.0[h]
Chromium	0.04[l]	1.0[c]	3,000[f]	40[d]
Copper	1.95[e]	0.394[e]	3,720[f]	290[g]
Iron	0.004[b]	1.0[c]	200[j]	200[k]
Lead	0.265[e]	0.561[e]	5,060[f]	45[g]
Manganese	3.0[l]	1.0[c]	65[l]	17.8[l]
Molybdenum	0.8[k]	1.0[c]	10[j]	10[k]
Nitrate	1.0[h]	1.0[h]	1.0[h]	1.0[h]
Selenium	0.508[e]	1.10[e]	269[m]	129[f]
Sulfate	1.0[h]	1.0[h]	1.0[h]	1.0[h]
Thallium	0.004[b]	1.0[c]	67.0[j]	67.0[n]
Uranium	0.023[k]	1.0[c]	27.1[j]	27.1[l]
Vanadium	0.0055[b]	1.0[c]	3,000[d]	10[d]
Zinc	4.831[e]	0.555[e]	1,130[o]	161[n]

[a]Ammonium assumed not to accumulate in tissue.
[b]From Baes and others (1984).
[c]The uptake model is linear; therefore, B_1 = 1.0.
[d]From Bodek and others (1988).
[e]From Bechtel Jacobs Company (1998).
[f]From NMED (2000).
[g]From Sample and others (1996).
[h]Default value.
[i]From NCRP (1989).
[j]Invertebrate bioaccumulation factor based on fish bioaccumulation factor.
[k]From IAEA (1974).
[l]From EPA (2000).
[m] From EPA 2000; geometric mean of selenite bioaccumulation factors for water fleas based on 14-day exposure.
[n]EPA (1995).
[o]From Eisler (1993).

Terrestrial exposure pathways are found on the floodplain and adjacent uplands. Deep-rooted plants (e.g., cottonwood) are considered only as potential receptors for E-COPCs in the ground water underlying the floodplain. For terrestrial wildlife on the floodplain, surface water is considered to be the primary source medium for E-COPC exposures, and therefore, risks to all terrestrial receptors listed above are evaluated based on potential consumption of drinking water from the various sources, including hypothetical pumping of ground water to a surface pond. Terrestrial wildlife receptors used represent both mammals and birds; mammals are represented by a range of body sizes, from a deer mouse to a mule deer.

For wetland habitats, emergent plants are considered to be the primary producers, and the muskrat and mallard are considered to be representative of herbivores that may consume such plants. The raccoon represents an omnivore in this habitat. The spotted sandpiper represents an insectivorous bird and the belted kingfisher represents a piscivorous bird. All animal prey of

these wildlife receptors (the muskrat being the only one modeled as purely herbivorous) are assumed to be aquatic (invertebrates or fish).

Receptors in the aquatic habitats are not specified. Risk to these receptors is based on comparisons of the media E-COPC concentrations (water and sediment) to broad-based benchmark values, such as ambient water quality criteria (AWQC), that are protective of a wide range of aquatic and benthic organisms. For the Animas River, fish are assumed to be included as potential aquatic receptors within this broad categorization. All wildlife receptors are modeled as potential receptors of E-COPCs in surface water through the consumption of that water at all sites where surface water is present as a medium of concern.

The species-specific parameters used to model exposures to these key indicator receptors (wildlife only) are presented in Table 6–13.

6.2.4.2 Effects Characterization

The potential for adverse effects to ecological receptors resulting from exposures to E-COPCs at the Durango site was evaluated through the comparison of the potential exposure in the receptor to a toxicity-based benchmark of exposure representing the threshold of potential adverse effects.

For aquatic and benthic receptors and plants, the exposure to an E-COPC is characterized by the concentration of that E-COPC in the medium (water or sediment, respectively) with which the receptor is principally in direct contact. Therefore, the benchmarks by which the potential for adverse effects is evaluated are also based on media concentrations. For surface water, either AWQC (EPA 1999) or Colorado Department of Public Health and Environment (CDPHE) Water Quality Standards (whichever was lesser) were used as the principal benchmarks for evaluating potential risk to aquatic life. When neither was available for an E-COPC, Tier II secondary values (Suter and Tsao 1996) or other ambient water quality standards for chronic exposure (e.g., Buchman 1999) were used. These water quality standards are lower than, and therefore inclusive of, the CDPHE standards for agricultural uses of the water. Sediment benchmarks were principally based on the lowest threshold effect levels (TELs) as presented in Buchman (1999), and supplemented from other sources (e.g., Haines and others 1994). Table 6–14 and Table 6–15 present these water and sediment quality benchmark values, respectively.

For plants, toxicity benchmarks are based primarily on the information provided in Efroymson and others (1997). These benchmarks are based on lowest-observed-adverse-effect levels (LOAELs) using 20 percent reduction in growth as the endpoint. Both the soil-based and solution-based benchmarks were used. Soil-based benchmarks were used to evaluate risk to wetland species exposed to sediments, while solution-based benchmarks were used to evaluate potential risk to phreatophytes that may be in contact with ground water. Although based on LOAELs, these benchmarks are considered conservative. The endpoint is sublethal; and reductions in plant growth may have no significant effect on the reproductive potential or the continued existence of a plant population. Further, these benchmarks are primarily based on studies in which the chemical of interest is added freshly to a soil (often as a soluble salt) and is typically more bioavailable than the COPCs in field situations where they have had time to bind more strongly with soil particles. The plant toxicity benchmarks are presented in Table 6–16.

Table 6–13. Exposure Parameters for Wildlife Receptors

Receptor	Body weight (kg)[a]	Food ingestion rate (kg [dry wt]/day)[b]	Soil/sediment ingestion rate (percent of food ingestion)[c]	Water ingestion rate (L/day)[d]	Dietary Composition (percent)[e]
Deer mouse (*Peromyscus maniculatus*)	0.0239[f]	NA	NA	0.00344	NA
Muskrat (*Ondatra zibethicus*)	1.135	0.0772[g]	9.4[h]	0.111	Plant: 100
Raccoon (*Procyon lotor*)	5.74	0.289	9.4[h]	0.477	Plant: 40 Invertebrate: 50 Fish: 10
Red fox (*Vulpes vulpes*)	4.54	NA	NA	0.386	NA
Mule deer (*Odocoileus hemionus*)	65[f]	NA	NA	4.24	NA
Northern harrier (*Circus cyaneus*)	0.180[i]	NA	NA	0.0187	NA
Mallard (*Anas platyrhynchos*)	1.134	0.0592	3.3	0.0642	Plant: 90 Invertebrate: 10
Spotted sandpiper (*Actitis macularia*)	0.0425	0.00503	18[j]	0.0711	Invertebrate: 100
Belted kingfisher (*Ceryle alcyon)*	0.147	0.0128	2.0[k]	0.0163	Invertebrate: 20 Fish 80

[a]From EPA (1993), except where noted.
[b]Based on allometric equations from Nagy (1987), as presented in EPA (1993), except where noted.
[c]From Beyer and others (1994). Data are species-specific except where noted.
[d]Based on allometric equations from Calder and Braun (1983), as presented in EPA (1993), except where noted.
[e]Diets are generalized to emphasize specific trophic levels. Dietary compositions of the river otter, mallard, and belted kingfisher are based on species-specific information presented in EPA (1993) and Martin and others (1951) and have generally been rounded to increments of 10 percent.
[f]From Silva and Downing (1995).
[g]Based on species-specific food intake rate from EPA (1993), with assumed water content of food of 80 percent.
[h]Based on soil/sediment ingestion for raccoon from Beyer and others (1994).
[i]From Dunning (1993).
[j]Based on the mean soil/sediment ingestion rate of four species of sandpipers as reported by Beyer and others (1994).
[k]No data available. Assumed value of 2 percent is based on the detection limit of the method used by Beyer and others (1994).

