CHAPTER 4- ENVIRONMENTAL CONSEQUENCES

CHAPTER 4 ENVIRONMENTAL CONSEQUENCES

This chapter discusses anticipated direct and indirect impacts of the Proposed Action, one alternative, and the No Action Alternative for the North Rasmussen Ridge Mine. The following table presents a brief comparison of the disturbance and reclamation areas of the different alternatives. Continued operation, closure, and reclamation of the North Rasmussen Ridge Mine would result in an irreversible or irretrievable commitment of various resources. These resources would be consumed, committed, or lost during and after the life of the project. Nonrenewable resources, such as minerals in the ore, would be irreversibly committed during ore-processing operations. Irreversible and irretrievable commitment of resources and residual effects that would likely occur as a result of the Proposed Action or alternatives are discussed for each resource. Potential mitigation measures developed in response to anticipated impacts are also discussed for each resource. The Proposed Action is described in Chapter 2 and it basically involves developing expanded mining facilities to continue mining on existing leases. A comparison of impacts between the Proposed Action and alternatives is summarized in **Table 2.6-1** in Chapter 2. Cumulative effects (discussed in Chapter 5) result from incremental effects of the action when added to other past, present, and reasonably foreseeable future actions.

Disturbance and Reclamation Comparison of Alternatives (acres)

Description	Existing Disturbance	New Disturbance	Reclaimed Area	Percent Reclaimed
South Rasmussen	257	0	257	100
Central Rasmussen	231	0	196	84.8
Proposed North Rasmussen Ridge Mine				
Proposed Action	0	269	197+35	86.2
Alternative 1 – Proposed Action with Impermeable cap	0	320	248+35	88.4
Alternative 2 – No Action	0	0	-35	

+35 and -35 refers to Central Rasmussen Ridge Mine final pit area

4.1 MINERALS, TOPOGRAPHY, GEOLOGY, AND PALEONTOLOGY

4.1.1 Direct and Indirect Impacts

4.1.1.1 Proposed Action

Mineral Resources

Mineral resources would be directly affected by removal of phosphate ore and overburden. The phosphate resources produced under the Proposed Action would be available to meet regional or national demands for this commodity.

Under the Proposed Action, the deeper phosphate resources that would remain after mining in the North Rasmussen reserve would be uneconomic to remove at currently anticipated prices. Prices for phosphate would need to increase for mining of the remaining resources to become economic. The potential for future recovery of the remaining phosphate resources would be reduced by backfilling of the pits. The backfill material in the pits would have to be removed, and the pits would have to be enlarged substantially for the remaining phosphate resource to be mined. A substantial increase in the value of the phosphate would be necessary to offset the costs associated with removal of the backfill in the pits and the stripping of additional overburden required to enlarge and deepen the pits.

Topography/Disturbance

The pattern of naturally occurring rock outcrops would be altered wherever rock exposures would be excavated. Existing topographic features and landforms would be altered by removal and relocation of the waste rock (overburden) during mining operations under the Proposed Action. Waste rock would be hauled to the Central Rasmussen Mine pit and used as backfill material or as backfill material within the North Rasmussen Ridge Mine pits. An estimated 269 acres of land surface in the project area would be disturbed under the Proposed Action.

The North Rasmussen Ridge Mine pits, which encompass 199 acres, would be excavated as two pits under the Proposed Action. The combined pits would be 11,435 feet in length starting on the south end, at section 12500N, and ending on the north end, at section 23935N. These pits would be separated by 70 feet of original ground allowing No Name Creek to pass through the mine area. Approximately 49 percent of the waste rock generated under the Proposed Action would be placed in North Rasmussen Ridge backfill areas A, B, and C. Under the Proposed Action, backfill area C would be only partially backfilled. The backfill would cover the exposed ore and waste shales and the final pit bottom. Backfilling of the North Rasmussen Mine pits would reclaim 127 acres to original contour and 72 acres of partial backfill that would reduce the height of the residual highwalls.

The remainder of the waste rock available for use in backfilling mine excavations would be used in the Central Rasmussen Mine pit. Approximately 46 percent of the waste rock generated under the Proposed Action would be placed in Central Rasmussen backfill area F. The remaining 5 percent of waste rock generated under the Proposed Action would be placed in the Central Coyote Corner backfill area. The waste rock would be run of mine and would be placed in the deepest area and covered with 8 to 10 feet of chert and limestone and 2 to 3 feet of growth media. Under the Proposed Action, all of the 231 acres disturbed by the Central Rasmussen Mine pit would be reclaimed. This amount represents an increase in the acreage that would be reclaimed in the Central Rasmussen Mine pit area, from 196 acres under the approved Central Rasmussen Ridge Mine plan, to 231 acres under the Proposed Action, an increase of 35 acres.

Geology/Geologic Hazards

The geology of the project area would not be changed by phosphate mining; however, surficial deposits and bedrock would be removed by excavation and waste rock would be redeposited. Phosphate mining under the Proposed Action would disrupt the naturally occurring stratigraphic sequence within the mine pit. This disruption would facilitate continued study of the phosphate-bearing strata where the stratigraphic section is exposed by excavation but making study difficult or impossible where large volumes of rock are removed or covered by waste rock. New human-engineered surficial deposits (pit backfill areas, and growth media storage areas) would be created during mining. At the conclusion of mining, reclaimed surface areas would also represent new human-engineered surficial deposits.

Depending on intensity, distance from the epicenter, and condition of structures, an earthquake may cause damage to mine facilities, surface rupture, displacement landslides, change in water flow from springs and wells, and failure of earthen dams. North Rasmussen is in seismic Zone III. Highwalls and backfill slopes are expected to be stable for facilities designed and operated in accordance with the practices currently in use at the Central Rasmussen Ridge Mine and in consideration of the potential seismic risks. The placement of backfill would provide additional support for highwalls that would further reduce the potential for instability. Because the areas for disposal of backfill are designed to incorporate convex faces at 3.0h:1.0v, no geotechnical stability hazards likely would be associated with the backfill areas.

Non-earthquake related potential impacts associated with geotechnical instability can be controlled using current sound operational practices. Operational practices have been developed to address each of the factors related to geotechnical stability. Where underlying slopes are too steep, material would be placed at the toe of the backfill to buttress the slopes. Trucks would be stopped on stable ground and unloaded to minimize shock loading on potentially unstable slopes. Rock would then be placed by dozer. Overloading would be reduced by limiting the height of backfill lifts. Reclamation recontouring would be performed concurrently or shortly after slope construction.

Geochemistry

The mining of ore and overburden under the Proposed Action would produce highly fractured rock from bedrock that is currently undisturbed and buried, with limited exposure to atmospheric oxygen or water. These rock fragments or particles of varying sizes would be exposed to surface conditions during mining and backfilling, introducing atmospheric oxygen and water that initiate weathering. The reactive surface area of the mined material used as backfill material would be far greater than that of the in-situ rocks. Weathering processes would include oxidation and the addition of moisture from precipitation. The increased surface area that is subject to weathering and leaching would most likely result in leaching harmful products into groundwater, surface waters and soils. Once the overburden is in its final backfilled site and is reclaimed, exposure to surface conditions and weathering processes would be reduced. However, it would take several hundred years or more for leaching products in the backfill to return to pre-disturbance levels.

Acid Rock Drainage (ARD)

Exposure of overburden rocks to the atmosphere could result in the oxidation of sulfide minerals and produce sulfuric acid and other chemical products. Because the solubility of most metals increases under acidic conditions, the weathering of waste rock could cause dissolution of metals and increased concentrations in surface or groundwaters.

ABA testing of 152 samples of overburden from Rasmussen Ridge indicates that the neutralizing potential for run of mine overburden is 17 time greater than the acid producing potential. This result indicates that the waste rock that would be held in disposal facilities and used as backfill under the Proposed Action is unlikely to generate ARD. Summary data for acid-base accounting tests on material proposed as backfill was presented in **Table 3.1-3**.

Results of ABA testing are also in agreement with the observed weathering behavior of historic waste rock at the Rasmussen Ridge Mine and other phosphate mines in the region. ARD has not been observed at existing waste rock dumps at Rasmussen Ridge or the neighboring Dry Valley and Smokey Canyon Mines (BLM et al 2000; BLM and USFS 2002). Dry Valley and Smokey Canyon mines recover phosphate from the same stratigraphic sequence that would be mined in the North Rasmussen Ridge pits.

