FINAL

ENGINEERING EVALUATION/COST ANALYSIS (EE/CA) FOR WATER MANAGEMENT AT THE ZORTMAN AND LANDUSKY MINES PHILLIPS COUNTY, MONTANA

Prepared for the

Bureau of Land Management

by

SPECTRUM ENGINEERING

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Cover photos, clockwise from upper left: Landusky Mine at full buildout in 1996, Bioreactor tanks and pond on the L87 leach pad dike, Landusky Mine at reclamation completion in 2005, and Landusky ARD water treatment plant.

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TABLE OF CONTENTS

Appendices:

List of Tables

List of Figures

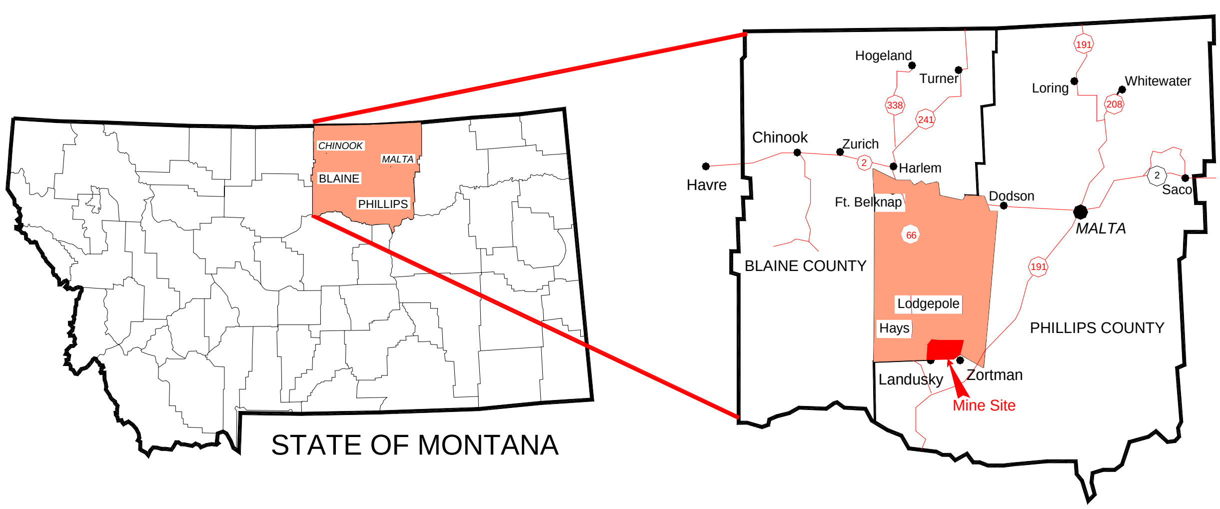
EXECUTIVE SUMMARY

The Zortman and Landusky Mines are located in north-central Montana in the Little Rocky Mountain. The mines are near the towns of Zortman and Landusky and located on a mixture of patented mining claims (private lands) and lands managed by the Bureau of Land Management (BLM). Pegasus Gold Corporation and Zortman Mining, Inc. operated the mines from 1979 through 1998, when the operator filed for bankruptcy protection. With filing of bankruptcy and exhaustion of the financial guarantees used to fund reclamation, the mines are abandoned. The BLM is the lead federal agency for conducting removal actions at the Site under its CERCLA authority. The Montana Department of Environmental Quality (DEQ) is assisting with water treatment activities at the Site according to the terms of the memorandum of understanding (MOU) entered by DEQ and BLM in August of 2004.

The purpose of this Engineering Evaluation and Cost Analysis (EE/CA) is to reassess the existing and anticipated water quality Site conditions, evaluate the performance of the current removal actions, and to assess the costs and amounts of funding available to continue or where needed, improve the water collection and treatment practices.

In June 2004, the BLM issued an Action Memorandum for Time-Critical removal actions in order to continue water treatment in the absence of a mine operator (BLM, 2004). This EE/CA is the next step in continuing removal actions needed to protect public health, welfare, or the environment. It addresses the management of Operable Units OU1, OU2, and OU3 which treat mine drainage, treat leach pad waters, and reclaim reactive mine waste units, respectively. This document includes an assessment of the potential human and ecological harm from the water currently being released from the Site, or that would be released if any of the capture or treatment systems, or reclaimed waste units, were modified. This EE/CA is built upon a substantial amount of data and studies. Section 9 lists publications and reports containing detailed site information.

Figure 1 - Location



Funding

The estimated annual operating and maintenance costs for the capture and treatment of mine-impacted water is $1.5 million, however, only $731,321 in annual funding is available under the near-term water treatment surety bond through year 2017. Since 1999, the BLM has provided on the average of $100,000 per year in additional funding to keep these facilities operating because the surety bond payment is not sufficient to pay for operation of the water treatment plants for the entire year.

With completion of reclamation earthwork, overall site management and water treatment costs are projected to exceed the available funding by about $770,000 annually.

A one-time lump sum amount of approximately $8 million is required to finance the yearly shortfall of $770,000 through 2017. After 2017, the source of funding switches to two long term trust funds; a $14.6 million fund established by the mine operator in 1996; and a $19.3 million supplemental trust fund created by the State of Montana House Bill 379 in 2005 (thanks in part to Representative Jonathan Windy Boy and the Fort Belknap Reservation who sponsored and supported the Bill). As of September 2006, a source of funding to ensure water treatment for years 2008 through 2017 has not been secured.

Current Site Conditions

The existing mine drainage water treatment plants and collection systems (OU1) generally do a good job meeting primary drinking water standards, but do not always meet chronic aquatic standards at the water treatment facility discharge points. With natural attenuation, the treated water generally satisfies the DEQ-7 water quality standards before leaving the site boundary (Section 2, Figure 2).

At the Zortman Mine, the majority of the treated water seeps into the bedrock beneath Ruby Gulch and does not appear as surface water downstream of the town of Zortman except during major run-off events. The treated water does infiltrate to the Madison Formation, an important aquifer, where it outcrops in Ruby Gulch near Zortman.

Treated water from the Landusky Mine water treatment plant flows down Montana Gulch into Rock Creek where it merges with flow from other drainages. November 2005 surface water testing of the co-mingled Landusky Mine water treatment plant discharge and the biological treatment plant (OU2) discharge along Rock Creek below the Landusky Mine showed all trace metal concentrations were below the Applicable or Relevant and Appropriate Requirements (ARARs)[1] downstream from the town of Landusky. It is interesting to note that some of the metals, sulfates and Total Dissolved Solids begin to increase downstream of where Rock Creek crosses highway 191 after flowing across the Cretaceous age sandstones and shales. If the water presently collected and treated at the Landusky Mine were not captured and treated there would be adverse consequences to the domestic wells in Landusky, and considering the acidic condition of the major leach pads, the water quality in Rock Creek would not meet ARARs for either the human health or aquatic life standards.

The treatment of the leach pad waters in the biological treatment plant (OU2) is working well in the removal of selenium and nitrate. Co-mingling of this treated water with treated water from the Landusky Mine water treatment plant in the Montana Gulch Pond provides a discharge that generally meets ARARs where it enters Montana Gulch.

Alternatives to Current Treatment Practices

Passive Treatment - Passive or semi passive water treatment systems could be used to some degree, but pilot scale testing must occur before any informed decisions could be made regarding feasibility. The large amount of aluminum and iron present in some of the untreated water can foul passive systems. Testing would also be necessary to determine the amount of flat real estate required to construct the ponds and passive facilities. The absence of suitable flat ground on site is a major constraint on passive systems. A small passive system would improve the quality of water entering the King Creek drainage.

1 - ARARs for water quality are from the Montana Water Quality Standards from publication DEQ-7.

Low Permeability Reclamation Capping – The ultimate performance of the existing vegetation covers at reducing infiltration is still unknown due to the relatively short time they have been in place. These vegetation covers could be replaced with barrier covers composed of synthetic material. The cost to cap the leach pads, dikes, and dumps with barrier covers is considerably more than the cost to operate the current treatment systems into perpetuity ($ 33.9 million). More importantly, capping the mine waste with barrier covers will only reduce, not eliminate, the production of acid rock drainage. Therefore, operation of the water treatment plants or possibly a passive system (that would require additional capital) would still be necessary. The cost to cap only the Landusky Mine 87/91 leach pads is estimated at $30 million. The most economical and technically reliable alternative is to continue to operate the current system and to continuously improve and fine-tune the treatment processes.

Power Generation - Electricity to operate the pumps and treatment plants presently costs about $260,000 per year and will probably increase in the future. Preliminary studies show that the average wind speed at the Landusky Mine is 17 mph, which is considered very high. Wind power could theoretically be used to generate power and perhaps generate revenue to offset other costs. The site probably has sufficient wind and real estate to generate 50 to 100 MW of power. Presently, the site uses less than 3 million kw-hr each year. This averages about 400 kw constant demand with a peak of about 1200 kw (or 1.2 MW) when the big pumps are turned on. Wind turbines could be used to provide intermittent power for the project. Since the wind does not blow continuously, it is not possible to generate 100% of the power needed by wind alone without relying on power from the local power grid owned by Big Flat Electric.

The economics of wind power are very sensitive to the size of the wind turbine. A turbine sized to satisfy the exact needs of each mine would cost about $0.02/kw-hr to operate and about $0.05-$0.06 for the capital costs. If the capital costs were paid for by a grant or through a demonstration project, then wind power has the potential to reduce about 40% of the yearly costs by about 5/7 or $74,000 per year (5/7 x 40% of $260,000) at current power rates. In other words, annual power costs could be cut by 28% if wind power generators were installed to supplement the power supplied from the local power grid.

Cost Saving Alternatives

The total amount of acid rock drainage reaction products (potential contaminants) is predicted to increase as the spent ore in the leach pads continues to react and become more acidic. This increase in acid rock drainage will increase the water treatment and sludge handling costs. The only way to materially decrease the costs, and to operate within the available funding, would be to eliminate an entire capture and treatment process, or to stop collection and treatment of certain seeps, adit drainage, or leach pad effluent. However, this could not occur without an increased release of contaminants and create a substantial risk of not meeting ARARs.

A summary of each alternative considered and its ability to meet ARARs in presented in Table 1.

Table 1 – EE/CA Summary of Alternatives

Alternative	Removal Action Description	Total Site Operating Cost/Year	Upfront Cost	Annual Savings or (Cost)	Years to Payoff	Effect on Removal Performance	ARARs Met at Site Boundary	Remarks
BASE CASE (Continuation of current removal actions)								
Alternative Z-100	Treat all Zortman capture systems in Zortman Water Treatment Plant (ZWTP).	$553,900	$0	$0	N/A	No change.	Yes	Current Base Case system, consisting of Alternatives Z-100, Z-500, L-100 and L-500, works well.
Alternative Z-500	Treat all Zortman leach pad waters in Landusky Biological Treatment Plant.	$157,300						
Alternative L-100	Treat all Landusky capture systems in Landusky Water Treatment Plant (LWTP).	$418,200						
Alternative L-500	Treat all Landusky leach pad waters in Landusky Biological Treatment Plant.	$370,600						
	Total Base Case:	**$1,500,000**						

EE/CA Summary of Alternatives								
Alternative	**Removal Action Description**	**Total Site Operating Cost/Year**	**Upfront Cost**	**Annual Savings or (Cost)**	**Years to Payoff**	**Effect on Removal Performance**	**ARARs Met at Site Boundary**	**Remarks**
VARIATIONS FROM BASE CASE								
Alternative Z-200	Shut down ZWTP, route all waters through LWTP via HDPE pipeline.	$1,380,000	$1,000,000	$120,000	8.3	Maximum LWTP capacity exceeded sometimes.	Not 100% of Time	Some untreated water would be released due to treatment plant design flow exceedance.
Alternative Z-300	Run Zortman capture water through constructed passive system.	$1,177,000	$2,000,000	$323,000	6.2	Unknown discharge results.	No	Additional testing needed.
Alternative Z-400	Shut down Zortman water treatment plant with no capture of waters.	$1,141,000	$0	$359,000	N/A	Elevated metals.	No	Elimination of a cost center.
Alternative Z-610	Treat Zortman leach pad water through ZWTP and discharge down Ruby Gulch.	$1,460,000	$0	$40,100	N/A	Higher nitrates.	No	Not as effective as Base Case. ARARs exceeded for nitrates.

