This appendix presents the estimated costs, economic impacts, and benefits of regulatory options under two alternative baselines, the "no prior treatment" baseline and the "prior treatment" baseline, for mineral processing wastes under Phase IV LDRs. Under the no prior treatment baseline, wastes are assumed to be managed, untreated, in unlined surface impoundments and waste piles, i.e., the practices that were generally in place prior to removal of these wastes from the Bevill exclusion in 1989 and 1990. Under the prior treatment baseline, wastes are either treated to UTS levels and disposed in a Subtitle D unit or stored prior to recycling in tanks, containers, and buildings if they are spent materials or in unlined land based units if they are sludges or byproducts. The prior treatment baseline assumes facility operators clearly understand the Subtitle C regulations that apply to their secondary materials, i.e., that spent materials intended for recycling are not currently excluded from Subtitle C regulation.

Although the costs and economic impacts under the no prior treatment baseline were analyzed in the December 1995 RIA to the proposed rule, they are not analyzed in today's RIA because the costs of managing wastes with no prior treatment are not properly attributed to this rule. In addition, while the prior treatment baseline may more accurately assess the cost attributable to this rulemaking than the modified prior treatment baseline (i.e., the baseline used in the main analysis), EPA believes the modified prior treatment baseline more accurately reflects actual practice in the mineral processing industry. In both cases, however, EPA has elected to present the cost and benefits attributable to these other baselines in this Appendix.

The methodology for estimating the costs and economic impacts under these alternative baselines is the same as the methodology used in the primary analysis, which is discussed in Section 3.1. The estimated costs and economic impacts under these baselines are presented in Section A.1 of this Appendix. Section A.2 presents the results of the risk analysis for the no prior treatment baseline. Additional information supporting the risk analysis is included in Section A.3.

A.1 Costs and Impacts

In developing its estimates of the proposed rule's costs and economic impacts, EPA used a dynamic analysis to predict changes in the management of newly identified mineral processing wastes. The dynamic analysis accounts for a shift in the amount of material that is recycled rather than being treated and disposed due to incentives and disincentives for future recycling. EPA estimated the percentage of hazardous material sent to treatment and disposed for each baseline and option. The *remaining* hazardous material is considered to be recycled. The dynamic analysis reflects the shifts in management anticipated in each baseline/option combination.

Exhibit A.1-1 presents required changes in management practices as a result of the proposed Phase IV Land Disposal Restrictions for the wasted portion and the recycled portion of hazardous mineral processing secondary materials for the four regulatory options. Exhibit A.1-2 presents the predicted changes in recycling, given the required changes in management practices listed in Exhibit A.1-1. The information in Exhibit A.1-2 combines into an overall impact <u>all</u> incentives operating at a facility. For instance, under Option 3 assuming the modified prior treatment baseline, Exhibit A.1-1 suggested that there would be (1) no change in the amount recycled due to treatment requirements, and (2) a decrease in the amount recycled because of the stricter recycling unit standards. Because, however, the incremental cost of storing material in a tank, container, or building prior to recycling is usually less than the cost of moving that material to treatment and disposal, the <u>overall</u> predicted effect of this option-baseline

combination is a small decrease in the amount of material recycled. (That is, a facility operator in this option-baseline combination would usually pay the extra cost of storage rather than changing management practices.)

Exhibit A.1-1

Changes in Management of Hazardous Mineral Processing Waste

Baseline/Option	Affected Material	Required Change in Management	Implied Change In Recycling
NPT	Wasted Portion	Disposal to UTS and Disposal	Increase
MPT/PT		TC to UTS	No Change
NPT/MPT to Option 1	Non- Bevill	Unlined Units to RCRA TCBs Legitimacy Test, Sig. Aff.	Decrease
	Bevill	Unlined Units to No Recycling	Complete Halt
NPT/MPT to Option 2	Non-Bevill	Unlined Units toTCBs	Decrease
	Bevill	Unlined Units to No Recycling	Complete Halt
NPT/MPT to Option 3	All	Unlined Units to TCBs	Decrease
NPT/MPT to Option 4	All	Unlined Units to Unlined Units	No Change
PT (SL/BP) to Option 1	Non- Bevill	Unlined Units to RCRA TCBs Legitimacy Test, Sig. Aff.	Decrease
	Bevill	Unlined Units to No Recycling	Complete Halt
PT (SL/BP) to Option 2	Non-Bevill	Unlined Units toTCBs	Decrease
	Bevill	Unlined Units to No Recycling	Complete Halt
PT (SL/BP) to Option 3	All	Unlined Units to TCBs	Decrease
PT (SL/BP) to Option 4	All	Unlined Units to Unlined Units	No Change
PT (SM) to Option 1	Non- Bevill	TCBs to RCRA TCBs Legitimacy Test, Sig. Aff.	Decrease
	Bevill	TCBs to No Recycling	Complete Halt
PT (SM) to Option 2	Non-Bevill	TCBs toTCBs	No Change
	Bevill	TCBs to No Recycling	Complete Halt
PT (SM) to Option 3	All	TCBs to TCBs	No Change
PT (SM) to Option 4	All	TCBs to Unlined Units	No Change

Option 1 - Storage in RCRA Tanks, Containers, and Buildings Only, Recycling of Materials through Bevill Units Prohibited

Option 2 - No Land-based Storage Recycling of Materials through Bevill Units Prohibited

Option 3 - No Land-based Storage

Option 4 - Land-based Storage without restriction

Bevill means that secondary materials are recycled through beneficiation or Bevill process units

Non-Bevill means that secondary materials are not recycled through beneficiation or Bevill process units

Exhibit A.1-2

Overall Predicted Changes in Recycling

	Option 1*	Option 2 *	Option 3	Option 4
No Prior Treatment	Small Decrease	Increase	Increase	Big Increase
Modified Prior Treatment and Prior Treatment (SL/BP)	Moderate Decrease	Small Decrease	Small Decrease	No Change
Prior Treatment (SM)	Decrease	No Change	No Change	Increase

* For materials recycled through non-Bevill Units only. Materials recycled through Bevill units will completely cease to be recycled under Options 1 and 2.

Exhibit A.1-3 presents the percentages of the hazardous portion of mineral processing waste streams that are sent to treatment and disposal, in both the baseline and post-rule options, and Exhibit A.1-4 presents the percentages stored prior to recycling. Exhibits A.1-3 and A.1-4 are based on (1) the overall predicted changes in recycling listed in Exhibit A.1-2 and (2) empirical data, as described below. For option-baseline combinations that eliminate the differences in regulatory requirements for recycled sludges, by-products, and spent materials, the proportion of material recycled is the same for all three types of material after the rule goes into effect. Lastly, Exhibit A.1-5 shows the change in recycling percentage for each option-baseline combination. For option-baseline combinations that increase recycling, the largest shift is seen in Y? materials, and the smallest shift is seen in YS? materials. The opposite is true for option-baseline combinations that decrease recycling. Generally the largest shift should be seen in the YS? case. This trend is not always apparent, however, because the percentage recycled is limited to the range from 0 to 100 percent.

The limited available data on the recycling of two listed wastes, K061 (emission control dust from electric arc steel furnaces) and F006 (wastewater treatment sludge from electroplating operations) were used to quantify the expected shift in recycling. These data were used due to the fact that an increase in the amount of K061 and F006 being recycled was observed after Land Disposal Restrictions (LDRs) for K061 and F006 were promulgated.[1] A 75 percent increase in K061 recycling was observed after the LDR for K061 was implemented, from an average of 15 percent recycled pre-LDR to 90 percent recycled post-LDR. Similarly, a 15-20 percent increase in the amount of F006 recycling was observed as a result of the F006 LDR, from 0 percent recycled pre-LDR to 15-20 percent recycled post-LDR.[2] Therefore, in the December 1995 RIA, the Agency modeled the 75 percent shift for Y? materials from the No Prior Treatment Baseline to Option 2 on K061, and the 15 percent shift for YS? materials from the No Prior Treatment Baseline to Option 2 on F006. Because Option 2 in the December RIA is no longer modeled, and Options 2 and 3 of todays proposal require slightly more expensive storage units (tanks, containers, and buildings instead of lined land-based units, EPA adjusted these data slightly for use in Options 2 and 3 of todays RIA. The predicted shift in these two options for Y? material is 70 percent and the predicted

[1] *1990 Survey of Selected Firms in the Hazardous Waste Management Industry*, Final Report, U.S. E.P.A. Office of Policy Analysis, (July 1992).

[2] *Report to Congress on Metal Recovery, Environmental Regulation, & Hazardous Waste*, U.S. E.P.A., Washington, D.C., (February 1994).

shift for YS? materials is 10 percent. EPA used best professional judgement to estimate the shifts in the other option-baseline combinations.

Exhibit A.1-3
Proportions of Waste Streams Treated and Disposed (in percent)

Baseline or Option	Affected Material	Percent Recycled				
		Certainty of Recycling				
		Y	Y?	YS	YS?	N
Prior Treatment	SL/BP	0	15	25	80	100
Prior Treatment	SM	0	25	35	85	100
Modified Prior Treatment	All	0	15	25	80	100
No Prior Treatment	All	0	100	60	100	100
Option 1 from PT	Bevill	100	100	100	100	100
	Non-Bevill	30	65	100	100	100
Option 2 from PT	Bevill	100	100	100	100	100
	Non-Bevill	0	25	35	85	100
Option 3 from PT	All	0	25	35	85	100
Option 4 from PT	All	0	15	25	80	100
Option 1 from MPT	Bevill	100	100	100	100	100
	Non-Bevill	30	65	100	100	100
Option 2 from MPT	Bevill	100	100	100	100	100
	Non-Bevill	0	25	35	85	100
Option 3 from MPT	All	0	25	35	85	100
Option 4 from MPT	All	0	15	25	80	100
Option 1 from NPT	Bevill	100	100	100	100	100
	Non-Bevill	20	100	90	100	100
Option 2 from NPT	Bevill	100	100	100	100	100
	Non-Bevill	0	30	40	85	100
Option 3 from NPT	All	0	30	40	85	100
Option 4 from NPT	All	0	15	25	80	100

Notes:

Y means that EPA has information indicating that the waste stream is fully recycled.
Y? means that EPA, based on professional judgment, believes that the waste stream could be fully recycled.
YS means that EPA has information indicating that a portion of the waste stream is fully recycled.
YS? means that EPA, based on professional judgment, believes that a portion of the waste stream could be fully recycled.
Bevill means that secondary materials are recycled through beneficiation or Bevill process units
Non-Bevill means that secondary materials are not recycled through beneficiation or Bevill process units

Exhibit A.1-4

Proportions of Waste Streams Stored Prior to Recycling (in percent)

Baseline or Option	Affected Material	Percent Recycled				
		Certainty of Recycling				
		Y	Y?	YS	YS?	N
Prior Treatment	SL/BP	100	85	75	20	0
Prior Treatment	SM	100	75	65	15	0
Modified Prior Treatment	All	100	85	75	20	0
No Prior Treatment	All	100	0	40	0	0
Option 1 from PT	Bevill	0	0	0	0	0
	Non-Bevill	70	35	0	0	0
Option 2 from PT	Bevill	0	0	0	0	0
	Non-Bevill	100	75	65	15	0
Option 3 from PT	All	100	75	65	15	0
Option 4 from PT	All	100	85	75	20	0
Option 1 from MPT	Bevill	0	0	0	0	0
	Non-Bevill	70	35	0	0	0
Option 2 from MPT	Bevill	0	0	0	0	0
	Non-Bevill	100	75	65	15	0
Option 3 from MPT	All	100	75	65	15	0
Option 4 from MPT	All	100	85	75	20	0
Option 1 from NPT	Bevill	0	0	0	0	0
	Non-Bevill	80	0	10	0	0
Option 2 from NPT	Bevill	0	0	0	0	0
	Non-Bevill	100	70	60	15	0
Option 3 from NPT	All	100	70	60	15	0
Option 4 from NPT	All	100	85	75	20	0

Notes:

Y means that EPA has information indicating that the waste stream is fully recycled.
Y? means that EPA, based on professional judgment, believes that the waste stream could be fully recycled.
YS means that EPA has information indicating that a portion of the waste stream is fully recycled.
YS? means that EPA, based on professional judgment, believes that a portion of the waste stream could be fully recycled.
Bevill means that secondary materials are recycled through beneficiation or Bevill process units
Non-Bevill means that secondary materials are not recycled through beneficiation or Bevill process units

Exhibit A.1-5

Change in Recycling Percentage for Affected Option-Baseline Combinations

Baseline or Option	Affected Material	Increase in Recycling (percent)				
		Certainty of Recycling				
		Y	Y?	YS	YS?	N
Option 1 from NPT	Bevill	-100	0.00	-40	0.00	0
	Non-Bevill	-20	0.00	-30	0.00	0
Option 2 from NPT	Bevill	-100	0.00	-40	0.00	0
	Non-Bevill	0.00	**70**	20	**10**	0
Option 3 from NPT	All	0.00	**70**	20	**10**	0
Option 4 from NPT	All	0.00	85	35	20	0
Option 1 from MPT & PT (SL/BP)	Bevill	-100	-85	-75	-20	0
	Non-Bevill	-30	-50	-75	-20	0
Option 2 from MPT & PT (SL/BP)	Bevill	-100	-85	-75	-20	0
	Non-Bevill	0.00	25	35	85	0
Option 3 from MPT & PT (SL/BP)	All	0.00	-10	-10	-5	0
Option 4 from MPT & PT (SL/BP)	All	0.00	0.00	0.00	0.00	0
Option 1 from PT (SM)	Bevill	-100	-75	-65	-15	0
	Non-Bevill	-30	-40	-65	-15	0
Option 2 from PT (SM)	Bevill	-100	-75	-65	-15	0
	Non-Bevill	0.00	0.00	0.00	0.00	0
Option 3 from PT (SM)	All	0.00	0.00	0.00	0.00	0
Option 4 from PT (SM)	All	0.00	10	10	5	0.00

Notes:

Bold type indicates shifts derived from empirical data.

Gray shading indicates shifts that break expected pattern because 100 percent is sent to treatment or recycling.

Cost results for all three baselines are summarized in Exhibit A.1-6. In general, the costs for the no prior treatment baseline are greater than for the modified prior treatment baseline (the baseline used in the main analysis) because facilities incur the full cost of waste treatment when coming into compliance from the no prior treatment baseline. Conversely, the costs in the prior treatment baseline are lower than the modified prior treatment baseline because recycled spent material are assumed to be already managed in tanks, containers, and buildings. The savings in the prior treatment baseline attributed to baseline management practices is most clearly seen under Option 4, which yields an overall savings. Sector specific cost results for the no prior treatment baseline are presented in Exhibits A.1-7 through A.1-10, and cost results for the prior treatment baseline are presented in Exhibits A.1-11 through A.1-14. Value of shipment impact results for the no prior treatment baseline and the prior treatment baseline are shown in Exhibits A.1-15 through A.1-22.