Selenium and Other Elements

Weathering of shales within the Meade Peak Member of the Phosphoria Formation could also cause the oxidation of minerals and organic materials in waste rock that contain selenium and other metals. Selenium and other constituents released from the overburden during weathering could infiltrate into underlying earth materials or could be flushed from the overburden by surface runoff. Surface runoff that carries selenium, dissolved metals, or other constituents of potential concern (COPCs) could be discharged to surface waters unless it is controlled by storm water management systems or backfilled into the mine panels. Infiltrating water could be discharged from the backfill as seeps or springs or could continue to percolate downward through soils and bedrock, where it could recharge shallow or deep aquifers (BLM and USFS 2002).

The potential for oxidation of selenium-bearing minerals and organic matter and subsequent release of metals and other elements has been identified at other mines in southeast Idaho that produce phosphate from the Meade Peak Member. These metals include selenium, arsenic, antimony, cadmium, chromium, copper, lead, manganese, nickel, iron, aluminum, and zinc. The release of these constituents has been inferred to result from oxidation of overburden and rinsing of secondary mineral salts (BLM and USFS 2002).

Elemental Geochemistry

Assays for 50 elements in 119 samples of overburden indicate that cadmium, nickel, antimony, selenium, and zinc occur in the proposed mine waste rock at concentrations above normal crustal abundances (Rose et al. 1979). Average concentrations of cadmium in the proposed overburden are highest in Footwall Mud (92.17 ppm) followed by limestone (43.24 ppm), Center Waste Shale (29.77 ppm), Hanging Wall Mud (22.89 ppm), alluvium (4.88 ppm), and Rex Chert (3.13 ppm). Average concentrations of nickel are highest in the Footwall Mud (557.7 ppm) and lowest in alluvium (75.4 ppm). The Footwall Mud also has the highest concentration of antimony and zinc (7.49 and 3,489 ppm, respectively). Concentrations of selenium are greatest in the Hanging Wall Mud (76.0 ppm) followed by the Center Waste Shale (51.6 ppm), Footwall Mud (26.4 ppm), Rex Chert (16.6 ppm), alluvium (6.5 ppm) and limestone (4.1 ppm) (Maxim 2002a). Concentrations for selected constituents in proposed overburden were presented in **Table 3.1-4**.

Although the elemental assays indicate which metals are present in the overburden and to what extent they are enriched relative to other lithologies, they do not provide information about the potential solubility or mobility of the metal in the environment.

Column Leaching Tests

Column leaching tests were performed to evaluate the potential for release of metals from overburden materials and to identify COPCs. Eleven columns were constructed using cuttings from exploration drilling in the area of the proposed pit. Columns were prepared for each significant overburden rock type, including one column for alluvium, one for Rex Chert, one for Hanging Wall Mud, one for Footwall Mud, two for unweathered Center Waste Shale, two for weathered Center Waste Shale, and three for limestone.

Concentrations in column leachates were generally highest in the initial pore volume and decreased in subsequent pore volumes before becoming stable at lower levels. Arithmetic mean concentrations in column test leachate for combined pore volumes 1 through 10 are summarized in **Table 4.1-1** (also see **Table 3.1-6**). Plots showing TDS and selenium concentrations as a function of pore volume are shown on **Figure 4.1-1**.

Results of the column leaching tests indicate that seven parameters are COPCs in groundwater and four parameters are identified as COPCs in surface water. COPCs for the proposed North Rasmussen Ridge Mine are summarized in **Table 4.1-2**.

With the exception of fluoride and pH in leachates for unweathered Center Waste Shale, all other parameters evaluated in column test leachates beside those identified as COPCs were present at levels below applicable standards for groundwater and surface water or below the method detection limit and are not considered constituents of potential concern. Fluoride and pH are not considered to be COPCs because their concentrations are below applicable standards when calculated on a run of mine basis.

Column leachates were analyzed for total selenium, selenite (selenium^{4+}) and selenate (selenium^{6+}). Selenate (selenium^{6+}) was the predominant species observed in column leachates and typically accounted for between 65 and 95 percent of the total concentration of selenium. Selenite (selenium^{4+}) concentrations were typically 10 to 20 times less than selenate (selenium^{6+}) concentrations. These comparisons are approximate however, because the methods used to analyze for total selenium and individual species typically yield slightly different results. Oxidation of selenite (selenium^{4+}) to selenate (selenium^{6+}) also may have occurred during or after sample collection.

The COPCs identified in **Table 4.1-2** have the potential to contaminate groundwater and surface water that may receive seepage from the backfilled pit or exposed pit walls. Potential environmental impacts from COPCs are further discussed in the water resources section of this chapter.

TABLE 4.1-1
ARITHMETIC MEAN CONCENTRATIONS FOR COLUMN TEST LEACHATES, ALL PORE VOLUMES

	Unit	Idaho Groundwater Standard	Idaho Aquatic Standard (CMC/CCC)	Method Detection Limit	Hanging Wall Mud	Footwall Mud	Alluvium	Shallow Limestone	Rex Chert	Unweathered Center Waste Shale	Unweathered Center Waste Shale	Weathered Center Waste Shale	Weathered Center Waste Shale	Deep Limestone	Deep Limestone	Run of Mine Weighted Average
Column ID		--		--	ARC 1	ARC 3	ARC 4	ARC 5	ARC 6	ARC 7	ARC 8	ARC 9	ARC 10	ARC 11	ARC 12	--
Calcium	mg/L	--	-- / --	1	293	70	42	45	376	204	214	22	24	NA	NA	178
Magnesium	mg/L	--	-- / --	1	62	26	4	21	85	52	47	2	3	NA	NA	42
Potassium	mg/L	--	-- / --	1	9	6	3	4	9	7	5	2	2	NA	NA	6
Sodium	mg/L	--	-- / --	1	9	9	8	10	14	9	6	6	6	NA	NA	10
Chloride	mg/L	250 (s)	-- / --	1	3	5	3	9	6	7	6	4	3	NA	NA	6
Sulfate	mg/L	250 (s)	-- / --	1	**889**	204	23	84	**1305**	**715**	**709**	28	28	5.6	7.6	**554**
Acidity as CaCO3	mg/L	--	-- / --	1	20	9	12	8	27	21	14	12	12	NA	NA	17
Alkalinity as CaCO3	mg/L	--	-- / --	1	83	75	111	111	37	4	22	36	38	68.2	81.2	60
Bicarbonate	mg/L	--	-- / --	1	101	91	136	136	45	5	27	44	46	NA	NA	81
Carbonate	mg/L	--	-- / --	1	1	1	1	1	1	1	1	1	1	NA	NA	1
Total Dissolved Solids	mg/L	500 (s)	-- / --	10	**1417**	402	184	253	**1950**	**1101**	**1098**	154	154	NA	NA	**925**
pH	s.u.	6.5-8.5 (s)	-- / --	0.1	7.6	7.8	7.9	8.0	7.1	**5.9**	6.8	7.4	7.5	7.89	8.09	7
Ammonia and N	mg/L	--	-- / --	0.05	0.10	0.04	0.04	0.04	0.04	0.04	0.06	0.05	0.04	NA	NA	0.05
Nitrate + Nitrite as N	mg/L	10	-- / --	0.01	0.06	0.12	0.09	0.26	0.49	0.17	0.21	0.46	0.16	NA	NA	0.29
Phosphorous, Total	mg/L	--	-- / --	0.005	0.409	0.215	0.269	0.046	0.106	1.288	0.499	2.334	3.148	NA	NA	0.52
Fluoride	mg/L	4.0	-- / --	0.1	0.80	2.66	0.73	1.51	0.92	**5.11**	**6.14**	0.87	0.83	NA	NA	1.57
Eh	mV	--	-- /--	1	221	210	198	215	251	275	306	232	227	200.6	189.0	234
Aluminum, Dissolved	mg/L	0.2 (s)	-- / --	0.1	0.1	0.1	0.1	0.1	**0.2**	**0.8**	**0.3**	**0.2**	**0.2**	NA	NA	**0.2**
Antimony, Dissolved	mg/L	0.006	-- / --	0.001	**0.007**	**0.011**	0.005	**0.008**	0.004	**0.011**	**0.012**	**0.006**	**0.009**	**0.008**	**0.006**	**0.006**
Arsenic, Dissolved	mg/L	0.050	0.05 / 0.05	0.001	0.010	0.008	0.002	0.001	0.003	0.011	0.005	0.004	0.011	0.0074	0.0026	0.005
Barium, Dissolved	mg/L	2	-- / --	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	NA	NA	0.2
Beryllium, Dissolved	mg/L	0.004	-- / --	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	NA	NA	0.002
Cadmium, Dissolved	mg/L	0.005	0.004 / 0.001	**0.0010**	**0.0085**	**0.0010**	0.0002	0.0001	**0.0175**	**0.0361**	**0.0256**	0.0005	0.0002	0.0003	0.0003	**0.0096**