EE/CA Summary of Alternatives								
Alternative	**Removal Action Description**	**Total Site Operating Cost/Year**	**Upfront Cost**	**Annual Savings or (Cost)**	**Years to Payoff**	**Effect on Removal Performance**	**ARARs Met at Site Boundary**	**Remarks**
Alternative Z-620	Treat Zortman leach pad water in ZWTP and then pump to Bio plant.	$1,532,000	$0	($32,000)	N/A	Same as Base Case.	Yes	Higher costs than Base Case plus additional handling of waters.
Alternative Z-630	Treat Zortman leach pad waters in ZWTP then land apply on Goslin Flats LAD.	$1,520,000	$0	($20,000)	N/A	Higher nitrates.	Yes	Not as effective as Alternative Z-500. Elevated nitrates are acceptable in LAD area. Assumes ZWTP continues to operate and pad water run through sludge.
Alternative Z-700	Treat Zortman leach pad water through LWTP.	$1,302,000	$1,000,000	$198,000	5.1	Higher nitrates.	No	Not as effective as Base Case.

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Alternative Z-800	Treat Zortman leach pad waters by land application on Goslin Flats LAD.	$1,456,000	$0	$44,000	N/A	Higher nitrates.	Yes	Not as effective as Base Case. Elevated nitrates are acceptable in LAD application. Assumes ZWTP continues to operate and pad water run through sludge pit.
Alternative Z-900	Treat Zortman leach pad waters in constructed passive treatment system.	$1,531,000	$1,500,000	($31,000)	Never	Unknown discharge results.	Maybe	Additional testing needed.
Alternative Z-1000	No capture or treatment of Zortman leach pad waters.	$1,355,000	$0	$145,000	N/A	Elevated metals and nitrates.	No	Low pH with metals discharged.

EE/CA Summary of Alternatives								
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Alternative Z-1100	Barrier cap all leach pads with liner.	$1,480,000	$5,100,000	$20,000	255	Reduced flow to treat.	Yes, with Treatment	High cost with minimal returns.
Alternative Z-1200	Generate electricity with wind turbine.	$1,430,000	$2,000,000	$50,000 to $74,000	33.3	No change.	N/A	Effective if capital is provided by a grant.
Alternative Z-1300	Alternative Z-100 but discontinue use of the ferric sulfate circuit.	$1,464,000	$0	$36,000	N/A	Higher arsenic discharged at times.	Yes	Discontinue use of the ferric sulfate circuit within the ZWTP (similar to LWTP). January 2006 test of this Alternative yielded a 0.001 mg/l arsenic result.

EE/CA Summary of Alternatives								
Alternative	**Removal Action Description**	**Total Site Operating Cost/Year**	**Upfront Cost**	**Annual Savings or (Cost)**	**Years to Payoff**	**Effect on Removal Performance**	**ARARs Met at Site Boundary**	**Remarks**
Alternative L-200	Close LWTP and pump Landusky capture water to ZWTP.	$1,600,000	$0	($100,000)	N/A	Maximum ZWTP flow exceeded 2-3 months per year.	Not 100% of Time	Not practical alternative. Not studied in detail. May work if Gold Bug and WS-3 closed. Then ARARs met.
Alternative L-300	Run Landusky capture water through constructed passive system.	$1,204,000	$2,500,000	$296,000	8.4	Unknown discharge results.	No	Additional testing needed.
Alternative L-400	Shut down Landusky water treatment plant with no capture of waters.	$1,187,000	$0	$313,000	N/A	Elevated metals.	No	Elimination of a cost center.
Alternative L-600	Shut down the bio treatment plant and treat pad water in LWTP.	$1,391,000	$0	$109,000	N/A	Higher nitrates and selenium.	No	Not as effective as Base Case. ARARs exceeded for selenium and nitrates.

EE/CA Summary of Alternatives								
Alternative	**Removal Action Description**	**Total Site Operating Cost/Year**	**Upfront Cost**	**Annual Savings or (Cost)**	**Years to Payoff**	**Effect on Removal Performance**	**ARARs Met at Site Boundary**	**Remarks**
Alternative L-700	Shut down the bio treatment plant and land apply pad waters on LAD.	$1,431,000	$0	$69,000	N/A	Higher nitrates, aluminum and selenium.	No	Not as effective as Base Case. Would exceed the capacity of the LAD.
Alternative L-800	No capture or treatment of Landusky leach pad waters.	$1,125,000	$0	$375,000	N/A	Elevated metals, Se, AL, nitrates.	No	Low pH, high metal values released.
Alternative L-900	Cap all the leach pads with a barrier cover.	$1,292,000	$35,000,000	$208,000	168.3	Reduced flow to treat.	Yes, with Treatment	High cost with minimal returns.
Alternative L-1000	Generate electricity with wind turbine.	$1,430,000	$2,000,000	$50,000 to $74,000	33.3	No change.	N/A	Effective if capital is provided by a grant or other outside source.

EE/CA Summary of Alternatives								
Alternative	**Removal Action Description**	**Total Site Operating Cost/Year**	**Upfront Cost**	**Annual Savings or (Cost)**	**Years to Payoff**	**Effect on Removal Performance**	**ARARs Met at Site Boundary**	**Remarks**
King Creek: Alternative KC-100	Continue to only monitor King Creek.	$3,800 (sampling costs)	$0	$0	N/A	No change.	Yes, at Site Boundary	Marginally exceeds nitrate and selenium at L-5 sample site
Alternative KC-200	Passive system installed below interception trench below L-5.	Increase by $5,000	$130,000	($5,000)	Never	Somewhat improved water quality in King Creek.	Yes	Recommend construction during summer of 2006
Swift Gulch: Alternative SG-100	Continue to only monitor Swift Gulch.	$6,900 (sampling costs)	$0	$0	N/A	No change.	Yes, at Site Boundary	Track changes in water quality for possible future action.
Alternative SG-200	Continue to monitor Swift Gulch & conduct characterization study.	$6,900 (sampling costs)	$300,000	$0	N/A	No change.	Yes, at Site Boundary	Conduct studies on drainage paths
Alternative SG-300	Monitor and study plus build settling ponds in old placer tailings at Bighorn-Swift confluence.	Increase by $5,000	$600,000	($5,000)	N/A	Decreased chance of contaminants leaving site due to extreme runoff event.	Yes, at Site Boundary	Eligible for RIT grant and BLM funding. Done in conjunction with above study.

EE/CA Summary of Alternatives								
Alternative	**Removal Action Description**	**Total Site Operating Cost/Year**	**Upfront Cost**	**Annual Savings or (Cost)**	**Years to Payoff**	**Effect on Removal Performance**	**ARARs Met at Site Boundary**	**Remarks**
Alder Gulch: Alternative AG-100	No action on Alder Gulch Waste Rock Dump. Leave the dump in its current condition.	No change.	$0	$0	N/A	No change.	Yes, with downstream capture	Current conditions.
Alternative AG-200	Regrade and recap the top portion of the Alder Gulch Waste Rock Dump.	Minimal change.	$300,000	$2,000	150	Decrease the quantity of water being captured and treated.	Yes, with downstream capture	Funding available.
Alternative AG-300	Regrade and recap the top portion of the Rock Dump in accordance with the 2001 SEIS Alternative Z6. Place the excavated waste rock into the North Alabama Pit.	Minimal change.	$2,200,000	$2,000	1,100	Decrease the quantity of water being captured.	Yes, with downstream capture	RIT grant available for $300,000.

Note: "Capture water" refers to mine drainage or ARD, recovered by the capture systems, wells such as WS-3, or from historic mine adits such as the Gold Bug Adit or Ruby Adit. "Leach pad waters" or "pad water" refers to solution remaining in the leach pads, which was part of the process circuit and may contain residual cyanide compounds, high nitrates, or elevated selenium levels; in addition to characteristics of ARD.

1.0 INTRODUCTION

1.1 BACKGROUND

The Bureau of Land Management (BLM) is conducting removal actions at the Zortman and Landusky Mines through the agency's delegated authority (Executive Order 12580) under the Comprehensive, Environmental, Response, Compensation, and Liability Act (CERCLA). All response actions will be consistent with the National Contingency Plan (40 CFR Part 300). Due to the intermingled private land at the mines, and the previous integration of BLM's mining regulation program (particularly reclamation bonding) with the State of Montana's mining regulation program, the removal actions will be conducted in conjunction with the Montana Department of Environmental Quality (DEQ) reclamation and water treatment activities at the Site.

The owner and operator of the mines, Zortman Mining, Inc. (ZMI) and Pegasus Gold Corporation (PGC), declared bankruptcy in 1998. Since that time, the BLM and DEQ have worked together with the bankruptcy trustee to implement closure of the mine using the reclamation and water treatment bonds along with other funding sources. With the liquidation of ZMI and the discharge of the bankruptcy proceedings, an operator of record no longer exists. However, conditions at the Site continue to pose a potential threat to public health or welfare or the environment; on, from, or to lands under the jurisdiction, custody, or control of the BLM.

The water quality conditions that exist before capture and treatment (shown in Tables 2 and 3) meet the criteria for a Removal Action under 40 CFR § 300.415 (b)(2) of the National Contingency Plan. Executive Orders 12580 and 13016 delegate this authority to the Department of the Interior. Secretarial Order 3201 further delegates the authority to the BLM when the release or potential release of hazardous substances is on or would affect BLM-managed lands.

Previously, the BLM designated three Operable Units at the Site:

1. **Operable Unit 1 (OU1)** is the capture and treatment systems used to recover and treat mine drainage from the waste rock dumps, leach pad dikes, areas beneath and adjacent the mine pits, and from historic underground workings. OU1 facilities include: the existing seepage capture systems in Ruby Gulch, Alder Spur, Carter Gulch, Montana Gulch, Mill Gulch, and Sullivan Gulch; the Zortman and Landusky mine water treatment plants; areas where treated water leaves the plants and sludge disposal pits; and the associated infrastructure serving these facilities including roads, power lines, pipelines, and current or future backup or supplemental power generation equipment.
2. **Operable Unit 2 (OU2)** is the leach pad containment areas holding residual process solutions; the biological treatment system used to treat leach pad solutions; associated ponds, pipelines, pumps and pre- or post-treatment apparatus; and the land application disposal system (LAD).
3. **Operable Unit 3 (OU3)** consists of the area of mine disturbance at the Site where reclamation has occurred. It includes discrete reclaimed mine waste units such as waste rock dumps, the reclaimed piles of spent-ore, the mine pit areas, and all associated access roads and monitoring sites.

Two other operable units, the King Creek passive treatment system (OU4) and the Swift Gulch settling ponds (OU5), have been identified for consideration.