Table 6–14. Surface Water Quality Benchmarks for E-COPC for the Protection of Freshwater Aquatic Life

Constituent of Potential Concern	Water Quality Benchmarks (mg/L)		
	AWQC[a]	CDPHE SWQS[b]	Other
Ammonium	--	0.02[c]	--
Antimony	--	--	0.03[d]
Arsenic	0.15	0.05	--
Cadmium	0.0022	0.0011	--
Chloride	230	250	--
Chromium	0.074	0.207	--
Copper	0.009	0.012	--
Iron	1.0	1.0	--
Lead	0.0025	0.0039	--
Manganese	--	0.05	0.08[e]
Molybdenum	--	--	0.24[e]
Nitrate	--	10[f]	--
Selenium	0.005	0.010	--
Sulfate	--	250	--
Thallium	--	--	0.04[d]
Uranium	--	1.5	--
Vanadium	--	--	0.019[e]
Zinc	0.120	0.106	--

[a]EPA ambient water quality criteria (EPA 1999). Hardness of 100 mg/L $CaCO_3$ was used for all hardness-dependent values.
[b]Colorado Department of Public Health and Environment Surface Water Quality Standard for aquatic life for the Animas River. Hardness of 100 mg/L $CaCO_3$ was used for all hardness-dependent values.
[c]Standard for NH_3 as N.
[d]Chronic freshwater value from Buchman (1999).
[e]Tier II secondary chronic value from Suter and Tsao (1996).
[f]Standard for NO_3 as N.
-- = No value available.

Table 6–15. Sediment Quality Benchmarks for E-COPC

Contaminant of Potential Concern	Sediment Quality Benchmark (mg/kg)
Arsenic	5.9[a]
Iron	188,400[a]
Lead	35[a]
Nitrate	2,440[b]
Selenium	5.0[c]
Zinc	123.1[a]

[a]From Buchman (1999) (Threshold Effects Level)
[b]Lowest effect level (Ontario) for total kjeldahl nitrogen (from Haines and others 1994) and converted from milligrams mitrogen per liter to milligrams nitrate per liter.
[c]Sediment quality criterion from British Columbia (Haines and others 1994).

Table 6–16. Plant Toxicity Benchmarks for E-COPC

Ecological Contaminant of Potential Concern	Plant Toxicity Benchmark for Soil[a] (mg/kg)	Plant Toxicity Benchmark for Water[a] (mg/L)
Ammonium	NA	--
Antimony	NA	--
Arsenic	10	0.001
Cadmium	NA	0.1
Chloride	NA	--
Chromium	NA	0.05
Copper	NA	0.06
Iron	--	10
Lead	50	0.02
Manganese	NA	4.0
Molybdenum	NA	0.5
Nitrate	--	--
Selenium	1.0	0.7
Sulfate	NA	--
Thallium	NA	0.05
Uranium	NA	40
Vanadium	NA	0.2
Zinc	50	0.4

[a]From Efroymson and others (1997).

NA = Not applicable
-- = No benchmark available.

For the wildlife receptors, no-observed-adverse-effect levels (NOAELs) for chronic oral exposure are used as benchmarks for toxic effects. The endpoints of particular interest in this assessment are those associated with reproductive health, development, and mortality. Therefore, NOAELs are defined as the maximum dosage tested that produced no effect that would be considered adverse to the receptor's survival, growth, or reproductive capacity. Because the NOAELs for the wildlife receptor species are based on NOAELs from test species, the latter are scaled to NOAELs specific to the wildlife receptor species using a power function of the ratio of body weights, as described by Sample and others (1996) and Sample and Arenal (1999). This scaling is based on the equation:

$$NOAEL_W = NOAEL_T \left(\frac{BW_T}{BW_W}\right)^s$$

where

$NOAEL_W$ is the no-observed-adverse-effect level for the wildlife receptor species (mg/kg-day),
$NOAEL_T$ is the no-observed-adverse-effect level for the test species (mg/kg-day),
BW_T is the body weight of the test species (kg),
BW_W is the body weight of the wildlife receptor species (kg), and
s is the body weight scaling factor; (s = 0.06 for mammals and s = -0.2 for birds (Sample and Arenal 1999).

Toxicity studies were considered to be studies of chronic toxicity if they are conducted over a period of 26 weeks (one-half year) or more. This period represents the period of seasonal use by migratory and hibernating species and is sufficient time for small animals to complete their

reproductive cycles. Studies of lesser duration (i.e., 1 to 25 weeks) are considered of subchronic toxicity, unless they specifically included reproductive effects as endpoints (Sample and others 1996). When only subchronic oral $NOAEL_T$ values were available, these are converted to chronic $NOAEL_T$ values by applying an uncertainty factor of 0.1 (Sample and others 1996).

When only a chronic LOAEL value was available for test data, an uncertainty factor of 0.1 was used to convert it to the chronic $NOAEL_T$. If only a subchronic LOAEL was available, then an uncertainty factor of 0.01 was used to estimate the chronic $NOAEL_T$. This uncertainty factor is the product of two uncertainty factors of 0.1, one to convert the subchronic value to a chronic value and the other to convert the LOAEL to an NOAEL. NOAELs were not determined if toxicity data could not be found for test species within the same class. Therefore, NOAELs for mammalian receptors are derived only from mammalian test species data and NOAELs for avian receptors are derived only from avian test species data. The toxicity data and receptor-specific NOAELs used in this assessment for mammalian and avian receptors are presented in Table 6–17 and Table 6–18, respectively.

6.2.5 Risk Characterization

The potential for risk to ecological receptors is determined through hazard quotients (HQs). HQs are specific to a particular receptor for exposure to a particular E-COPC. An HQ is defined by:

$$HQ = \frac{Exposure}{Benchmark}$$

For aquatic and benthic organisms and plants, exposures are equivalent to media concentrations (surface water or sediment) with which the organism is in contact. For wetland wildlife, exposures are modeled from multiple pathways by the methods described in Section 6.2.4.1. The methods for determining toxicity benchmark values for these receptors are discussed in Section 6.2.4.2.

The value of the HQ is greater than 1.0 if the magnitude of the exposure is greater than the corresponding benchmark, and conversely, the HQ is less than or equal to 1.0 if the exposure is less than or equal to the benchmark. An HQ value less than or equal to 1.0 is interpreted as evidence of no potential risk to that receptor for that E-COPC. If the HQs for an E-COPC are less than unity for all receptors, that E-COPC is eliminated from further consideration as a potential ecological risk driver. However, because exposure for the screening of E-COPCs is conservatively estimated, an HQ value greater than unity is not interpreted as evidence of risk, but only as evidence that the potential for risk cannot be ruled out.

For the purposes of this evaluation, potential exposures were conservatively based on the maximum measured E-COPC in each medium of ecological concern (surface water, sediment, and ground water) at each of the areas evaluated. When sufficient data existed, the UCL_{95} concentrations were used to calculate HQs that better reflect average (yet still conservatively estimated) risks to receptors in these areas. The following are summaries of the risk assessment results for specific media and associated receptor groups.