Exhibit A.1-6

Summary of Cost Results for All Option-Baseline Combinations

	Minimum	Expected	Maximum
Option 1 PT	43,000,000	53,000,000	66,000,000
Option 2 PT	33,000,000	40,000,000	48,000,000
Option 3 PT	2,000,000	3,000,000	5,000,000
Option 4 PT	(3,000,000)	(4,900,000)	(7,100,000)
Option 1 MPT	46,000,000	58,000,000	75,000,000
Option 2 MPT	37,000,000	45,000,000	55,000,000
Option 3 MPT	5,200,000	8,400,000	13,000,000
Option 4 MPT	71,000	190,000	190,000
Option 1 NPT	67,000,000	120,000,000	220,000,000
Option 2 NPT	54,000,000	110,000,000	200,000,000
Option 3 NPT	24,000,000	74,000,000	160,000,000
Option 4 NPT	17,000,000	63,000,000	140,000,000

Exhibit A.1-7

Option 1 Incremental Costs Assuming No Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	3,000,000	130,000	4,800,000	210,000	6,400,000	280,000
Antimony	-	-	1,600,000	270,000	2,500,000	410,000
Beryllium	-	-	1,800,000	910,000	10,000,000	5,100,000
Bismuth	-	-	510,000	510,000	1,700,000	1,700,000
Cadmium	-	-	670,000	330,000	7,000,000	3,500,000
Calcium	-	-	4,300	4,300	7,300	7,300
Coal Gas	-	-	-	-	390,000	390,000
Copper	15,000,000	1,500,000	15,000,000	1,500,000	15,000,000	1,500,000
Elemental Phosphorus	3,500,000	1,700,000	3,500,000	1,700,000	3,500,000	1,700,000
Fluorspar and Hydrofluoric Acid	-	-	290,000	97,000	590,000	200,000
Germanium	-	-	220,000	54,000	500,000	120,000
Lead	21,000,000	5,200,000	32,000,000	7,900,000	43,000,000	11,000,000
Magnesium and Magnesia from Brines	1,600,000	820,000	1,700,000	830,000	2,100,000	1,000,000
Mercury	-	-	850,000	120,000	2,600,000	370,000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	8,100,000	740,000	29,000,000	2,600,000
Platinum Group Metals	-	-	160,000	54,000	290,000	98,000
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	1,600,000	820,000	5,400,000	2,700,000
Rare Earths	220,000	220,000	1,600,000	1,600,000	5,600,000	5,600,000
Rhenium	-	-	2,600,000	1,300,000	5,100,000	2,500,000
Scandium	-	-	370,000	53,000	590,000	85,000
Selenium	580,000	290,000	830,000	280,000	1,900,000	640,000
Synthetic Rutile	-	-	1,600,000	1,600,000	3,000,000	3,000,000
Tantalum, Columbium, and Ferrocolumbium	810,000	410,000	870,000	440,000	960,000	480,000
Tellurium	-	-	510,000	250,000	1,600,000	780,000
Titanium and Titanium Dioxide	1,300,000	640,000	17,000,000	2,400,000	31,000,000	4,400,000
Tungsten	-	-	230,000	38,000	710,000	120,000
Uranium	-	-	980,000	58,000	2,400,000	140,000
Zinc	20,000,000	6,500,000	23,000,000	7,700,000	27,000,000	9,000,000
Zirconium and Hafnium	-	-	1,600,000	790,000	12,000,000	5,900,000
Total	67,000,000		120,000,000		220,000,000	

Exhibit A.1-8

Option 2 Incremental Costs Assuming No Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	1,200,000	52,000	3,300,000	140,000	4,700,000	210,000
Antimony	-	-	1,600,000	270,000	2,500,000	410,000
Beryllium	-	-	1,800,000	910,000	10,000,000	5,000,000
Bismuth	-	-	490,000	490,000	1,700,000	1,700,000
Cadmium	-	-	620,000	310,000	4,400,000	2,200,000
Calcium	-	-	4,300	4,300	7,300	7,300
Coal Gas	-	-	-	-	390,000	390,000
Copper	15,000,000	1,500,000	15,000,000	1,500,000	15,000,000	1,500,000
Elemental Phosphorus	3,500,000	1,700,000	3,500,000	1,700,000	3,500,000	1,700,000
Fluorspar and Hydrofluoric Acid	-	-	180,000	60,000	370,000	120,000
Germanium	-	-	200,000	51,000	480,000	120,000
Lead	21,000,000	5,200,000	32,000,000	7,900,000	43,000,000	11,000,000
Magnesium and Magnesia from Brines	1,600,000	820,000	1,700,000	830,000	1,800,000	900,000
Mercury	-	-	850,000	120,000	2,600,000	370,000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	8,100,000	740,000	29,000,000	2,600,000
Platinum Group Metals	-	-	160,000	53,000	250,000	83,000
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	1,500,000	770,000	5,300,000	2,700,000
Rare Earths	220,000	220,000	1,600,000	1,600,000	5,500,000	5,500,000
Rhenium	-	-	2,600,000	1,300,000	5,100,000	2,500,000
Scandium	-	-	260,000	38,000	470,000	67,000
Selenium	580,000	290,000	770,000	260,000	1,700,000	570,000
Synthetic Rutile	-	-	1,300,000	1,300,000	2,400,000	2,400,000
Tantalum, Columbium, and Ferrocolumbium	470,000	240,000	620,000	310,000	700,000	350,000
Tellurium	-	-	390,000	200,000	1,500,000	730,000
Titanium and Titanium Dioxide	1,200,000	610,000	16,000,000	2,300,000	29,000,000	4,100,000
Tungsten	-	-	230,000	38,000	710,000	120,000
Uranium	-	-	820,000	48,000	1,500,000	91,000
Zinc	9,600,000	3,200,000	13,000,000	4,300,000	17,000,000	5,600,000
Zirconium and Hafnium	-	-	1,500,000	750,000	11,000,000	5,600,000
Total	54,000,000		110,000,000		200,000,000	

Exhibit A.1-9

Option 3 Incremental Costs Assuming No Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	1,200,000	52,000	3,300,000	140,000	4,700,000	210,000
Antimony	-	-	1,600,000	270,000	2,500,000	410,000
Beryllium	-	-	1,800,000	910,000	10,000,000	5,000,000
Bismuth	-	-	490,000	490,000	1,700,000	1,700,000
Cadmium	-	-	590,000	300,000	4,300,000	2,200,000
Calcium	-	-	1,400	1,400	1,400	1,400
Coal Gas	-	-	-	-	260,000	260,000
Copper	8,200,000	820,000	8,100,000	810,000	8,200,000	820,000
Elemental Phosphorus	540,000	270,000	540,000	270,000	540,000	270,000
Fluorspar and Hydrofluoric Acid	-	-	180,000	60,000	370,000	120,000
Germanium	-	-	200,000	51,000	480,000	120,000
Lead	120,000	30,000	6,100,000	1,500,000	13,000,000	3,200,000
Magnesium and Magnesia from Brines	1,600,000	820,000	1,700,000	830,000	1,800,000	900,000
Mercury	-	-	420,000	60,000	1,400,000	210,000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	8,100,000	740,000	29,000,000	2,600,000
Platinum Group Metals	-	-	160,000	53,000	250,000	83,000
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	1,500,000	770,000	5,300,000	2,700,000
Rare Earths	220,000	220,000	1,500,000	1,500,000	5,000,000	5,000,000
Rhenium	-	-	2,600,000	1,300,000	5,100,000	2,500,000
Scandium	-	-	260,000	38,000	470,000	67,000
Selenium	550,000	270,000	730,000	240,000	1,700,000	570,000
Synthetic Rutile	-	-	1,300,000	1,300,000	2,400,000	2,400,000
Tantalum, Columbium, and Ferrocolumbium	470,000	240,000	620,000	310,000	700,000	350,000
Tellurium	-	-	390,000	200,000	1,500,000	730,000
Titanium and Titanium Dioxide	1,200,000	610,000	16,000,000	2,300,000	29,000,000	4,100,000
Tungsten	-	-	320,000	53,000	690,000	110,000
Uranium	-	-	820,000	48,000	1,500,000	91,000
Zinc	9,600,000	3,200,000	13,000,000	4,300,000	17,000,000	5,600,000
Zirconium and Hafnium	-	-	1,500,000	750,000	11,000,000	5,600,000
Total	24,000,000		74,000,000		160,000,000	

Exhibit A.1-10

Option 4 Incremental Costs Assuming No Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	770,000	34,000	2,200,000	95,000	3,000,000	130,000
Antimony	-	-	1,600,000	260,000	2,400,000	400,000
Beryllium	-	-	1,800,000	900,000	9,500,000	4,700,000
Bismuth	-	-	480,000	480,000	1,700,000	1,700,000
Cadmium	-	-	560,000	280,000	3,600,000	1,800,000
Calcium	-	-	1,400	1,400	1,400	1,400
Coal Gas	-	-	-	-	180,000	180,000
Copper	5,200,000	520,000	5,200,000	520,000	5,200,000	520,000
Elemental Phosphorus	57,000	29,000	57,000	29,000	57,000	29,000
Fluorspar and Hydrofluoric Acid	-	-	120,000	39,000	270,000	89,000
Germanium	-	-	180,000	46,000	460,000	110,000
Lead	65,000	16,000	4,800,000	1,200,000	10,000,000	2,600,000
Magnesium and Magnesia from Brines	1,600,000	820,000	1,700,000	830,000	1,700,000	870,000
Mercury	-	-	190,000	27,000	810,000	120,000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	8,100,000	740,000	29,000,000	2,600,000
Platinum Group Metals	-	-	160,000	53,000	240,000	79,000
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	1,500,000	740,000	5,200,000	2,600,000
Rare Earths	220,000	220,000	1,400,000	1,400,000	4,500,000	4,500,000
Rhenium	-	-	2,600,000	1,300,000	5,100,000	2,500,000
Scandium	-	-	360,000	51,000	430,000	61,000
Selenium	500,000	250,000	670,000	220,000	1,600,000	520,000
Synthetic Rutile	-	-	1,100,000	1,100,000	2,100,000	2,100,000
Tantalum, Columbium, and Ferrocolumbium	260,000	130,000	470,000	230,000	550,000	280,000
Tellurium	-	-	380,000	190,000	1,400,000	700,000
Titanium and Titanium Dioxide	1,100,000	560,000	15,000,000	2,200,000	28,000,000	4,100,000
Tungsten	-	-	280,000	47,000	650,000	110,000
Uranium	-	-	780,000	46,000	1,400,000	84,000
Zinc	7,600,000	2,500,000	9,800,000	3,300,000	13,000,000	4,200,000
Zirconium and Hafnium	-	-	1,400,000	690,000	11,000,000	5,300,000
Total	17,000,000		63,000,000		140,000,000	

Exhibit A.1-11

Option 1 Incremental Costs Assuming Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	1,400,000	62,000	2,400,000	100,000	2,900,000	130,000
Antimony	-	-	40,000	6,700	52,000	8,600
Beryllium	-	-	24,000	12,000	440,000	220,000
Bismuth	-	-	30,000	30,000	53,000	53,000
Cadmium	-	-	56,000	28,000	2,400,000	1,200,000
Calcium	-	-	4,300	4,300	7,300	7,300
Coal Gas	-	-	-	-	220,000	220,000
Copper	10,000,000	1,000,000	10,000,000	1,000,000	10,000,000	1,000,000
Elemental Phosphorus	3,100,000	1,600,000	3,100,000	1,600,000	3,100,000	1,600,000
Fluorspar and Hydrofluoric Acid	-	-	190,000	63,000	330,000	110,000
Germanium	-	-	30,000	7,500	37,000	9,200
Lead	21,000,000	5,200,000	26,000,000	6,500,000	30,000,000	7,600,000
Magnesium and Magnesia from Brines	2,800	1,400	3,100	1,500	240,000	120,000
Mercury	-	-	500,000	72,000	1,300,000	190,000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	16,000	1,400	16,000	1,400
Platinum Group Metals	-	-	5,900	2,000	38,000	13,000
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	93,000	46,000	110,000	56,000
Rare Earths	6,100	6,100	200,000	200,000	1,100,000	1,100,000
Rhenium	-	-	9,500	4,700	31,000	15,000
Scandium	-	-	82,000	12,000	140,000	20,000
Selenium	53,000	27,000	110,000	36,000	280,000	94,000
Synthetic Rutile	-	-	550,000	550,000	1,000,000	1,000,000
Tantalum, Columbium, and Ferrocolumbium	370,000	180,000	260,000	130,000	260,000	130,000
Tellurium	-	-	140,000	71,000	160,000	78,000
Titanium and Titanium Dioxide	93,000	46,000	810,000	120,000	1,300,000	190,000
Tungsten	-	-	(62,000)	(10,000)	45,000	7,500
Uranium	-	-	220,000	13,000	1,100,000	63,000
Zinc	7,100,000	2,400,000	7,600,000	2,500,000	8,800,000	2,900,000
Zirconium and Hafnium	-	-	110,000	57,000	900,000	450,000
Total	43,000,000		53,000,000		66,000,000	

Exhibit A.1-12

Option 2 Incremental Costs Assuming Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	310,000	14,000	810,000	35,000	1,500,000	64,000
Antimony	-	-	8,500	1,400	8,500	1,400
Beryllium	-	-	2,800	1,400	2,800	1,400
Bismuth	-	-	1,400	1,400	2,100	2,100
Cadmium	-	-	47,000	23,000	530,000	270,000
Calcium	-	-	4,300	4,300	7,300	7,300
Coal Gas	-	-	-	-	220,000	220,000
Copper	10,000,000	1,000,000	10,000,000	1,000,000	10,000,000	1,000,000
Elemental Phosphorus	3,100,000	1,600,000	3,100,000	1,600,000	3,100,000	1,600,000
Fluorspar and Hydrofluoric Acid	-	-	52,000	17,000	84,000	28,000
Germanium	-	-	6,400	1,600	8,600	2,200
Lead	21,000,000	5,200,000	26,000,000	6,500,000	30,000,000	7,600,000
Magnesium and Magnesia from Brines	2,800	1,400	3,900	2,000	49,000	25,000
Mercury	-	-	500,000	72,000	1,300,000	190,000
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	16,000	1,400	16,000	1,400
Platinum Group Metals	-	-	4,600	1,500	11,000	3,700
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	2,800	1,400	2,800	1,400
Rare Earths	6,100	6,100	200,000	200,000	980,000	980,000
Rhenium	-	-	9,500	4,700	31,000	15,000
Scandium	-	-	9,900	1,400	9,900	1,400
Selenium	53,000	27,000	71,000	24,000	140,000	47,000
Synthetic Rutile	-	-	71,000	71,000	130,000	130,000
Tantalum, Columbium, and Ferrocolumbium	2,800	1,400	2,800	1,400	2,800	1,400
Tellurium	-	-	4,500	2,300	17,000	8,500
Titanium and Titanium Dioxide	3,200	1,600	130,000	19,000	260,000	37,000
Tungsten	-	-	(62,000)	(10,000)	45,000	7,500
Uranium	-	-	43,000	2,500	100,000	6,000
Zinc	(1,200,000)	(390,000)	(1,100,000)	(370,000)	(1,000,000)	(350,000)
Zirconium and Hafnium	-	-	2,800	1,400	2,800	1,400
Total	33,000,000		40,000,000		48,000,000	

Exhibit A.1-13

Option 3 Incremental Costs Assuming Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	310,000	14,000	810,000	35,000	1,500,000	64,000
Antimony	-	-	8,500	1,400	8,500	1,400
Beryllium	-	-	2,800	1,400	2,800	1,400
Bismuth	-	-	1,400	1,400	2,100	2,100
Cadmium	-	-	18,000	8,800	460,000	230,000
Calcium	-	-	1,400	1,400	1,400	1,400
Coal Gas	-	-	-	-	68,000	68,000
Copper	2,600,000	260,000	2,500,000	250,000	2,600,000	260,000
Elemental Phosphorus	200,000	100,000	200,000	100,000	200,000	100,000
Fluorspar and Hydrofluoric Acid	-	-	52,000	17,000	84,000	28,000
Germanium	-	-	6,400	1,600	8,600	2,200
Lead	56,000	14,000	120,000	30,000	150,000	38,000
Magnesium and Magnesia from Brines	2,800	1,400	3,900	2,000	49,000	25,000
Mercury	-	-	9,900	1,400	9,900	1,400
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	16,000	1,400	16,000	1,400
Platinum Group Metals	-	-	4,600	1,500	11,000	3,700
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	2,800	1,400	2,800	1,400
Rare Earths	1,400	1,400	92,000	92,000	320,000	320,000
Rhenium	-	-	3,700	1,800	6,200	3,100
Scandium	-	-	9,900	1,400	9,900	1,400
Selenium	2,800	1,400	14,000	4,600	110,000	37,000
Synthetic Rutile	-	-	71,000	71,000	130,000	130,000
Tantalum, Columbium, and Ferrocolumbium	2,800	1,400	2,800	1,400	2,800	1,400
Tellurium	-	-	4,500	2,300	17,000	8,500
Titanium and Titanium Dioxide	3,200	1,600	130,000	19,000	260,000	37,000
Tungsten	-	-	8,500	1,400	8,500	1,400
Uranium	-	-	43,000	2,500	100,000	6,000
Zinc	(1,200,000)	(390,000)	(1,100,000)	(370,000)	(1,100,000)	(350,000)
Zirconium and Hafnium	-	-	2,800	1,400	2,800	1,400
Total	2,000,000		3,000,000		5,000,000	