Table 2 – Zortman Mine Water Quality Summary, November, 2005

			pH	AL	As	Cd	CN-wad	Cu	Fe	Mn	N+N	Ni	Se	SO4	Tl	Zn
Aquatic Acute (mg/l)	Exceedence		6.50	0.750	0.340	0.009	0.022	0.052				1.57	0.02	250		0.39
Aquatic Chronic (mg/l)	Exceedence		6.50	0.087	0.150	0.001	0.022	0.030				0.17	0.005	250		0.39
Human Health Surface Water (mg/l)	Exceedence		6.50		0.010	0.005	0.200	1.30	0.30	0.05	10.00	0.010	0.050	250	0.00024	2.00
Human Health Ground Water (mg/l)	Exceedence		6.50		0.010	0.005	0.200	1.30	0.30	0.05	10.00	0.100	0.050	250	0.0020	2.00
Precip. Inches	5 yr avg	17.04	inches													
	gpm	**gal/Yr**	pH	AL	As	Cd	CN-wad	Cu	Fe	Mn	N+N	Ni	Se	SO4	Tl	Zn
Capture Systems Before Treatment																
Alder Spur	13 gpm	6.79 M	4.50	8	0.002	0.026	-	0.4	1	7	4.3	0.4	0.004	1,710	-	1.05
Carter Gulch	17 gpm	8.83 M	3.58	739	-	0.613	-	6.2	2	161	33.6	5.2	0.028	9,200	-	24.00
Ruby Gulch	92 gpm	48.34 M	3.66	345	0.192	0.153	-	8.9	108	26	1.2	1.8	0.011	4,440	-	4.60
Zortman Leach Pads Before Treatment																
Z-79/81	8 gpm	4.40 M	4.38	82	-	0.186	0.015	1.2	1	23	59.9	0.7	0.015	2,690	-	11.30
Z-82	0 gpm	0.00 M	removed													
Z-83	7 gpm	3.80 M	4.60	299	-	0.442	0.025	2.1	13	88	123.0	5.8	0.075	6,350	-	52.00
Z-84	8 gpm	4.10 M	5.50	71	0.016	0.103	0.032	0.5	1	21	96.4	1.0	0.017	3,900	-	19.00
Z-85/86	18 gpm	9.50 M	2.62	1,390	3.290	0.865	0.095	20.9	557	106	72.5	7.6	0.084	12,800	-	82.00
Z-89	8 gpm	4.20 M	±6	188	0.001	0.489	0.025	2.2	4	85	94.2	4.9	0.049	6,020	-	52.30
Total Zortman Leach Pads	49 gpm	26.00 M														
Water Treatment Plant After Treatment	122 gpm	63.96 M	-	-	0.000	0.004	-	0.0	0.3	6	4.8	0.1	0.009	2,251	-	0.02

Table 3 – Landusky Mine Water Quality Summary, November, 2005

			pH	AL	As	Cd	CN-wad	Cu	Fe	Mn	N+N	Ni	Se	SO4	Tl	Zn
Aquatic Acute (mg/l)	Exceedence		6.50	0.750	0.340	0.009	0.022	0.052				1.57	0.02	250		0.39
Aquatic Chronic (mg/l)	Exceedence		6.50	0.087	0.150	0.001	0.022	0.030	1.00			0.17	0.005	250		0.39
Human Health Surface Water (mg/l)	Exceedence		6.50		0.010	0.005	0.200	1.30	0.30	0.05	10.00	0.010	0.050	250	0.00024	2.00
Human Health Ground Water (mg/l)	Exceedence		6.50		0.010	0.005	0.200	1.30	0.30	0.05	10.00	0.100	0.050	250	0.0020	2.00
Precip. Inches	5 yr avg	17.52	inches													
			pH	AL	As	Cd	CN-wad	Cu	Fe	Mn	N+N	Ni	Se	SO4	Tl	Zn
Capture Systems Before Treatment	**gpm**	**gal/Yr**														
Mill Gulch	39 gpm	20.46 M	4.50	97.6	-	0.254	-	0.62	0.4	24.8	4	0.89	0.016	2,310		4.93
Sullivan Gulch	10 gpm	5.04 M	4.01	761.0	0.006	0.249	-	0.96	8.1	72.0	6	3.65	0.062	10,000	-	22.50
Frog Pond	1 gpm	0.75 M	3.08	663.0	0.005	0.071	-	3.92	43.3	108.0	2	5.31	0.023	9,440	-	19.80
Upper MT	10 gpm	5.26 M	5.58	17.9	0.009	0.084	-	0.19	0.1	13.4	12	0.54	0.020	1,890	-	2.91
Gold Bug	143 gpm	74.90 M	5.78	3.8	0.209	0.003	-	0.01	30.1	3.8	0	0.16	-	485	-	1.20
WS-3	178 gpm	93.56 M	6.06	0.0	0.151	-	-	0.00	15.3	2.4	0	0.03	-	505	-	0.11
Landusky Leach Pads Before Treatment																
L-79	1 gpm	0.50 M	6.54	34.2	0.102	0.035	0.150	1.05	2.1	3.2	284	0.19	0.072	2,220	-	4.96
L-80	14 gpm	7.20 M	8.12	20.6	0.078	0.009	0.050	0.02	0.5	0.0	282	0.15	0.068	1,740	-	0.08
L-83	8 gpm	4.40 M	6.83	0.1	0.012	0.01	0.100	0.02	0.1	6.0	81	0.14	0.05	1,960	-	1.00
L-84	6 gpm	3.40 M	6.71	3.7	-	0.066	0.100	0.10	0.1	25.5	105	0.64	0.056	2,390	-	6.83
L-85-86	0 gpm	0.00 M	removed				0.115									
L-87	51 gpm	26.80 M	4.24	251.0	0.006	0.507	0.040	5.06	1.8	85.1	177	4.05	0.420	8,630	0.009	32.00
L-91	53 gpm	27.70 M	3.97	726.0	-	0.800	0.200	11.40	351.0	108.0	241	6.36	1.260	9,090	-	56.20
Total Landusky Leach Pads	133 gpm	70.00 M														
Untreated Springs and Seeps																
August #2 Waste Dump (L-5) 2 to 30 gpm	6 gpm	3.15 M	7.20	-	-	0.004	-	0.01	0.0	2.0	21	0.06	0.046	1,040	-	0.24
Water Treatment Plant After Treatment	380 gpm	199.97 M	6.78	0.5	0.007	0.002	-	0.00	0.1	2.7	1	0.05	0.006	882	0.003	0.02
Biological Treat Plant (Land & Zort Leach Pads)	183 gpm	96.00 M	6.73	2.7	0.001	0.008	0.150	0.02	0.7	59.3	0	0.12	0.024	6,390	0.003	1.36
Average WTP + Bio Plant	563 gpm	295.97 M		1.2	0.005	0.004	0.049	0.01	0.3	21.1	1	0.07	0.012	2,669	0.003	0.45

1.2 OBJECTIVE

The objective of the Engineering Evaluation/Cost Analysis (EE/CA) is to screen, develop, and evaluate alternatives that could be used to modify existing OUI and OU2 treatment systems. The EE/CA will determine whether current practices are sufficiently effective and economical, and if not, identify better treatment options for mine drainage and heap solutions that will satisfy Applicable or Relevant and Appropriate Requirements (ARAR)s to the extent practicable. The defining ARAR in this case is the substantive Montana water quality standards described in DEQ-7 (See Section 5.3 for a detailed review of the ARARs).

The potential for additional source control (enhanced reclamation of OU3 facilities) measures that might prove effective in reducing or eliminating treatment requirements is considered for each mine facility that produces effluent requiring treatment. Any other alternatives identified through the public input process, as well as any combination of the above alternatives, are considered. All removal actions at the Site build upon the preferred reclamation plans selected by the BLM in its 2002 Record of Decision (ROD), to the extent practical considering the exigencies of the situation. Removal actions are to be conducted in conjunction and cooperation with the Montana DEQ actions at the Site. The BLM will also continue to provide Fort Belknap with monthly monitoring reports and consult with the Fort Belknap government as removal actions are implemented. It planned that the DEQ will continue to conduct water treatment and site maintenance using funds from the reclamation bonds, water treatment trust fund, or with supplemental funding provided by the BLM. The DEQ's water treatment activities meet the BLM removal action objectives. Coordination with the DEQ would continue under a Memorandum of Understanding (MOU) entered in August 2004 between the BLM and DEQ regarding Site activities and funding.

1.3 REPORT ORGANIZATION

This EE/CA is organized into ten sections plus the Executive Summary. The Executive Summary is first. Section 1 provides introductory information along with tables showing the current water quality. Section 2 provides the site location and description, mining history, current ownership, and a timeline of important action items. Section 3 describes the site characterization (detailed mine site features description) and the issues of concern (risk assessment). Section 4 presents information concerning the sources, nature, and extent of contamination. Section 5 provides the removal action objectives. Section 6 outlines the response action technologies and development of alternatives. Section 7 provides a detailed analysis of each alternative. Section 8 lists the recommended alternative action. Section 9 provides a list of references. The Appendices provide supporting material.

2.0 SITE LOCATION AND HISTORICAL TIMELINE

The Site is a geographically contiguous area that includes the Zortman and Landusky Mines, associated facilities such as the land application area, and adjacent drainages that receive runoff from the mine areas where capture, treatment and monitoring operations are conducted (Figure 2). The towns of Zortman and Landusky, and the Montana Gulch campground, are included in the Site to the extent the drainages of Ruby Gulch and Montana Gulch are potentially affected by upstream activity. The northwest corner of the Site boundary is adjacent the Fort Belknap Indian Reservation.

2.1 SITE LOCATION

The Site includes open pit and historic underground gold mines situated near the crest of the Little Rocky Mountains in north central Montana. The Zortman Mine is located in Sections 7, 17, and 18, Township 25 North, Range 25 East. The Landusky Mine is west of the Zortman Mine in Sections 14, 15, 22, and 23, Township 25 North, Range 24 East. The Goslin Flats Land Application Disposal (LAD) area is located south of the town of Zortman in Sections 20, 21, and 28, Township 25 North, Range 25 East. Both mines and the LAD area are south of the Fort Belknap Indian Reservation in the southwest corner of Phillips County. The towns of Hays and Lodgepole are located in the southern portion of the Reservation, just to the north of the mountains. The town of Landusky is in the southwest portion of the Little Rocky Mountains, about one-half a mile south of the Landusky Mine. The town of Zortman is about 1 mile south of the Zortman Mine, on the southern edge of the Little Rocky Mountains. The mines are 7 to 10 miles north of the US 191/State Highway 66 Junction, known as DY Junction, and can be accessed by local roads branching off either of these highways.