Table 6–17. Mammal Toxicity Benchmarks for E-COPCs

E-COPC	Mammalian Test Data[a]			Mammalian Receptor NOAELs (mg/kg-day)				
	Test Species	Body weight (kg)	NOAEL (mg/kg-day)	Deer mouse	Muskrat	Raccoon	Red fox	Mule deer
Ammonium	---	---	---	---	---	---	---	---
Antimony	Mouse	0.03	0.125	0.127	0.101	0.0912	0.0925	0.0788
Arsenic	Rabbit	4.396	0.396	0.541	0.430	0.390	0.395	0.37
Cadmium	Rat	0.303	1.0	1.16	0.924	0.838	0.850	0.725
Chloride	---	---	---	---	---	---	---	---
Chromium	Rat	0.350	2,737	3,220	2,550	2,310	2,350	2,000
Copper	Mink	1.0	11.7	14.6	11.6	10.5	10.7	9.11
Iron	---	---	---	---	---	---	---	---
Lead	Rat	0.350	42.0	49.3	39.1	35.5	36.0	30.7
Manganese	Rat	0.35	88.0	103	82.0	74.4	75.5	64.3
Molybdenum	Mouse	0.03	0.26	0.264	0.209	0.190	0.192	0.164
Nitrate	Guinea pig	0.86	507	629	499	452	459	391
Selenium	Rat	0.35	0.20	0.235	0.186	0.169	0.171	0.146
Sulfate	---	---	---	---	---	---	---	---
Thallium	Rat	0.365	0.0074	0.00871	0.00691	0.00627	0.00636	0.00542
Uranium	Mouse	0.028	3.07	3.10	2.46	2.23	2.26	1.93
Vanadium	Rat	0.26	0.21	0.242	0.192	0.174	0.177	0.151
Zinc	Rat	0.35	160	188	149	135	137	117

[a]From Sample and others (1996), except where noted.
[b]Based on information from the Integrated Risk Information System database (EPA 2001).
NA = Not applicable.
--- = Insufficient toxicity information.

Table 6–18. Avian Toxicity Benchmarks for E-COPCs

E-COPC	Avian Test Data[a]			Avian Receptor NOAELs (mg/kg-day)			
	Test Species	Body weight (kg)	NOAEL (mg/kg-day)	Northern harrier	Mallard	Spotted Sandpiper	Belted kingfisher
Ammonium	---	---	---	---	---	---	---
Antimony	---	---	---	---	---	---	---
Arsenic	Mallard	1.0	5.14	3.65	5.27	2.73	3.50
Cadmium	Mallard	1.153	1.45	1.00	1.45	0.749	0.960
Chloride	---	---	---	---	---	---	---
Chromium	Black duck	1.25	1.0	0.679	0.981	0.509	0.652
Copper	Chicken	0.534	47.0	37.8	54.6	28.3	36.3
Iron	---	---	---	---	---	---	---
Lead	Japanese quail	0.15	1.13	1.17	1.69	0.878	1.13
Manganese	Japanese quail	0.072	977	1,170	1,700	879	1,130
Molybdenum	Chicken	1.5	3.53	2.31	3.34	1.73	2.22
Nitrate	---	---	---	---	---	---	---
Selenium	Mallard	1.0	0.40	0.284	0.410	0.213	0.273
Sulfate	---	---	---	---	---	---	---
Thallium	---	---	---	---	---	---	---
Uranium	Black duck	1.25	16.0	10.9	15.7	8.14	10.4
Vanadium	Mallard	1.17	11.4	7.84	11.3	5.87	7.53
Zinc	Chicken	1.935	14.5	9.02	13.0	6.76	8.66

[a]From Sample and others (1996).
NA = Not applicable.
--- = Insufficient toxicity information.

6.2.5.1 Risk to Ecological Receptors Associated with Surface Water and Sediment

Table 6–19 presents the comparison of surface water concentrations (from the Animas River and Lightner Creek) to water quality benchmarks for the protection of aquatic life. These data represent existing surface water conditions at the Durango site. Comparisons are made with both the maximum measured concentration and UCL_{95} values. Of the E-COPCs identified for surface water, only ammonium and sulfate exceeded their respective water quality benchmarks. In the case of ammonium, this was true for both the maximum and UCL_{95} concentrations. However, the HQ value for the UCL_{95} was relatively low (HQ = 2.21). The UCL_{95} for sulfate did not exceed the water quality benchmark.

Table 6–19. Hazard Quotients for Aquatic and Benthic Communities at the Durango Site

E-COPC	Surface Water				Sediment			
	Maximum		UCL_{95}		Maximum		UCL_{95}	
	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient	Concentration (mg/kg)	Hazard Quotient	Concentration (mg/kg)	Hazard Quotient
Ammonium	0.49	**19.1**	0.0575	**2.21**	Not an E-COPC for sediment			
Arsenic	Not an E-COPC for surface water				31.2	**5.29**	19.6	**3.32**
Iron	Not an E-COPC for surface water				32,800	0.174	25,290	0.134
Lead	0.00033	0.132	0.000204	0.0816	159	**4.54**	106	**3.18**
Nitrate	Not an E-COPC for surface water				2.3	0.000943	1.55	0.000635
Selenium	0.003	0.600	0.000764	0.153	1.9	0.380	1.60	0.320
Sulfate	809	**3.24**	146	0.584	Not an E-COPC for sediment			
Zinc	Not an E-COPC for surface water				702	**5.70**	417	**3.39**

Note: Based on comparison of surface water and sediment concentrations to water and sediment quality benchmarks for the protection of aquatic life. See Table 6–14 and Table 6–15 for the surface water and sediment quality benchmarks, respectively.
Hazard quotient values in **Bold** are greater than 1.

The small number of E-COPCs identified for surface water at this site, as determined by comparisons to upstream concentrations, verify previous observations that past milling operations have had very little effect on water quality of the Animas River and Lightner Creek (DOE 1995a). Of the four nonradiological constituents with maximum measured concentrations exceeding the maximum background concentration, three (lead, selenium, and sulfate) had maximum values that only marginally exceeded background and had UCL_{95} values that were approximately equal to or less than their respective UCL_{95} for background. Only ammonium concentrations appear to increase significantly in the Animas River as it passes the Durango site. However, concentrations of ammonium exceeding the water quality standard are sporadic. Of the 61 surface water samples collected at this site between June 1999 and June 2001, only 12 (approximately 1 in 5) have shown ammonium concentrations exceeding the standard. Thus, exposure to high ammonium levels does not appear to be a chronic condition in these surface waters.

Table 6–19 also presents a comparison of the maximum measured E-COPC concentrations in sediment (from the 1993 sampling effort) to sediment quality benchmarks. The maximum and UCL_{95} concentrations of arsenic, lead, and zinc exceeded their respective benchmark values; however, the HQs were relatively low (all HQs for the maximum concentrations were less than 6 and those for the UCL_{95} were less than 3.4). For all three of these E-COPCs, the Animas River background concentrations also exceeded the sediment quality benchmark, and for both lead and zinc, the UCL_{95} values for the site are less than the background concentrations. (At Lightner Creek, all three constituents were found at concentrations less than their corresponding upstream concentrations.) Therefore, these constituents are relatively high in background and HQs within

the range the range of 2 to 4 might well be expected based on background conditions in this area. The contribution of the Durango site appears to be small with regard to potential risk to the benthic communities of the river.

Table 6–20 shows the comparison of maximum sediment concentrations to plant toxicity benchmarks. Arsenic, lead, and zinc again result in HQs greater than unity, as well as selenium. As discussed above, the HQs for arsenic, lead, and zinc can be ascribed primarily to relatively high background concentrations in this area. Selenium can similarly be ascribed to background; the UCL_{95} is equal to the upstream concentration measured at Lightner Creek. Again, the fact that the HQ for zinc exceeded 8 for the UCL_{95}, which was less than the background zinc concentration, indicates both the high background concentrations at this site and the conservative nature of the plant toxicity benchmarks.