Exhibit A.1-14

Option 4 Incremental Costs Assuming Prior Treatment

Commodity	Minimum Value Case		Expected Value Case		Maximum Value Case	
	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)	Total Incremental Cost ($/yr)	Avg. Fac. Incremental Cost ($/yr)
Alumina and Aluminum	32,000	1,400	32,000	1,400	32,000	1,400
Antimony	-	-	(6,900)	(1,100)	(17,000)	(2,900)
Beryllium	-	-	(11,000)	(5,700)	(330,000)	(160,000)
Bismuth	-	-	(5,900)	(5,900)	(16,000)	(16,000)
Cadmium	-	-	(3,600)	(1,800)	(26,000)	(13,000)
Calcium	-	-	1,400	1,400	1,400	1,400
Coal Gas	-	-	-	-	1,400	1,400
Copper	14,000	1,400	14,000	1,400	14,000	1,400
Elemental Phosphorus	(240,000)	(120,000)	(240,000)	(120,000)	(240,000)	(120,000)
Fluorspar and Hydrofluoric Acid	-	-	4,200	1,400	4,200	1,400
Germanium	-	-	(3,100)	(780)	(3,000)	(740)
Lead	2,700	660	(920,000)	(230,000)	(1,700,000)	(430,000)
Magnesium and Magnesia from Brines	2,800	1,400	2,800	1,400	2,800	1,400
Mercury	-	-	(160,000)	(23,000)	(480,000)	(68,000)
Molybdenum, Ferromolybdenum, and Ammonium Molybdate	-	-	16,000	1,400	16,000	1,400
Platinum Group Metals	-	-	4,200	1,400	4,200	1,400
Pyrobitumens, Mineral Waxes, and Natural Asphalts	-	-	(39,000)	(20,000)	(49,000)	(25,000)
Rare Earths	(1,700)	(1,700)	(30)	(30)	18	18
Rhenium	-	-	2,800	1,400	2,800	1,400
Scandium	-	-	110,000	16,000	(20,000)	(2,900)
Selenium	(23,000)	(11,000)	(24,000)	(8,000)	(15,000)	(5,100)
Synthetic Rutile	-	-	(6,100)	(6,100)	(13,000)	(13,000)
Tantalum, Columbium, and Ferrocolumbium	(160,000)	(80,000)	(120,000)	(60,000)	(120,000)	(60,000)
Tellurium	-	-	(2,600)	(1,300)	(17,000)	(8,500)
Titanium and Titanium Dioxide	(65,000)	(32,000)	(85,000)	(12,000)	(110,000)	(15,000)
Tungsten	-	-	(9,800)	(1,600)	(16,000)	(2,600)
Uranium	-	-	20,000	1,200	22,000	1,300
Zinc	(2,600,000)	(870,000)	(3,400,000)	(1,100,000)	(3,700,000)	(1,200,000)
Zirconium and Hafnium	-	-	(87,000)	(44,000)	(300,000)	(150,000)
Total	(3,000,000)		(4,900,000)		(7,100,000)	

Exhibit A.1-15
Option 1 No Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	3,000,000	4,800,000	6,400,000	0.07	0.11	0.15
Antimony	18,000	1,764	*31,752,000*	-	1,600,000	2,500,000	0.00	5.04	7.87
Beryllium	159	352,640	*56,069,760*	-	1,800,000	10,000,000	0.00	3.21	17.83
Bismuth	1,100	7,824	*8,606,400*	-	510,000	1,700,000	0.00	5.93	19.75
Cadmium	1,050	992	*1,041,600*	-	670,000	7,000,000	0.00	64.32	672.04
Calcium	1,200	4,605	*5,526,000*	-	4,300	7,300	0.00	0.08	0.13
Coal Gas			*170,000,000*	-	-	390,000	0.00	0.00	0.23
Copper	1,770,000	2,029	*3,591,330,000*	15,000,000	15,000,000	15,000,000	0.42	0.42	0.42
Elemental Phosphorus	311,000	1,833	*570,063,000*	3,500,000	3,500,000	3,500,000	0.61	0.61	0.61
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	290,000	590,000	0.00	2.50	5.09
Germanium	10	1,060,000	*10,600,000*	-	220,000	500,000	0.00	2.08	4.72
Lead	290,000	706	*204,740,000*	21,000,000	32,000,000	43,000,000	10.26	15.63	21.00
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	1,600,000	1,700,000	2,100,000	0.34	0.36	0.45
Mercury	70	5,512	*385,840*	-	850,000	2,600,000	0.00	220.30	673.85
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	8,100,000	29,000,000	0.00	3.38	12.09
Platinum Group Metals			53,203,971	-	160,000	290,000	0.00	0.30	0.55
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	1,600,000	5,400,000	0.00	640.00	2,160.00
Rare Earths			57,372,120	220,000	1,600,000	5,600,000	0.38	2.79	9.76
Rhenium	5	1,200,000	*6,000,000*	-	2,600,000	5,100,000	0.00	43.33	85.00
Scandium	25	1,500,000	*37,500,000*	-	370,000	590,000	0.00	0.99	1.57
Selenium	250	11,246	2,811,500	580,000	830,000	1,900,000	20.63	29.52	67.58
Synthetic Rutile	140,000	345	48,300,000	-	1,600,000	3,000,000	0.00	3.31	6.21
Tantalum, Columbium, and Ferrocolumbium			60,897,400	810,000	870,000	960,000	1.33	1.43	1.58
Tellurium	60	59,508	*3,570,480*	-	510,000	1,600,000	0.00	14.28	44.81
Titanium and Titanium Dioxide			2,516,300,000	1,300,000	17,000,000	31,000,000	0.05	0.68	1.23
Tungsten	9,406	40	*376,240*	-	230,000	710,000	0.00	61.13	188.71
Uranium			40,734,000	-	980,000	2,400,000	0.00	2.41	5.89
Zinc	505,000	1,014	*512,070,000*	20,000,000	23,000,000	27,000,000	3.91	4.49	5.27
Zirconium and Hafnium			379,899,000	-	1,600,000	12,000,000	0.00	0.42	3.16
Total				67,000,000	120,000,000	220,000,000			

Exhibit A.1-16
Option 2 No Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	1,200,000	3,300,000	4,700,000	0.03	0.08	0.11
Antimony	18,000	1,764	*31,752,000*	-	1,600,000	2,500,000	0.00	5.04	7.87
Beryllium	159	352,640	*56,069,760*	-	1,800,000	10,000,000	0.00	3.21	17.83
Bismuth	1,100	7,824	*8,606,400*	-	490,000	1,700,000	0.00	5.69	19.75
Cadmium	1,050	992	*1,041,600*	-	620,000	4,400,000	0.00	59.52	422.43
Calcium	1,200	4,605	*5,526,000*	-	4,300	7,300	0.00	0.08	0.13
Coal Gas			*170,000,000*	-	-	390,000	0.00	0.00	0.23
Copper	1,770,000	2,029	*3,591,330,000*	15,000,000	15,000,000	15,000,000	0.42	0.42	0.42
Elemental Phosphorus	311,000	1,833	*570,063,000*	3,500,000	3,500,000	3,500,000	0.61	0.61	0.61
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	180,000	370,000	0.00	1.55	3.20
Germanium	10	1,060,000	*10,600,000*	-	200,000	480,000	0.00	1.89	4.53
Lead	290,000	706	*204,740,000*	21,000,000	32,000,000	43,000,000	10.26	15.63	21.00
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	1,600,000	1,700,000	1,800,000	0.34	0.36	0.39
Mercury	70	5,512	*385,840*	-	850,000	2,600,000	0.00	220.30	673.85
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	8,100,000	29,000,000	0.00	3.38	12.09
Platinum Group Metals			53,203,971	-	160,000	250,000	0.00	0.30	0.47
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	1,500,000	5,300,000	0.00	600.00	2,120.00
Rare Earths			57,372,120	220,000	1,600,000	5,500,000	0.38	2.79	9.59
Rhenium	5	1,200,000	*6,000,000*	-	2,600,000	5,100,000	0.00	43.33	85.00
Scandium	25	1,500,000	*37,500,000*	-	260,000	470,000	0.00	0.69	1.25
Selenium	250	11,246	2,811,500	580,000	770,000	1,700,000	20.63	27.39	60.47
Synthetic Rutile	140,000	345	48,300,000	-	1,300,000	2,400,000	0.00	2.69	4.97
Tantalum, Columbium, and Ferrocolumbium			60,897,400	470,000	620,000	700,000	0.77	1.02	1.15
Tellurium	60	59,508	*3,570,480*	-	390,000	1,500,000	0.00	10.92	42.01
Titanium and Titanium Dioxide			2,516,300,000	1,200,000	16,000,000	29,000,000	0.05	0.64	1.15
Tungsten	9,406	40	*376,240*	-	230,000	710,000	0.00	61.13	188.71
Uranium			40,734,000	-	820,000	1,500,000	0.00	2.01	3.68
Zinc	505,000	1,014	*512,070,000*	9,600,000	13,000,000	17,000,000	1.87	2.54	3.32
Zirconium and Hafnium			379,899,000	-	1,500,000	11,000,000	0.00	0.39	2.90
Total				54,000,000	110,000,000	200,000,000			

Exhibit A.1-17
Option 3 No Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	1,200,000	3,300,000	4,700,000	0.03	0.08	0.11
Antimony	18,000	1,764	*31,752,000*	-	1,600,000	2,500,000	0.00	5.04	7.87
Beryllium	159	352,640	*56,069,760*	-	1,800,000	10,000,000	0.00	3.21	17.83
Bismuth	1,100	7,824	*8,606,400*	-	490,000	1,700,000	0.00	5.69	19.75
Cadmium	1,050	992	*1,041,600*	-	590,000	4,300,000	0.00	56.64	412.83
Calcium	1,200	4,605	*5,526,000*	-	1,400	1,400	0.00	0.03	0.03
Coal Gas			*170,000,000*	-	-	260,000	0.00	0.00	0.15
Copper	1,770,000	2,029	*3,591,330,000*	8,200,000	8,100,000	8,200,000	0.23	0.23	0.23
Elemental Phosphorus	311,000	1,833	*570,063,000*	540,000	540,000	540,000	0.09	0.09	0.09
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	180,000	370,000	0.00	1.55	3.20
Germanium	10	1,060,000	*10,600,000*	-	200,000	480,000	0.00	1.89	4.53
Lead	290,000	706	*204,740,000*	120,000	6,100,000	13,000,000	0.06	2.98	6.35
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	1,600,000	1,700,000	1,800,000	0.34	0.36	0.39
Mercury	70	5,512	*385,840*	-	420,000	1,400,000	0.00	108.85	362.84
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	8,100,000	29,000,000	0.00	3.38	12.09
Platinum Group Metals			53,203,971	-	160,000	250,000	0.00	0.30	0.47
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	1,500,000	5,300,000	0.00	600.00	2,120.00
Rare Earths			57,372,120	220,000	1,500,000	5,000,000	0.38	2.61	8.72
Rhenium	5	1,200,000	*6,000,000*	-	2,600,000	5,100,000	0.00	43.33	85.00
Scandium	25	1,500,000	*37,500,000*	-	260,000	470,000	0.00	0.69	1.25
Selenium	250	11,246	2,811,500	550,000	730,000	1,700,000	19.56	25.96	60.47
Synthetic Rutile	140,000	345	48,300,000	-	1,300,000	2,400,000	0.00	2.69	4.97
Tantalum, Columbium, and Ferrocolumbium			60,897,400	470,000	620,000	700,000	0.77	1.02	1.15
Tellurium	60	59,508	*3,570,480*	-	390,000	1,500,000	0.00	10.92	42.01
Titanium and Titanium Dioxide			2,516,300,000	1,200,000	16,000,000	29,000,000	0.05	0.64	1.15
Tungsten	9,406	40	*376,240*	-	320,000	690,000	0.00	85.05	183.39
Uranium			40,734,000	-	820,000	1,500,000	0.00	2.01	3.68
Zinc	505,000	1,014	*512,070,000*	9,600,000	13,000,000	17,000,000	1.87	2.54	3.32
Zirconium and Hafnium			379,899,000	-	1,500,000	11,000,000	0.00	0.39	2.90
Total				24,000,000	74,000,000	160,000,000			

Exhibit A.1-18
Option 4 No Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	770,000	2,200,000	3,000,000	0.02	0.05	0.07
Antimony	18,000	1,764	*31,752,000*	-	1,600,000	2,400,000	0.00	5.04	7.56
Beryllium	159	352,640	*56,069,760*	-	1,800,000	9,500,000	0.00	3.21	16.94
Bismuth	1,100	7,824	*8,606,400*	-	480,000	1,700,000	0.00	5.58	19.75
Cadmium	1,050	992	*1,041,600*	-	560,000	3,600,000	0.00	53.76	345.62
Calcium	1,200	4,605	*5,526,000*	-	1,400	1,400	0.00	0.03	0.03
Coal Gas			*170,000,000*	-	-	180,000	0.00	0.00	0.11
Copper	1,770,000	2,029	*3,591,330,000*	5,200,000	5,200,000	5,200,000	0.14	0.14	0.14
Elemental Phosphorus	311,000	1,833	*570,063,000*	57,000	57,000	57,000	0.01	0.01	0.01
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	120,000	270,000	0.00	1.04	2.33
Germanium	10	1,060,000	*10,600,000*	-	180,000	460,000	0.00	1.70	4.34
Lead	290,000	706	*204,740,000*	65,000	4,800,000	10,000,000	0.03	2.34	4.88
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	1,600,000	1,700,000	1,700,000	0.34	0.36	0.36
Mercury	70	5,512	*385,840*	-	190,000	810,000	0.00	49.24	209.93
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	8,100,000	29,000,000	0.00	3.38	12.09
Platinum Group Metals			53,203,971	-	160,000	240,000	0.00	0.30	0.45
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	1,500,000	5,200,000	0.00	600.00	2,080.00
Rare Earths			57,372,120	220,000	1,400,000	4,500,000	0.38	2.44	7.84
Rhenium	5	1,200,000	*6,000,000*	-	2,600,000	5,100,000	0.00	43.33	85.00
Scandium	25	1,500,000	*37,500,000*	-	360,000	430,000	0.00	0.96	1.15
Selenium	250	11,246	2,811,500	500,000	670,000	1,600,000	17.78	23.83	56.91
Synthetic Rutile	140,000	345	48,300,000	-	1,100,000	2,100,000	0.00	2.28	4.35
Tantalum, Columbium, and Ferrocolumbium			60,897,400	260,000	470,000	550,000	0.43	0.77	0.90
Tellurium	60	59,508	*3,570,480*	-	380,000	1,400,000	0.00	10.64	39.21
Titanium and Titanium Dioxide			2,516,300,000	1,100,000	15,000,000	28,000,000	0.04	0.60	1.11
Tungsten	9,406	40	*376,240*	-	280,000	650,000	0.00	74.42	172.76
Uranium			40,734,000	-	780,000	1,400,000	0.00	1.91	3.44
Zinc	505,000	1,014	*512,070,000*	7,600,000	9,800,000	13,000,000	1.48	1.91	2.54
Zirconium and Hafnium			379,899,000	-	1,400,000	11,000,000	0.00	0.37	2.90
Total				17,000,000	63,000,000	140,000,000			

Exhibit A.1-19
Option 1 Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	1,400,000	2,400,000	2,900,000	0.03	0.06	0.07
Antimony	18,000	1,764	*31,752,000*	-	40,000	52,000	0.00	0.13	0.16
Beryllium	159	352,640	*56,069,760*	-	24,000	440,000	0.00	0.04	0.78
Bismuth	1,100	7,824	*8,606,400*	-	30,000	53,000	0.00	0.35	0.62
Cadmium	1,050	992	*1,041,600*	-	56,000	2,400,000	0.00	5.38	230.41
Calcium	1,200	4,605	*5,526,000*	-	4,300	7,300	0.00	0.08	0.13
Coal Gas			*170,000,000*	-	-	220,000	0.00	0.00	0.13
Copper	1,770,000	2,029	*3,591,330,000*	10,000,000	10,000,000	10,000,000	0.28	0.28	0.28
Elemental Phosphorus	311,000	1,833	*570,063,000*	3,100,000	3,100,000	3,100,000	0.54	0.54	0.54
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	190,000	330,000	0.00	1.64	2.85
Germanium	10	1,060,000	*10,600,000*	-	30,000	37,000	0.00	0.28	0.35
Lead	290,000	706	*204,740,000*	21,000,000	26,000,000	30,000,000	10.26	12.70	14.65
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	2,800	3,100	240,000	0.00	0.00	0.05
Mercury	70	5,512	*385,840*	-	500,000	1,300,000	0.00	129.59	336.93
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	16,000	16,000	0.00	0.01	0.01
Platinum Group Metals			53,203,971	-	5,900	38,000	0.00	0.01	0.07
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	93,000	110,000	0.00	37.20	44.00
Rare Earths			57,372,120	6,100	200,000	1,100,000	0.01	0.35	1.92
Rhenium	5	1,200,000	*6,000,000*	-	9,500	31,000	0.00	0.16	0.52
Scandium	25	1,500,000	*37,500,000*	-	82,000	140,000	0.00	0.22	0.37
Selenium	250	11,246	2,811,500	53,000	110,000	280,000	1.89	3.91	9.96
Synthetic Rutile	140,000	345	48,300,000	-	550,000	1,000,000	0.00	1.14	2.07
Tantalum, Columbium, and Ferrocolumbium			60,897,400	370,000	260,000	260,000	0.61	0.43	0.43
Tellurium	60	59,508	*3,570,480*	-	140,000	160,000	0.00	3.92	4.48
Titanium and Titanium Dioxide			2,516,300,000	93,000	810,000	1,300,000	0.00	0.03	0.05
Tungsten	9,406	40	*376,240*	-	(62,000)	45,000	0.00	-16.48	11.96
Uranium			40,734,000	-	220,000	1,100,000	0.00	0.54	2.70
Zinc	505,000	1,014	*512,070,000*	7,100,000	7,600,000	8,800,000	1.39	1.48	1.72
Zirconium and Hafnium			379,899,000	-	110,000	900,000	0.00	0.03	0.24
Total				43,000,000	53,000,000	66,000,000			