TABLE 4.1-1 (CONT.)
ARITHMETIC MEAN CONCENTRATIONS FOR COLUMN TEST LEACHATES, ALL PORE VOLUMES

	Unit	Idaho Groundwater Standard	Idaho Aquatic Standard (CMC/CCC)	Method Detection Limit	Hanging Wall Mud	Footwall Mud	Alluvium	Shallow Limestone	Rex Chert	Unweathered Center Waste Shale	Unweathered Center Waste Shale	Weathered Center Waste Shale	Weathered Center Waste Shale	Deep Limestone	Deep Limestone	Run of Mine Weighted Average
Chromium, Dissolved	mg/L	0.100	0.549 / 0.178	0.005	0.005	0.013	0.006	0.005	0.005	0.005	0.005	0.012	0.014	NA	NA	0.006
Copper, Dissolved	mg/L	1.30	0.017 / 0.011	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	NA	NA	0.01
Iron, Dissolved	mg/L	0.3 (s)	-- / --	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.086	0.086	0.108
Lead, Dissolved	mg/L	0.015	0.065 / 0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	NA	NA	0.001
Manganese, Dissolved	mg/L	0.05 (s)	-- / --	0.015	**1.2**	**0.4**	**0.3**	**0.2**	**5.6**	**1.6**	**1.7**	**0.1**	**0.1**	**0.07**	**0.07**	**2.1**
Mercury, Dissolved	mg/L	0.0020	0.0021 / 0.000012	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	NA	NA	0.0000
Nickel, Dissolved	mg/L	--	1.415 / 0.157	0.05	**0.79**	0.07	0.05	0.05	**4.02**	**0.60**	**0.47**	0.05	0.05	NA	NA	**1.39**
Selenium, Dissolved	mg/L	0.050	0.02 / 0.005	0.001	**2.517**	**0.212**	**0.003**	**0.075**	**0.433**	**0.280**	**0.256**	**0.375**	**0.661**	0.0012	0.001	**0.372**
Selenium IV, Dissolved	mg/L	--	-- / --	0.001	0.017	0.013	0.001	0.033	0.008	0.049	0.049	0.058	0.231	0.0009	0.0008	0.033
Selenium VI, Dissolved	mg/L	--	-- / --	0.001	4.03	0.310	0.004	0.061	0.551	0.371	0.355	0.453	0.462	0.0015	0.001	0.508
Silver	mg/L	0.1 (s)	3.4 / --	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	NA	NA	0.003
Strontium, Dissolved	mg/L	--		0.1	0.4	0.2	0.2	0.2	0.8	0.3	0.3	0.1	0.1	NA	NA	0.4
Thallium, Dissolved	mg/L	0.002		0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	NA	NA	0.002
Zinc, Dissolved	mg/L	5.00	0.114 / 0.105	0.05	0.08	**0.13**	0.07	0.05	**5.86**	**1.57**	1.01	0.05	0.05	0.05	0.05	**2**

Notes:
Column ARC 2 was a control column and is not included in this summary table
NA denotes that samples were not analyzed for the constituent
NC denotes that the run of mine concentration was not calculated because all concentrations in column leachates were below the method detection limit
-- Denotes no established standard
(s) Denotes a secondary groundwater standard
Values that exceed applicable standards are in **bold** type

Figure 4.1-1 Concentrations in Column Test Leachates

TABLE 4.1-2
CONSTITUENTS OF POTENTIAL CONCERN

Constituent	Potential Concern in	
	Groundwater	Surface Water
Total Dissolved Solids	√	
Sulfate	√	
Aluminum	√	
Antimony	√	
Cadmium	√	√
Manganese	√	
Nickel		√
Selenium	√	√
Zinc		√

Existing Overburden Seeps

Data on water quality from existing overburden seeps at Rasmussen Ridge indicate that selenium, cadmium, manganese, nickel, and zinc, are mobile in seepage at concentrations that exceed applicable standards for groundwater and surface water. Observed concentrations in samples from the South Rasmussen Ridge mine range from 0.038 to 0.17 mg/L for selenium, less than 0.003 to 0.007 mg/L for cadmium, 0.044 to 1.64 mg/L for manganese, 0.03 to 0.17 mg/L for nickel, and 0.024 to 0.52 mg/L for zinc. Data are not available for other constituents in external waste rock dump seepage from South Rasmussen Ridge. Available field data generally agree with results for column tests regarding COPCs that were identified as mobile in seepage from overburden rocks.

Paleontology

Impacts to paleontological resources could occur from the disturbance of the phosphate ore from the Phosphoria Formation (Meade Peak Member) or waste rock from the Phosphoria Formation (Meade Peak and Rex Chert members) and the Wells Formation when Panels A and B would be mined. Invertebrate fossils in these geologic units are not known to be significant or restricted to the Rasmussen Ridge area and are likely to be found throughout the outcrop areas of these formations in southeastern Idaho and adjacent areas.

Paleontological resources are fragile and, once disturbed, lose much of their preserved information. Avoidance of significant sites is the preferred mitigation measure for adverse effects on paleontological resources. However, it is anticipated that those resources found in the ore or waste rock, would be mined, and the ore sent to the mill for processing. Little or no protection or avoidance would be possible if mining occurs. Appropriate agency mitigation would be implemented if resources are discovered.

Paleontological resources are non-renewable and can become exhausted. Although fossils are rarely one of a kind, a limited number of specimens may be preserved in any geologic formation and use for scientific study can be greatly reduced or foregone if they are damaged, destroyed, or removed without proper scientific documentation. Mining activities would result in a loss of resources and/or scientific values. The loss of resources at North Rasmussen Ridge is not quantifiable.

4.1.1.2 Alternative 1 - Proposed Action with Impermeable Capping of Backfilled Area

Under Alternative 1, it is assumed that the potential for release of constituents from overburden would be the same as for the Proposed Action. The direct and indirect effects under Alternative 1 would be similar to the Proposed Action, with the following exceptions.

An additional 26 acres of land surface in the project area would be disturbed under Alternative 1 for a new external waste rock dump that would contain an estimated 2.7 million lcy of waste rock. This dump would be needed to accommodate excess waste rock that could not be used as backfill. There would be excess waste rock because construction of an impermeable cap requires flatter slopes to maintain stability. Flatter slopes do not have as much capacity for backfill as do steeper slopes.

New disturbance would also be required under Alternative 1 for a surface mining operation and mine roads needed to supply clay material for the impermeable cap in backfill areas at Rasmussen Ridge. The acreage affected by this new disturbance has not been quantified, but likely would be about 25 acres. If clay cannot be located in the nearby area, the costs of the clay cap would increase substantially. Use of a synthetic material for the impermeable cap would eliminate the disturbance for a clay source but would substantially increase the cost of implementing Alternative 1.

4.1.1.3 Alternative 2 – No Action

As a result of the direct and indirect effects associated with Alternative 2 - No Action, the phosphate resources in the North Rasmussen Ridge area would not be mined. Remaining phosphate resources would remain in place and would be available to be mined at some future date. However, it is likely that the quantity of remaining phosphate resources would be insufficient to justify the expense of mine startup in the Rasmussen Ridge area after a period of inactivity and after mine access roads in the Central and South Rasmussen areas have been reclaimed.

No new disturbance of the land surface in the project area would occur under Alternative 2. Existing disturbances from roads and facilities as part of ongoing mining at Rasmussen Ridge would be reclaimed when operations at the Central Rasmussen pit conclude.

Under Alternative 2, the reclamation plans for the Central Rasmussen Mine area would not be changed. An estimated 35 acres of the Central Rasmussen Mine pit would not be backfilled and would remain in an unreclaimed state, as specified in the approved mine plan. Highwalls in the unreclaimed portion of the pit would not be eliminated through backfilling of waste rock from North Rasmussen. Pit materials that contain selenium and other elements would be exposed to weathering processes if the 35 acre portion of the Central Rasmussen pit were not backfilled.

Earth materials containing selenium or other elements that are exposed in the Central Rasmussen pit would likely release these constituents into groundwater, surface waters or soils. The release of concentrations of selenium or other elements into the environment and subsequent uptake could have adverse effects on plant or animal life.

4.1.2 Irreversible and Irretrievable Commitment of Resources

Each level of agency decision-making ensures the orderly development of federally owned phosphate resources. Agency actions are incrementally more irreversible as more site-specific analysis occurs. Leasing of the mineral and surface occupancy rights has already occurred within the project area and has conveyed to the lessees the right to explore for, develop, and produce phosphate resources that are contained in the lease holdings. Thus, development or production that requires surface disturbance is reasonably foreseeable within the lease holdings and can be authorized by the agencies. The Proposed Action would authorize site-specific phosphate mining, including production, within the project area.