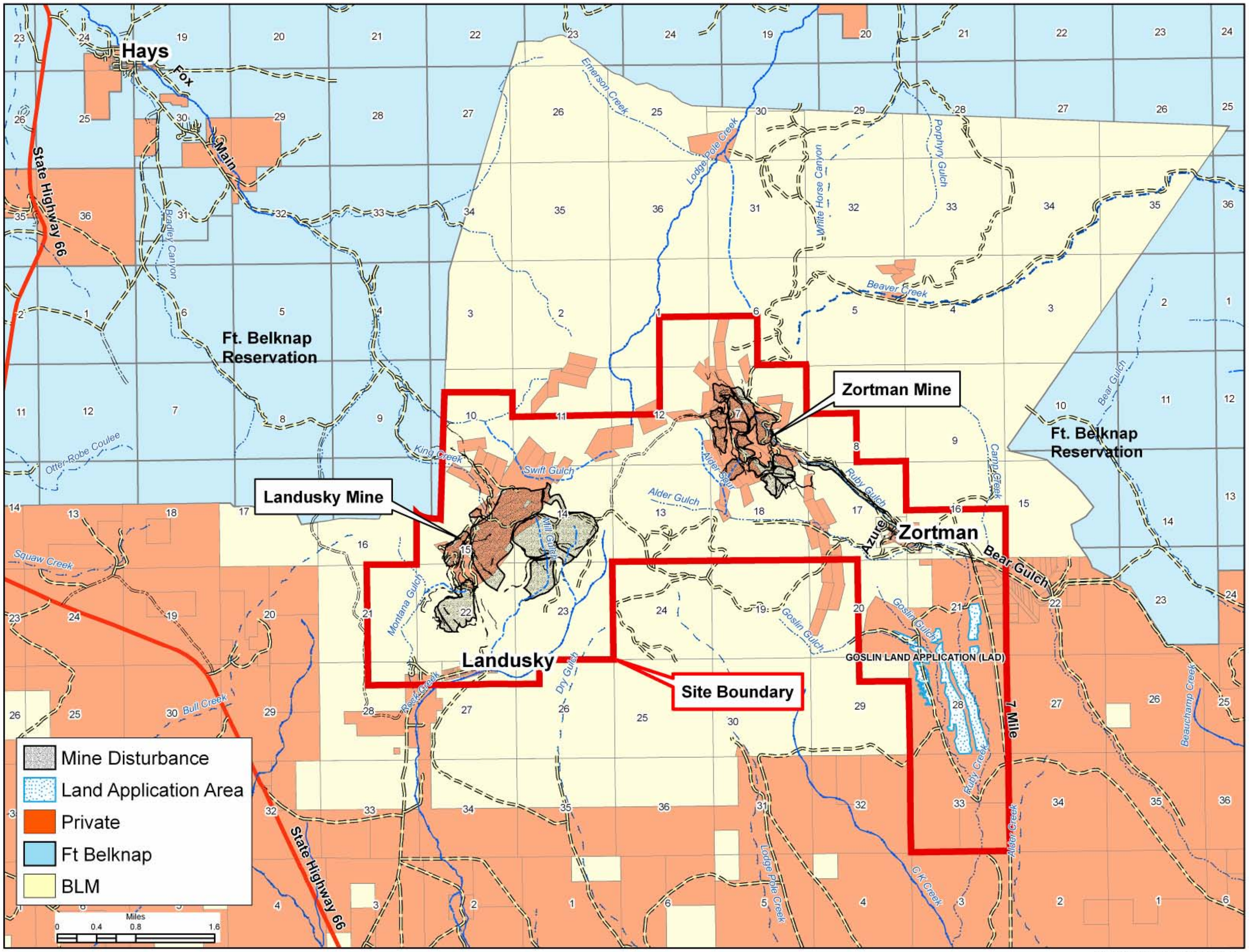
2.2 SITE DESCRIPTION

The Site is in the Little Rocky Mountains, which are surrounded by rolling prairie dissected by streams and interrupted by "Island Mountains" that rise out of the relatively flat plains like islands in the ocean. Site elevations range from 3800 to 5600 feet. Topography within the mountains is rugged, with high outcrops and steep V-shaped valleys. Soil resources include young and relatively undeveloped soil in the mountain areas where the mines are located. More developed soils occur in the plains areas where the Goslin Flats LAD area is located. Over the last 18 years, annual precipitation has averaged 18 inches with a high of nearly 24 inches. However, within the last five years, annual precipitation has averaged about 17.2 inches.

The mountains are mostly forested with occasional open grassy meadows. Primary plant community types include lodgepole pine forest, ponderosa pine forest, Douglas fir forest, deciduous tree forest, grassland, shrubland, and outcrop/scree communities. Small wetlands occur along the lower reach of most drainages. The area supports a wide variety of plants. No plants listed as federally threatened or endangered or of special interest or concern by the State of Montana are known to occur within the area. A wide variety of wildlife species are also found at the Site, including big game animals, upland game birds, raptors, and bats. Eighteen species of special concern at either the federal and/or state level potentially occur in the region. Herds of bighorn sheep and mule deer are common on the reclaimed areas within the Site.

The headwaters of several streams are located in the mine areas. Most streams are ephemeral or intermittent in nature. These drainages and the subsurface aquifers in the area have been or can be affected by acid rock drainage associated with mining activity, or as part of baseline conditions, in this highly mineralized area. Surface water and groundwater have exhibited elevated chemical concentrations on occasion downstream as far as the towns of Zortman and Landusky since before 1979.

Figure 2 – Site Boundary



The Zortman and Landusky mines were open pit, cyanide heap leach, gold mines. Ore was mined from pits, located mostly on private lands, and stacked in valley-fill leach pads, constructed mostly on BLM lands, where standard cyanide heap-leach technology was used to extract the precious metals (gold and silver) from the ore. Cyanide solution was applied to the heaps by spray or drip irrigation. Gold was dissolved from the ore as the solution percolated through the heaps to sumps at the base of the leach pads. The "pregnant" solution was then pumped to a gold/silver recovery plant. During mining, rock not meeting the ore grade cutoff (waste rock) was placed in waste rock dumps, used as mine pit backfill, or used in the construction of retaining dikes for the leach pads. The mines operated from 1979 through 1997, with leaching operations occurring through 1998.

With the end of mining, reclamation and water treatment activities became the predominant land uses in the area. The Fort Belknap Indian Reservation provides some recreational facilities including the various picnic areas and Pow Wow grounds located in Mission Canyon, northwest of the Landusky Mine. The Little Rocky Mountains were determined eligible for listing on the National Register of Historic Places as a Traditional Cultural Property. The Alder Gulch Historic District, which contains historic mining remains, is considered eligible for the National Register. Other areas in and around the mountains are designated as Areas of Critical Environmental Concern (ACEC). These include Azure Cave and prairie dog towns 20 miles east of the Little Rocky Mountains. Three other areas nominated for ACEC designation include the entire Little Rocky Mountains landform, Saddle Butte, and Old Scraggy Peak.

Detailed characterization of both mines and the surrounding environment can be found in two recently completed documents, *Final Environmental Impact Statement, Zortman and Landusky Mines, Reclamation Plan Modifications and Mine Life Extensions* (BLM, DEQ, 1996); and *Final Supplemental Environmental Impact Statement for Reclamation of the Zortman and Landusky Mines* (BLM, DEQ, 2001).

Streams in the Zortman Mine area include Lodgepole Creek, which drains to the north; Ruby Gulch, which flows south through the town of Zortman; and Alder Gulch, a tributary of Ruby Gulch. Flow in Lodgepole Creek is intermittent near the mine but perennial in its lower reaches and supports a limited brook trout population several miles from the site. Flows in Ruby and Alder Gulch are intermittent but may run quite high after storm events or rapid snowmelt.

The Zortman Mine disturbance covers approximately 406 acres, of which about 122 acres are on BLM land. Approximately 20 million tons of ore were mined during operations from 1979 through 1994. The open pits are located on private lands and cover approximately 96 acres. The leach pads and waste rock dumps are located on a mixture of private and BLM lands.

Streams in the Landusky Mine area include King Creek and Swift Gulch (both tributaries of South Bighorn Creek), which flow northwest onto the Fort Belknap Indian Reservation. There is a Tribal cultural and recreation use area located along South Bighorn Creek about a mile downstream of the northern portion of the Landusky Mine. Montana Gulch, Mill Gulch, and Sullivan Gulch are all tributaries of Rock Creek, which flows to the south. Mill Gulch, and Sullivan Gulch flow intermittently. The release of water from the water treatment facilities provides Montana Gulch with a perennial flow. Small brook trout populations exist in perennial segments of both Rock Creek and South Bighorn Creek/Little Peoples Creek, several miles downstream of the mine. Recently, brook trout were observed by site personnel collecting water samples at the BLM campground located along Montana Gulch about half a mile downstream of the mine area.

The Landusky Mine disturbance covers 783 acres, of which about 452 acres are on BLM land. Approximately 117 million tons of ore were mined during operations from 1979 through 1996. The mine pits are located mostly on private lands and cover approximately 235 acres. Nearly all of the leach pads and most of the waste rock facilities are located on BLM lands.

The LAD area at Goslin Flats is adjacent to both Ruby Gulch Creek and Goslin Gulch. The entire LAD area is on private property, once owned by ZMI (Figure 3). It is now owned by the Square Butte Grazing Association with land application rights reserved to the State of Montana.

2.3 MINING HISTORY

Gold was discovered in Alder Gulch on July 3, 1884, which triggered a gold rush. Part of the Little Rocky Mountains were ceded from the Fort Belknap Tribes in 1896, and underground mining proceeded intermittently in both the Landusky and Zortman areas until the second world war. Additional historical information is included in Appendix 1.

Mining in the Little Rocky Mountains can be characterized as heavy during the late 1800s through the turn of the century, cyclical from the 1920's through the 1940's, and sporadic through 1951. After 1951, little serious mining activity occurred in the Little Rocky Mountains until modern surface-mining operations were initiated in 1979.

During the mid-1970's, Pegasus Gold Corporation was able to identify a viable low-grade gold and silver deposit. An environmental impact analysis was completed in 1979.[2] This was followed by issuance of State operating permits for two open pit mining and heap leaching operations in 1979.

Pegasus Gold Corporation through its wholly owned subsidiary operating company, ZMI, operated the Zortman and Landusky Mines from 1979 through 1998. Pegasus and eighteen of its affiliates commenced voluntary chapter 11 proceedings in the United States Bankruptcy Court for the District of Nevada on January 16, 1998. Since that time, the BLM and Montana DEQ have worked together with the bankruptcy trustee (serving in the role of mine operator) to implement closure of the mine using reclamation and water treatment bonds along with other funding sources. The transition from chapter 11 bankruptcy (reorganization) to chapter 7 bankruptcy (liquidation) of ZMI, along with completion of the bankruptcy proceedings in December 2003, means an operator of record for the mines no longer exists.

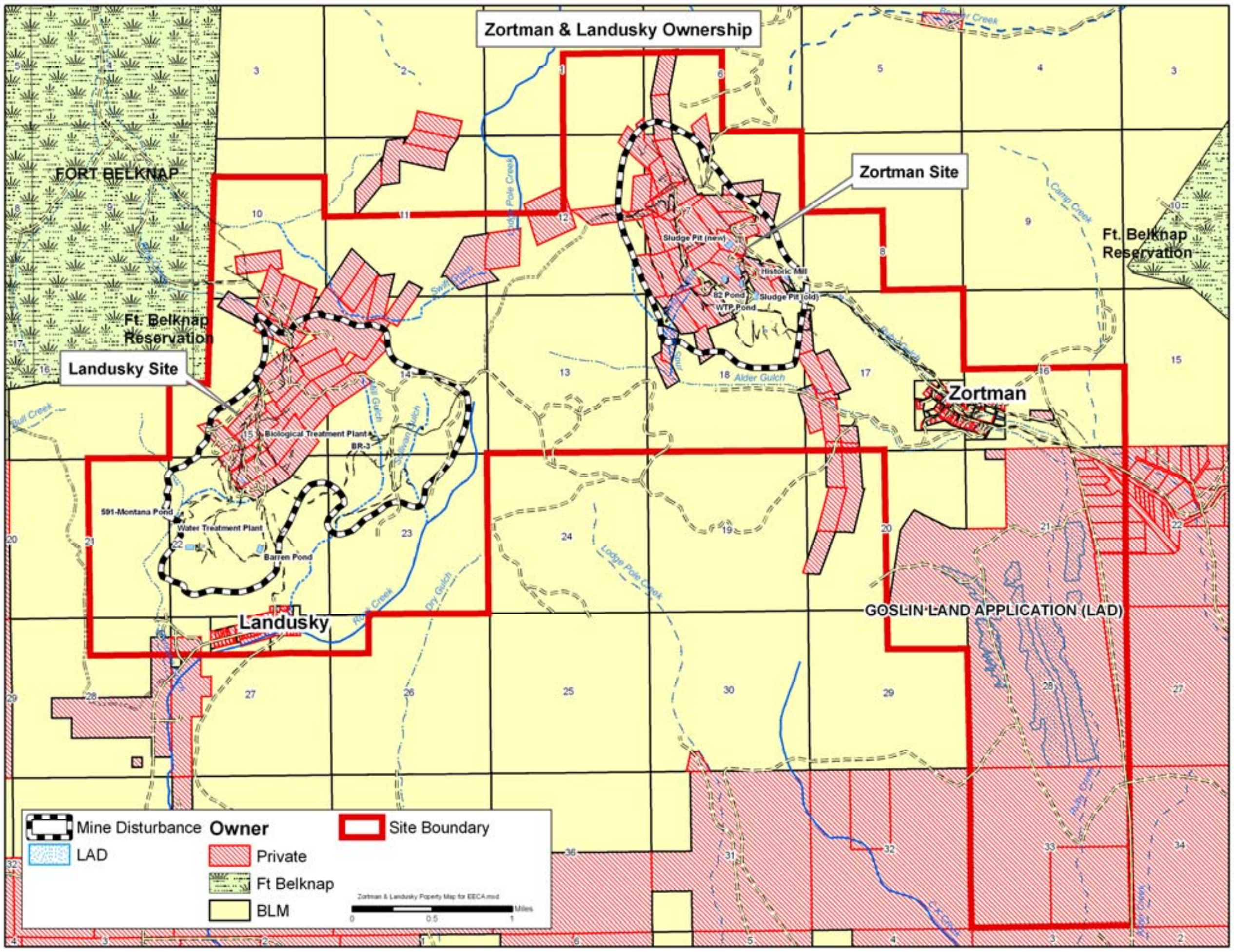
2.4 CURRENT OWNERSHIP

There are three primary owners. They include the BLM, Luke Ployhar (purchaser of all of the ZMI patented claims in the mine areas), and Vernon Smith, et. al. with a block of claims on the northern edge of the Landusky Mine.