Exhibit A.1-20
Option 2 Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	310,000	810,000	1,500,000	0.01	0.02	0.03
Antimony	18,000	1,764	*31,752,000*	-	8,500	8,500	0.00	0.03	0.03
Beryllium	159	352,640	*56,069,760*	-	2,800	2,800	0.00	0.00	0.00
Bismuth	1,100	7,824	*8,606,400*	-	1,400	2,100	0.00	0.02	0.02
Cadmium	1,050	992	*1,041,600*	-	47,000	530,000	0.00	4.51	50.88
Calcium	1,200	4,605	*5,526,000*	-	4,300	7,300	0.00	0.08	0.13
Coal Gas			*170,000,000*	-	-	220,000	0.00	0.00	0.13
Copper	1,770,000	2,029	*3,591,330,000*	10,000,000	10,000,000	10,000,000	0.28	0.28	0.28
Elemental Phosphorus	311,000	1,833	*570,063,000*	3,100,000	3,100,000	3,100,000	0.54	0.54	0.54
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	52,000	84,000	0.00	0.45	0.73
Germanium	10	1,060,000	*10,600,000*	-	6,400	8,600	0.00	0.06	0.08
Lead	290,000	706	*204,740,000*	21,000,000	26,000,000	30,000,000	10.26	12.70	14.65
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	2,800	3,900	49,000	0.00	0.00	0.01
Mercury	70	5,512	*385,840*	-	500,000	1,300,000	0.00	129.59	336.93
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	16,000	16,000	0.00	0.01	0.01
Platinum Group Metals			53,203,971	-	4,600	11,000	0.00	0.01	0.02
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	2,800	2,800	0.00	1.12	1.12
Rare Earths			57,372,120	6,100	200,000	980,000	0.01	0.35	1.71
Rhenium	5	1,200,000	*6,000,000*	-	9,500	31,000	0.00	0.16	0.52
Scandium	25	1,500,000	*37,500,000*	-	9,900	9,900	0.00	0.03	0.03
Selenium	250	11,246	2,811,500	53,000	71,000	140,000	1.89	2.53	4.98
Synthetic Rutile	140,000	345	48,300,000	-	71,000	130,000	0.00	0.15	0.27
Tantalum, Columbium, and Ferrocolumbium			60,897,400	2,800	2,800	2,800	0.00	0.00	0.00
Tellurium	60	59,508	*3,570,480*	-	4,500	17,000	0.00	0.13	0.48
Titanium and Titanium Dioxide			2,516,300,000	3,200	130,000	260,000	0.00	0.01	0.01
Tungsten	9,406	40	*376,240*	-	(62,000)	45,000	0.00	-16.48	11.96
Uranium			40,734,000	-	43,000	100,000	0.00	0.11	0.25
Zinc	505,000	1,014	*512,070,000*	(1,200,000)	(1,100,000)	(1,000,000)	-0.23	-0.21	-0.20
Zirconium and Hafnium			379,899,000	-	2,800	2,800	0.00	0.00	0.00
Total				33,000,000	40,000,000	48,000,000			

Exhibit A.1-21
Option 3 Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	310,000	810,000	1,500,000	0.01	0.02	0.03
Antimony	18,000	1,764	*31,752,000*	-	8,500	8,500	0.00	0.03	0.03
Beryllium	159	352,640	*56,069,760*	-	2,800	2,800	0.00	0.00	0.00
Bismuth	1,100	7,824	*8,606,400*	-	1,400	2,100	0.00	0.02	0.02
Cadmium	1,050	992	*1,041,600*	-	18,000	460,000	0.00	1.73	44.16
Calcium	1,200	4,605	*5,526,000*	-	1,400	1,400	0.00	0.03	0.03
Coal Gas			*170,000,000*	-	-	68,000	0.00	0.00	0.04
Copper	1,770,000	2,029	*3,591,330,000*	2,600,000	2,500,000	2,600,000	0.07	0.07	0.07
Elemental Phosphorus	311,000	1,833	*570,063,000*	200,000	200,000	200,000	0.04	0.04	0.04
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	52,000	84,000	0.00	0.45	0.73
Germanium	10	1,060,000	*10,600,000*	-	6,400	8,600	0.00	0.06	0.08
Lead	290,000	706	*204,740,000*	56,000	120,000	150,000	0.03	0.06	0.07
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	2,800	3,900	49,000	0.00	0.00	0.01
Mercury	70	5,512	*385,840*	-	9,900	9,900	0.00	2.57	2.57
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	16,000	16,000	0.00	0.01	0.01
Platinum Group Metals			53,203,971	-	4,600	11,000	0.00	0.01	0.02
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	2,800	2,800	0.00	1.12	1.12
Rare Earths			57,372,120	1,400	92,000	320,000	0.00	0.16	0.56
Rhenium	5	1,200,000	*6,000,000*	-	3,700	6,200	0.00	0.06	0.10
Scandium	25	1,500,000	*37,500,000*	-	9,900	9,900	0.00	0.03	0.03
Selenium	250	11,246	2,811,500	2,800	14,000	110,000	0.10	0.50	3.91
Synthetic Rutile	140,000	345	48,300,000	-	71,000	130,000	0.00	0.15	0.27
Tantalum, Columbium, and Ferrocolumbium			60,897,400	2,800	2,800	2,800	0.00	0.00	0.00
Tellurium	60	59,508	*3,570,480*	-	4,500	17,000	0.00	0.13	0.48
Titanium and Titanium Dioxide			2,516,300,000	3,200	130,000	260,000	0.00	0.01	0.01
Tungsten	9,406	40	*376,240*	-	8,500	8,500	0.00	2.26	2.26
Uranium			40,734,000	-	43,000	100,000	0.00	0.11	0.25
Zinc	505,000	1,014	*512,070,000*	(1,200,000)	(1,100,000)	(1,100,000)	-0.23	-0.21	-0.21
Zirconium and Hafnium			379,899,000	-	2,800	2,800	0.00	0.00	0.00
Total				2,000,000	3,000,000	5,000,000			

Exhibit A.1-22
Option 4 Prior Treatment Baseline Impacts

Sector	Production MT	Price $/MT	Value of Shipments $	Incremental Sector Cost $			Economic Impact (percent of Value of Shipments)		
				Minimum	Expected	Maximum	Minimum	Expected	Maximum
Alumina and Aluminum	3,700,000	1,168	*4,321,600,000*	32,000	32,000	32,000	0.00	0.00	0.00
Antimony	18,000	1,764	*31,752,000*	-	(6,900)	(17,000)	0.00	-0.02	-0.05
Beryllium	159	352,640	*56,069,760*	-	(11,000)	(330,000)	0.00	-0.02	-0.59
Bismuth	1,100	7,824	*8,606,400*	-	(5,900)	(16,000)	0.00	-0.07	-0.19
Cadmium	1,050	992	*1,041,600*	-	(3,600)	(26,000)	0.00	-0.35	-2.50
Calcium	1,200	4,605	*5,526,000*	-	1,400	1,400	0.00	0.03	0.03
Coal Gas			*170,000,000*	-	-	1,400	0.00	0.00	0.00
Copper	1,770,000	2,029	*3,591,330,000*	14,000	14,000	14,000	0.00	0.00	0.00
Elemental Phosphorus	311,000	1,833	*570,063,000*	(240,000)	(240,000)	(240,000)	-0.04	-0.04	-0.04
Fluorspar and Hydrofluoric Acid	60,000	193	*11,580,000*	-	4,200	4,200	0.00	0.04	0.04
Germanium	10	1,060,000	*10,600,000*	-	(3,100)	(3,000)	0.00	-0.03	-0.03
Lead	290,000	706	*204,740,000*	2,700	(920,000)	(1,700,000)	0.00	-0.45	-0.83
Magnesium and Magnesia from Brines	145,000	3,219	*466,755,000*	2,800	2,800	2,800	0.00	0.00	0.00
Mercury	70	5,512	*385,840*	-	(160,000)	(480,000)	0.00	-41.47	-124.40
Molybdenum, Ferromolybdenum and Ammonium Molybdate			239,864,579	-	16,000	16,000	0.00	0.01	0.01
Platinum Group Metals			53,203,971	-	4,200	4,200	0.00	0.01	0.01
Pyrobitumens, Mineral Waxes, and Natural Asphalt	10,000	25	250,000	-	(39,000)	(49,000)	0.00	-15.60	-19.60
Rare Earths			57,372,120	(1,700)	(30)	18	0.00	0.00	0.00
Rhenium	5	1,200,000	*6,000,000*	-	2,800	2,800	0.00	0.05	0.05
Scandium	25	1,500,000	*37,500,000*	-	110,000	(20,000)	0.00	0.29	-0.05
Selenium	250	11,246	2,811,500	(23,000)	(24,000)	(15,000)	-0.82	-0.85	-0.53
Synthetic Rutile	140,000	345	48,300,000	-	(6,100)	(13,000)	0.00	-0.01	-0.03
Tantalum, Columbium, and Ferrocolumbium			60,897,400	(160,000)	(120,000)	(120,000)	-0.26	-0.20	-0.20
Tellurium	60	59,508	*3,570,480*	-	(2,600)	(17,000)	0.00	-0.07	-0.48
Titanium and Titanium Dioxide			2,516,300,000	(65,000)	(85,000)	(110,000)	0.00	0.00	0.00
Tungsten	9,406	40	*376,240*	-	(9,800)	(16,000)	0.00	-2.60	-4.25
Uranium			40,734,000	-	20,000	22,000	0.00	0.05	0.05
Zinc	505,000	1,014	*512,070,000*	(2,600,000)	(3,400,000)	(3,700,000)	-0.51	-0.66	-0.72
Zirconium and Hafnium			379,899,000	-	(87,000)	(300,000)	0.00	-0.02	-0.08
Total				(3,000,000)	(4,900,000)	(7,100,000)			

A.2 Risk and Benefits Assessment Assumptions, Methods, and Results

A.2.1. Introduction

As discussed in Section 4.1, while EPA's current judgement is that the modified prior treatment baseline best represents current industry practice, the Agency has conducted a substantial amount of risk and benefits assessment work for the alternative baseline scenarios. This is particularly true for the no prior treatment baseline, which was regarded early in the regulatory development process as a prudently conservative characterization of current practice. EPA has also evaluated some potential risks and benefits for the prior treatment baseline as well. As will be discussed further below, some of the risk and benefits assessment for the activities evaluated (disposal or storage) are applicable to more than one baseline, and to more than one regulatory option, because the behavioral assumptions made for that activity are the same under the various baselines and options. Thus they can be used to infer baseline risks and risk reduction benefits for other sets of baseline assumptions.

This appendix describes in detail the risk and benefits assessments that have been performed for the alternative baselines. The primary focus is on the work that EPA has done to evaluate groundwater pathway risks associated with waste disposal under the no prior treatment baseline. In addition, it discusses in less detail aspects of the risk and benefits assessments for the storage of recycled materials compared to the modified prior treatment baseline that are relevant to the alternative baselines.

A.2.1.1 Groundwater Risk and Benefits Assessment for Waste Disposal

The bulk of this appendix is devoted to a description of the risk and benefits analysis for mineral processing waste disposal. As discussed in Section 4.1, EPA has performed quantitative risk and benefits analysis for the groundwater pathway risks associated with the disposal of these wastes. EPA analyzed risks for all 42 (later reduced to 34) of the spent materials, sludges, and byproduct streams from the mineral processing industry for which constituent concentration data were available. Pre-regulatory risks were analyzed under the no prior treatment baseline, which assumed final disposal of untreated materials in land units (waste piles and surface impoundment). Benefits were estimated for the three regulatory options under consideration at the time of the analysis. For all three options, it was assumed that the wastes would be treated to meet UTS levels for all constituents prior to disposal.

Since the modified prior treatment baseline assumes that all wastes would be treated to meet TC regulatory levels, the no prior treatment and modified prior treatment baseline risks are not the same, and the health benefits of moving from the baseline to the regulated environment are not equivalent. On the other hand, the post-regulatory requirements for treatment of all wastes to meet the UTS requirements remains a feature of the current regulatory options. Thus, the post-regulatory risks calculated for waste disposal are still relevant to the current options, as was discussed in Section 4.2.

A.2.1.2 Groundwater and Multipathway Risk Assessment for Recycled Materials

The methods used to evaluate risks associated with the storage of recycled materials are described in detail in Appendix H, and will not be discussed in detail here. Risks were assessed for waste storage under the modified prior treatment baseline, which assumes that the recycled materials would be stored in unlined land-based units (waste piles and surface impoundments). This assumption is the same as that made in the no prior treatment baseline. Therefore the risks associated with these two baselines are the same, and this provides the rationale for including a discussion of these results in this appendix.

Because suitable models and data are not available that would allow risk estimation for tanks, containers, and buildings, the risks associated with the storage of recycled materials under the prior treatment baseline and under regulatory Options 1-3 have not been evaluated quantitatively. In section 4.2, the potential degrees of risk reduction associated with the various regulatory options are discussed qualitatively.

A.2.2 RISK AND BENEFITS ASSESSMENT METHODS

A.2.2.1 Risk Assessment Methods for Waste Disposal

A.2.1.1 Identification of Waste Streams for Quantitative Risk and Benefits Analysis

The procedures used to identify waste streams for inclusion in the risk and benefits assessments in the December 1995 RIA are described in Section 5.1.1.1 of that RIA.[3] The number of waste streams that could be evaluated with regard to risks and benefits was limited by the lack of constituent concentration data to a small fraction of the wastes that were evaluated in the cost and economic analysis. To evaluate pre-LDR constituent concentrations, bulk concentration data were used for wastewaters (WW), and EP leachate data were used to estimate release concentrations for liquid nonwastewaters (LNWW) and nonwastewaters (NWW). Wastes for which these types of data were not available were excluded from the quantitative risk and benefits assessments.

The procedures used to identify waste streams for inclusion in the sample-specific risk and benefits were slightly different, as described in Section 5.5.1.1 of the December RIA. First, the data requirements for including a waste in the quantitative risk assessment were relaxed somewhat, allowing inclusion of LNWW and NWW wastes for which only bulk concentration data were available. Second, the assumed proportion of high-probability ("Y") recycled materials that would be disposed was reduced from 20 percent to zero. This resulted in the removal of the two recycled materials for which constituent concentration data were available from the quantitative risk assessment, making the risk and benefits analysis for Regulatory Options 1 and 2 the same, in terms of the waste streams that were included.

A total of 42 waste streams ultimately met the criteria for inclusion in the sample-specific risk and benefits assessments for changes in waste disposal practices under the proposed LDRs. These waste streams represent a relatively small proportion, in terms of numbers, of the waste streams included in the cost and economic analysis. However, as discussed in the December RIA Appendix J, the wastes that are included in the risk and benefits analysis for waste disposal account for between 71 and 92 percent of the estimated total waste volume covered by the cost and economic analysis, depending on which volume estimates are used.

These same 42 wastes were included in the preliminary risk and benefits calculations (ICF Incorporated 1996a). Since that time, as discussed above, a number of waste streams have been eliminated from the risk and benefits assessments, as summarized in Exhibit A.2-1. Two beryllium sector waste streams were removed because they are beneficiation wastes, and would not be addressed by LDRs. One waste stream in the copper commodity sector was removed from the waste disposal risk and benefits assessment because EPA believes that it is fully recycled. Another copper waste stream was removed because it appears to be redundant with another stream. Two waste streams from lead production were

[3] *Regulatory Impact Analysis of the Supplemental Proposed Rule Applying Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes*, December 1995.