Table 6–20. Hazard Quotients for Wetland Plants at the Durango Site

E-COPC	Maximum		UCL_{95}	
	Concentration (mg/kg)	Hazard Quotient	Concentration (mg/kg)	Hazard Quotient
Arsenic	31.2	**3.12**	19.6	**1.96**
Iron	32,800	--	25,290	--
Lead	159	**3.18**	106	**2.12**
Nitrate	2.3	--	1.55	--
Selenium	1.9	**1.90**	1.60	**1.60**
Zinc	702	**14.0**	417	**8.34**

Note: Based on comparison of sediment concentrations to plant toxicity benchmarks. See Table 6–16 for the plant toxicity benchmarks.
-- = No benchmark value available
Hazard quotient values in **Bold** are greater than 1.

Table 6–21 presents the risk results for wetland wildlife exposed to E-COPCs in surface water and sediment at the Durango site through ingestion of water and food. These results indicate only lead and zinc have been measured in these media at concentrations sufficient to indicate potential risk to wildlife. In both cases, the HQs that exceed unity are limited to the spotted sandpiper, which is modeled as having a diet of aquatic invertebrates, with a high incidental consumption rate (18 percent) of sediment. However, as discussed above, neither of these constituents have concentrations that are highly elevated above background levels for sediments, and the UCL_{95} values for these E-COPCs in both water and sediment are within background range. Therefore, the HQs do not represent significant risk to this receptor above background conditions. Table 6–22 presents the HQs for the terrestrial wildlife receptors based on exposures through the ingestion of surface water at the Durango site. All of the HQs that could be determined for these E-COPCs are well below unity for these receptors.

Table 6–21. Hazard Quotients for Wetland Wildlife Along the Animas River at the Durango Site

E-COPC	Muskrat		Raccoon		Mallard		Spotted Sandpiper		Belted Kingfisher	
	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}
Ammonium	--	--	--	--	--	--	--	--	--	--
Arsenic	0.615	0.407	0.430	0.277	0.0187	0.0129	0.244	0.154	0.0162	0.0102
Iron	--	--	--	--	--	--	--	--	--	--
Lead	0.0339	0.0236	0.0250	0.0169	0.293	0.212	**4.08**	**2.71**	0.275	0.182
Nitrate	0.000757	0.000386	0.000725	0.000310	--	--	--	--	--	--
Selenium	0.443	0.366	0.344	0.189	0.137	0.107	0.642	0.275	0.459	0.124
Sulfate	--	--	--	--	--	--	--	--	--	--
Zinc	0.114	0.0806	0.0681	0.0462	0.787	0.573	**3.58**	**2.25**	0.656	0.436

Note: Exposure based on surface water- and sediment-based pathways, including direct ingestion of water and sediment, and ingestion of plants, invertebrates, and fish with tissue concentrations estimated from water concentrations.
-- = No toxicity benchmark available.
Hazard quotient values in **Bold** are greater than 1.

Table 6–22. Hazard Quotients for Terrestrial Wildlife from Drinking Water Along the Animas River at the Durango Site

E-COPC	Deer Mouse		Red Fox		Mule Deer		Northern Harrier	
	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}
Ammonium	--	--	--	--	--	--	--	--
Lead	9.62×10^{-7}	5.95×10^{-7}	7.80×10^{-7}	4.82×10^{-7}	7.01×10^{-7}	4.33×10^{-7}	2.93×10^{-5}	1.81×10^{-5}
Selenium	0.00184	0.000468	0.00149	0.000379	0.00134	0.000341	0.00110	0.000280
Sulfate	--	--	--	--	--	--	--	--

Note: Exposure limited to surface water ingestion from the Animas River and Lightner Creek adjacent to the Durango site.
-- = No toxicity benchmark available.

6.2.5.2 Risk to Ecological Receptors Associated with Ground Water

Few complete exposure pathways potentially exist between ground water at the Durango site and ecological receptors. The most credible of these is the potential for contact with contaminated ground water and by deep-rooted plants, such as phreatophytes (e.g., cottonwoods). Potential risk to such plants was assessed by the comparison of ground water concentrations (maximum and UCL_{95}) to plant toxicity benchmarks based on water concentrations (see Table 6–16). Table 6–23 presents the results of these comparisons for both the mill tailings area and the raffinate ponds area. For the maximum ground water concentrations from the mill tailings area, HQs were greater than unity for arsenic, manganese, vanadium, and zinc. The highest HQ was 6.53 (for zinc). Based on the UC_{95} concentrations, however, only one E-COPC showed an HQ greater than unity (1.28 for zinc). For the maximum ground water concentrations measured at the raffinate ponds area, HQs were greater than unity for arsenic, iron, lead, manganese, selenium, and zinc. The highest HQ among these was 17.6 (for selenium). Again, however, based on the UC_{95} concentrations, only one E-COPC showed an HQ greater than unity (1.22 for selenium). Therefore, the potential for significant risk to deep-rooted plants that may contact either of these ground water plumes is low.

Table 6–23. Hazard Quotients for Deep-Rooted Plants

E-COPC	Ground Water at the Mill Tailings Area				Ground Water at the Raffinate Ponds Area			
	Maximum		UCL_{95}		Maximum		UCL_{95}	
	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient
Ammonium	Not an E-COPC for ground water at this area				9.08	--	2.36	--
Antimony	Not an E-COPC for ground water at this area				0.0022	--	0.000477	--
Arsenic	0.0015	**1.50**	0.000376	0.376	0.0041	0.0015	**1.50**	0.000376
Cadmium	0.0435	0.435	0.00699	0.0699	0.0037	0.0435	0.435	0.00699
Chloride	358	--	96.4	--	1,400	358	--	96.4
Chromium	0.005	0.100	0.00173	0.0346	0.0068	0.005	0.100	0.00173
Copper	Not an E-COPC for ground water at this area				0.0518	0.863	0.00425	0.0708
Iron	Not an E-COPC for ground water at this area				9.78	0.978	1.34	0.134
Lead	Not an E-COPC for ground water at this area				0.0107	0.535	0.000836	0.0418
Manganese	5.4	**1.35**	1.06	0.265	7.07	5.4	**1.35**	1.06
Molybdenum	0.15	0.300	0.0260	0.0520	0.0899	0.15	0.300	0.0260
Nitrate	Not an E-COPC for ground water at this area				50	--	2.33	--
Selenium	0.123	0.176	0.0238	0.0340	12.3	0.123	0.176	0.0238
Sulfate	3,450	--	1,808	--	8,530	3,450	--	1,808
Thallium	Not an E-COPC for ground water at this area				0.00024	0.0048	0.000103	0.00206
Uranium	2.12	0.0530	0.538	0.0135	0.356	2.12	0.0530	0.538
Vanadium	0.448	**2.24**	0.0749	0.375	0.0235	0.448	**2.24**	0.0749
Zinc	2.61	**6.53**	0.510	**1.28**	0.464	2.61	**6.53**	0.510

Note: Based on comparison of ground water concentrations to plant toxicity benchmarks. See Table 6–16 for the plant toxicity benchmarks.
-- = No benchmark available
Hazard quotient values in **Bold** are greater than 1.

Another way by which ecological receptors could be exposed to ground water would be under the hypothetical situation whereby ground water is pumped to a surface pond, and made available to wildlife as a source of drinking water, or creates a habitat for the development of an aquatic or wetland community. To assess potential risk to aquatic and wetland receptors under this hypothetical scenario, the ground water data were evaluated by comparing the maximum and UCL_{95} concentrations to the surface water quality benchmarks for the protection of aquatic life and by evaluating the potential risk to terrestrial and wetland wildlife based on using this water as a sole drinking water source or feeding on the organisms associated with such a habitat. Table 6–24 through Table 6–26 present the results of these evaluations.