4.1.2.1 Proposed Action

Mineral resources are non-renewable. Phosphate production under the Proposed Action would represent an irreversible and irretrievable commitment of resources, as the phosphate produced would no longer be available for future use. Economically mineable reserves of phosphate ore in the Rasmussen Ridge area would be depleted when mining ends under the Proposed Action. This loss would be small when compared with the total phosphate reserves available for future use in this region. Supplies of phosphate within southeastern Idaho, western Wyoming, and southwestern Montana are vast. Therefore, economically mineable reserves of this commodity are not likely to be exhausted at any reasonably foreseeable future date.

Impacts to topographic features and rock exposures that would result from excavation under the Proposed Action would be irreversible and irretrievable. New human-engineered features, such as the North Rasmussen Mine pits, or surficial deposits (pit backfill areas and growth media storage areas) created during mining and modified during reclamation would be irreversible and irretrievable engineered features when mining ends.

Any loss of paleontological resources associated with activities under the Proposed Action would represent an irreversible and irretrievable commitment of resources. However, similar fossils found in the project area could possibly be found in southeastern Idaho in similar formations. These losses would probably not represent a significant impact.

4.1.2.2 Alternative – 1 Proposed Action with Impermeable Capping of Backfilled Area

The irreversible and irretrievable commitments of resources under Alternative 1 would be similar to the Proposed Action, with the following exceptions. Mineral materials are non-renewable resources. Production of material for the impermeable cap under Alternative 1 would represent an irretrievable commitment of resources, as the materials produced would no longer be available for future use. This loss would be insignificant when compared with the total volume of mineral materials that are available for future use in this region.

4.1.2.3 Alternative 2 – No Action

Under Alternative 2, there would be no irreversible or irretrievable commitment to development of the phosphate resources in the North Rasmussen Ridge area. Economically mineable phosphate reserves would not be depleted within the North Rasmussen Ridge area.

Under Alternative 2, the final 35 acre Central Rasmussen Mine pit would not be backfilled. Mining would continue in the Central Rasmussen Mine pit, in accordance with approved mine plans. An estimated 231 acres would be disturbed during mining, and an estimated 196 acres (or 85 percent of the disturbed area) would be reclaimed at the conclusion of mining. The unreclaimed portion of the pit would be an irretrievable engineered feature when mining ends.

4.1.3 Residual Impacts

4.1.3.1 Proposed Action

Metals and other elements, including selenium, introduced into the near-surface environment by weathering processes that would occur during activities under the Proposed Action would not disappear when mining ends. Metals and other elements, including selenium, would continue to be present in residual pit highwalls and in-pit backfill areas, and would continue to be dissolved and mobilized in seepage for hundreds of years after the facilities have been reclaimed (BLM and USFS 2002). Control factors included in project design, mitigating measures, and use of BMPs would greatly limit the severity of residual impacts.

Collectively, the following procedures would reduce the exposure of ore and waste shale zones that contain potentially seleniferous materials, limiting residual impacts under the Proposed Action. Backfill material would be placed selectively so that center waste shale and other potentially seleniferous material would be located in the middle to deep areas of the backfill. Eight to 10 feet of non-seleniferous limestone and chert would be used to cover any potentially seleniferous materials, providing a barrier to their exposure. Enough non-seleniferous backfill material would be rehandled, about 1.2 million lcy, to ensure that ore and shale exposures in the pit would be covered. Rehandled materials would be covered with up to 2 to 3 feet of growth media and revegetated as directed by BMPs for backfill reclamation.

The probability that a post-mining pit lake would form in backfill area C as a residual impact would be greatly reduced by the project design. The rehandled backfilled material would be sloped so that water would flow toward the limestone footwall over a distance and area that are adequate to allow the water to drain into the footwall or backfill. Analysis of infiltration through the rehandled backfill indicated that water from a 10-year, 24-hour storm would infiltrate into the footwall limestone in 23 days. The 10-year, 24-hour storm involved rain on top of snow and comprised the worst case storm for runoff.

The potential for geotechnical instability of remaining highwalls in the North Rasmussen Mine pit would represent a residual impact. The probability of pit wall failures that would occur as a residual impact would be reduced because the rehandled materials would be placed along the pit wall toes to provide a buttress for the lower portions of the pit walls.

4.1.3.2 Alternative 1 - Proposed Action with Impermeable Capping of Backfilled Area

The residual impacts under Alternative 1 would be similar to the Proposed Action, with the following exceptions. Placement of an impermeable cap would greatly reduce exposure of meteoric water to the ore, waste shale zones, and backfill that could contain potentially seleniferous materials. This procedure would further limit the residual impacts associated with the exposure of seleniferous materials under Alternative 1 to less than the impacts that are anticipated under the Proposed Action.

4.1.3.3 Alternative 2 – No Action

Metals and other elements, including selenium, introduced into the near-surface environment by weathering processes that act on the unreclaimed portion of the Central Rasmussen pit would continue long after mining operations end. Metals and other elements, including selenium, would continue to be dissolved and mobilized in seepage for hundreds of years after the facilities have been reclaimed (BLM and USFS 2002). Water runoff control factors included in the Central Rasmussen Mine design and mitigating measures (backfilling pits, capping and revegetation) would limit the severity of residual impacts.

The potential for geotechnical instability of highwalls in the unreclaimed portion of the Central Rasmussen Ridge mine pit also would represent a residual impact. The potential for a pit lake to form in the Central Rasmussen Ridge Mine and allow exposure to seleniferous outcrops would also represent a residual impact.

4.1.4 Mitigation Summary

Project design features, BMPs, and the proposed Reclamation Plan (see Chapter 2) are the elements of the Proposed Action designed to reduce environmental impacts to minerals, topography, and geology.

Conditions of approval for the mine plan require protection and prompt reporting of vertebrate paleontological resources discovered during the project. Operations must be suspended until the discovery and mitigation are evaluated. In addition to potential adverse impacts during construction or mine excavation, significant fossils may become exposed during subsequent erosion of freshly excavated rocks at the mine site. The mitigating measures applicable to the Proposed Action would also apply to Alternative 1.

4.2 AIR RESOURCES

4.2.1 Direct and Indirect Impacts

This section discusses the potential direct and indirect impacts to air quality related to the Proposed Action and alternatives. In general, none of the alternatives would result in a significant increase in air quality impacts beyond the current level.

4.2.1.1 Proposed Action

The Proposed Action would continue the levels of air pollutant emissions that currently result from mining at the Central and South Rasmussen mines.

Table 4.2-1 presents estimates of emissions for current operations at the Central Rasmussen Ridge Mine and the overall emissions as mining moves into the North Rasmussen Ridge Mine. These emissions are based on the current level of mining. All emissions are and would be within NAAQS and would not be considered an impact to human health, as the nearest residence is over two miles north of the proposed project area. These emissions would be a continuation of similar emissions that are currently approved and no downwind effects to persons or sensitive sites would occur.

The stationary sources include three diesel generators and one propane boiler. The internal combustion engines include the mobile gasoline and diesel equipment that is involved in mining, hauling, and personnel transport. Fugitive dust is related to vehicle activity on unpaved roads, and to windblown soil, overburden, and ore handling.

TABLE 4.2-1
TOTAL ANNUAL EMISSIONS (TON/YR)

Source	NO_x	CO	VOC	SO_2	PM_{10}
Stationary Sources	66.18	14.19	5.23	4.32	4.66
Equipment Engines	1,207.53	669.35	85.29	125.76	79.54
Mining Fugitive Emissions	-	-	-	-	515.88

4.2.1.2 Alternative 1 – Proposed Action with Impermeable Capping of Backfilled Area

Alternative 1, Proposed Action with impermeable capping of backfill, would result in a temporary increase in impacts to air quality for all criteria pollutants. This increase would be related to increased vehicle and material handling activity related to capping. Proposed emissions would not be substantially greater than for the Proposed Action and would be within NAAQS.

4.2.1.3 Alternative 2 – No Action

Alternative 2, No Action, would result in declining impacts to air quality over time as mining declines along with diminishing reserves at the existing Central Rasmussen Mine.

4.2.2 Irreversible and Irretrievable Commitment of Resources

Impacts to air quality from the Proposed Action or from either alternative would not involve any irreversible commitment of resources. Continuing mining for eight years would constitute an irretrievable degradation of air quality from dust and emissions.