Exhibit A.2-1
Commodity Waste Streams Included in Revised Benefits Analysis

Commodity	Waste Stream
Aluminum and Alumina	Cast house dust
Antimony	Autoclave filtrate
Beryllium	Spent barren filtrate streams
~~Beryllium~~	~~Bertrandite thickener slurry~~
Beryllium	Chip treatment wastewater
~~Beryllium~~	~~Spent raffinate~~
Copper	Acid plant blowdown (1)
Copper	Scrubber blowdown
~~Copper~~	~~Spent bleed electrolyte~~
~~Copper~~	~~Surface impoundment waste liquids~~
Elemental Phosphorous	AFM rinsate
Elemental Phosphorous	Furnace offgas solids
Elemental Phosphorous	Furnace scrubber blowdown
Elemental Phosphorous	Slag quenchwater
Germanium	Waste acid wash/rinse water
Germanium	Chlorinator wet air pollution control sludge
Germanium	Hydrolysis filtrate
Germanium	Waste still liquor
~~Lead~~	~~Process wastewater~~
~~Lead~~	~~Surface impoundment waste liquids~~
Magnesium and Magnesia (brine)	Smut
Molybdenum, Ferromolybdenum, Ammonium Molybdate	Liquid residues
Rare Earths	Spent ammonium nitrate processing solution (2)
Rare Earths	Process wastewater (2)
Selenium	Plant process wastewater
Tantalum, Columbium, and Ferrocolumbium.	Process wastewater
Titanium and Titanium Dioxide	Pickle liquor & wash water
Titanium and Titanium Dioxide	Leach liquor & sponge wash water
Titanium and Titanium Dioxide	Scrap milling scrubber water
Titanium and Titanium Dioxide	Spent surface impoundment liquids
Titanium and Titanium Dioxide	Spent surface impoundment solids
~~Titanium and Titanium Dioxide~~	~~Waste acids (Chloride process)~~
Titanium and Titanium Dioxide	Waste acids (Sulfate process)
Titanium and Titanium Dioxide	Wastewater treatment plant sludge/solids
Tungsten	Spent acid & rinse water
Zinc	Waste ferrosilicon
~~Zinc~~	~~Process wastewater~~
Zinc	Spent surface impoundment liquids (3)
Zinc	Spent surface impoundment solids (4)
Zinc	Spent synthetic gypsum (3)
Zinc	Wastewater treatment plant liquid effluent (3)
Zinc	Zinc lean slag

removed, one because it is fully recycled, and another because it is no longer generated. Acid waste from titanium chloride production was removed from the analysis because EPA received information indicating that it is currently deep-well injected, and not land disposed. One waste stream from zinc production was removed because it is either recycled or not stored in land-based units. After removing these streams, 34 were left in the risk and benefits analysis for waste disposal. A zinc waste stream, "spent surface impoundment solids," was renamed to "waste water treatment plant solids," but remained in the analysis.

A.2.2.1.2 Waste Characterization Data and Release Concentration Estimates

The source of the mineral processing waste constituent concentration data used in the pre-LDR risk estimates is the same source as that used in the December 1995 RIA sample-specific risk assessment. These data are summarized in Appendix K of the December RIA. In this analysis a slightly different approach from that used in the RIA was adopted to enumerate samples of each waste type. In the December RIA, when both bulk analyses and EP leachate sample results were available for a LNWW or NWW stream, only the leachate data were used to estimate release concentrations. In the revised risk assessment presented below, both types of samples, when available, were used in the risk assessment to develop separate risk estimates. This approach makes the best possible use of the available data, and takes into account that, in many cases, it was not clear that the EP and bulk analyses for a given waste stream were from the same samples or batch of waste.

In adopting this approach, it was assumed that the observed differences in the release concentrations calculated from the two types of samples of the same wastes reflect real variability in waste stream constituent concentrations and in the leaching characteristics of the various constituents. In the December RIA, a total of 126 waste samples were evaluated for carcinogenic risks, and 217 samples were evaluated for noncarcinogenic risks. Using all of the available data in the revised risk assessment and excluding the wastes as described above, EPA calculated carcinogenic risks and noncarcinogenic hazard quotients for 115 samples and 190 samples, respectively. The number of samples evaluated for carcinogenicity was also reduced because EPA no longer calculated carcinogenic risks for beryllium (see below), and thus only streams containing arsenic were assumed to be carcinogenic.

For WW streams, the bulk concentration sample results were used directly as release concentration estimates. For LNWW and NWW streams, EP leachate concentrations were also used directly as release concentrations. For LNWW and WW bulk samples, release concentrations (mg/l) were conservatively estimated as being equal to the bulk constituent concentrations (mg/kg) divided by 20. This approach conservatively assumes that all waste constituents are completely leachable into the EP leachant.

For the post-LDR scenario, release concentrations for all constituents were estimated to be equal to one-half the landfill UTS concentrations for each constituent, or they were to be as being equal to the sample concentration, if that value was less than one-half the UTS concentration. The decision to use one-half the UTS concentration, instead of the UTS concentration itself, was based on EPA's assumption that waste managers required to comply with UTS would give themselves a conservative margin of safety and assume that all of the constituents are completely leachable. The basis for this judgment is discussed in Section 5.5.1.3 of the December RIA.

A.2.2.1.3 Exposure Assessment

Exposure concentrations of the waste constituents in ground water were estimated by dividing the release concentrations by the recently-developed constituent-specific DAF values derived for mineral

processing wastes. Under the no-treatment baseline scenario, all NWW streams were assumed to be disposed in waste piles. Therefore, the 75th and 95th percentile wastepile DAF values were used to evaluate central tendency (CT) and high end (HE) exposure concentrations, respectively. All WW and LNWW wastes were assumed to be disposed in surface impoundments, and the 75th and 95th percentile impoundment DAFs were therefore used to calculate the CT and HE exposure concentrations for these wastes.

In evaluating risks, the 75th percentile constituent-specific DAFs were used to estimate central tendency (CT) groundwater concentrations. The rationale for using the 75th percentile DAFs rather than, for example, the 50th percentile value was that the EPACMTP model used to derive DAFs does not consider fractured or channeled flow or other facilitated transport mechanisms which may occur at some sites, resulting in higher groundwater concentrations than those predicted for homogeneous flow processes modeled by EPACMTP. The 95th percentile constituent-specific DAF values were used to estimate high-end (HE) groundwater concentrations, in keeping with the definition of a high-end receptor as someone exposed at levels between the 90th and 99th percentiles of all exposed individuals.

In the post-LDR case, all wastes (WW, LNWW, NWW) were assumed to be treated and disposed of in landfills. Since no data related to mineral processing waste disposal in landfills were available, DAFs values derived for waste piles were used for estimating all of the exposure concentrations in the post-LDR scenario.

As noted above, the DAF values used in this analysis differed from those used previously. The DAF values used here were derived based on data on constituent concentrations, facility and waste volumes, and locational data specifically for mineral processing wastes, rather than on generic values. In addition, the DAF values used in this assessments were calculated separately for pre- and post-LDR release concentration distributions. Thus, these values better reflect the expected fate and transport characteristics of the mineral processing industry waste constituents than did the values used previously. In particular, the revised DAFs account for the concentration-dependence of groundwater transport for each constituent and regional variations in precipitation and groundwater transport. These variations were not taken into account in the previous DAF derivations.

The constituent-specific DAF values used in this risk assessment are provided in Exhibit A.2-2. The surface impoundment DAFs, which are used in this analysis only for evaluating pre-LDR risks for liquid wastes, are summarized in the second and third columns of the Exhibit A.2-2. Most of the 75th percentile DAF (CT) values are lower than the CT value of 500 used in the RIA risk analysis. The values for antimony, arsenic, chromium, mercury, and thallium are only slightly lower (within about a factor of ten), while the values for barium, beryllium, cadmium, nickel, selenium, silver, and zinc are much lower (greater than a factor of ten) than the CT DAF values used in the December RIA. For these liquid waste stream constituents, the estimated pre-LDR constituent groundwater concentrations were greater than those estimated in the RIA. In contrast, the 75th percentile surface impoundment DAF value for lead and cyanide used in this analysis increased by several orders of magnitude over the CT DAFs used in the RIA, and thus the pre-LDR groundwater concentration estimates are lower for lead- and cyanide-containing liquid waste streams than they were in previous analyses.

The 95th percentile surface impoundment DAF values derived for this analysis are generally similar to the HE DAF values used in the RIA. The HE DAF values in the December RIA risk analysis ranged between 6 and 100. The constituent-specific DAFs used in this analysis range between 1.3 and 200 for all but one constituent. The sole outlier is the DAF for cyanide, which is 4200. For all constituents except cyanide, the 95th percentile surface impoundment DAFs used in this assessment result

Exhibit A.2-2
Revised Constituent-Specific DAFs for the Mineral Processing Industry

	Surface Impoundments (1)		Waste Piles			
Constituent	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Post-LDR	High End (95th percentile) Post-LDR
Antimony	1.93E+02	2.28E+01	$>10^9$	8.36E+03	$>10^9$	8.36E+03
Arsenic	1.66E+02	1.71E+01	$>10^9$	2.56E+03	4.37E+09	2.56E+03
Barium	5.81E+00	1.17E+00	2.22E+03	1.38E+01	2.33E+03	1.46E+01
Beryllium	8.47E+00	1.24E+00	$>10^9$	4.87E+02	$>10^9$	5.54E+02
Cadmium	2.49E+01	1.40E+00	$>10^9$	2.67E+03	$>10^9$	3.26E+03
Chromium	9.82E+01	1.15E+01	2.21E+04	1.60E+02	2.21E+04	1.60E+02
Cyanide	2.81E+10	4.20E+03	-- (2)	--(2)	--(2)	--(2)
Lead	7.11E+05	4.98E+00	$>10^9$	2.27E+05	$>10^9$	8.93E+08
Mercury	1.97E+02	8.05E+00	$>10^9$	4.29E+03	$>10^9$	4.29E+03
Nickel	2.23E+01	1.51E+00	1.54E+06	1.41E+02	1.97E+06	1.46E+02
Selenium	2.70E+01	3.38E+00	1.18E+08	4.28E+02	1.19E+08	4.28E+02
Silver	1.11E+01	1.23E+00	$>10^9$	4.96E+02	$>10^9$	4.87E+02
Thallium	2.97E+02	4.15E+01	$>10^9$	9.63E+04	$>10^9$	9.63E+04
Vanadium	5.67E+00	2.03E+00	$>10^9$	$>10^9$	$>10^9$	$>10^9$
Zinc	1.23E+01	1.35E+00	$>10^9$	$>10^9$	$>10^9$	$>10^9$

Source: U.S. EPA (1996)

Notes:

(1) Post LDR DAFs for surface impoundments were not used in the risk calculations because it was assumed that all liquid wastes would be dewatered under LDRs.

(2) No DAFs were derived for cyanide disposed in waste piles because cyanide concentration data for non-liquid wastes were not available.

in pre-LDR estimated groundwater concentrations and health risks for liquid waste streams of generally similar magnitude to those calculated in the December RIA.

The constituent-specific waste pile DAF values derived for mineral processing wastes are shown in the last four columns of Exhibit A.2-2. These values were derived for both pre-LDR and post-LDR constituent concentrations. The former values were used to evaluate risks for all non-liquid waste streams pre-LDR, and the latter were used to evaluate risks post-LDR for all wastes, as explained above. The 75th percentile waste pile DAFs used in this analysis are, with few exceptions, many orders of magnitude greater than the CT DAF value (50) used in the December RIA. Thus, the predicted pre- and post-LDR risks for non-liquid waste streams containing these constituents are much lower than in the RIA. The lowest CT waste pile DAF value (about 2200), which was estimated for barium, is still about 40 times greater than the CT DAF value used in the RIA.

In comparison, most of the 95th percentile constituent-specific DAFs for the mineral processing wastes are somewhat closer to the range of HE values (12 to 100) used in the RIA. The pre-LDR HE waste pile DAFs are less than 10,000 for all but two contaminants, which are within two to three orders of magnitude of the RIA HE DAF range. Lead, vanadium, and thallium have HE DAFs that are higher than the values used in previous assessments. Post-LDR, the situation is similar. Most of the constituent-specific post-LDR DAF values for waste piles are less than 10,000, with the outliers again being lead and vanadium for which the DAF values are much higher. As with the 75th percentile DAFs, these revised 95th percentile DAF values result in the prediction of lower groundwater concentrations than those predicted in the previous assessments.

A.2.2.1.4 Risk Characterization

Lifetime cancer risks for the hypothetical receptor are calculated using the following equation:

$$CancerRisk = \frac{EC * IR * EF * ED * CSF}{BW * 365 * AT} \quad (1)$$

Where:

EC = Exposure concentration of constituent in groundwater, mg/l
IR = Water ingestion rate (1.4 l/day)
EF = Exposure frequency (350 days/year)
ED = Exposure duration (9 years)
CSF = Ingestion pathway Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$
BW = Adult body weight (70 kg)
AT = Averaging time for dose estimation (70 years)

Chronic noncancer hazard quotients for exposure to waste constituents in groundwater are calculated as follows:

$$HazardQuotient = \frac{EC * IR * EF}{BW * 365 * RfD} \quad (2)$$

where the RfD is the EPA chronic ingestion pathway Reference Dose for the constituent,[4] and the other variables have the same meaning as in Equation (1). The rationale for selecting the exposure factor values used in Equations (1) and (2) is discussed in Section 5.2.1.2 of the December RIA.

Two changes were made in the toxicological parameter values which were used to calculate risk results in this analysis. First, beryllium was no longer treated as an ingestion pathway carcinogen. While EPA has published an ingestion pathway cancer slope factor for beryllium, the Agency has not applied this value in several recent rulemakings, citing the great uncertainty surrounding the data supporting the cancer-causing potential of beryllium by the oral route. Thus, cancer risks are no longer calculated for beryllium-containing wastes, and arsenic is the sole carcinogenic constituent by the ingestion route included in the risk assessment. The other change in the toxicological parameter values was to use an updated IRIS RfD value for manganese, which had a very limited effect on the risk and benefits results.

A.2.2.2 Risk Assessment Methods for Storage of Recycled Materials

Risks associated with the storage recycled streams were assessed both for groundwater and non-groundwater pathways, as described in Appendix H. These methods will not be discussed in detail here.

A.2.2.3 Benefits Assessment Methods for Waste Disposal

A.2.2.3.1 Unit of Analysis for Benefits Assessment

Consistent with the December RIA, the unit of analysis of the benefits assessment is the "waste stream-facility combination." To calculate the benefits of improved management for a given waste stream, the number of facilities is first estimated, as described in Section A.2.2.3.2 of the RIA. Then, the numbers of facilities the imposition of the LDRs would result in changes in risk are calculated and categorized based on the order-of-magnitude change in risks pre- and post-LDR. The benefit measure is the number of facilities generating the waste (i.e., waste stream-facility combinations) that move from high-risk categories pre-LDR to lower-risk categories post-LDR. One feature of this approach is that a single facility that disposes of more than one waste stream will be counted in the benefits assessment as more than one waste stream-facility combination. Thus, the total number of waste stream-facility combinations in the benefits assessment exceeds the total number of facilities affected by the LDRs.

Another feature of this approach is that, as will be seen in Appendix A.2.2.3.3, not every exceedence of risk levels of concern pre-LDR results in an estimated benefit post-LDR. This is because if only a small number of samples from a given waste stream (one of 20, for example) give risk results above the level of concern, this may not translate into even one facility waste-stream combination if the number of facilities managing the waste is small (two or three). In this case, the estimated number of facilities with pre-LDR risks at levels of concern is zero. (Or more properly, it is less than one.)

This approach does not provide an estimate of risk reduction for identifiable exposed individuals, nor does it allow calculations of population risk reduction. As explained in the December RIA, the lack of data regarding the number of individuals exposed to groundwater around mineral processing facilities precludes the development of population risk and benefit estimates.

[4] Since there is currently no RfD value for lead, EPA calculated the hazard quotient for lead as the ratio of the exposure concentration to the MCL of 15 ug/l.

A.2.2.3.2 Estimation of Numbers of Facilities Managing Mining Wastes

The total number of facilities managing specific wastes were estimated as described in Chapter 4 of the December 1995 RIA. For the HE benefits estimates, the total estimated numbers of facilities generating the various waste streams nation-wide were used in the benefits estimation. For the CT benefits estimates, a reduced number of facilities managing some of the waste streams was used. For all of the waste streams categorized "Y?" (i.e., low likelihood of being TC hazardous), the CT number of facilities was estimated as the total facilities generating the waste stream divided by two. Odd numbers of facilities were rounded up by one to generate an even number (e.g., an HE estimate of seven facilities resulted in a CT estimate of four facilities).