There is a Potential Responsible Party (PRP) search underway to determine all parties who have had an ownership interest, a role in directing operations, or an economic interest in the Zortman and Landusky Mines since the pre-mining era.

2 - On May 17, 1979 the Montana Department of State Lands (precursor agency to the DEQ) issued the State's final EIS documentation. The documentation consisted of responses to comments and designating the draft EIS as the final EIS for purposes of making a decision on the Operating Permit applications.

Figure 3 - Property Map



2.5 TIMELINE OF IMPORTANT ACTIONS

The Zortman and Landusky mines operated from 1979 until 2003 under State-approved Operating Permits, and from 1981 until 2003 under BLM-approved Plans of Operations. Active mining operations ceased in 1997. Between 1979 and 1990, the Landusky Mine state permit boundary increased from 530 acres to 1,287 acres and the approved mine disturbance area increasing from 256 acres to 814 acres. During the same period, the Zortman Mine state permit boundary increased from 619 acres to 961 acres with the approved mine disturbance area increasing from 273 acres to 401 acres.

Noteworthy events that occurred during this period relative to the development of the acid rock drainage issue include the following:

- ZMI held Montana Pollutant Discharge Elimination System (MPDES) permit (MT0024864) for the Landusky Mine, which authorized discharge of storm water into King Creek, and another permit (MT0024856) for discharge of water into Ruby Gulch and Glory Hole Creek. MPDES permits must be renewed every five years. ZMI requested that these permits be renewed in late 1991, and DEQ issued a Public Notice on March 9, 1992 with the intent to renew these permits. After reviewing ZMI's Annual Water Resources Report for 1991, DEQ became concerned about deteriorating water quality near the Zortman and Landusky mines. During the ten years, ZMI held valid discharge permits (1981 to1991), the company had reported no discharge on their Discharge Monitoring Reports (DMR) submitted to the State.

Despite this condition, water quality monitoring associated with the mine Operating Permits showed decreasing pH levels and increasing concentrations of metals and sulfate in State waters.

- May, 1992 - ZMI submits the Zortman Mine Life Extension Application for expanding the Zortman Mine operations.
- Summer, 1992 - Based on ongoing field inspections and a review of water quality monitoring data (1985-1992), BLM and DSL determine that ZMI's approved operating and reclamation plans were not adequate to address mine material with ARD potential.
- November, 1992 - BLM sends a letter to ZMI regarding the development of low pH in effluent from various mine facilities. BLM requests ZMI provide plans to correct the situation.
- January-February, 1993 - DSL sends two letters to ZMI with detailed reports evaluating the water quality situation and requiring changes in mine operations to address ARD. ZMI responds with proposed changes regarding water quality problems.
- April, 1993 – The BLM State Director issues decision requiring modification of Zortman and Landusky mine plans to prevent unnecessary or undue degradation from ARD.
- In April 1993, DEQ sent ZMI a request for additional information and completed an on-site inspection of the mine site. The EPA also sent ZMI a request for information under Section 308 of the Federal CWA. DEQ and EPA conducted a joint inspection of the mine sites in May, 1993 and identified several potential water quality violations. On July 18, 1993, EPA sent formal notification to DEQ and ZMI of violations of the Federal CWA. (Under delegation provisions of the Federal CWA, DEQ has primary authority for CWA enforcement*)*
- July, 1993 - ZMI provides remediation plans for the Landusky Mine and revises Zortman expansion plans to include remediation of existing facilities.
- August, 1993 – the BLM District Manager issues Notices of Noncompliance to ZMI for violation of the Clean Water Act based upon correspondence sent from EPA to ZMI.
- On August 30, 1993, DEQ (then known as Montana Department of Health and Environmental Sciences, DHES) filed a Civil Complaint and Application for Injunction (Cause No. BOV 93-1511) in District Court in Lewis and Clark County, Montana, naming Pegasus Gold Corporation and Zortman Mining, Inc. (Pegasus/ZMI) as defendants. The Complaint alleges violations of the Montana WQA in each of seven drainages. These violations include the placement of wastes in a location likely to cause pollution of State waters; discharge of wastes to State waters without a valid permit; and, violations of Montana water quality standards in both surface and groundwater. The Complaint sought a prohibition of all waste discharges and further mining activities unless ZMI:
    - Submitted and implemented an DEQ-approved Improvement Plan, providing for corrective measures and monitoring;
    - Made application for an MPDES permit or stopped discharging wastes to State water; and,
    - Paid civil penalties as specified in the WQA.
- The complaint was later amended on October 13, 1993.
- November, 1993 – The BLM and DSL issue a Supplemental Environmental Assessment (EA) for the Landusky Mine. The EA addresses modifications needed to the mining and reclamation plans in order to control ARD.

- March, 1994 – BLM and DSL issue a Decision Record on corrective measures needed to address ARD at Landusky Mine. The decision is to approve interim corrective measures but to withhold approval of final long-term reclamation and closure designs until an EIS is done.
- In May, 1994, the District Court ruled on several preliminary motions in this case. One of these motions granted intervener status to Island Mountain Protectors (IMP). On February 15, 1995, the Montana Supreme Court ruled on the motions in favor of DHES.
- ZMI submitted an expanded MPDES permit application in the fall of 1993, and a Water Quality Improvement Plan in March, 1994. The Improvement Plan underwent several revisions during its review by DEQ, EPA, and IMP. However, DEQ determined that adequate hydrologic and water quality data was not available on which to base a discharge permit at that time. So, a court-approved Improvement Plan and Schedule replaced the discharge permit and established interim effluent limits and conditions until a MPDES permit could be developed. Because sufficient information was not available to develop MPDES permit limits, DHES issued ZMI an Administrative Order on September 28, 1994 authorizing the construction and discharge from the Zortman water treatment plant in the Ruby Gulch drainage. Interim effluent limits and monitoring requirements were contained in this order.
- In June 1995, the EPA filed suit against ZMI alleging violations of the Clean Water Act at drainages impacted by mining operations. During 1995 and early 1996, EPA, DEQ, and ZMI continued detailed negotiations regarding a compliance plan and consent decree to address the above issues.
- Construction began on capture and treatment systems used to recover and treat mine drainage from the waste rock dumps, leach pad dikes, areas beneath the mine pits, or from historic underground workings.
- March, 1996 - Final Environmental Impact Statement Zortman and Landusky Mine-Reclamation Plan Modifications and Mine Life Extensions was issued. The preferred alternative was similar to the actions proposed by ZMI for both mine expansion and modification of reclamation plans with agency mitigation to reduce or avoid potential environmental impacts.
- September, 1996 - Consent Decree (CD) entered between the mine operator, State of Montana, EPA, the Fort Belknap Tribes, and Island Mountain Protectors in order to resolve a complaint filed under the Federal Clean Water Act and Montana Water Quality Act over discharges from the mines. ZMI is required to implement various compliance plans involving monitoring, capture, and treatment of impacted waters and to perform supplemental environmental projects of benefit to the Fort Belknap Indian Reservation.
- October, 1996 – BLM and DSL issue the Record of Decision after completion of the FEIS and signing of the water quality Consent Decree. Fort Belknap, Island Mountain Protectors, and the National Wildlife Federation appeal the BLM approval of additional mining to the Interior Board of Land Appeals (IBLA) in late 1996.
- January, 1997 – The DEQ approval of expanded mining was challenged in State District Court by Fort Belknap, the National Wildlife Federation and the Montana Environmental Information Center.
- June, 1997 - The IBLA orders the mine expansion approvals stayed during the appeal period.
- May, 1998 - IBLA remands BLM's approval decision and orders additional consultation with the Fort Belknap government. After reconsideration in view of bankruptcy IBLA orders BLM consult with Fort Belknap on final mine reclamation plans in November of 1998.

<table>
<tr><th colspan="3">Table 4 - Major Tasks Completed by BLM and DEQ since the Bankruptcy</th></tr>
<tr><th></th><th>Zortman Mine</th><th>Landusky Mine</th></tr>
<tr><td>1998</td><td colspan="2">In January 1998, PGC and ZMI declared bankruptcy and a Federal bankruptcy court appointed a Trustee who disposed of assets at the mines, some of which were needed for reclamation.

In March 1998, ZMI announced they were no longer going to proceed with the mine expansion plans approved in the 1996 ROD.

The surety companies (USF&G and National Union Fire Insurance) reached an agreement with the DEQ to fund reclamation and water treatment to the limits of the surety bonds. The agreement allows the sureties to not pay out funds until the expenditures are actually incurred by DEQ, thus causing the reclamation and water treatment bonds to lose value over time.</td></tr>
<tr><td>1999</td><td colspan="2">In February, the DEQ began administering reclamation and water treatment activities at the Site. Reclamation Service Corporation (RSC) was formed by the PGC trustees to manage the reclamation and water treatment. RSC managed the site until they were replaced by Spectrum Engineering in June.

In March, the BLM begins consultation with the Fort Belknap government on final mine reclamation and closure. The consultation process continues through April of 2002.

In June, Spectrum Engineering, Inc. of Billings, Montana is retained by the DEQ to manage the Site. Within a couple of months Spectrum was able to cut the operating costs in half. Governor Racicot signs an emergency order authorizing Spectrum to immediately begin reclamation activities. It was recognized that the reclamation costs exceeded the funding provided by the bond, so it became necessary to prioritize the reclamation tasks so that the more serious problems could be given higher priority.

By late 1999, Spectrum began regrading and backfilling some of the open pits and leach pads. Field investigations were started to identify the sources of the acid drainage and to identify non-acid generating (NAG) material that could be used for subsoil and cover soil.</td></tr>
<tr><td>2000</td><td>Regrading and highwall reduction began in the Ross Pit. NAG used to cover the upper benches.

The highly sulfidic stockpile on the Z82 leach pad is placed in the OK pit bottom covering a dangerous glory hole in the pit floor.

Regrading starts on the lower leach pads. When the regrading of Z83, Z84 and Z89 pads is completed, the NAG tailings from upper Ruby Gulch are used as subsoil. Prior to placement of tailings, sampling was conducted on a 100 foot grid for ABA, and sites were pH amended as necessary with lime to ensure proper acid/base ratio prior to topsoil placement.

Backfilling the Zortman Mine pits began in November.

A large quantity of mining related trash is cleaned up and removed from the Site.</td><td>The heap leach plumbing systems are re-plumbed so that the water can continue to be managed while the leach pads are regraded and reclaimed. Regrading of the L80-82, L83 and L84 leach pads begins.

EPA conducts a non time-critical removal of the historic mine tailings in King Creek. The tailings are used as non-acid generating top soil on the lower leach pads.