Table 6–24. Hazard Quotients for Aquatic Communities

E-COPC	Ground Water at the Mill Tailings Area				Ground Water at the Raffinate Ponds Area			
	Maximum		UCL_{95}		Maximum		UCL_{95}	
	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient	Concentration (mg/L)	Hazard Quotient
Ammonium	Not an E-COPC for ground water at this area				9.08	**349**	2.36	**90.8**
Antimony	Not an E-COPC for ground water at this area				0.0022	0.0733	0.000477	0.0159
Arsenic	0.0015	0.0300	0.000376	0.00752	0.0041	0.0820	0.000619	0.0124
Cadmium	0.0435	**39.5**	0.00699	**6.35**	0.0037	**3.36**	0.000514	0.467
Chloride	358	**1.56**	96.4	0.419	1,400	**6.09**	557	**2.42**
Chromium	0.005	0.0676	0.00173	0.0234	0.0068	0.0919	0.00168	0.0227
Copper	Not an E-COPC for ground water at this area				0.0518	**5.76**	0.00425	0.472
Iron	Not an E-COPC for ground water at this area				9.78	**9.78**	1.34	**1.34**
Lead	Not an E-COPC for ground water at this area				0.0107	**4.28**	0.000836	0.334
Manganese	5.4	**108**	1.06	**21.2**	7.07	**141**	1.07	**21.4**
Molybdenum	0.15	0.625	0.0260	0.108	0.0899	0.375	0.00861	0.0359
Nitrate	Not an E-COPC for ground water at this area				50	**1.13**	2.33	0.0526
Selenium	0.123	**24.6**	0.0238	**4.76**	12.3	**2,460**	0.851	**170**
Sulfate	3,450	**13.8**	1,808	**7.23**	8,530	**34.1**	3,499	**14.0**
Thallium	Not an E-COPC for ground water at this area				0.00024	0.00600	0.000103	0.00258
Uranium	2.12	**1.41**	0.538	0.359	0.356	0.237	0.0593	0.0395
Vanadium	0.448	**23.6**	0.0749	**3.94**	0.0235	**1.24**	0.00137	0.0721
Zinc	2.61	**24.6**	0.510	**4.81**	0.464	**4.38**	0.0497	0.469

Note: Based on comparison of ground water concentrations to water quality benchmarks for the protection of aquatic life. See Table 6-28 for the water quality benchmarks.
Hazard quotient values in **Bold** are greater than 1.

At the mill tailings area, maximum ground water concentrations exceeded surface water quality benchmarks for cadmium, chloride, manganese, selenium, sulfate, uranium, vanadium, and zinc. Based on the UCL_{95} values for this plume, only chloride and uranium drop from this list; the rest still show the potential for risk to aquatic organisms. Manganese showed the highest HQs at this area, with a HQ of 108 for the maximum measured concentration, dropping to 21.2 for the UCL_{95}. Although ground water from this area did not show potential risk to terrestrial wildlife receptors from its use as drinking water, it did show potential risk to wetland wildlife from exposures through the food chain to cadmium, chromium, selenium, vanadium, and zinc at both the maximum and UCL_{95} concentrations (risk from exposure to uranium was also indicated at its maximum measured concentration). Several of these HQs were greater than 10, and two (maximums for cadmium and vanadium) were greater than 100. Because of the potential for risk to ecological receptors in both the aquatic and wetland communities, ground water from this area should not be used as a source for surface ponds or wetlands accessible to wildlife.

Table 6–25. Hazard Quotients for Terrestrial Wildlife from Drinking Water Pumped from Ground Water at the Durango Site

E-COPC	Deer Mouse		Red Fox		Mule Deer		Northern Harrier	
	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}
Mill Tailings Area								
Arsenic	0.000398	0.0000999	0.000323	0.0000810	0.000290	0.0000728	0.0000427	0.0000107
Cadmium	0.00537	0.000863	0.00435	0.000700	0.00391	0.000629	0.00537	0.000726
Chloride	--	--	--	--	--	--	--	--
Chromium	2.24×10^{-7}	7.74×10^{-8}	1.81×10^{-7}	6.27×10^{-8}	1.63×10^{-7}	5.64×10^{-8}	0.000765	0.000265
Manganese	0.00751	0.00147	0.00609	0.00120	0.00548	0.00107	0.000478	0.0000939
Molybdenum	0.0818	0.0142	0.0664	0.0115	0.0596	0.0103	0.00675	0.00117
Selenium	0.0753	0.0146	0.0610	0.0118	0.0549	0.0106	0.0450	0.00871
Sulfate	--	--	--	--	--	--	--	--
Uranium	0.0984	0.0250	0.0797	0.0202	0.0717	0.0182	0.0203	0.00515
Vanadium	0.266	0.0444	0.216	0.0360	0.194	0.0324	0.00594	0.000993
Zinc	0.00200	0.000390	0.00162	0.000316	0.00146	0.000284	0.0301	0.00588
Raffinate Ponds Area								
Ammonium	--	--	--	--	--	--	--	--
Antimony	0.00250	0.000541	0.00202	0.000439	0.00182	0.000395	--	--
Arsenic	0.00109	0.000164	0.000883	0.000133	0.000794	0.000120	0.000117	0.0000176
Cadmium	0.000457	0.0000635	0.000370	0.0000515	0.000333	0.0000463	0.000384	0.0000534
Chloride	--	--	--	--	--	--	--	--
Chromium	3.04×10^{-7}	7.51×10^{-8}	2.47×10^{-7}	6.09×10^{-8}	2.22×10^{-7}	5.48×10^{-8}	0.00104	0.000257
Copper	0.000509	0.0000418	0.000413	0.0000338	0.000371	0.0000304	0.000142	0.0000117
Iron	--	--	--	--	--	--	--	--
Lead	0.0000312	2.44×10^{-6}	0.0000253	1.98×10^{-6}	0.0000227	1.78×10^{-6}	0.000949	0.0000741
Manganese	0.00984	0.00149	0.00797	0.00121	0.00717	0.00108	0.000626	0.0000947
Molybdenum	0.0491	0.00470	0.0398	0.00381	0.0358	0.00342	0.00404	0.000387
Nitrate	0.0114	0.000533	0.00927	0.000432	0.00834	0.000389	--	--
Selenium	**7.53**	0.521	**6.10**	0.422	**5.49**	0.380	**4.50**	0.311
Sulfate	--	--	--	--	--	--	--	--
Thallium	0.00396	0.00170	0.00321	0.00138	0.00289	0.00124	--	--
Uranium	0.0165	0.00275	0.0134	0.00223	0.0120	0.00201	0.00341	0.000567
Vanadium	0.0139	0.000813	0.0113	0.000659	0.0102	0.000593	0.000311	0.0000182
Zinc	0.000355	0.0000380	0.000288	0.0000308	0.000259	0.0000277	0.00535	0.000573

NOTE:Exposure limited to the ingestion of ground water under the assumption that it is pumped to the surface and made available to wildlife.
--- = No toxicity benchmark available.
Hazard quotient values in **Bold** are greater than 1.