A.2.2.3.3 Attribution of Risks to Facility-Waste Stream Combinations

If there were always one and only one sample result per waste stream per facility, then the attribution of risks across waste streams and facilities would have been simple. (Each sample risk result would correspond to one facility-waste stream combination in the benefits analysis.) Unfortunately, the number of samples per waste stream and per facility varied considerably, necessitating the development of a method for distributing risk results from single samples and groups of samples across multiple facility-waste stream combinations. The approach used to distribute risks across facilities used in the revised benefits assessment is essentially identical to that described in detail in Section 5.5.2.4 of the December RIA, and can be summarized as follows:

- Where there is only one sample result for a waste stream, all of the facilities managing that waste are assigned the risk value associated with the pre- or post-LDR disposal of a waste having the same composition as the sample;

- Where there are multiple samples from a waste stream, the facilities disposing of that waste are assigned risk values in the same proportion as the risks are distributed across the samples. For example, if there are four waste samples and eight facilities disposing of the wastes, the risk results from each of the four waste samples are assigned to two facility-waste stream combinations;

- Where there are multiple samples from a single facility, the risk results for each sample at the facility are counted as separate risk estimates only if they are significantly different from one another.[5] However, if multiple samples from a single facility result in risks that are very similar, the risks for all of those samples are averaged and counted as a single sample for purposes of the benefits analysis. The facility-waste stream combinations for a waste stream are then assigned to risk categories according the risk results from the individual samples from that waste stream, and from the combined samples counted as a single sample. This approach avoids giving too great a weight to multiple samples from the same facility and the same batch of wastes.

The approach described above is rather complex, and requires a certain amount of professional

[5] Risk from multiple samples are considered to be similar (homogeneous) if the same constituents account for the bulk of the risks, and if all of the sample-specific cancer risks or hazard quotients are within one to two orders of magnitude. (See the December RIA, p. 5-37.)

judgment. However, as was the case for the sample-specific risk analysis in the December RIA, decisions about whether to combine samples within facilities had relatively little impact on either the pre-LDR or post LDR risk distributions, and the distribution of facility-wastes stream combinations across risk categories followed the distribution of the individual samples risk results quite closely.

A.2.2.4 Benefits Assessment Methods for Storage or Recycled Materials

As discussed in Section 4.2, a quantitative benefits assessment was not performed for recycled materials storage. Instead, the baseline risks are identified as an upper bound estimate of the risk reduction that could occur if all releases of toxic constituents were eliminated by storage in tanks containers, and buildings. This assumption also holds true for the no treatment baseline, since no treatment of stored materials is assumed under that baseline. The risk assessment for storage does not provide an estimate of the magnitude of the potential benefits associated with the prior treatment baseline. Analogous to the case for the disposal of treated wastes, it is likely that the benefits of improved storage under any of the regulatory options over the prior treatment baseline would be minimal.

A.2.3 RESULTS OF RISK AND BENEFITS ASSESSMENT FOR THE NO TREATMENT BASELINE

This section summarizes the results of the revised screening risk and benefits calculations that were completed using the constituent-specific DAFs, as described in Section A.2.2.1.

A.2.3.1 Risk and Benefits Assessment Results for Waste Disposal

The results of the risk assessment for mineral processing wastes are summarized in Exhibits A.2-3 and A.2-4. Exhibit A.2-3 provides the results of the pre- and post-LDR assessments of the individual cancer risks calculated for each sample, and Exhibit A.2-4 provides the results of the noncancer hazard quotient calculations for the samples.

The general pattern of waste disposal risks calculated in the December RIA is replicated in the risk calculations that use the newly-revised constituent-specific DAFs are used, but in a more extreme fashion. Waste streams move from higher risk categories pre-LDR to lower risk categories post-LDR. The most striking difference between the risk results presented here and those in the RIA is that all of the wastes with estimated health risks (both CT and HE) above levels of concern pre-LDR (greater than 10^{-5} cancer risk or hazard quotient > 1.0) move to below the levels of concern post-LDR.

Pre-LDR, CT cancer risks greater than 10^{-5} are predicted for 58 of 115 samples, with risk results distributed through all of the categories up to $>10^{-1}$. The pre-LDR HE cancer risks for 80 of 115 samples were greater than 10^{-5}, with the highest risks again reaching the highest risk category. These proportions are not very different from those seen pre-LDR in both the December RIA. As noted above, estimated cancer risks for all of the waste samples post-LDR are below 10^{-5}.

EXHIBIT A.2-3
Distribution of Samples by Groundwater Risk Category: Cancer Risks

Commodity	Waste Stream	Number of Samples with Cancer Risk	Central Tendency												High End											
			Pre-LDR						Post-LDR						Pre-LDR						Post-LDR					
			<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1
Al and Alumina	Cast house dust	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Sb	Autoclave filtrate	8	0	0	0	2	6	0	8	0	0	0	0	0	0	0	0	0	2	6	8	0	0	0	0	0
Be	Spent barren filtrate streams	2	1	0	1	0	0	0	2	0	0	0	0	0	0	1	0	1	0	0	2	0	0	0	0	0
Be	Chip treatment WW	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Cu	Acid plant blowdown	30	7	4	10	4	3	2	30	0	0	0	0	0	1	6	4	10	4	5	30	0	0	0	0	0
Cu	Scrubber blowdown	3	1	0	2	0	0	0	3	0	0	0	0	0	0	1	0	2	0	0	3	0	0	0	0	0
Elemental Phosphorous	AFM rinsate	2	1	1	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
Elemental Phosphorous	Furnace offgas solids	9	9	0	0	0	0	0	9	0	0	0	0	0	9	0	0	0	0	0	9	0	0	0	0	0
Elemental Phosphorous	Furnace scrubber blowdown	8	4	3	1	0	0	0	8	0	0	0	0	0	1	3	3	1	0	0	8	0	0	0	0	0
Elemental Phosphorous	Slag quenchwater	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Ge	Waste acid wash/rinse water	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Ge	Chlorinator wet air poll. ctrl. sludge	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Ge	Hydrolysis filtrate	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Ge	Waste still liquor	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Mg and Magnesia (brine)	Smut	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Mo, FeMo, Amm. Mo	Liquid residues	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Rare Earths	Spent ammon. nitrate proc. sol.	5	5	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0
Rare Earths	PWW	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Se	Plant PWW	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Ta, Columbium, and FeCol.	PWW	13	8	2	2	1	0	0	13	0	0	0	0	0	6	3	1	3	0	0	13	0	0	0	0	0
Titanium and TiO2	Pickle liquor & wash water	3	2	1	0	0	0	0	3	0	0	0	0	0	0	2	1	0	0	0	3	0	0	0	0	0
Titanium and TiO2	Leach liquor & sponge wash water	2	1	1	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
Titanium and TiO2	Scrap milling scrubber water	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Titanium and TiO2	Spent s.i. liquids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Titanium and TiO2	Spent s.i. solids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Titanium and TiO2	Waste acids (Sulfate process)	4	1	3	0	0	0	0	4	0	0	0	0	0	1	0	3	0	0	0	4	0	0	0	0	0
Titanium and TiO2	WWTP sludge/solids	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	Spent acid & rinse water	2	1	0	1	0	0	0	2	0	0	0	0	0	0	1	0	1	0	0	2	0	0	0	0	0
Zn	Waste ferrosilicon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	Spent s.i. liquids	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
Zn	WWTP solids	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Zn	Spent synthetic gypsum	4	4	0	0	0	0	0	4	0	0	0	0	0	2	0	2	0	0	0	4	0	0	0	0	0
Zn	WWTP liquid effluent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	Zinc lean slag	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Totals		115	57	21	17	9	9	2	115	0	0	0	0	0	35	21	22	18	8	11	115	0	0	0	0	0

EXHIBIT A.2-4

Distribution of Samples by Groundwater Hazard Category: Non-Cancer Hazards

			Central Tendency												High End											
			Pre-LDR						Post-LDR						Pre-LDR						Post-LDR					
Commodity	Waste Stream	Number of Samples with Non-cancer Hazard	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k
Al and Alumina	Cast house dust	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Sb	Autoclave filtrate	8	0	0	0	4	4	0	8	0	0	0	0	0	0	0	0	2	2	4	8	0	0	0	0	0
Be	Spent barren filtrate streams	5	0	1	4	0	0	0	5	0	0	0	0	0	0	0	1	4	0	0	5	0	0	0	0	0
Be	Chip treatment WW	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Cu	Acid plant blowdown	35	6	8	13	5	3	0	35	0	0	0	0	0	0	3	8	14	5	5	35	0	0	0	0	0
Cu	Scrubber blowdown	3	0	1	2	0	0	0	3	0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	0
Elemental Phosphorous	AFM rinsate	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Elemental Phosphorous	Furnace offgas solids	14	14	0	0	0	0	0	14	0	0	0	0	0	14	0	0	0	0	0	14	0	0	0	0	0
Elemental Phosphorous	Furnace scrubber blowdown	14	5	6	2	1	0	0	14	0	0	0	0	0	1	1	6	5	1	0	14	0	0	0	0	0
Elemental Phosphorous	Slag quenchwater	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Ge	Waste acid wash/rinse water	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Ge	Chlorinator wet air poll. ctrl. sludge	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Ge	Hydrolysis filtrate	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Ge	Waste still liquor	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Mg and Magnesia (brine)	Smut	2	2	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	0
Mo, FeMo, Amm. Mo	Liquid residues	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Rare Earths	Spent ammon. nitrate proc. sol.	6	5	1	0	0	0	0	6	0	0	0	0	0	4	1	1	0	0	0	6	0	0	0	0	0
Rare Earths	PWW	4	2	2	0	0	0	0	4	0	0	0	0	0	1	1	1	1	0	0	4	0	0	0	0	0
Se	Plant PWW	2	1	1	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
Ta, Columbium, and FeCol.	PWW	21	13	2	5	0	1	0	21	0	0	0	0	0	8	2	3	2	2	4	21	0	0	0	0	0
Titanium and TiO2	Pickle liquor & wash water	3	0	3	0	0	0	0	3	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0
Titanium and TiO2	Leach liquor & sponge wash water	2	0	1	1	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Titanium and TiO2	Scrap milling scrubber water	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Titanium and TiO2	Spent s.i. liquids	10	10	0	0	0	0	0	10	0	0	0	0	0	10	0	0	0	0	0	10	0	0	0	0	0
Titanium and TiO2	Spent s.i. solids	6	6	0	0	0	0	0	6	0	0	0	0	0	3	3	0	0	0	0	6	0	0	0	0	0
Titanium and TiO2	Waste acids (Sulfate process)	4	0	0	4	0	0	0	4	0	0	0	0	0	0	0	2	2	0	0	4	0	0	0	0	0
Titanium and TiO2	WWTP sludge/solids	2	2	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	0
W	Spent acid & rinse water	4	3	1	0	0	0	0	4	0	0	0	0	0	2	1	0	1	0	0	4	0	0	0	0	0
Zn	Waste ferrosilicon	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Zn	Spent s.i. liquids	22	4	4	3	6	4	1	22	0	0	0	0	0	0	5	2	3	6	6	22	0	0	0	0	0
Zn	WWTP solids	7	7	0	0	0	0	0	7	0	0	0	0	0	2	4	1	0	0	0	7	0	0	0	0	0
Zn	Spent synthetic gypsum	4	4	0	0	0	0	0	4	0	0	0	0	0	2	2	0	0	0	0	4	0	0	0	0	0
Zn	WWTP liquid effluent	3	0	1	1	0	0	1	3	0	0	0	0	0	0	0	2	0	0	1	3	0	0	0	0	0
Zn	Zinc lean slag	3	3	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0
Totals		197	95	35	36	16	13	2	197	0	0	0	0	0	58	26	35	41	16	21	197	0	0	0	0	0

The distribution of pre-LDR cancer risks across waste streams is generally the same as that seen in the previous risk assessments, with exception that several of the high-risk waste streams have been eliminated from the analysis, as described above. The majority of samples with risks above 10^{-5} pre-LDR were from antimony autoclave filtrate, copper acid plant blowdown, elemental phosphorous furnace scrubber blowdown, tantalum, columbium and ferrocolumbium process wastewater, and titanium/titanium oxide waste acids from the sulfate process. High-risk streams from the previous analysis which were eliminated in this analysis include beryllium spent raffinate, lead process wastewater, and zinc process wastewater.

As was the case for cancer risks, all of the wastes with pre-LDR noncancer hazard quotients above the level of concern drop below this level post-LDR, under both CT and HE assumptions (Exhibit A.2-4). Pre-LDR, the CT hazard quotients for 102 of 197 waste samples are above 1.0, while 139 of 197 samples had HE pre-LDR hazard quotients above 1.0. All of the same wastes having high pre-LDR cancer risks also had high pre-LDR hazard quotients. In addition, a substantial number of samples from zinc spent surface impoundment liquids and waste water treatment plant solids both had high noncancer hazard quotients pre-LDR. As was the case for cancer risks, the reduction in hazard quotients below the level of concern post-LDR is the result of the higher post-LDR DAF values that were derived using data for the mineral processing waste constituents.

The results of the benefits analysis for cancer risks and noncancer risks under the no prior treatment baseline are summarized in Exhibits A.2-5 and A.2-6, respectively. As discussed previously, the distribution of risks across facility-waste stream combinations closely follows that seen for the individual samples.

In the CT case, the number of facility-waste stream combinations with pre-LDR cancer risks greater than 10^{-5} is 33 out of an estimated 108 facilities.[6] Post-LDR, all of the facility-waste stream combinations fall below the 10^{-5} CT risk level. In the HE case, 62 out of 133 facility-waste stream combination have pre-LDR cancer greater than 10^{-5}. All of these waste stream-facility combinations fall into the risk category less than 10^{-5} post-LDR

The number of facility-waste stream combinations with pre-LDR CT hazard quotients greater than 1.0 is 39 out of 108. In the HE case, 70 of 133 facilities have pre-LDR hazard quotients greater than 1.0. Post-LDR, all of the waste stream-facility combinations fall below the level of concern. The changes in the distributions of facility-waste stream combinations across cancer risk and hazard quotient categories associated with the LDRs for mineral processing wastes are shown graphically in Exhibit A.2-7.

A.2.3.2 Risk and Benefits Assessment Results for Storage of Recycled Materials

EPA's evaluation of the potential groundwater risks associated with the storage of recycled streams under the modified prior treatment baseline is described in Section 4.2.1 of this RIA. Estimated

[6] In reviewing Exhibits 5, the reader will note that the sums of the waste-stream-facility combinations in each risk category do not add up to the total number of facilities. This is because some of the facilities do not produce wastes with carcinogenic constituents (e.g., arsenic).

EXHIBIT A.2-5

Distribution of Waste Stream/Facility Combinations by Groundwater Risk Category: Cancer Risks

Commodity	Waste Stream	Number of Waste Stream/ Facility Combinations* #		Central Tendency												High End											
				Pre-LDR						Post-LDR						Pre-LDR						Post-LDR					
		Central Tendency	High End	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1	<10-5	10-5 to 10-4	10-4 to 10-3	10-3 to 10-2	10-2 to 10-1	>10-1
Al and Alumina	Cast house dust	23	23	23	0	0	0	0	0	23	0	0	0	0	0	23	0	0	0	0	0	23	0	0	0	0	0
Sb	Autoclave filtrate	4	7	0	0	0	2	2	0	4	0	0	0	0	0	0	0	0	0	4	4	7	0	0	0	0	0
Be	Spent barren filtrate streams	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0
Be	Chip treatment WW	1	2	1	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Cu	Acid plant blowdown	7	7	2	0	2	1	0	1	7	0	0	0	0	0	0	1	0	2	1	1	7	0	0	0	0	0
Cu	Scrubber blowdown	10	10	3	0	7	0	0	0	10	0	0	0	0	0	0	3	0	7	0	0	10	0	0	0	0	0
Elemental Phosphorous	AFM rinsate	2	2	1	1	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
Elemental Phosphorous	Furnace offgas solids	2	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Elemental Phosphorous	Furnace scrubber blowdown	2	2	1	1	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
Elemental Phosphorous	Slag quenchwater	2	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Ge	Waste acid wash/rinse water	2	4	2	0	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	4	0	0	0	0	0
Ge	Chlorinator wet air poll. ctrl. sludge	2	4	2	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0
Ge	Hydrolysis filtrate	2	4	2	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0
Ge	Waste still liquor	2	4	2	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0
Mg and Magnesia (brine)	Smut	2	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Mo, FeMo, Amm. Mo	Liquid residues	1	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0
Rare Earths	Spent ammon. nitrate proc. sol.	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Rare Earths	PWW	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Se	Plant PWW	2	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Ta, Columbium, and FeCol.	PWW	2	2	1	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	0
Titanium and TiO2	Pickle liquor & wash water	2	3	1	1	0	0	0	0	2	0	0	0	0	0	0	2	2	0	0	0	3	0	0	0	0	0
Titanium and TiO2	Leach liquor & sponge wash water	1	2	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0	0
Titanium and TiO2	Scrap milling scrubber water	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Titanium and TiO2	Spent s.i. liquids	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Titanium and TiO2	Spent s.i. solids	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Titanium and TiO2	Waste acids (Sulfate process)	1	2	0	1	0	0	0	0	1	0	0	0	0	0	1	0	2	0	0	0	2	0	0	0	0	0
Titanium and TiO2	WWTP sludge/solids	7	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W	Spent acid & rinse water	3	6	2	0	2	0	0	0	3	0	0	0	0	0	0	3	0	3	0	0	6	0	0	0	0	0
Zn	Waste ferrosilicon	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	Spent s.i. liquids	3	3	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0
Zn	WWTP solids	3	3	3	0	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0
Zn	Spent synthetic gypsum	3	3	3	0	0	0	0	0	3	0	0	0	0	0	2	0	2	0	0	0	3	0	0	0	0	0
Zn	WWTP liquid effluent	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	Zinc lean slag	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
TOTALS*		108	133	56	11	11	8	2	1	89	0	0	0	0	0	46	20	14	13	10	5	108	0	0	0	0	0

* Sums by risk category may not add to the number of central or high-end waste stream/facility combinations due to rounding.