4.2.3 Residual Impacts

Impacts to air quality from the Proposed Action or from either alternative would not involve any residual impacts.

4.2.4 Mitigation Summary

Current measures to control or mitigate emissions of air pollutants at the existing mine would also be employed in the Proposed Action or Alternative 1. Project design features and BMPs (see Chapter 2) are the elements of the Proposed Action designed to reduce environmental impacts from air emissions. No mitigation measures are deemed necessary.

4.3 WATER RESOURCES

4.3.1 Direct and Indirect Impacts

4.3.1.1 Proposed Action

Under the Proposed Action, the panels would be mined in sequence (Panel A and Panel B) and all of the waste rock would be placed in either the Central or North Rasmussen pits. North Rasmussen backfill areas A and B would be completely backfilled, capped with non-seleniferous limestone or chert, covered with growth media, and revegetated. Backfill area C would be partially backfilled and revegetated as described in Section 2.2.3. The open panel would have the potential to affect flow of surface water and groundwater during mining. The fully and partially backfilled panels would have the potential to affect the flow and quality of surface water and groundwater after mining. Potential impacts to water resources were assessed using (1) infiltration modeling to estimate the rate of precipitation infiltration through the backfill, (2) spreadsheet modeling to evaluate potential changes in flow of surface water, alluvium, and Rex Chert, (3) geochemical modeling to calculate chemical reactions as seepage moves through the unsaturated zone, and (4) a numerical groundwater model to evaluate impacts to flow and water quality in the Wells Formation regional aquifer.

It should be noted that model results have a large degree of uncertainty associated with them, and that they are useful for screening potential impacts. However, model results should not be interpreted as firm, fixed numbers. A more detailed discussion of the degree of uncertainty in the model results is presented in the Water Resources Technical Report (Whetstone 2002).

Conceptual Model / Overview

The hydrostratigraphy of the proposed pit is shown in **Figure 4.3-1**. Conceptual diagrams of the flow system before, during, and after mining are shown in **Figure 4.3-2**. Before mining, precipitation that falls within the project area runs off into the creeks, evaporates or is transpired by plants back into the atmosphere, or infiltrates into aquifers in the alluvium, Rex Chert, or Wells Formation (**Figure 4.3-2(a)**). During mining, the open pit would intercept surface water runoff and shallow flow in the alluvium (**Figure 4.3-2(b)**). After mining, the pits would be backfilled and surface water runoff would be restored to pre-mining conditions (**Figure 4.3-2(c)**), except in the area of the partially backfilled pit. Flow paths in the alluvium would be intercepted by the backfilled pit, except where surface drainage control structures would be built to re-direct flow of surface water. Recharge rates to the alluvium and Rex Chert beneath the backfilled panels would be lower than before mining because of the effectiveness of the engineered cover in limiting infiltration and the preferred flow path of water through the coarser backfill material. Recharge rates to the Wells Formation regional aquifer would be decreased beneath the fully backfilled panels and increased beneath the partially backfilled panels.

These changes to the flow system would also affect water quality because meteoric water that infiltrates through pit backfill or runs off of exposed pit walls would leach selenium and other COPCs from the rock. The chemistry of seepage from backfill and runoff from pit walls would be affected by a number of factors including the volume of infiltration or runoff, the chemical composition of the rocks, the reactive surface area of the rocks, pH conditions, oxygen availability, adsorption of ions to clay and mineral surfaces, and precipitation and dissolution reactions. Bacterially mediated reactions could also occur; however, chemically active oxidizing bacteria have not been observed historically at the site.

Overburden rocks would be exposed to surface weathering when they are mined and transported to backfill other areas in the pit. Mining also increases the reactive surface area of the rocks by breaking them into smaller pieces. Exposure to meteoric water and oxygen may leach metals or other constituents that are soluble or adsorbed to mineral surfaces in the overburden and can initiate oxidation of sulfide minerals, resulting in the release of sulfate, selenium, and other metals. Constituents of potential concern that may be released from overburden and pit walls includes sulfate, aluminum, antimony, cadmium, manganese, nickel, selenium, and zinc (Maxim 2002b).

Seepage through backfill and runoff from pit walls would infiltrate through rocks in the pit floor and walls and move through bedrock and alluvium before it enters groundwater or surface water. As water moves through the bedrock and alluvium, reactions may occur that would decrease concentrations of COPCs in seepage. Attenuation reactions include precipitation, adsorption, and changes in pH.

Figure 4.3-1 Cross Section 22,260 Showing Hydrostratigraphy at the Proposed Pit

Figure 4.3-2 Conceptual Diagrams of Hydrologic System Flow

Numerical Models

Numerical models were developed, based on the conceptual models described above, to quantify the infiltration through the backfill, interception of surface runoff, recharge to the upper aquifers, geochemical reactions in seepage from pit backfills, and flow and transport in the regional aquifer.

Infiltration through the Backfilled Panels

Seepage through the proposed backfilled pit panels was modeled using the U.S. Environmental Protection Agency HELP3 model a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills (Hydrologic Evaluation of Landfill Performance, version 3.06, Schroeder et al 1994a). This model was developed by the Corps of Engineers Waterway Experiment Station under contract to EPA to compare alternate landfill cover designs. The model utilizes input data on weather, soil and waste rock conditions, and cover design. The model uses numerical solution techniques that account for the effects of surface storage, ground frost, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, and leakage through various types of liners (Schroeder et al 1994a). Run-on from upgradient slopes was calculated externally and input to the HELP model as additional precipitation (Whetstone 2002). The backfilled panels were divided into seven zones according to geometry and potential to receive run-on from upslope. These zones are illustrated in **Figure 4.3-3**.

The steps and assumptions involved in the HELP modeling are summarized in **Table 4.3-1**. More detailed descriptions of HELP model input parameters, assumptions, and results are provided in the Water Resources Technical Report (Whetstone Associates 2002).

The results of infiltration modeling are shown in **Table 4.3-2**. Zones A1, C1, and C2 received no run-on from upgradient sources; average infiltration was 0.78 inches/year (in/yr), with minor variations caused by percent and length of slope. Higher infiltration was predicted for zone A2 (0.93 in/yr), zone B1 (0.80 in/yr), and zone B2 (0.87 in/yr) as a result of runon from upgradient sources. Infiltration rates in zone C3 would be very high (88.5 in/yr) because the area receives run-on from zones C1, C2, the pit walls, and upgradient undisturbed ground, while no runoff would occur. The area-weighted average infiltration for the six fully backfilled zones with engineering controls was 0.83 in/yr. If surface water engineering controls were not employed to reduce or eliminate run-on to the reclaimed pits, area-weighted average infiltration rate through the fully backfilled pits would be 1.22 in/yr. This seepage would infiltrate through the floor of the pit and through 400 feet of unsaturated rock to the underlying regional aquifer.

Geochemical Modeling

Modeling of chemical reactions in seepage from pit backfills was performed using the program PHREEQC v.2.6 (Parkhurst and Appelo 2000) to develop input concentrations for transport modeling of COPCs in the regional aquifer (Maxim 2002a). PHREEQC has been widely used to model the chemistry of waters impacted by mining and was developed by scientists at the United States Geological Survey.

Geochemical modeling runs were made for sequential pore volumes of seepage from the partially and fully backfilled panels (a pore volume is the volume of seepage equal to the pore space of the backfill material). Chemical reactions in seepage from the fully backfilled panels were modeled in three steps:

- Step 1 evaluated the composition of seepage before leaving the pit. Volume-weighted concentrations from column tests were mixed to simulate the expected composition of seepage from run of mine (ROM) backfill and oversaturated minerals were allowed to precipitate. Sorption of metals to precipitating minerals (calcite ferrihydrite, and manganite) was modeled.
- Step 2 evaluated chemical reactions that would occur as seepage moves through the unsaturated limestone below the bottom of the pit before reaching the water table. Oversaturated minerals in seepage in contact with limestone were allowed to precipitate and sorption to iron oxides and calcite were modeled.
- Step 3 modeled chemical reactions that would occur at the water table. Oversaturated minerals were allowed to precipitate.

The approach for modeling of seepage chemistry from the partially backfilled panel was identical to that used for the fully backfilled panel with the addition of an initial step which considered the reactions that would occur in runoff from the pit walls before entering the backfill material. A summary of assumptions and reactions used for the geochemical models is presented in **Table 4.3-3**.