A large quantity of mining related trash was cleaned up and removed from the site.</td></tr>
</table>

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<tr><td>2001</td><td>The OK Pit was backfilled with spent ore from the Z82 pad. The sulfides were placed in the pit and capped with clay and a PVC liner. Accessible waste rock was hauled back into the pits. The eastern side of the OK pit highwall was knocked down and reclaimed.

Regrading the Z85/86 pad began so that run on from the regraded open pit areas could be carried across the pad in a lined ditch. A notch was carved above Ruby Gulch to convey stormwater away from the leach pads and capture systems.

Old mine tailings were removed from Ruby Gulch and the streambed restored. The tailings were used as subsoil to cover the leach pads and mine areas.</td><td>The lower leach pads were covered with topsoil and seeded.

Grading started on the L91 leach pad. The work involved dozers and trucks.

The waste rock in the Suprise and Queen Rose pits and the August #2 Dump were used to regrade the Suprise Pit so that it drained (3% slope).

Potential ARD generating rock in the pit floor was covered with a bentonite liner. Non acid generating rock was used to cover the floor and highwalls in the Suprise pit.</td></tr>
<tr><td rowspan="2">2002</td><td colspan="2">On May 1st, the BLM and DEQ issued decisions modifying the operator’s (Trustee’s) reclamation plans as described in the SEIS preferred alternatives. These plans were developed over several years in a collaborative effort between BLM, DEQ, EPA, and the Fort Belknap Tribes. The reclamation plans selected in the 2002 ROD were estimated to cost approximately $22.5 million more than the surety bonds. Through removal actions sponsored by the BLM’s Abandoned Mine Lands program, DEQ grants, and cost savings under the competitive bidding process, the reclamation earthwork shortfall was eventually reduced from $22.5 million to about $2 million.</td></tr>
<tr><td>The pit backfilling was completed. Tailings were hauled from Ruby Gulch and used as a subsoil over most of the site. Grading of the Z85/86 pad was completed.

To make up for the topsoil deficiency, 247,230 cy of topsoil was hauled from Landusky to Zortman from October 2002 through March 2003.

Lime amendment added to the Z85/86 leach pad (this pad is very acidic), placed 6” of Ruby Tailings on Z85/86. Reduced the slope of the Z85/86 dike by hauling in NAG material.

A severe thunderstorm (1.8 inches in 20 minutes) damaged the Ruby pump house and highlighted some drainage issues that were repaired.

Exploration roads reclaimed in 2001-2002.</td><td>The Gold Bug highwall was reduced. Waste rock hauled from the August #1 rock dump into the Gold Bug and August-Little Ben pits.

L91 leach pad regrading continued. Regrading of L87 leach pad begins.

Placed GCL liner on floor of Queen Rose Pit. Removed 85,500 yd limestone stockpile from Gold Bug and placed in Queen Rose (7100 yd) and L91 leach pad north slope.

Some of L85/86 pad material was hauled to the South Gold Bug pit.

Covered sulfide highwall in Queen Rose & Suprise Pits with August #2 NAG waste.

The bio treatment plant to treat the nitrates, selenium and cyanide in the leach pad water is constructed and placed in service.

Exploration roads reclaimed in 2001-2002.</td></tr>
</table>

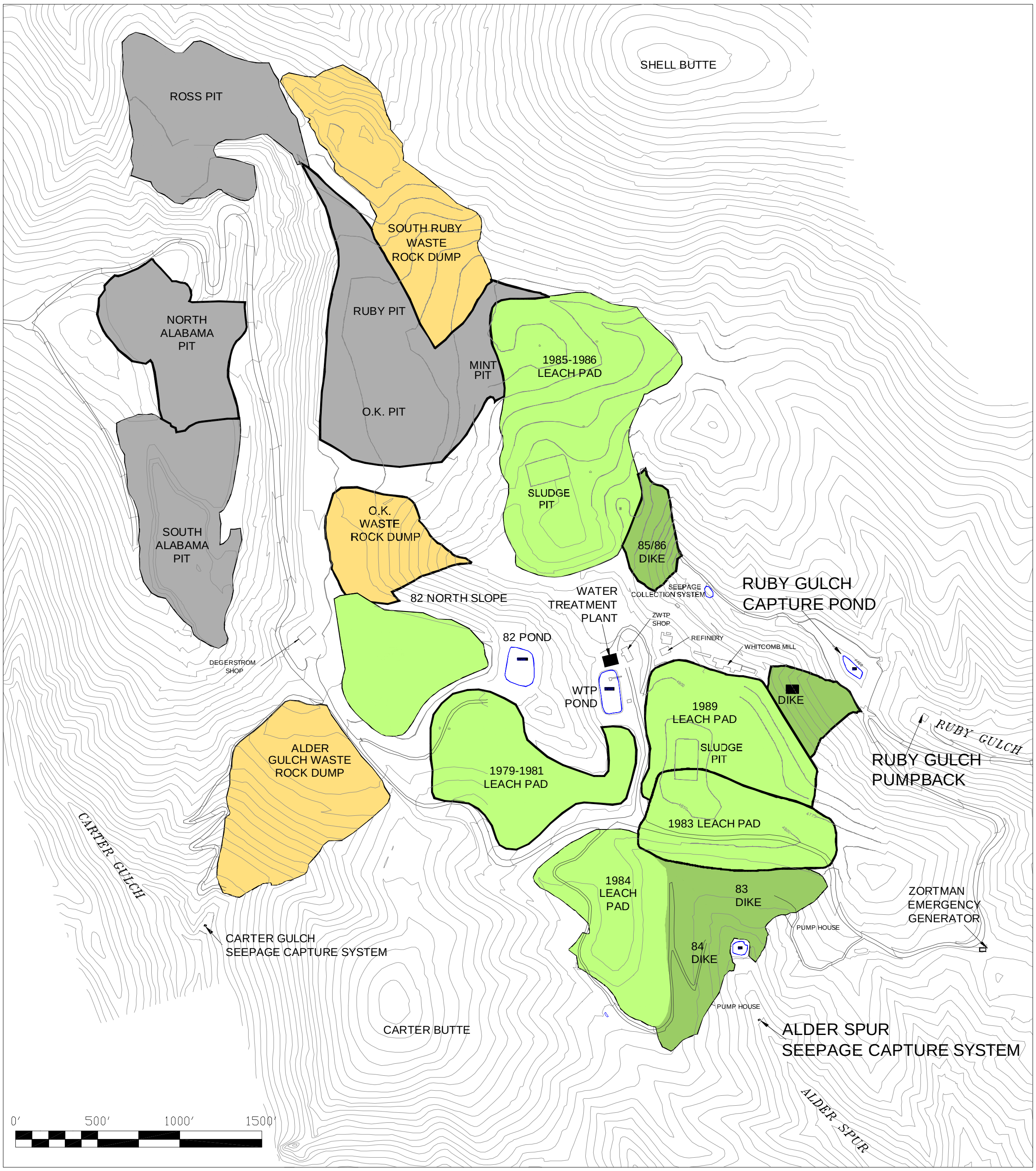
Table 4 - Major Tasks Completed by BLM and DEQ since the Bankruptcy		
	Zortman Mine	**Landusky Mine**
2003	Regrading and topsoil placement in the North Ruby and Ross Pits is finished using topsoil hauled from the Landusky Mine. Continued hauling tailings from Ruby Gulch. (1.02 million yards were excavated for $2.96 million). Rebuilt the road to the Zortman Mine. Completed storm water erosion controls and structures.	From 2003 to 2005,the L85/86 leach pad and dike were excavated from the Montana Gulch drainage in order to remove a potential source of contaminants and open the plugged drainage. Completed regrading the L87/91 pads to 3h:1v. Began topsoiling and revegetating the L87 pad. Finished topsoiling the Queen Rose Pit. Regraded and covered August #1 dump with NAG. Graded and topsoiled August #2 dump. The L85/86 pad material was hauled to the August-Little Ben Pit. Plugged exploration drill holes. Reclaimed the Williams Clay Pit (source of clay for leach pads and reclamation covers).
2004	On June 28, BLM uses its CERCLA authority in order to continue removal actions (water capture and treatment) in the absence of a mine operator. MPDES permit MT0024864 for the Landusky Mine and permit MT0024856 for the Zortman Mine are terminated by the State as of July 1, 2004, because the Site activities are being conducted under CERCLA authority.	
	Tree planting and final topsoiling and revegetation on remaining areas in Ross and Alabama pits.	The project office is moved to the remodeled Landusky Mine shop. Graded L91 pad and dike by hauling material to top of Mill Gulch Waste Rock Dump. Continued hauling L85/86 pad material to August-Little Ben and Gold Bug pits as backfill. Revegetation and tree planting.
2005	North Alabama pit was topsoiled and revegetated. SEIS Preferred Reclamation Alternative Z6 is completed-minus capping the upper part of the Alder Gulch Dump. Modifications are made to Zortman Mine water treatment plant.	Excavation of the L85/86 leach pad and dike is completed. All disturbed areas are replanted and SEIS Preferred Reclamation Alternative L4 is completed.
2006	Potential Responsible Party (PRP) search completed in May. King Creek passive treatment system design is completed (OU4). Swift Gulch testing is done to determine depth to bedrock and to verify settling pond feasibility. Water capture, treatment, monitoring, and site maintenance continue.	

3.0 SITE CHARACTERIZATION AND RISK ASSESSMENT

3.1 ZORTMAN MINE FEATURE CHARACTERIZATION

This section presents a brief summary of the individual Zortman Mine features. Between 1979 and 1989, surface mining operations created a number of large excavations along the ridge at the head of Ruby Gulch. The Zortman Mine Facility Map shows the individual mine features.

Figure 4 – Zortman Mine Facility Map



The following table summarizes the production from the mine.

Table 5 - Zortman Mine Production History						
YEAR	**ORE** Tons x 1000	**GOLD** Oz/Ton (ave.)	**SILVER** Oz/Ton (ave.)	**WASTE** Tons x 1000	**TOTAL** Tons x 1000	**STRIP RATIO** Waste/Ore
1979	218	0.057	0.39	0	218	
1980	675	0.0310	0.29	620	1,295	0.92
1981	1,023	0.025	0.25	418	1,441	0.41
1982	1,889	0.035	0.25	968	2,857	0.51
1983	2,008	0.034	0.15	2,217	4,225	1.10
1984	2,373	0.022	0.07	1,491	3,864	0.63
1985	5,334	0.026	0.20	2,356	7,690	0.44
1986	1,654	0.027	0.14	993	2,647	0.60
1987	NA	NA	NA	NA	NA	NA
1988	1,043	0.024	0.04	1,493	2,536	1.43
1989	3,683	0.019	0.05	2,939	6,622	0.80
	4,726			**4,432**	**9,158**	

3.1.1 Open Pits

North Alabama Pit – The North and South Alabama pits are along the top of a ridge. The North Alabama is the highest pit on the hillside. It is an open-ended cut (not a sub-excavated pit). The floor of this pit has been graded to provide positive drainage. 24 inches of topsoil has been spread over the regraded pit floor. This area was seeded in May, 2005.

South Alabama Pit – The South Alabama pit is on the top of the ridge, immediately south of the North Alabama Pit. This pit is a free draining cut that mined through a large glory hole. It was partially backfilled with mill tailings excavated from Ruby Gulch in 2002 and 2003. Graded areas were dressed with cover soil and seeded in 2004. Substantial pit walls on the north and west sides of the pit extend above the backfilled area.

O.K. Pit and Ruby Pit – The Ruby and O.K. were sub-excavated pits that eventually combined into one large excavation. These combined pits were in the center of the mine and were backfilled with materials from the Z85/86 Leach Pad, the Z82 Leach Pad, the east pit wall rim reduction, the South Ruby Waste Rock Dump, and two sulfide stockpiles. The backfill area was capped with a reclamation cover that includes a 30-mil PVC liner. ABA testing on 100-foot grids took place and liming was completed (120.05 tons of lime). After liming, the area was covered with Ruby Gulch tailings and coversoil. On the west side of the pit, a substantial pit wall rises above the backfilled area.