Includes waste stream/facility combinations with no cancer risk (but with an associated non-cancer hazard)

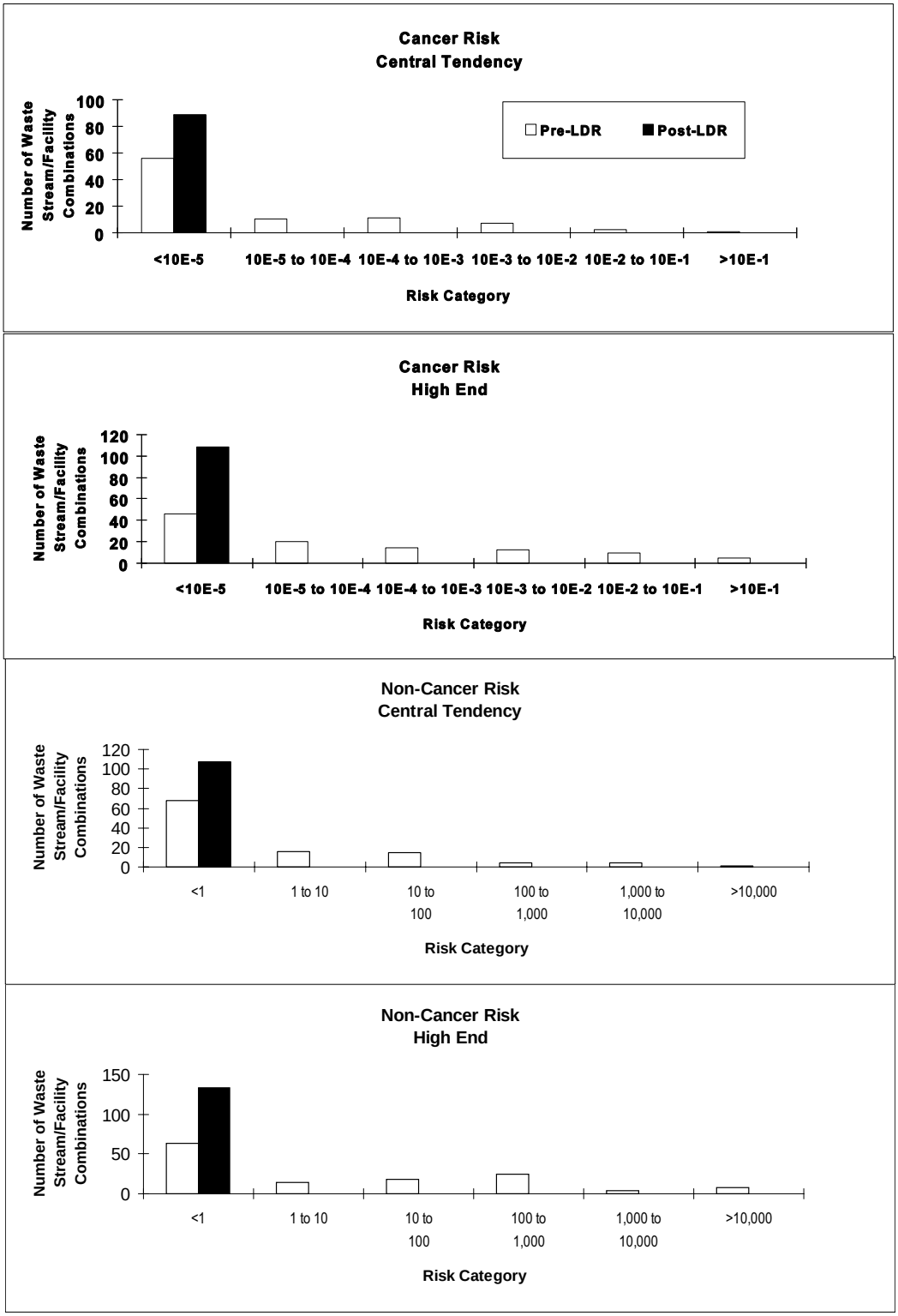
EXHIBIT A.2-6

Distribution of Waste Stream/Facility Combinations by Groundwater Hazard Category: Non-Cancer Hazards

Commodity	Waste Stream	Number of Waste Stream/ Facility Combinations*		Central Tendency												High End											
				Pre-LDR						Post-LDR						Pre-LDR						Post-LDR					
		Central Tendency	High End	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k	<1	1 to 10	10 to 100	100 to 1k	1k to 10k	>10k
Al and Alumina	Cast house dust	23	23	23	0	0	0	0	0	23	0	0	0	0	0	23	0	0	0	0	0	23	0	0	0	0	0
Sb	Autoclave filtrate	4	7	0	0	0	3	1	0	4	0	0	0	0	0	0	0	0	2	2	2	7	0	0	0	0	0
Be	Spent barren filtrate streams	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Be	Chip treatment WW	1	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0
Cu	Acid plant blowdown	7	7	1	2	2	1	1	0	7	0	0	0	0	0	0	1	1	2	1	1	7	0	0	0	0	0
Cu	Scrubber blowdown	10	10	0	3	7	0	0	0	10	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	0
Elemental Phosphorous	AFM rinsate	2	2	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Elemental Phosphorous	Furnace offgas solids	2	2	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0
Elemental Phosphorous	Furnace scrubber blowdown	2	2	1	1	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
Elemental Phosphorous	Slag quenchwater	2	2	2	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0
Ge	Waste acid wash/rinse water	2	4	2	0	0	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	4	0	0	0	0	0
Ge	Chlorinator wet air poll. ctrl. sludge	2	4	2	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0
Ge	Hydrolysis filtrate	2	4	2	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0
Ge	Waste still liquor	2	4	2	0	0	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	4	0	0	0	0	0
Mg and Magnesia (brine)	Smut	2	2	2	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	0	0
Mo, FeMo, Amm. Mo	Liquid residues	1	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0
Rare Earths	Spent ammon. nitrate proc. sol.	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Rare Earths	PWW	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Se	Plant PWW	2	2	1	1	0	0	0	0	2	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
Ta, Columbium, and FeCol.	PWW	2	2	1	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0
Titanium and TiO2	Pickle liquor & wash water	2	3	0	2	0	0	0	0	2	0	0	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0
Titanium and TiO2	Leach liquor & sponge wash water	1	2	0	1	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0
Titanium and TiO2	Scrap milling scrubber water	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Titanium and TiO2	Spent s.i. liquids	4	7	4	0	0	0	0	0	4	0	0	0	0	0	7	0	0	0	0	0	7	0	0	0	0	0
Titanium and TiO2	Spent s.i. solids	4	7	4	0	0	0	0	0	4	0	0	0	0	0	5	2	0	0	0	0	7	0	0	0	0	0
Titanium and TiO2	Waste acids (Sulfate process)	1	2	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0
Titanium and TiO2	WWTP sludge/solids	7	7	7	0	0	0	0	0	7	0	0	0	0	0	4	4	0	0	0	0	7	0	0	0	0	0
W	Spent acid & rinse water	3	6	2	1	0	0	0	0	3	0	0	0	0	0	3	2	0	2	0	0	6	0	0	0	0	0
Zn	Waste ferrosilicon	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Zn	Spent s.i. liquids	3	3	0	1	1	0	1	0	3	0	0	0	0	0	0	1	0	1	0	1	3	0	0	0	0	0
Zn	WWTP solids	3	3	3	0	0	0	0	0	3	0	0	0	0	0	1	1	1	0	0	0	3	0	0	0	0	0
Zn	Spent synthetic gypsum	3	3	3	0	0	0	0	0	3	0	0	0	0	0	2	2	0	0	0	0	3	0	0	0	0	0
Zn	WWTP liquid effluent	3	3	0	1	1	0	0	1	3	0	0	0	0	0	0	0	2	0	0	1	3	0	0	0	0	0
Zn	Zinc lean slag	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
TOTALS*		108	133	68	16	14	4	4	1	108	0	0	0	0	0	63	15	19	24	4	8	133	0	0	0	0	0

* Sums by hazard category may not add to the number of central or high-end waste stream/facility combinations due to rounding.

Exhibit A.2-7
Distribution of Waste Stream/Facility Combinations by Groundwater Risk and Hazard Categories



groundwater pathway cancer risks under high-end (HE) baseline assumptions exceeded 10^{-5} at 24 of 57 facilities storing recycled streams, while under central tendency (CT) assumptions, only 11 facilities exceed this level (Exhibit 4-8). The HE noncancer hazard quotients for groundwater exposures exceed 1.0 at 28 facilities storing recycled materials, and under CT assumptions baseline hazard quotients exceed 1.0 at 12 facilities. All of the facilities for which baseline cancer risks or noncancer hazard quotients exceed levels of concern manage wastewater and liquid nonwastewater streams in impoundments. Owing primarily to the low recycled volumes and small facility sizes, the baseline groundwater risks for the two nonwastewater streams managed in waste piles are below levels of concern under both CT and HE assumptions.

The analysis of non-groundwater pathway risks associated with waste storage under the modified prior treatment baseline indicated that, for the majority of the pathways evaluated, estimated risks were far below levels of concern. As was the case for the groundwater pathway risk assessment, risks from the storage of the two nonwastewater streams in waste piles were all less than levels of concern for all release events and exposure pathways.

Baseline risks greater than levels of concern were found for exposures to surface water contaminated by releases from surface impoundment failures for some waste streams, however. In the case of the direct ingestion pathway, one facility storing copper acid plant blowdown had an HE cancer risk exceeding 10^{-5}. Under CT assumptions, the estimated cancer risk for this facility was below the level of concern. When exposure through fish consumption is considered , six facilities from three commodity sectors had HE risks from waste storage exceeding cancer or noncancer levels of concern. Under CT assumptions, risks from only two storage facilities exceeded levels of concern for the fish ingestion pathway. These results are summarized in Exhibit 4-12.

As noted above, the EPA did not quantitatively estimate the extent of risk reduction or the level of health benefits that could be brought about by the proposed LDRs' effects on recycled materials storage. This is because the available data and models do not allow the development of risk reduction estimates for tanks, containers, and buildings, which would be required management units for most of the recycled streams under regulatory Options 1-3. If these options completely or substantially abolish the release of recycled streams to groundwater and other media, the baseline risks discussed in the previous paragraphs could all be reduced to below levels of concern. Lesser degrees of control would results in less risk reduction and lower health benefits. Under options 1 and 2, it is clear that risks for three of the streams currently managed through Bevill units (copper acid plant blowdown, and the two streams from elemental phosphorous production) would be greatly reduced by the requirement to manage these wastes in Subtitle C units. Copper acid plant blowdown figures prominently as a contributor to storage risks through both the groundwater and non-groundwater pathways. Under Option 4, no health benefits associated with the storage of recycled streams would be realized, as there is no requirement for improved management of these streams.

A.2.4.0 LIMITATIONS AND UNCERTAINTIES OF RISK AND BENEFITS ASSESSMENT

The section presents a brief discussion of the major uncertainties and limitations in the risk and benefits assessment for the no prior treatment baseline scenario. As stated in A.2.1, the discussion will be limited primarily to the sources of uncertainty specific to the revised analysis, and issues associated with previous risk and benefits work will only be mentioned briefly.

A.2.4.1 Major Uncertainties in the Risk Assessment for Waste Disposal

The major uncertainties associated with the risk assessment for mineral processing wastes are discussed in detail in Section 5.3.4 of December RIA, the major factors limiting the ability to quantify risks associated with the pre- and post-LDR disposal of mineral processing wastes include:

- Uncertainty about the identities, amounts, toxicity characteristics, elemental composition, and leaching behavior of wastes;
- Uncertainty about pre- and post-LDR waste amounts, waste management, recycling, and disposal practices;
- The use of the generic chemical release, groundwater transport, and exposure models instead of facility-specific data;
- The use of toxicity criteria derived primarily from animal studies; and
- The use of simplified models for predicting cancer risks and the potential for adverse noncancer affects.

This analysis represents EPA's an attempt to address some of these uncertainties, continuing the process of refinement which began with the sensitivity analysis performed as part of the December RIA. In addition, EPA has incorporated information received from commenters on the RIA to further assure that the risk assessment is consistent with the most recent information available. The efforts taken to incorporate new data, and their affect on the risk results, are discussed below.

EPA has received no substantial new information regarding the identities of additional waste streams or constituent concentrations that could be incorporated into the risk analysis. Based on public comments on the December RIA, a number of waste streams were removed from the risk and benefits analysis, either because they are no longer generated, or because EPA has determined that they are fully recycled and not disposed in land units. Removing these wastes from the analysis resulted in a reduction in the number of samples for which risks were calculated and in the number of facilities in the benefits analysis. The analysis is more accurate than the previous risk and benefits assessment in that it no longer includes waste streams that would not be covered by the LDRs. It should be remembered, however, that the risk and benefits assessment, while it still covers the majority of the estimated mineral processing waste volume, does not address the majority of waste streams that are included in the cost and economic impact analysis. Thus, it is likely that benefits from controls on waste disposal are underestimated, given that the risks for many wastes streams could not be calculated.

Several commenters on the December RIA noted the relatively limited amount of constituent concentration data that was used for the risk and benefits analysis, and criticized the assumptions used to characterize the leaching characteristics of wastes for which only bulk concentration data were used. In order to help address the shortage of data and to evaluate the impact of the leaching assumption, the both the EP and bulk analysis data were used in this analysis to develop separate risk estimates for NWW and LNWW waste streams when both are available, instead of using only the leachate data. This expansion of the analysis resulted in increases in the numbers of samples for which risk estimates were developed, as discussed in Section 2.1.2. This change in approach, which was adopted to make the fullest possible use of the available data, did not result in significant changes in the distribution of risks for the mineral

processing waste samples as a whole, or for any of the individual waste streams. This also suggests that the particular leaching assumption that was used did not result in any significant bias in the risk assessment results.

The major change in the risk results from previous analyses of waste management practices is the dramatic reduction in estimated post-LDR risks, to the extent that no waste samples had CT or HE post-LDR cancer risk or hazard quotients above levels of concern. This change is due to the changes in the method used to estimate groundwater concentrations. Like the previous analyses, the results presented in this assessment were derived using DAF values instead of site-specific modeling. In the original risk modeling, the DAFs were specific to the type of management unit, but were not constituent-specific, and they were derived for a nationally representative set of hydrogeological conditions. They, therefore, did not reflect (1) the inherent geochemical properties of the waste constituents, (2) the variations in transport that could be expected to occur as release concentrations varied, or (3) the specific hydrogeologic regimes at mineral processing facilities. In contrast, the DAF values used in this analysis take into account all of these factors. They were derived using constituent-specific geochemical characteristics, waste management unit sizes, waste volumes, and constituent concentrations from mineral processing industries, as well as hydrogeological variable values typical of the regional distribution of mineral processing facilities (e.g., primarily western, with low rainfall and high depth to groundwater).

Thus, while the approach to groundwater transport modeling taken in this analysis is still not site-specific, it has been carefully adjusted to incorporate all of the available data affecting potential releases and transport of waste constituents in groundwater. The degree of uncertainty associated with groundwater transport modeling, while still large, has thus been reduced substantially from previous analysis, and biases in the modeling resulting from failure to incorporate key variables has been greatly reduced.

The only major change in the toxicological parameter values that has been made since the previous risk analyses has been to eliminate consideration of beryllium as an ingestion pathway carcinogen. This change resulted in minimal impacts on the risk or benefits analysis, because beryllium was a risk driver for only a few waste streams. The impact of this change was reduced further because two of the waste streams from the beryllium industry were removed from the analysis for other reasons, as discussed in Section A.2.2.1.2.