Model results for the proposed action indicate that selenium and aluminum concentrations would be below their respective groundwater standards of 0.05 mg/L and 0.2 mg/L in seepage reaching the water table. Cadmium, antimony, sulfate and TDS concentrations would exceed their respective groundwater standards of 0.005 mg/L, 0.006 mg/L, 250 mg/L, and 500 mg/L in seepage for some pore volumes, and manganese would exceed its groundwater standard of 0.05 mg/L in all seepage pore volumes reaching the water table. Groundwater standards for cadmium and antimony are primary standards based on human health considerations. Groundwater standards for sulfate, TDS, and manganese are secondary standards based on aesthetic qualities (IDAPA 58.01.11). Geochemical modeling results were used as input for the source term in the contaminant transport model and are summarized in **Table 4.3-3**.

4.3.1.2 Flow and Transport in the Regional Aquifer

A three-dimensional groundwater flow and contaminant transport model of the regional groundwater system was prepared to evaluate migration of COPCs from the backfilled mine pit. The groundwater flow model simulates flow and transport in the Grandeur Tongue, Wells Formation, and Thaynes Formation, and was prepared using the computer codes MODFLOW and MT3DMS. MODFLOW was developed by the USGS (McDonald and Harbaugh 1988) to simulate groundwater flow and was used to develop the flow field for contaminant transport modeling. MT3DMS was used to model the transport of COPCs in the regional aquifer and is an updated version of the program MT3D that was developed by S. S. Papadopulos & Associates in conjunction with the EPA (Zheng 1990; Zheng and Wang 1999). Both programs are widely accepted by regulatory agencies for modeling groundwater flow and contaminant fate and transport.

Figure 4.3-3 Infiltration Zones for Help Model

(page two)

TABLE 4.3-1
INFILTRATION MODELING SUMMARY

Modeling Step		Assumptions
1	Determine long-term monthly average temperature and precipitation values.	Somsen Ranch is a valid representative station for site, based on elevation (6,800 feet), close proximity to the mine (4.1 miles), and long period of record (20 years)
2	Generate daily values for temperature, precipitation, solar radiation.	Daily weather data is stochastically described by mean and extremes from Somesen Ranch station with stochastic coefficients from Pocatello Idaho; solar radiation is a function of latitude and precipitation (cloud cover).
3	Identify applicable wind speed, relative humidity, growing season, evaporative zone depth, leaf area index.	Average annual wind speed is 10.2 mph; quarterly relative humidity is 70%, 52%, 43%, 65%; LAI is 2.0; growing season for grasses starts on Day 132 and ends on Day 259; EZD is 24 inches (See Water Resources Technical Report for extensive detail on parameter selection).
4	Identify backfill infiltration zones based on slope length, slope angle, and potential for run-on.	Backfill area is divided into 7 infiltration zones.
5	Set up model layers based on proposed capping design and alternatives. Assign layer material properties based on in-situ and laboratory testing of site-specific materials.	Material soil properties are described by Brook-Corey parameters determined from laboratory soil moisture retention curves, including wilting point, field capacity, porosity, and saturated hydraulic conductivity for ROM, limestone/chert, and growth media (See Water Resources Technical Report for extensive detail on model layer geometry and material properties).
6	Calculate run-on from upgradient sources.	Run-off from bare pit walls and upgradient undisturbed ground estimated using initial abstraction and runoff coefficient; runoff from upgradient capped slopes onto downgradient capped slopes is calculated by HELP model.
7	Increase the precipitation data set (100 years of daily precipitation) to account for run-on.	Run-on to downgradient slopes is evenly distributed over the entire receiving slope; Time delay between precipitation and run-on is less than 24 hours; run-on has no effect on daily temperature or solar radiation.
8	Run HELP model and use final moisture contents as starting moisture content for 100 year simulation.	No water is taken into or released from storage in the backfill (quasi-steady-state conditions); Incident daily precipitation is routed to runoff, evapotranspiration, lateral drainage, or percolation using equations and methodology described in HELP3 model documentation.
9	Run sensitivity analyses for increased precipitation, lower evaporative zone depth, a range of leaf area indices, and alternative cover designs including a non-engineered cover, clay cap, and synthetic liner cap.	Reasonable range of parameter variation for sensitivity analysis includes: decreasing growth media thicknesses to 24 inches and 18 inches; changing leaf area indices to 0.5, 1.0, 1.5, and 2.5; increasing evaporative zone depth to 36 inches; increasing average annual precipitation to 28.6 inches.

TABLE 4.3-2
WATER BALANCE RESULTS OF HELP INFILTRATION MODELING FOR NORTH RASMUSSEN RIDGE MINE BACKFILL (IN INCHES/YEAR)

Zone[1]	Precipitation + Run-on	Runoff	Evapo-transpiration	Infiltration
NR Backfill Area A1	26.84	10.57	15.47	0.79
NR Backfill Area A2[2]	29.45	12.38	16.13	0.93
NR Backfill Area B1[2]	27.45	11.07	15.57	0.80
NR Backfill Area B2[2]	28.15	11.58	15.71	0.87
NR Backfill Area C1	26.84	10.64	15.45	0.75
NR Backfill Area C2	26.84	10.59	15.46	0.78
NR Backfill Area C3	109.32	0.00	20.86	88.45

[1]See Figure 4.3-3
[2]Includes engineered controls for run-on.

The model area is shown in cross-section on **Figure 4.3-4**, in plan view in **Figure 4.3-5**, and is 5 miles wide by 10 miles long. The locations of the cross sections are shown on **Figure 3.1-1**. Six layers were used to model a 500-foot thick section of bedrock starting at the water table or top of the Wells Formation where confined conditions exist. The layers have variable elevations and simulate the structure of the Snowdrift Anticline. Groundwater flow was modeled as moving north 40° west at a gradient of 0.0057, consistent with the regional groundwater flow system (Maxim 2002d). Constant head cells were used at the northwest and southeast boundaries of the model to establish the flow field.
Assumptions used for the groundwater flow and contaminant transport model include:

- The hydraulic conductivity of the aquifer is isotropic parallel to bedding and is equal to the average value of 1.82 ft/day calculated from the available pumping test data (Whetstone 2003). Hydraulic conductivity across bedding is assumed to be 5 times less than hydraulic conductivity parallel to bedding (estimated) and is 0.364 ft/day.
- Faults have high permeability along strike and low permeability across the fault plane compared with the surrounding aquifer. Hydraulic conductivity along faults was assumed to be 10 times greater than in the surrounding bedrock (estimated). Hydraulic conductivity across faults is 10 times less than surrounding bedrock (estimated). The Limerock, Enoch Valley, Henry, and Offset faults were included in the model, along with one other unnamed fault.
- Storage is equal to an average value of 0.0047 as derived from available pumping test data (Whetstone 2003). Specific yield is modeled as being 0.10 in unconfined portions of the aquifer (Ralston et al 1980).

TABLE 4.3-3
GEOCHEMICAL MODELING SUMMARY

Modeling Step	Assumptions	Precipitating Minerals	Sorption Substrates
Geochemical Modeling of Fully Backfilled Pit			
Step 1 - Pore water chemistry in pit backfill	- Volume weighted average of column test leachates - System slightly removed from atmosphere - Eh = 350 mV - P CO2 = -3.0	- Calcite - Gypsum - Ferrihydrite - Gibsite - Barite - Cr(OH)3 - MnHPO4 - Otavite - Hydroxyapatite	- Ferrihydrite precipitate - Calcite precipitate
Step 2 - Seepage chemistry in unsaturated Wells Limestone	- Initial water chemistry from Step 1 - System removed from atmosphere - Eh = 120 mV - P CO2 = -2.7	- Gibsite - Otavite - Gypsum - Cr(OH)3	- Ferrihydrite in limestone - Calcite in limestone
Step 3 – Seepage chemistry at water table	- Initial water chemistry from Step 2 - System removed from atmosphere - Eh = -60 mV - P CO2 = -2.0	- Gypsum - NiSe - Se0	
Geochemical Modeling of Partially Backfilled Pit			
Step 1 – Runoff chemistry from pit walls	- Volume weighted average of leachates from pit walls - System open to atmosphere - Eh = 550 mV - P CO2 = -3.5	- Ferrihydrite - Gibsite - Barite - Cr(OH)3 - Manganite - Hydroxyapatite - Calcite	- Ferrihydrite precipitate - Manganite precipitate - Calcite Precipitate
Step 2 - Pore water chemistry in pit backfill	- Volume weighted average of column test leachates mixed with chemistry from Step 1		
Step 3 - Seepage chemistry in unsaturated Wells Limestone	- Initial water chemistry from Step 2 - System removed from atmosphere - Eh = 120 mV - P CO2 = -2.7	- Ferrihydrite - Gibsite - Barite - Cr(OH)3 - Hydroxyapatite	- Ferrihydrite in limestone - Calcite in limestone
Step 4 – Seepage chemistry at water table	- Initial water chemistry from Step 3 - System removed from atmosphere - Eh = -60 mV - P CO2 = -2.0		