Table 6–26. Hazard Quotients for Wetland Wildlife from Water Pumped from Ground Water at the Durango Site

E-COPC	Muskrat		Raccoon		Mallard		Spotted Sandpiper		Belted Kingfisher	
	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}	Maximum	UCL_{95}
Mill Tailings Area										
Arsenic	0.00403	0.00177	0.00991	0.00273	0.000332	0.000126	0.00483	0.00121	0.00261	0.000655
Cadmium	0.137	0.0494	**17.5**	**2.82**	0.604	0.109	**23.8**	**3.82**	**159**	**25.5**
Chloride	--	--	--	--	--	--	--	--	--	--
Chromium	0.00000472	0.00000163	0.000167	0.0000576	0.0883	0.0302	**3.49**	**1.21**	0.486	0.168
Manganese	0.880	0.173	0.436	0.0855	0.0305	0.00598	0.0483	0.00947	0.0297	0.00582
Molybdenum	0.851	0.147	0.679	0.118	0.0387	0.00671	0.117	0.0203	0.207	0.0359
Selenium	0.156	0.0274	**6.90**	**1.34**	0.467	0.0895	**18.5**	**3.58**	**18.3**	**3.55**
Sulfate	--	--	--	--	--	--	--	--	--	--
Uranium	0.691	0.175	**1.44**	0.366	0.0925	0.0235	0.879	0.223	**1.65**	0.491
Vanadium	0.271	0.0454	**195**	**32.5**	0.622	0.104	**27.1**	**4.53**	**3.27**	0.547
Zinc	0.0308	0.0121	0.622	0.124	**1.42**	0.326	**51.7**	**10.1**	**19.4**	**3.80**
Raffinate Ponds Area										
Ammonium	--	--	--	--	--	--	--	--	--	--
Antimony	0.0155	0.00337	0.0129	0.00280	--	--	--	--	--	--
Arsenic	0.00743	0.00238	0.0259	0.00432	0.000707	0.000177	0.0132	0.00199	0.00715	0.00108
Cadmium	0.0347	0.0117	**1.50**	0.210	0.0616	0.0116	**2.02**	0.281	**13.5**	**1.88**
Chloride	--	--	--	--	--	--	--	--	--	--
Chromium	0.00000642	0.00000159	0.000226	0.0000560	0.120	0.0297	**4.75**	**1.17**	0.661	0.163
Copper	0.0125	0.00453	0.493	0.0416	0.0202	0.00218	0.805	0.0661	0.207	0.0170
Iron	--	--	--	--	--	--	--	--	--	--
Lead	0.00167	0.000395	0.0392	0.00315	0.194	0.0193	**7.30**	0.570	0.956	0.0747
Manganese	**1.15**	0.174	0.570	0.0863	0.0399	0.00603	0.0632	0.00956	0.0388	0.00588
Molybdenum	0.510	0.0488	0.407	0.0390	0.0232	0.00222	0.0702	0.00672	0.124	0.0119
Nitrate	0.0166	0.000775	0.0164	0.000765	--	--	--	--	--	--
Selenium	**21.3**	**1.22**	**692**	**47.8**	**48.5**	**3.28**	**1,850**	**128**	**1,830**	**127**
Sulfate	--	--	--	--	--	--	--	--	--	--
Thallium	0.00409	0.00176	0.120	0.0513	--	--	--	--	--	--
Uranium	0.116	0.0193	0.242	0.0404	0.0155	0.00259	0.148	0.0246	0.277	0.0462
Vanadium	0.0142	0.000830	**10.2**	0.595	0.0327	0.00190	**1.42**	0.0828	0.172	0.0100
Zinc	0.0115	0.00326	0.113	0.0127	0.300	0.0483	**9.19**	0.985	**3.46**	0.370

NOTE: Exposure based on surface water- and sediment-based pathways, including direct ingestion of water and sediment, and ingestion of plants, invertebrates, and fish (with tissue concentrations estimated from water concentrations) under the assumption that ground water is pumped to the surface and used to create a pond or wetland.
--- = No toxicity benchmark available.

At the raffinate ponds area, maximum ground water concentrations exceeded surface water quality benchmarks for ammonium, cadmium, chloride, copper, iron, lead, manganese, nitrate, selenium, sulfate, vanadium, and zinc. Based on the UCL_{95} values for this plume, only ammonium, chloride, iron, manganese, selenium, and sulfate still show risk to aquatic organisms. Selenium showed the highest HQs at this area, with an HQ of 2,460 for the maximum measured concentration, dropping to 170 for the UCL_{95}. Selenium, at least at the maximum concentration measured at this area, also showed potential risk to terrestrial wildlife receptors if used as drinking water. Among the E-COPCs showing potential risk to wetland wildlife from exposures through the food chain were cadmium, chromium, lead, manganese, selenium, vanadium, and zinc. Maximum selenium HQs were greater than 1,800 for the spotted sandpiper and kingfisher. Because of the potential for risk to ecological receptors in both the aquatic and wetland communities, ground water from this area should not be used as a source for surface ponds or wetlands that are accessible to wildlife.

6.2.5.3 Potential Risks from Radionuclides

Potential risks from radiological E-COPCs were evaluated using the screening-level benchmarks for aquatic biota (specifically large and small fish) derived for Oak Ridge National Laboratory (Bechtel Jacobs 1998b), as based on the methodology for estimating dose rates for aquatic biota developed by Blaylock and others (1993). In addition to these ecological-based benchmarks, CDPHE has established a water quality standard for radium-226+288 (total) at 5 pCi/L and for uranium (total) at 40 pCi/L (the latter is specific to the Animas River basin).

Radionuclide analyses of surface water and ground water samples from the Durango site have included uranium-238 and four of its daughter isotopes (radium-226, thorium-230, lead-210, and polonium-210), as well as uranium-234, radium-228, gross alpha, and gross beta activity. As shown in Table 6–27, all of these analytes except lead-210 and radium-228 have been identified as E-COPCs in the surface water at this site. Ecological benchmarks were available for all radiological analytes except gross alpha and gross beta. All of the HQs that can be determined for these radiological E-COPCs in the surface water are well below 1. Further, the sum of the maximum concentrations of radium-226 (0.21 pCi/L) and radium-228 (<1 pCi/L) is well below the CDPHE standard for these isotopes. Similarly, total uranium (uranium-234 plus uranium-238) for the surface water at this site is 10.2 pCi/L, which is also well below the CDPHE water quality standard of 40 pCi/L.

Table 6–27. Hazard Quotients for Radiological E-COPCs in Surface Water Based on Maximum Measured Activities

E-COPC	Ecological Benchmark Value[a] (pCi/L)[b]	Durango Site	
		Maximum Measured Activity (pCi/L)	Hazard Quotient
Gross Alpha	---	17.9	ND
Gross Beta	---	16.7	ND
Polonium-210	725	0.08	0.000110
Radium-226	160	0.21	0.00250
Thorium-230	413	4.1	0.00993
Uranium-234	4,040	5.6	0.00139
Uranium-238	4,550	4.6	0.00101

[a]Benchmark is the minimum for large and small fish (from Bechtel Jacobs 1998b).
[b]Picocuries per liter.
--- = No benchmark available.
ND = Not determined.

In the ground water at the mill tailings area, gross alpha and beta, polonium-210, radium-226 and -228, and uranium-234 and -238 were identified as E-COPCs. At the raffiante ponds area, all of these except radium-226 were identified as E-COPCs. Table 6–28 presents the comparison (as HQs) of the maximum concentrations of these radionuclides to their ecological screening benchmark values. Although no benchmark was available for radium-228, the HQs for the other radionuclides were less than unity. Therefore, potential doses to aquatic biota (particularly to fish) from ground water pumped to a surface pond should not pose a risk to these receptors. The total of the maximum concentrations of radium-226 and -228 at these areas (1.16 pCi/L at the mill tailings area and 1.53 pCi/L at the raffiante ponds area) were below the CDPHE standard for these isotopes. However, the total uranium concentration in ground water at both areas significantly exceeded the CDPHE standards for surface water. Therefore, these waters should not be used as a source of surface water.