A.2.4.2 Major Uncertainties in the Risk Assessment for Storage of Recycled Materials

The major limitations and sources of uncertainty in the multipathway risk assessment for the storage of recycled materials are discussed in detail in Appendix H, and will not be further addressed here.

A.2.5 REFERENCES CITED

ICF Incorporated (1996a), "Preliminary Results of Mineral Processing Wastes Risk and Benefits Assessments Using Constituent-Specific DAFs" technical memorandum submitted to the USEPA Office of Solid Waste, May 8, 1996.

ICF Incorporated (1996b), "Revised Results of Mineral Processing Wastes Risk and Benefits Assessments Using Constituent-Specific DAFs Derived for Mineral Processing Waste" technical memorandum submitted to the USEPA Office of Solid Waste, July 2, 1996.

ICF Incorporated (1995), "Regulatory Impact Analysis of the Supplemental Proposed Rules Applying Phase IV Land Disposal Restrictions to Newly Identified Mineral Processing Wastes", submitted to the USEPA Office of Solid Waste, December 1995.

USEPA, Office of Solid Waste (1996), "Groundwater Pathway Analysis for Mineral Processing Wastes Background Document (Draft), July 1996.

A.3 Risk Characterization Spreadsheets

This section of Appendix A presents the data and calculations that were used to characterize risk changes for waste disposal pre- and post-LDR under the no prior treatment baseline scenario. Exhibit A.3-1 presents the list of wastes for which constituent-specific data were available. Exhibit A.3-2 presents the constituent-specific DAFs used to evaluate groundwater exposures. Exhibit A.3-3 presents the toxicity parameter values used in the risk analysis. Finally, Exhibit A.3-4 presents an example risk calculation for a single waste sample from concentration data to risk results.

Exhibit A.3-1
List of Wastes for Which Constituent-Specific Data were Available

Commodity	Waste Stream
Aluminum and Alumina	Cast house dust
Antimony	Autoclave filtrate
Berryllium	Spent barren filtrate streams
Berryllium	Chip treatment wastewater
Copper	Acid plant blowdown
Copper	Scrubber blowdown
Elemental Phosphorous	AFM rinsate
Elemental Phosphorous	Furnace offgas solids
Elemental Phosphorous	Furnace scrubber blowdown
Elemental Phosphorous	Slag quenchwater
Germanium	Waste acid wash/rinse water
Germanium	Chlorinator wet air pollution control sludge
Germanium	Hydrolysis filtrate
Germanium	Waste still liquor
Magnesium and Magnesia (brine)	Smut
Molybdenum, Ferromolybdenum, Ammonium Molybdate	Liquid residues
Rare Earths	Spent ammonium nitrate processing solution
Rare Earths	Process wastewater
Selenium	Plant process wastewater
Tantalum, Columbium, and Ferrocolumbium	Process wastewater
Titanium and Titanium Dioxide	Pickle liquor & wash water
Titanium and Titanium Dioxide	Leach liquor & sponge wash water
Titanium and Titanium Dioxide	Scrap milling scrubber water
Titanium and Titanium Dioxide	Spent surface impoundment liquids
Titanium and Titanium Dioxide	Spent surface impoundment solids
Titanium and Titanium Dioxide	Waste acids (Sulfate process)
Titanium and Titanium Dioxide	Wastewater treatment plant sludge/solids
Tungsten	Spent acid & rinse water
Zinc	Waste ferrosilicon
Zinc	Spent surface impoundment liquids
Zinc	Wastewater treatment plant solids
Zinc	Spent synthetic gypsum
Zinc	Wastewater treatment plant liquid effluent
Zinc	Zinc lean slag

Exhibit A.3-2

Constituent-Specific DAFs Used to Evaluate Groundwater Exposures

	Surface Impoundments		Waste Piles			
Constituent	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Pre-LDR	High End (95th percentile) Pre-LDR	Central Tendency (75th percentile) Post-LDR	High End (95th percentile) Post-LDR
Antimony	1.93E+02	2.28E+01	$>10^9$	8.36E+03	$>10^9$	8.36E+03
Arsenic	1.66E+02	1.71E+01	$>10^9$	2.56E+03	4.37E+09	2.56E+03
Barium	5.81E+00	1.17E+00	2.22E+03	1.38E+01	2.33E+03	1.46E+01
Beryllium	8.47E+00	1.24E+00	$>10^9$	4.87E+02	$>10^9$	5.54E+02
Cadmium	2.49E+01	1.40E+00	$>10^9$	2.67E+03	$>10^9$	3.26E+03
Chromium	9.82E+01	1.15E+01	2.21E+04	1.60E+02	2.21E+04	1.60E+02
Cyanide	2.81E+10	4.20E+03	--	--	--	--
Lead	7.11E+05	4.98E+00	$>10^9$	2.27E+05	$>10^9$	8.93E+08
Mercury	1.97E+02	8.05E+00	$>10^9$	4.29E+03	$>10^9$	4.29E+03
Nickel	2.23E+01	1.51E+00	1.54E+06	1.41E+02	1.97E+06	1.46E+02
Selenium	2.70E+01	3.38E+00	1.18E+08	4.28E+02	1.19E+08	4.28E+02
Silver	1.11E+01	1.23E+00	$>10^9$	4.96E+02	$>10^9$	4.87E+02
Thallium	2.97E+02	4.15E+01	$>10^9$	9.63E+04	$>10^9$	9.63E+04
Vanadium	5.67E+00	2.03E+00	$>10^9$	$>10^9$	$>10^9$	$>10^9$
Zinc	1.23E+01	1.35E+00	$>10^9$	$>10^9$	$>10^9$	$>10^9$

Note: Central Tendency values are the 75th percentile of the distribution of DAF values and the High End values are the 95th percentile.

Exhibit A.3-3
Toxicity Parameter Values Used in the Risk Analysis

Constituent	Oral Cancer Slope Factor (CSF) 1/(mg/kg-day)	Oral Reference Dose (RfD) mg/kg-day
Antimony	----	0.0004
Arsenic	1.5	0.0003
Barium	----	0.07
Beryllium	----	0.005
Boron	----	0.09
Cadmium	----	0.0005
Chromium	----	0.005
Lead	----	0.0003
Manganese	----	0.047
Mercury	----	0.0003
Molybdenum	----	0.005
Nickel	----	0.02
Selenium	----	0.005
Silver	----	0.005
Thallium	----	0.00008
Vanadium	----	0.007
Zinc	----	0.3
Cyanide	----	0.02
Fluoride	----	0.06

Source: EPA IRIS (1996) and HEAST (1995)

The Lead RfD is derived from the EPA action level of 0.015 mg/L.
The RfD for Chromium is from Cr+6.
The RfD for Thallium is from Thallium sulfate.

There were no toxicity values for the following constituents: Aluminum, Cobalt, Copper, Iron, Magnesium, Phosphate, Silica, Chloride, TSS, pH, Organics (TOC), Sulfide, or Sulfate.

Exhibit A.3-4 - Example Risk Calculation for a Single Waste Sample from Concentration Data to Risk Results

Waste Stream Data & Calculations

Commodity	Waste Stream	Sample Number	Cancer: Central Tendency Pre-LDR	Cancer: Central Tendency Post-LDR	Cancer: High End Pre-LDR	Cancer: High End Post-LDR	Non-Cancer: Central Tendency Pre-LDR	Non-Cancer: Central Tendency Post-LDR	Non-Cancer: High End Pre-LDR	Non-Cancer: High End Post-LDR
Rare Earths	Spent ammonium nitrate processing solution	7	5.57E-08	2.12E-12	5.41E-07	5.41E-07	3.85E-03	4.47E-04	1.41E-01	1.17E-02

Facility Identifier = Res. Chem, Phoenix
State = AZ

The cancer risk values are the sum of risks from each constituent in a sample.
The non-cancer hazard values represent the highest hazard quotient for a constituent in a sample.

Treatment Type: Waste Water	Treatment Type: 1 10% Solids	Treatment Type: Solid	Constituents	Total Constituent Analysis (ppm)	EP Toxicity Analysis (ppm)	Pre-LDR DAFS: Central Tendency	Pre-LDR DAFS: High End	Post-LDR DAFS: Central Tendency	Post-LDR DAFS: High End
1	0	0	Aluminum						
1	0	0	Antimony			1.93E+02	2.28E+01	3.00E+13	8.36E+03
1	0	0	Arsenic	0.0025		1.66E+02	1.71E+01	4.37E+09	2.56E+03
1	0	0	Barium	0.05		5.81E+00	1.17E+00	2.33E+03	1.46E+01
1	0	0	Beryllium			8.47E+00	1.24E+00	2.13E+15	5.54E+02
1	0	0	Boron	0.12					
1	0	0	Cadmium	0.0025		2.49E+01	1.40E+00	6.12E+16	3.26E+03
1	0	0	Chromium	0.01		9.82E+01	1.15E+01	2.21E+04	1.60E+02
1	0	0	Copper	0.005					
1	0	0	Iron						
1	0	0	Lead	0.011		7.11E+05	4.98E+00	1.00E+30	8.93E+08
1	0	0	Magnesium						
1	0	0	Manganese	0.005					
1	0	0	Mercury	0.0001		1.97E+02	8.05E+00	6.37E+12	4.29E+03
1	0	0	Molybdenum						
1	0	0	Nickel			2.23E+01	1.51E+00	1.97E+06	1.46E+02
1	0	0	Selenium	0.0025		2.70E+01	3.38E+00	1.19E+08	4.28E+02
1	0	0	Silver	0.005		1.11E+01	1.23E+00	1.33E+10	4.87E+02
1	0	0	Thallium			2.97E+02	4.15E+01	1.23E+28	9.63E+04
1	0	0	Vanadium			5.67E+00	2.03E+00	1.00E+30	1.00E+30
1	0	0	Zinc	0.005		1.23E+01	1.35E+00	1.34E+16	1.77E+03
1	0	0	Cyanide	0.005		2.81E+10	4.20E+03		
1	0	0	Sulfide	0.025					
1	0	0	Fluoride						

For constituents with a DAF, if the treatment type is solid (the solid column has a 1), the DAF value returned is for waste piles; otherwise, the DAF value returned is for surface impoundments. See Exhibit A.3-2 for the DAF values.

Exhibit A.3-4 (Continued) - Example Risk Calculation for a Single Waste Sample from Concentration Data to Risk Results

	Pre-LDRs - Central Tendency					Pre-LDRs - High End				
Constituents	Groundwater Conc (ppm=mg/L)	Cancer Dose (mg/kg-d)	Noncancer Dose (mg/kg-d)	Lifetime Excess Cancer Risk	Hazard Quotient	Groundwater Conc (ppm=mg/L)	Cancer Dose (mg/kg-d)	Noncancer Dose (mg/kg-d)	Lifetime Excess Cancer Risk	Hazard Quotient
Aluminum										
Antimony										
Arsenic	1.51E-05	3.71E-08	2.89E-07	5.57E-08	9.63E-04	1.46E-04	3.60E-07	2.80E-06	5.41E-07	9.35E-03
Barium	8.61E-03	2.12E-05	1.65E-04		2.36E-03	4.27E-02	1.05E-04	8.20E-04		1.17E-02
Beryllium										
Boron										
Cadmium	1.00E-04	2.48E-07	1.93E-06		3.85E-03	1.79E-03	4.40E-06	3.42E-05		6.85E-02
Chromium	1.02E-04	2.51E-07	1.95E-06		3.91E-04	8.70E-04	2.14E-06	1.67E-05		3.34E-03
Copper										
Iron										
Lead	1.55E-08	3.81E-11	2.97E-10		9.89E-07	2.21E-03	5.45E-06	4.24E-05		1.41E-01
Magnesium										
Manganese										
Mercury	5.08E-07	1.25E-09	9.74E-09		3.25E-05	1.24E-05	3.06E-08	2.38E-07		7.94E-04
Molybdenum										
Nickel										
Selenium	9.26E-05	2.28E-07	1.78E-06		3.55E-04	7.40E-04	1.82E-06	1.42E-05		2.84E-03
Silver	4.50E-04	1.11E-06	8.64E-06		1.73E-03	4.07E-03	1.00E-05	7.80E-05		1.56E-02
Thallium										
Vanadium										
Zinc	4.07E-04	1.00E-06	7.80E-06		2.60E-05	3.70E-03	9.13E-06	7.10E-05		2.37E-04
Cyanide	1.78E-13	4.39E-16	3.41E-15		1.71E-13	1.19E-06	2.94E-09	2.28E-08		1.14E-06
Sulfide										
Fluoride										

Groundwater (gw) concentration = total constituent analysis concentration / DAF (for waste waters with a total constituent analysis concentration)
gw concentration = EP toxicity analysis concentration / DAF (for non-waste waters with an EP toxicity analysis concentration)
gw concentration = total constituent analysis concentration / 20 / DAF (for solids with a total constituent analysis concentration and no EP toxicity analysis concentration)
gw concentration = total constituent analysis concentration / DAF (for 10% solids with a total constituent analysis concentration and no EP toxicity analysis concentration)
No gw values are returned for constituents with no DAF or total constituent analysis concentration.

Cancer dose = gw concentration x cancer gw inta Noncancer dose = gw concentration x noncancer gw intake.
Cancer gw intake = (gw intake*exposure duration*exposure frequency)/(cancer averaging time*365*body weight) = 0.00247 L/kg-day.
Noncancer gw intake = (gw intake*exposure duration*exposure frequency)/(noncancer averaging time*365*body weight) = 0.01918 L/kg-day.
Cancer risk = slope factor x cancer dose. Hazard quotient (hq) = noncancer dose / RfD. See Exhibit A.3-3 for slope factors and RfDs.
Body Weight = 70 kg Exposure Duration = 9 years Non-cancer Averaging Time = 9 years
Exposure Frequency = 350 days/year Cancer Averaging Time = 70 years Groundwater Ingestion Rate = 1.4 L/day

No cancer risk values are returned for constituents with no slope factor; no hq values are returned for constituents with no RfD.

Exhibit A.3-4 (Continued) - Example Risk Calculation for a Single Waste Sample from Concentration Data to Risk Results

	Post-LDRs (UTS) - Central Tendency					Post-LDRs (UTS) - High End				
Constituents	Groundwater Conc (ppm=mg/L)	Cancer Dose (mg/kg-d)	Noncancer Dose (mg/kg-d)	Lifetime Excess Cancer Risk	Hazard Quotient	Groundwater Conc (ppm=mg/L)	Cancer Dose (mg/kg-d)	Noncancer Dose (mg/kg-d)	Lifetime Excess Cancer Risk	Hazard Quotient
Aluminum										
Antimony										
Arsenic	5.72E-10	1.41E-12	1.10E-11	2.12E-12	3.66E-08	1.46E-04	3.60E-07	2.80E-06	5.41E-07	9.35E-03
Barium	1.63E-03	4.02E-06	3.13E-05		4.47E-04	4.27E-02	1.05E-04	8.20E-04		1.17E-02
Beryllium										
Boron										
Cadmium	1.55E-18	3.83E-21	2.98E-20		5.95E-17	2.91E-05	7.19E-08	5.59E-07		1.12E-03
Chromium	1.95E-05	4.80E-08	3.73E-07		7.46E-05	8.70E-04	2.14E-06	1.67E-05		3.34E-03
Copper										
Iron										
Lead	1.85E-31	4.56E-34	3.55E-33		1.18E-29	2.07E-10	5.11E-13	3.97E-12		1.32E-08
Magnesium										
Manganese										
Mercury	1.96E-15	4.84E-18	3.76E-17		1.25E-13	2.91E-06	7.18E-09	5.59E-08		1.86E-04
Molybdenum										
Nickel										
Selenium	6.72E-10	1.66E-12	1.29E-11		2.58E-09	1.87E-04	4.61E-07	3.58E-06		7.17E-04
Silver	1.13E-11	2.78E-14	2.16E-13		4.33E-11	3.08E-04	7.59E-07	5.91E-06		1.18E-03
Thallium										
Vanadium										
Zinc	1.98E-16	4.88E-19	3.79E-18		1.26E-17	1.50E-03	3.69E-06	2.87E-05		9.57E-05
Cyanide										
Sulfide										
Fluoride										

Groundwater (gw) concentration = treatment level / DAF (if pre-LDR gw concentration is greater than the treatment level / DAF); otherwise gw concentration = pre-LDR gw concentration

No gw values are returned for constituents with no DAF or treatment level.
See the previous page for an explanation of the dose, risk, and hazard calculations.