Figure 4.3-4 Cross Sections Showing Groundwater Model Domain

Figure 4.3-5 Potential Water Level Mounding in the Regional Aquifer (Wells Formation)

- Recharge to the regional aquifer is assumed to be equal to 9.5 percent of the average annual precipitation of about 27 inches (Whetstone 2002), and is applied to outcrop areas of the Wells and Thaynes formations where the aquifer is unconfined.
- The effective porosity of the aquifer that is interconnected and transmits water in appreciable quantities is a portion of the total porosity and is assumed to be equal to specific yield (0.1).
- Contaminant transport is governed by physical advection and dispersion. Advection occurs in response to the gradient of the flow field. Dispersion is caused by the irregular nature of the flow path through pores, fractures, and bedding planes, with longitudinal dispersivity equal to 40 feet, transverse dispersivity equal to 4 feet, and vertical dispersivity equal to 0.4 feet (Whetstone 2002; Gelhar et al 1993).
- After solutes enter the aquifer, they behave conservatively without reaction, degradation, attenuation, or sorption to aquifer materials.
- Solutes travel from the floor of the backfilled pit panels through 400 feet of unsaturated rock. The travel time through the unsaturated zone is 3.3 years below the partially backfilled pit and 86.7 years below the fully backfilled pit (Whetstone 2002), which is incorporated into the groundwater transport model by delaying the source term correspondingly (**Table 4.3-4**).

COPCs are added to the groundwater model based on seepage rates predicted by HELP3 (Whetstone 2002) and concentrations from the column leachate tests and geochemical modeling (Maxim 2002b, 2002c). Solutes are added in two recharge zones. Recharge from the fully backfilled pit (zones A1, A2, B1, B2, C-1 and C-2) is applied at an average seepage rate of 0.83 inches per year with concentrations shown in **Table 4.3-4**. Recharge from the partially backfilled pit (zone C3) is applied at an average seepage rate of 88.45 inches per year, with concentrations shown in **Table 4.3-2**. The concentrations of COPCs in seepage were derived by Maxim (2002c). The modeled concentrations in seepage generally decline with time, as subsequent pore volumes of infiltrating water move through the backfill. It would take 1.6 years to flush one pore volume through the partial backfill and 319 years to flush one pore volume through the full backfill to reach the bottom of the pit. Then it would take another 3.3 and 86.7 years, respectively, to reach the water table. The modeled concentration of the source term changes after each pore volume, in accordance with the data from the column leachate tests and geochemical modeling.

TABLE 4.3-4
SEEPAGE RATE AND CONCENTRATIONS FOR GROUNDWATER TRANSPORT MODEL SOURCE TERM

Stress Period	Cum Years	Event	Rate (ft/day)	TDS (mg/L)	Sulfate (mg/L)	Aluminum (mg/L)	Antimony (mg/L)	Cadmium (mg/L)	Manganese (mg/L)	Selenium (mg/L)
I. Fully Backfilled Pit										
1	3.3	Travel through vadose zone from PB pit	0.000578	0	0	0	0	0	0	0
2	4.8	Limestone PV 1 leaches	0.000578	0	0	0	0	0	0	0
3	6.4	Limestone PV 2 leaches	0.000578	0	0	0	0	0	0	0
4	8.0	Limestone PV 3 leaches	0.000578	0	0	0	0	0	0	0
5	9.5	Limestone PV 4 leaches	0.000578	0	0	0	0	0	0	0
6	11.1	Limestone PV 5 leaches	0.000578	0	0	0	0	0	0	0
7	12.7	Limestone PV 6 leaches	0.000578	0	0	0	0	0	0	0
8	14.3	Limestone PV 7 leaches	0.000578	0	0	0	0	0	0	0
9	15.8	Limestone PV 8 leaches	0.000578	0	0	0	0	0	0	0
10	17.4	Limestone PV 9 leaches	0.000578	0	0	0	0	0	0	0
11	86.7	Limestone PV 10 leaches	0.000578	0	0	0	0	0	0	0
12	100.0	ROM PV 1 leaches	0.000190	1859	1229	0.013	0.007	0.005	3.16	0.0011
13	200.0	ROM PV 1 leaches	0.000190	1859	1229	0.013	0.007	0.005	3.16	0.0011
14	300.0	ROM PV 1 leaches	0.000190	1859	1229	0.013	0.007	0.005	3.16	0.0011
15	400.0	ROM PV 1 leaches	0.000190	1859	1229	0.013	0.007	0.005	3.16	0.0011
16	406.0	ROM PV 1 leaches	0.000190	1859	1229	0.013	0.007	0.005	3.16	0.0011
17	500.0	ROM PV 2 leaches	0.000190	1234	799	0.014	0.006	0.004	2.96	0.0011

TABLE 4.3-4 (CONT.)
SEEPAGE RATE AND CONCENTRATIONS FOR GROUNDWATER TRANSPORT MODEL SOURCE TERM

Stress Period	Cum Years	Event	Rate (ft/day)	TDS (mg/L)	Sulfate (mg/L)	Aluminum (mg/L)	Antimony (mg/L)	Cadmium (mg/L)	Manganese (mg/L)	Selenium (mg/L)
II. Partially Backfilled Pit										
1	3.3	Travel through vadose zone from PB pit	0.000578	0	0	0	0	0	0	0
2	4.8	Limestone PV 1 leaches	0.018911	579	173	0.014	0.0083	0.0004	0.460	0.0002
3	6.4	Limestone PV 2 leaches	0.018911	325	73	0.014	0.0099	0.0003	0.160	0.0005
4	8.0	Limestone PV 3 leaches	0.018911	300	61	0.014	0.0080	0.0003	0.120	0.0005
5	9.5	Limestone PV 4 leaches	0.018911	300	61	0.014	0.0080	0.0003	0.120	0.0005
6	11.1	Limestone PV 5 leaches	0.018911	242	55	0.014	0.0063	0.0002	0..110	0.0005
7	12.7	Limestone PV 6 leaches	0.018911	242	55	0.014	0.0063	0.0002	0.0.110	0.0005
8	14.3	Limestone PV 7 leaches	0.018911	289	57	0.014	0.0065	0.0002	0.0.110	0.0005
9	15.8	Limestone PV 8 leaches	0.018911	289	57	0.014	0.0065	0.0002	0.0.110	0.0005
10	17.4	Limestone PV 9 leaches	0.018911	289	57	0.014	0.0071	0.0002	0.0.110	0.0005
11	86.7	Limestone PV 10 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005
12	100.0	ROM PV 1 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005
13	200.0	ROM PV 1 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005
14	300.0	ROM PV 1 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005
15	400.0	ROM PV 1 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005
16	406.0	ROM PV 1 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005
17	500.0	ROM PV 2 leaches	0.018911	298	63	0.014	0.0071	0.0002	0.0.110	0.0005

4.3.1.3 Impacts to Surface Water

Impacts to Flow

The surface water drainages of Reese Canyon Creek, No Name Creek, and the West Fork of Sheep Creek would be affected by the Proposed Action. The mine pits would capture surface water runoff during mining, and this flow would be denied to the drainages. The impacts would lessen after mining ends because surface water would run off from the cap over areas of the pits that are fully backfilled. Only the areas of the pits that were partially backfilled would capture surface water runoff after mining ends. The impacts to surface water runoff can be quantified based on the areas of the fully and partially backfilled panels (**Figure 4.3-6, Table 4.3-5**), assuming there is a direct, proportional relationship between the percentage of drainage area removed and the change in runoff.

Surface runoff to Reese Canyon Creek drainage could decrease by 31 percent during mining. Impacts would decrease to 4 percent after mining ends because all of the panels in the Reese Canyon Creek drainage would be fully backfilled and capped to allow water to run off naturally.

Surface runoff to the No Name Creek drainage could decrease by about 11 percent during mining and 3 percent after mining. Surface runoff to the West Fork of Sheep Creek drainage could decrease by about 37 percent during and after mining. Impacts in runoff to West Fork of Sheep Creek would not change after mining, because the partially backfilled pit would continue to intercept runoff.