Table 6–28. Hazard Quotients for Radiological E-COPCs in Ground Water Based on Maximum Measured Activities

E-COPC	Ecological Benchmark Value[a] (pCi/L)[b]	Mill Tailings Area		Raffinate Ponds Area	
		Maximum Measured Activity (pCi/L)	Hazard Quotient	Maximum Measured Activity (pCi/L)	Hazard Quotient
Gross Alpha	---	1,655	ND	261	ND
Gross Beta	---	666	ND	161	ND
Polonium-210	725	0.1	0.000138	1.12	0.00154
Radium-226	160	0.46	0.00288	Not an E-COPC in this area	
Radium-228	---	0.7	ND	0.99	ND
Uranium-234	4,040	732	0.181	105	0.0260
Uranium-238	4,550	766	0.168	111	0.0244

[a]Benchmark is the minimum for large and small fish (from Bechtel Jacobs 1998b).
[b]Picocuries per liter.
--- = No benchmark available.
ND = Not determined.

6.2.5.4 Potential Risks to Sensitive Species

As stated in Section 6.2.2, the southwestern willow flycatcher is an endangered species that has the potential for occurring in the riparian habitat along the Animas River at or near the Durango site. The diet of the southwestern willow flycatcher principally consists of flying insects, at least some of which possibly having been exposed to water or sediment of the site during their development. The spotted sandpiper, which was modeled as having a diet consisting entirely of invertebrates exposed to E-COPCs in the surface water of the site, and with additional exposure through direct ingestion of sediments from the site, conservatively represents potential exposure and risk to the southwestern willow flycatcher individuals that may occur at the site (the southwestern willow flycatcher, for example, is not expected to have as high a sediment ingestion rate as the sandpiper). For the spotted sandpiper, some potential risk was indicated from exposure to lead and zinc as indicated by HQs exceeding unity. However, as described in Section 6.2.5.1, the exposures to lead and zinc in the spotted sandpiper at this site are within the range of background for the area. Therefore, the potential for risk to the southwestern willow flycatcher is also expected to be within background ranges.

6.2.6 Recent Data

The results described above were based on monitoring data collected between June 1999 and June 2001 (with the exception of the sediment data, which were from a single sampling round conducted in 1993). Subsequent to the completion of the risk analyses described in this section, the ground water and surface water monitoring data for the August 2001 sampling round were received and validated. In addition, data from January 2001 sediment samples (from each of the surface water sampling locations) were also received. These most recent data are described in the following paragraphs qualitatively with regard to their potential implications to the risk results and conclusions.

For the mill tailings area ground water plume, the August 2001 sampling data showed a large increase in the maximum measured lead concentration, from 0.00043 mg/L to 0.0023 mg/L; however, because the new maximum equaled but did not exceed the maximum background concentration, lead would still not be considered an E-COPC for this plume. Smaller increases in the maximum site concentrations from the August 2001 data were also seen for sulfate (a 2 percent increase to 3,510 mg/L) and zinc (a 3 percent increase to 2.68 mg/L). Neither of these increases will significantly affect the risk results for this plume. Other analytes were within the ranges of the June 1999 through June 2001 data. Chromium and radium-228, identified as E COPCs for this plume, were not detected in the August 2001 samples.

For the raffinate ponds area ground water plume, the August 2001 sampling data showed significant increases in the maximum measured concentrations for selenium (from 12.3 to 19.4 mg/L) and thorium-230 (from less than 3.2 to 9.8 pCi/L). Therefore, the potential for risk to aquatic organisms and wetland wildlife from exposure to selenium (from ground water pumped to the surface from this ground water plume) continues to be considered very high, and for deep-rooted plants will probably remain medium-low; however, the potential for risk to terrestrial wildlife receptors would be increased from very low to low based on this higher maximum. Section 6.4 discusses the categories of potential risk. Although the new maximum for thorium-230 would identify this radionuclide as an E-COPC for this plume based on the comparison to the background maximum, it is still well below the risk benchmark of 413 pCi/L, indicating no risk. Smaller increases in the maximum site concentrations from the August 2001 data were also seen for cadmium (an 11 percent increase to 0.0041 mg/L) and chloride (a 9 percent increase to 1,520 mg/L). Neither of these increases will significantly affect the risk results for this plume. The other analytes were within the ranges of the June 1999 through June 2001 data. Antimony, arsenic, chromium molybdenum, thallium, and radium-228, identified as E-COPCs for this plume, were found to be within the range of background in the August 2001 samples. Of these, antimony, molybdenum, and thallium were not detected. In the case of radium-228, although the August 2001 maximum (1.02 pCi/L) was slightly greater than the previous maximum, the background maximum increased to 1.56 pCi/L based on the new data.

In the case of surface water, concentrations of all nonradiological E-COPCs identified from the June 1999 through June 2001 data were found to be within background ranges in the August 2001 data. Therefore, potential risks from exposures to these E-COPCs in surface water will be within the range of background risk. For the radiological analytes, only radium-226 and thorium-230 were detected. (uranium-234 and uranium-238 were not evaluated in the August 2001 samples.) Gross-alpha and gross-beta activities were within background ranges. The maximum background concentration for radium-226 increased to 0.27 pCi/L, which put all previous site

data within the range of background. Although the maximum background for thorium-230 also increased (to 3.3 pCi/L), the new site maximum (6.5 pCi/L) still exceeded background; however, this new maximum is still much less than the risk benchmark of 413 pCi/L. Therefore, based on the August 2001 surface water results, no risks to ecological receptors are predicted.

The 2001 sediment sampling included ten site locations and five background (upgradient) locations. The sediment samples were analyzed for the same suite of metals used in the 1993 analyses (arsenic, cadmium, iron, lead, manganese, mercury, molybdenum, selenium, uranium, and zinc), as well as for nitrate and sulfate. These analyses were performed on "wet" samples (as received by the laboratory); however, corresponding moisture content measurements were not taken. Therefore, the reported concentration values are expected to be less than those that would be based on the dry weight of the sediment, and for this reason are not exactly comparable to the 1993 sediment sampling results or to dry-weight-based benchmark concentrations. However, some general patterns of concentration distributions were observed in these data that shed light on the possible sources of metal concentrations along the Animas River at the Durango site.

For example, concentrations of all of the metals exceeded their respective maximum background (upgradient) concentration in at least one sample; however, nitrate and sulfate, which are E-COPCs in one or both ground water plumes and are expected to be mobile in ground water and migrate with the plumes, were detected at levels within the range of the background samples. Further, for all metals except mercury, the maximum measured concentration came from a single sample, 0691, which is located on the Animas River adjacent to the downstream end of the old smelter site. In all of these cases except zinc, all other samples were within the background range or very close to the maximum background value (for zinc, only one other sample [location 0584] exceeded the background range by a significant degree). In several cases (cadmium, iron, lead, manganese, molybdenum, uranium, and zinc), the concentration measured in the sample from location 0691 exceeded to maximum background by at least twofold (to about 100-fold for cadmium). These data indicate a hot spot of high metal concentrations in the sediment at location 0691, which is likely to be associated with the historical use of the adjacent area as a smelter.