Mint Pit – The Mint was a much smaller sub-excavated pit that was located below the east wall of the O.K./Ruby Pit. The pit received 334,000 cubic yards of backfill (108,000 cubic yards from the east rim reduction of the O.K./Ruby, 158,000 cubic yards from the South Ruby Waste Rock Dump, and 68,000 cubic yards from the Z85/86 Leach Pad). The completely backfilled pit has been graded, topsoiled, and revegetated.

Ross Pit – The Ross is situated on the north-facing nose of the ridge. This pit is the northern most excavation. An actual pit or hole was never developed as the area was mined as an open cut. Many of the benches and the entire pit floor have been backfilled and graded. ABA testing on 100-foot grids took place and liming was completed using 581 tons of lime. After liming, the area was dressed with cover soil. Revegetation of this area was completed in 2004. Additional pit bench areas were reclaimed with scree slopes.

3.1.2 Waste and Topsoil

Waste rock, removed during mining, was deposited in the Alder Gulch Waste Dump, the O.K. Waste Dump, and the South Ruby Rock Dump; or it was used for leach pad buttresses and other construction.

South Ruby Waste Dump - This facility was constructed on the Ruby Gulch side of the Glory Hole Draw/ Ruby Gulch saddle. It was situated directly above the Mint Pit. The dump originally covered 15.4 acres and contained approximately 901,000 tons of waste. It was constructed between 1980 and 1981 and received materials from the first benches mined in the Ruby and North Ruby Pits, where the rock was partially oxidized, and from a cut associated with Z82 Leach Pad construction.

Between 2000 and 2003, a large portion of this dump was excavated and used to backfill the O.K./Ruby Pit and the Mint Pit. Lower portions of the dump, which remained in-place following this excavation, were graded to blend with the surrounding contours. A reclamation cover consisting of 6 inches of mill tailings and 18 inches of cover soil was placed over the entire dump footprint during this same period. Seeding was completed in 2003.

O.K. Waste Dump - This facility was constructed on an east-facing slope in Ruby Gulch. It was situated just south of the O.K./Ruby Pit. The dump originally covered 7.8 acres and contained 1,219,600 tons of waste. It was constructed between 1985 and 1986 with materials from the North Alabama, South Alabama, and O.K. Pits. About 25 percent of the materials in this facility were oxide waste from the North Alabama Pit that was mined in 1986. The remainder of the material is from the lower benches of the O.K. and South Alabama Pits. A mix of partially oxidized materials and sulfides would have been removed from the benches that were mined at that time. ABA testing on 100-foot grids took place and liming was completed using 418.56 tons of lime. This dump has been completely regraded and revegetated.

Alder Gulch Waste Dump - This dump was constructed at the head of a small draw on the east side of Carter Gulch. Between 1981 and 1990, waste materials from the O.K. Pit, the Mint Pit, the South Alabama Pit, the North Alabama Pit, and the Ross Pit were used in construction. The mine records indicate that between 15 and 25 percent of this dump was constructed with sulfide waste. Most of the material in the lower portion of the dump was mined from the lowest benches in the O.K. Pit, which carried a relatively high percentage of sulfides. Waste materials from the Alabama and Ross Pits were placed in the upper lifts of this dump. Approximately 20 percent of this material was characterized as sulfide waste. The top of the Alder dump sits on the ridge dividing Ruby Gulch and Alder Gulch. It occupies 17.9 acres in the southwest corner of the mine site and contains 3,659,700 tons of material and extends from an elevation of 4550 feet at its toe to an elevation of over 5000 feet at the top. This facility has been reclaimed since 1992. All exposed intermediate benches are covered with liner that intercepts runoff from steep upper slopes and routes the collected water to drainage systems on the outer edges of the dump.

82 Sulfide Stockpile - This facility was constructed on a clay liner above the spent ore on the top of the Z82 Leach Pad. The stockpile contained 49,100 tons of waste. In the year 2000, the sulfide material in the stockpile was relocated to a sulfide disposal area inside the O.K./Ruby Pit. All of the waste rock placed in the pit sulfide disposal cell was capped with clay and covered with a 30-mil PVC liner to minimized water infiltration.

South Ruby Sulfide Stockpile – This stockpile sat on top of the South Ruby Waste Rock Dump. It contained 221,600 tons of sulfide waste. The sulfide material in the stockpile was relocated to a sulfide disposal area inside the O.K./Ruby Pit in 2000. This material was capped with clay and covered with a 30-mil PVC liner.

Coversoil - Available coversoil was salvaged, prior to mine-related surface disturbance, and stored in three stockpiles. The North Ruby Saddle Topsoil Stockpile with 185,400 cubic yards of soil was located in the saddle between Shell Butte and the Ross Pit. The South Ruby Saddle Topsoil Stockpile with 33,000 cubic yards of soil was located on top of the South Ruby Waste Rock Dump. The 82 Topsoil Stockpile, with 27,500 cubic yards of soil, was located along the top edge of the O.K. Waste Rock Dump. All of the stockpiled soil has been used during reclamation of the mine.

3.1.3 Ore and Leach Pads

Ore mined from the open pits was deposited on heap leach pads. These heap leach pads were named according to the year they were constructed. They include the Z79/81, Z82, Z83, Z84, Z85/86 and Z89 pads. The current quantity of ore within each leach pad is summarized in the following table.

Table 6 - Zortman Mine Leach Pad Quantities

LEACH PADS	ACRES	TONS	LCY
		(2000 lbs/ton)	(16.5 cu ft/ton)
Z79/81 Leach Pad	15.18	1,916,400	1,170,900
Z82 Leach Pad (removed)	0	0	0
Z83 Leach Pad	12.89	2,008,300	1,227,100
Z84 Leach Pad	14.20	2,389,400	1,459,900
Z85/86 Leach Pad	32.52	7,559,100	4,618,600
Z89 Leach Pad	14.21	3,558,600	2,174,300
	89.0	**17,431,800**	**10,650,800**

Z79/81 Leach Pad – This facility was constructed along the ridge dividing Ruby Gulch and Alder Spur. This pad complex received 1,916,400 tons of oxide ore from the Ruby and North Ruby Pits. An additional 523,700 tons of oxide waste was used to construct the pad and buttress. The pad complex was reclaimed between 1980 and 1992. Trees have been planted on the reclaimed slopes.

Z82 Leach Pad – Approximately 1,889,400 tons of ore were leached on this pad. Probably less than 10 percent of the total tonnage in the heap was sulfide ore. The ore was mined from the O.K. Pit. The pad was located between the O.K. Waste Dump and the Alder Gulch Waste Dump. It sat on the divide between the Alder Spur and Ruby Gulch drainage areas. 321,400 tons of mixed oxide and sulfide waste was used for pad and dike construction. Of this total, 141,400 tons went into dike construction. Before it was removed and used to backfill the O.K./Ruby Pit complex between 2001 and 2002, the lined area of the Z82 Leach Pad covered 10.68 acres.

Z83 Leach Pad – The Z83 Pad was constructed on the ridge dividing Ruby Gulch and Alder Spur. 660,100 tons of waste was used to construct the dike. Another 630,000 tons of waste was used to construct the basin and the northeast buttress. 2,008,300 tons of ore extracted from the Mint, Ross, and O.K. pits were leached on this pad. Ore that was sulfide in character was placed near the top of the heap and between the elevations of 4760 feet and 4800 feet. This Pad was regraded with 3H:1V slopes, ABA tested and limed, covered with 6 inches of tailings and 18 inches of coversoil and planted by late 2000.

Z84 Leach Pad – The Z84 Pad is situated adjacent to the Z83 Pad in the Alder Spur drainage area. The Z84 Pad Dike was constructed using 1,000,200 tons of waste from oxide areas in the O.K. Pit. Another 577,000 tons of waste from sulfide areas was used to construct the basin.

2,389,400 tons of ore extracted from the O.K. Pit and the South Alabama Pit were leached on this pad. Although all of the ore from the South Alabama Pit was oxide, large sulfide zones were mined during this period in the O.K. Pit. The pad was regraded with 3H:1V slopes, ABA tested and limed, covered with 6 inches of tailings and 18 inches of coversoil and planted by late 2000.

Z85/86 Leach Pad - The Z85/86 pad was constructed in the bottom of Ruby Gulch, where it covered a large portion of the abandoned Whitcomb town site and several springs. The dike is positioned below a fork in the gulch. 7,989,500 tons of ore extracted from the O.K. Pit lower benches, the Ross Pit and the South Alabama Pit were leached on this pad. The bottom half of the heap contains a significant percentage of sulfides from the O.K. Pit. The upper lifts contain oxides from the other pits. Approximately 1,538,000 tons of waste from the pit complex went into construction of the pad basin and the original dike. A portion of the dike was later removed leaving 375,100 tons of sulfide material in-place as the dike. This pad was regraded with 3H:1V slopes, ABA tested and limed (using 418.56 tons of lime), covered with 6 inches of tailings and 18 inches of coversoil and planted in 2003.

Z89 Leach Pad – The Z89 Pad was constructed in a small draw on the southwest side of Ruby Gulch. The toe of its dike extends down to the western edge of the Ruby Gulch Capture Pond. 1,948,000 tons of waste rock from the Ross and South Alabama pits plus a minor amount from the North Alabama went into building the basin, buttresses and dike. The Z89 Pad Dike, which stands over 200 feet high, contains 1,032,220 tons of this material. Production records indicate that about 20 percent of the waste rock material contained significant amounts of sulfides. After the basin was covered with a thick layer of clay followed by an impermeable liner, 3,558,600 tons of ore from the North Alabama Pit, the South Alabama Pit and the Ross Pit were placed on this pad. The records indicate that less than five percent of the material in this heap was high sulfide ore. This Pad was regraded with 3H:1V slopes, ABA tested and limed (the Z83, Z84 and Z89 Pads received a total of 538.95 tons), covered with 6 inches of tailings and 18 inches of coversoil and planted by late 2000..

3.1.4 Historic Tailings in Ruby Gulch

Tailings from the three cyanide mills that operated near the head of Ruby Gulch prior to 1953 were removed from the drainage bottom and hauled up to the mine where they were used as reclamation material. The tailings cleanup project extended through the town of Zortman to where the tailings deposits ended near Goslin Gulch. Tailings were used as backfill in the South Alabama Pit and as bedding material under the liner covering the O.K./Ruby backfill area. Because the tailings were predominantly a sandy material and finer grained than most of the available soils, tailings were used as the bottom 6-inch lift in all of the reclamation covers constructed after 1999. About 15 acres have been planted in the Ruby Gulch tailings removal area above the access control gate near Zortman. Additional reclamation in the Ruby Gulch tailings removal area also extends through the town of Zortman. This removal action took place within the Site boundary.

The tailings removal project, which ended in April 2003, removed approximately 1 million bank cubic-yards of historic tailings from the gulch. This total includes the quantity removed through the Zortman town site. The tailings were very erosive and were a source of sediment problems within the basin. Following tailings removal, all disturbed areas except the running surface on the relocated access road, rock road cuts, and rock fill road embankments were seeded with a mixture of grasses. The area above the filter dike has 15.0 acres of permanent reclamation and 3.7 acres of long-term access disturbance. Sediment controls include several rock filter dikes and several sub-excavated sediment ponds. These sediment control features are installed at intervals down the drainage bottom.

3.1.5 Zortman Mine Waters and Watersheds

The Zortman Mine is located in Sections 7, 17, and 18, Township 25 North, Range 25 East, Montana Principal Meridian. It is drained by Ruby Creek, which flows south through the town of Zortman, and Lodge Pole Creek, which drains to the north. Only about 421 acres were disturbed by the mining operation and associated site facilities at the Zortman Mine. Another 18.7 acres of land was disturbed by the removal of tailings from the bottom of Ruby Gulch and reconstruction of the mine access road.