TABLE 4.3-5
POTENTIAL IMPACTS TO SURFACE WATER RUNOFF FROM THE PROPOSED ACTION

Drainage	Reese Canyon Creek	No Name Creek	West Sheep Creek
Calculation Location	Impacts calculated at confluence of Reese Canyon Creek with Little Blackfoot River	Impacts calculated at confluence of No Name Creek and its intermittent western tributary	Impacts calculated at confluence of West Sheep Creek with Sheep Creek
During and After Mining			
Drainage area (ft^2)	20,665,760	39,062,630	9,061,190
Surface areas intercepted (ft^2)	6,339,740	4,259,230	3,347,160
Percent change surface runoff	-30.7%	-10.9%	-36.9%

Impacts to Water Quality

The backfilled pits may intercept flow paths of shallow groundwater and may introduce contaminants that may reach springs and seeps. Because the overburden would be placed in the mined-out panels, rather than above ground, no new surface seeps would develop. In addition, the pits would be capped with 8 to 10 feet of relatively inert limestone and chert, and then covered with 2 to 3 feet of growth media. This engineered cover would prevent surface water runoff from coming into contact with reactive materials in the backfilled overburden.

Sediment and Channel Related Impacts

Runoff from haul roads, temporary overburden storage areas, growth media storage areas, pit backfills, and other disturbed areas would have the potential for erosion and subsequent sediment loading to Reese Canyon Creek, No Name Creek, and West Fork of Sheep Creek. Additionally, magnesium chloride used on roads to reduce dust would be entrained in the erosion from the roads. The potential for sediment loading would be controlled because runoff would be directed into sediment basins. Water from the haul roads would be diverted to sediment retention ponds located at 10 different locations adjacent to the road. Culverts and ditching would be used to collect water from the haul roads and divert it into the retention ponds. The ponds would be dredged and the sediment placed in the pit backfill as sediment accumulates in the retention ponds and the storage capacity decreases. These measures would prevent magnesium chloride from degrading vegetation, increasing the salinity of soils, and raising the pH of surface waters. Storm water retention structures would be inspected visually quarterly, annually, and more frequently during spring runoff and after summer thunderstorms, in accordance with Agrium's Multi-Sector General Permit for storm water discharges.

Mining would occur on both sides of No Name Creek where the creek crosses the outcrop. Mining would not proceed through No Name Creek, but rather, would leave a land bridge for the creek. However, because of a one-lane haul road in that location and to minimize sedimentation into the creek, a culvert would be placed across the land bridge to contain any flow in No Name Creek, which is dry for a majority of the year. The culvert would be several hundred feet long and include an energy dissipator below the culvert exit. BMPs for this installation include completion of all construction during the dry season, using silt fences and straw bales or wattles during construction, and also removing the culvert after mining using the same techniques as for installation. The stream channel would be relocated on native ground material to reduce infiltration following postmining reclamation.

The East Road Extension would also cross Reese Canyon Creek. A 24-inch culvert, sized for the 100 year 24 hour storm would be placed in the channel to convey water downstream to maintain the seasonal flow pattern and wetlands during mining. After mining ends, the culvert and fill would be removed and the stream channel would be re-established. These activities would not affect flow in Reese Canyon Creek. Potential impacts to sediment loading during and after construction would be mitigated using BMPs, including silt fences, straw bales or wattles, sediment basins, or other structures.

Figure 4.3-6 Areas of Surface Runoff and Alluvial Flow Potentially Interrupted by the Pit

(page two)

4.3.1.4 Groundwater Impacts

Alluvium

The alluvium is intermittently saturated. On the ridge tops, the alluvium is unsaturated, and much of the precipitation that percolates into the alluvium moves vertically downward to the underlying bedrock. After major precipitation or snowmelt enters the alluvium on the ridgetops some water may also travel laterally. The alluvium is saturated during some or most of the year in the drainage valleys. For example, water was encountered in the alluvium in Reese Canyon while drilling exploration borings NR-00-86, NR-00-77, and NR-00-71. Alluvial monitoring wells higher in the drainages were typically dry during the winter of 2001 and showed water level rises of up to 20 feet during the spring and summer of 2002. Alluvial monitoring wells located lower in the drainages contained water throughout the year, and also showed rising water levels in the spring and summer.

Groundwater flow in the alluvial aquifers would be intercepted by the mine pits. The alluvial flow system is connected with surface flow, seeps, and springs in Reese Canyon, West Fork of Sheep Creek, and No Name Creek. The reduction in flow in the alluvium can be quantified based on the areas of alluvium intercepted by the pit panels (**Figure 4.3-6, Table 4.3-6**).

Alluvium will be covered by backfill only on the east side of Panels A and B. After closure, the alluvium will be exposed at the top of the highwall in Panel C (**Figure 4.3-2(c)**). The area of alluvium to be overlain by backfill is approximately 4.8 acres (209,360 ft^2) in the B-panel area and 6.3 acres (273,160 ft^2) in the A-panel area. Seepage from backfill into alluvium in these areas would account for 0.45% (less than one half of one percent) of the flow in the alluvium in Reese Canyon and 0.25% (one quarter of one percent) of the flow in the No Name Creek above the confluence with its unnamed tributary (**Table 4.3-7**) (Whetstone 2002). Although seepage

TABLE 4.3-6
POTENTIAL IMPACTS TO GROUNDWATER FLOW IN THE ALLUVIUM FROM THE PROPOSED ACTION

Drainage	Reese Canyon Creek	No Name Creek	West Fork of Sheep Creek
Calculation Location	**Impacts calculated at confluence of Reese Canyon Creek with Little Blackfoot River**	**Impacts calculated at confluence of No Name Creek and its intermittent western tributary**	**Impacts calculated at confluence of West Sheep Creek with Sheep Creek**
During and After Mining			
Drainage area (ft^2)	20,665,760	39,062,630	9,061,190
Area of alluvium intercepted by pits (ft^2)	6,339,740	4,259,230	3,347,160
Percent change alluvial flow	-30.7%	-10.9%	-36.9%

TABLE 4.3.7
CALCULATION OF FRACTION OF RECHARGE TO ALLUVIUM FROM BACKFILL SEEPAGE

	Reese Canyon[a]	No Name Creek[b]	West Sheep Creek[c]
Total drainage area (ft^2)	20,665,760	39,062,630	9,061,190
Alluvium areas permanently intercepted (ft^2)	-6,339,740	-4,259,230	-3,347,160
Area of alluvium receiving recharge at background rate (ft^2)	14,326,020	34,803,400	5,714,030
Background recharge rate (in/yr)	2.680	2.680	2.680
Seepage flowing laterally in alluvium (in/yr)	0.26	0.26	0.26
Volumetric recharge rate (gpm)	4.417	10.731	1.762
Area of alluvium overlain by backfill (ft^2)	209,360	273,160	
Seepage rate through backfill (in/yr)	0.8303	0.8303	0.8303
Seepage flowing laterally in alluvium (in/yr)	0.083	0.083	0.083
Total seepage to alluvium from backfill (gpm)	0.021	0.027	0.000
Fraction of alluvial recharge derived from backfill seepage	0.0047	0.0025	0.0000
Fraction of alluvial recharge derived from backfill seepage	0.47%	0.25%	0.00%

Notes: a: Impacts calculated at confluence of Reese Canyon with Little Blackfoot River.
b: Impacts calculated at confluence of No Name Creek and its intermittent western tributary.
c: Impacts calculated at confluence of West Sheep Creek with Sheep Creek.

rates to the alluvium would be low, the concentrations of COPCs in the seepage would be generally high, compared to background concentrations in alluvium. Potential water quality changes in the alluvium were calculated by mass balance (mixing) of the backfill seepage and concentration and the alluvium recharge and concentration. The results of the mass balance evaluation (**Table 4.3-8**) indicate that that concentrations of antimony, cadmium, manganese, nickel, sulfate, and TDS in alluvial groundwater in the No Name Creek area would increase by 0.2% to 37%. Selenium concentrations would increase by 112% and aluminum concentrations would decrease by 0.1% (Whetstone 2002). None of the COPCs would increase above groundwater or surface water standards, except for aluminum, manganese, and nickel, which currently exceed standards in background groundwater. In the Reese Canyon area, the mixing water quality analysis indicates that concentrations of aluminum, antimony, cadmium, manganese, nickel, sulfate, and TDS in alluvial groundwater would increase by 0.4% to 42%. Selenium concentrations would increase by 178% (Whetstone 2002). None of the COPCs would increase above groundwater or surface water standards, except for manganese and nickel, which currently exceed standards in background groundwater. Manganese standards in ground and surface water are based on aesthetic criteria. Nickel standards are applicable to surface water and are based on human health considerations.

Since concentrations at seeps and springs are affected by surface water runoff, alluvial groundwater, and shallow bedrock groundwater, the changes in concentrations calculated for the alluvium do not directly represent concentrations at the seeps and springs. Natural attenuation of selenium and other constituents was not considered in this analysis.