For mercury, three samples had concentrations that exceeded the background data range (concentrations of all background samples were less than the detection limit of 0.02 mg/kg). These were locations 0583 (0.039 mg/kg), 0691 (0.053 mg/kg), and 0587 (0.063 mg/kg). Although mercury was not detected on the 1993 sediment samples, the higher detection limit of that analytical method (0.1 mg/kg dry weight) might not have detected mercury at the levels found in the 2001 samples. Mercury has not been considered a COPC in ground water at the mill tailings area or the raffinate ponds area or the surface water of the site. The 1997 EPA study concluded that the locally elevated mercury levels in sediment were not attributable to past milling operations (see Section 4.7.2). Although mercury was not evaluated in this risk assessment, the concentrations, albeit based on the wet weight of sediment, are well below the sediment quality benchmark of 0.174 mg/kg dry weight, as presented by Buchman (1999).

6.2.7 Ecological Risk Summary

For the purpose of summarization, the receptors are categorized into six groups: aquatic organisms, benthic organisms, deep-rooted plants, wetland plants, terrestrial wildlife, and wetland wildlife. One or more of these groups may be exposed to the different media evaluated in this assessment at each of the two sites. These media include surface water, sediment, food (exposed to E-COPCs in

water or sediment), and ground water. Further, the potential risk to each group based on the HQs presented earlier in this section was categorized as follows:

- None: HQs less than or equal to 1 for both the maximum and UCL_{95} concentrations
- Very low: Maximum HQs less than 10 but greater than 1; UCL_{95}-based HQs less than 1
- Low: Both maximum and UCL_{95}-based HQs less than 10, but greater than 1
- Medium-Low: Maximum HQ greater than or equal to 10 but less than 100; UCL_{95}-based HQs less than 10
- Medium: Both maximum and UCL_{95}-based HQs greater than or equal to 10 but less than 100
- High: Maximum HQ greater than or equal to 100 but less than 1,000; UCL_{95}-based HQs greater than 10
- Very high: Maximum HQs greater than or equal to 1,000.

Table 6–29 presents the results of this categorization of potential risk. In the cases where multiple receptors are included in the receptor group (i.e., the terrestrial and wetland wildlife groups), the risk is based on the highest (worst-case) risk result among the receptors. Because many conservatisms were incorporated in the calculation of these HQs, including the use of maximum and UCL_{95} values as exposure point concentrations, the use of conservative toxicity benchmarks, such as water quality criteria and NOAELs, and the assumption of 100 percent area and seasonal use, the HQs are expected to overestimate actual risk to most individual receptors, and therefore, risks categorized as medium-low to none are not expected to represent significant potential risks to populations of nonsensitive species. Although for those receptor groups that may include sensitive species, risk categorizations of medium-low to low might still be considered to be of concern; as discussed in Section 6.2.5.4, the indicated low risks for wetland receptors (including the southwestern willow flycatcher) from exposure to lead and zinc along the Animas River are expected to be within the range of background.

Table 6–30 summarizes the E-COPCs that remain at each of the evaluated areas. These constituents are considered to be of potential concern because their concentrations in environmental media indicate a potential for adverse toxicological effects to ecological receptors. Ammonium was the only E-COPC identified as a potential risk driver in surface water. Ammonium concentrations have been found sporadically at concentrations exceeding the CDPHE standard for the Animas River. Because of the sporadic nature of these exceedences, the rapid dilution by the river, and the ability of organisms to use ammonium as a nutrient, this E-COPC does not pose a significant hazard to the aquatic systems below the site. No E-COPCs were identified for the sediments at this site, in part due to the relatively high natural concentrations that exist in the area. Although low and medium-low were indicated for some receptors exposed to E-COPCs in sediment from the site, similar levels of risk were also indicated from exposure to background levels of these constituents.

Table 6–29. Summary of Potential Ecological Risks at the Durango Site

E-COPC	Aquatic Organisms	Benthic Organisms	Wetland Plants	Wetland Wildlife	Terrestrial Wildlife	Deep-Rooted Plants
(principal exposure media)	Surface water	Sediment	Sediment	Surface water Sediment Food	Surface water	Ground water
Surface Water (Animas River and Lightner Creek)						
Ammonium	Medium-low	NA	NA	--	--	NA
Arsenic	NA	Low	low	none	NA	NA
Iron	NA	None	--	--	NA	NA
Lead	None	Low	low	low	none	NA
Nitrate	NA	None	--	none[a]	NA	NA
Selenium	None	None	low	none	none	NA
Sulfate	Very low	NA	NA	--	--	NA
Zinc	NA	Low	medium-low	low	NA	NA
Mill Tailings Area Ground Water Plume[b]						
Arsenic	None	NA	NA	none	none	very low
Cadmium	Medium-low	NA	NA	high	none	None
Chloride	Very low	NA	NA	--	--	--
Chromium	None	NA	NA	low	none	None
Manganese	High	NA	NA	none	none	very low
Molybdenum	None	NA	NA	none	none	None
Selenium	Medium-low	NA	NA	medium-low	none	None
Sulfate	Medium-low	NA	NA	--	--	--
Uranium	Very low	NA	NA	very low	none	None
Vanadium	Medium-low	NA	NA	high	none	very low
Zinc	Medium-low	NA	NA	medium	none	Low
Raffinate Ponds Area Ground Water Plume[b]						
Ammonium	High	NA	NA	--	--	--
Antimony	None	NA	NA	none[a]	none[a]	--
Arsenic	None	NA	NA	none	none	very low
Cadmium	Very low	NA	NA	medium-low	none	None
Chloride	Low	NA	NA	--	--	--
Chromium	None	NA	NA	low	none	None
Copper	Very low	NA	NA	none	none	None
Iron	Low	NA	NA	--	--	None
Lead	Very low	NA	NA	low	none	None
Manganese	High	NA	NA	very low	none	very low
Molybdenum	None	NA	NA	none	none	None
Nitrate	Very low	NA	NA	none[a]	none[a]	--
Selenium	Very high	NA	NA	very high	very low	Medium-low
Sulfate	Medium	NA	NA	--	--	--
Thallium	None	NA	NA	none[a]	none[a]	None
Uranium	None	NA	NA	none	none	None
Vanadium	Very low	NA	NA	very low	none	None
Zinc	Very low	NA	NA	very low	none	very low

[a]Avian benchmark not available. Risk based on mammalian receptors only.
[b]Exposures to aquatic organisms and wildlife based on the hypothetical scenario that ground water is pumped to a surface pond or wetland.
-- = No hazard quotients available.
NA = Not applicable to this area.

Table 6–30. Summary of E-COPC at the Durango Site Based on the Ecological Risk Screening Results

Animas River and Lightner Creek		**Ground Water Plume[a]**	
Surface water	Sediment	Mill Tailings Area	Raffinate Ponds Area
Ammonium	(none)	Cadmium	Ammonium
		Manganese	Cadmium
		Selenium	Manganese
		Sulfate	Selenium
		Vanadium	Sulfate
		Zinc	Uranium-234
		Uranium-234	Uranium-238
		Uranium-238	

[a]Potential risk to deep-rooted plants from exposure to ground water is limited to selenium at the raffinate ponds area.

For the surface waters and sediments of Lightner Creek and the Animas River, the potential for ecological risk was generally low. Medium-low potentials for risk to aquatic organisms and wetland plants were associated with ammonium and zinc, respectively. For ground water, high potentials for risks to ecological receptors were found at the mill tailings area plume for cadmium, manganese, and vanadium, and very high potentials for risk were found at the raffinate ponds area plume for selenium; high potentials were also indicated for ammonium and manganese. The concentrations of uranium in the ground water at both of these sites exceed the CDPHE surface water quality standard (see Section 6.2.5.3). For these reasons, ground water in these plumes is considered unsuitable for use in surface ponds or wetlands. However, the ground water at these sites does not appear to pose a significant risk to either deep-rooted plants or terrestrial wildlife (if hypothetically used as a drinking water source).

End of current text