3.1.5.1 Ruby Creek Watershed

Ruby Creek and its two major tributaries, Alder Gulch and Ruby Gulch, drain the western, southern, and eastern portions of the Zortman Mine and are within the Missouri River drainage basin. These streams are classified as C-3 by the State of Montana Surface Water Quality Standards (ARM 16.20.607[5]). Flows in Ruby and Alder Gulch are intermittent but may run quite high after storm events or rapid snowmelt. The LAD area at Goslin Flats is adjacent to both Ruby Gulch Creek and Goslin Gulch.

3.1.5.1.1 Ruby Gulch

This gulch drains the northern and eastern sides of the Zortman Mine site. Ruby Gulch is usually dry at Zortman, but flows in response to major rainfall and snowmelt events and periodic releases of treated water from the water treatment plant. Approximately one mile downstream of the town of Zortman, Alder Gulch and Ruby Gulch channels combine to form Ruby Creek, which is a stream with grass and brush-covered banks typical of the plains area. Ruby Creek is ephemeral, flowing only in response to rainfall or snowmelt events. The Ruby Creek drainage runs south for approximately 6 miles where it joins the CK drainage south of Highway 191.

Prior to surface mining, two springs fed the upper section of the creek; but this flow traveled only a short distance before infiltrating into the alluvium. The Whitcomb town site was situated in this area along with a number of mine adits. Glory holes and other underground subsidence features were associated with the extensive underground workings in this gulch. The ruins of the last cyanide mill are still standing not far south of the Z85/86 Dike. Tailings from this mill and from two previous mills filled the bottom of the gulch in this area and had been washed down the creek past the town of Zortman.

Surface mining and subsequent reclamation efforts have significantly changed the upper portion of the gulch and the tailings filled creek bed. The O.K./Ruby and Mint pits were developed along the top of the ridge on the west side of the gulch. The upper benches of the O.K./Ruby cut through the drainage divide into Ross Gulch. The open cut made in this area was called the Ross Pit. The South Ruby Dump and a small sulfide stockpile were deposited at the head of the northern fork of the gulch, while the O.K. Rock Dump was constructed at the head of the southern fork. The Z85/86 Leach Pad was constructed over the area where the springs and most of the Whitcomb town site had been located. The mine's refinery and processing plant was situated below the fork and west of the old Whitcomb mill. The Z79 Pad, Z89 Pad, and Z83 Pad were built along the drainage divide just to the south of the plant. An extensive diversion system was constructed around the north and east sides of the mine to route runoff from undisturbed areas around the mine disturbance. In addition, numerous exploration roads were constructed on Shell Butte and an access road was constructed from the Ruby Creek drainage bottom up the top of the ridge dividing Ruby and Alder Spur.

In the final stage of ZMI's operations, the Zortman Mine Water Treatment Plant was constructed near the gold processing facilities. In addition, the Ruby Gulch Capture System was constructed in the creek bottom below the Z85/86 and Z89 dikes. This system required a by-pass diversion channel and several drop structures. Seepage occurring below these buttresses is collected and pumped to the Zortman Water Treatment Plant.

During reclamation, all of the leach pad areas within the Ruby Gulch area were graded and covered with soil reclamation covers. Steep slopes on the Z85/86 Dike and on the northeast side of the Z82 Pad were backfilled and graded. The pits were backfilled to establish free draining surfaces. Backfill materials were obtained from the Z82 Leach Pad and Dike, the O.K. Rock Dump, sulfide stockpiles, the South Ruby Rock Dump, and the Z85/86 Leach Pad. Other reclamation actions in the Ruby Gulch drainage included construction of the Z85/86 Drainage Notch, reclaiming exploration roads, and routing acid rock drainage from two mine adits located near the southern edge of the Z85/86 Pad to the Ruby Gulch Capture System.

3.1.5.1.2 Alder Gulch

This gulch has two tributaries, Carter Gulch and Alder Spur, in the southern portion of the Zortman Mine area.

Carter Gulch drains 107 acres in the south and west portions of the Zortman Mine. It is a tributary of Alder Gulch. Carter Gulch has an east and a west fork. The Alder Gulch Waste Rock Repository is located on the east fork, with the repository toe extending to within approximately 200 feet of the confluence with the west fork. In addition to storm water, seepage from the base of the Alder Gulch Waste Rock Repository and is captured by the seepage capture system in Carter Gulch. The 17.5 acre Alder Gulch Waste Rock Dump is the only mine disturbance in Carter Gulch. However, a diversion ditch carries runoff from the South Alabama Pit and the North Alabama Pit into Carter Gulch.

Alder Spur drains approximately 114.4 acres in the southern portion of the Zortman Mine. Alder Spur has only been observed to have a surface flow in response to major rainfall and snowmelt events. The Alder Spur Seepage Capture System was installed about 500 feet downstream from the Z83 and Z84 dikes to intercept impacted water that might enter alluvial materials at the bottom of the gulch. The footprints of the Z82 Leach Pad and the Z82 Dike, which were reclaimed by complete removal of the spent ore and dike, were located at the top of this drainage area. The surface mine disturbance area within Alder Spur includes: the Z80-81 Leach Pad; the southern part of the Z79 Leach Pad; the Z84 Leach Pad, the Z84 Dike; part of the south-facing slope of the Z83 Leach Pad; and, the Z83 Dike. All of these mine facilities have been reclaimed. The pumping facilities associated with the Z83 and Z84 Pad, the site access road, several diversions and the Alder Spur Seepage Capture System remain.

3.1.5.2 Lodge Pole Creek Watershed

Lodge Pole Creek and its tributary, Glory Hole Creek, drain the northern portions of the Zortman Mine and are classified as B-1 in the State of Montana Surface Water Quality Standards (ARM 16.20.607[8][c]). The flow in Lodge Pole Creek generally increases toward the Fort Belknap Indian Reservation as it receives water from numerous tributaries. Flow in Lodge Pole Creek is intermittent near the mine but perennial in its lower reaches. It supports a limited brook trout population several miles downstream of the mine. Because Lodge Pole Creek drains toward reservation lands, reclamation in the northern part of the mine site has been designed to reduce the runoff toward the north to only 10.2 acres. Approximately 5.7 acres are within the reclaimed footprint area of a former topsoil stockpile. This area was planted with a mixture of grasses in 2003. The remainder of the area is a regraded area along the outside edge of the former floor of the Ross Pit. This area was reclaimed in 2003.

3.1.5.2.1 Glory Hole Creek

This creek is a minor tributary of Lodge Pole Creek. It consists of one small draw that drains about 10 acres of the mine site between Shell Butte and the Ross Pit. Glory Hole Creek has only been observed to flow in response to major rainfall and snowmelt events. The northern edge of the Ross Pit and the South Ruby Topsoil Stockpile were the only surface disturbances in the Glory Hole Creek drainage area. The area was reclaimed in 2003.

3.1.6 Zortman Mine Regrading and Backfilling Reclamation (OU3)

About 281 acres of the mine disturbance has been reclaimed with a reclamation cover and vegetated with a mixture of grasses. Trees have been planted in some areas. About 121 acres of disturbed land within the mine area plus another 4 acres of access road disturbance in Ruby Gulch still remains occupied by roads, facilities, steep rock pit-walls, and/or scree slopes.

In addition to the grading, capping, and revegetation work, a general cleanup of the site debris and removal of excess buildings and equipment was accomplished. In 2003, the former barren pond that had previously been reserved as a contingency pond was removed and covered with a 30-mil PVC liner (over 2.17 acres). Reclamation of area exploration roads and drill holes is complete. Only three lined ponds, the truck shop, portions of the mine diversion system, leach pad pumping facilities, several pipelines, three ground water capture systems, 42 monitoring wells, the water treatment plant and the gold refinery remain are all that remain of the facilities constructed by Zortman Mining Inc. The shop and refinery are on private land, and the landowner has requested that these structures be left for his use. In addition, the ruins of the historic Whitcomb Mill are on private ground. The landowner has also asked to have the old mill left, even though SHPO gave clearance for its removal.

Leach Pads - Reclamation of leach pads and waste repositories began in 1989, concurrent with mining operations. The Z82 Leach Pad and a portion of the Z85/86 Leach Pad were removed and used for pit backfill. All of the remaining leach pads or pad areas have been graded and capped with reclamation covers. Reclamation of the leach pad areas was completed in 2003.

Waste Dumps - All waste repositories and stockpile areas have also been graded, covered with topsoil and planted. The Alder Gulch Waste Rock Dump has been reclaimed since 1992. During the reclamation process, large portions of the South Ruby Waste Rock Dump and the O.K. Waste Rock Dump were removed for use as backfill materials prior to reclamation. Final reclamation on these footprint areas was completed by 2003.

Mine Pits – Major efforts to reclaim the mine pits began in 2000. Rock from leach pads, waste dumps, Ruby Creek tailings, and pit wall reduction were used to backfill and restore free-drainage to the pit areas. A 30-mil PVC liner was installed over the O.K./Ruby Pit backfill area to limit infiltration of water into the backfill. The drainage channel leading away from the lined area and across the mine disturbance area was lined. Above the pit backfill surface, the pit walls remain as cliffs and scree slopes. The Mint Pit has been filled and reclaimed. In the Ross pit, scree slope backfill and grading were used to cover the pit walls. At the South Alabama pit, the entire pit floor and lower portions of the pit walls were buried with mine tailings removed from Ruby Gulch. Steep, exposed pit walls still extend around the upper areas of the pit. Earthwork on the North Alabama pit included excavation at the south end for borrow material, minor drainage improvements on the pit floor, placing topsoil over the pit floor, and revegetation.

Work Remaining - The preferred reclamation alternative selected in the 2002 ROD for the Zortman Mine was Alternative Z6. This alternative has been completed except for one remaining work task, which involved relocating 432,000 cubic yards of waste rock from the top of the Alder Gulch Waste Rock Dump to the North Alabama Pit. This would have removed 19% of the total 2,300,000 cubic yards of rock in the dump. The purpose was to cap the top portion of the rock dump with a synthetic liner to reduce infiltration. Because the North Alabama Pit highwalls are all oxides, no additional sulfides would have been covered. This work would not eliminate the need for the Carter Gulch Capture System. This reclamation component was developed as part of the SEIS process and was not part of the original ZMI reclamation plans. A Technical Working Group, consisting of BLM, DEQ, and Fort Belknap, are currently exploring options for implementing the intent of the Alder Gulch Z6 Alternative. The plan under consideration in this EE/CA is designed to keep all sulfides contained within the existing dump area. The top of the dump would be graded to drain to the east into the Alder Spur drainage. Surface water and seepage captured on the lined area would flow into the existing diversion that carries water to Outfall 607, located on the east side of Carter Butte. The grading would be limited to 31,000 cubic yards of excavation needed to shape the drainage area. The cut would be placed along the southwest edge of the bench. A 30-mil PVC liner would be installed over the 6.34 acre area, graded to maximum slopes of 4H:1V. Most of the area would have 5-10 percent slopes. The reclaimed North Alabama Pit would not be involved in this reclamation effort and would not receive any sulfides that would require a barrier reclamation cover.

Low permeability capping of the top of the Alder Gulch Waste Rock Dump will reduce infiltration. In 2005, a total of 11,326,990 gallons were captured in the Carter Gulch Capture System after an annual rainfall of 20.05 inches. The drainage area contains 17.94 acres. Assuming 50% infiltration and 50% run-off, then rainfall contributed 4,890,000 gallons of the total with the rest contributed by seeps and runon. The modified completion of Alternative Z6 will reduce infiltration by 48.9% and the total captured water by 21.3% for a predicted reduction of 2,416,000 gallons of water requiring treatment based on the 2005 water capture rates and rainfall.

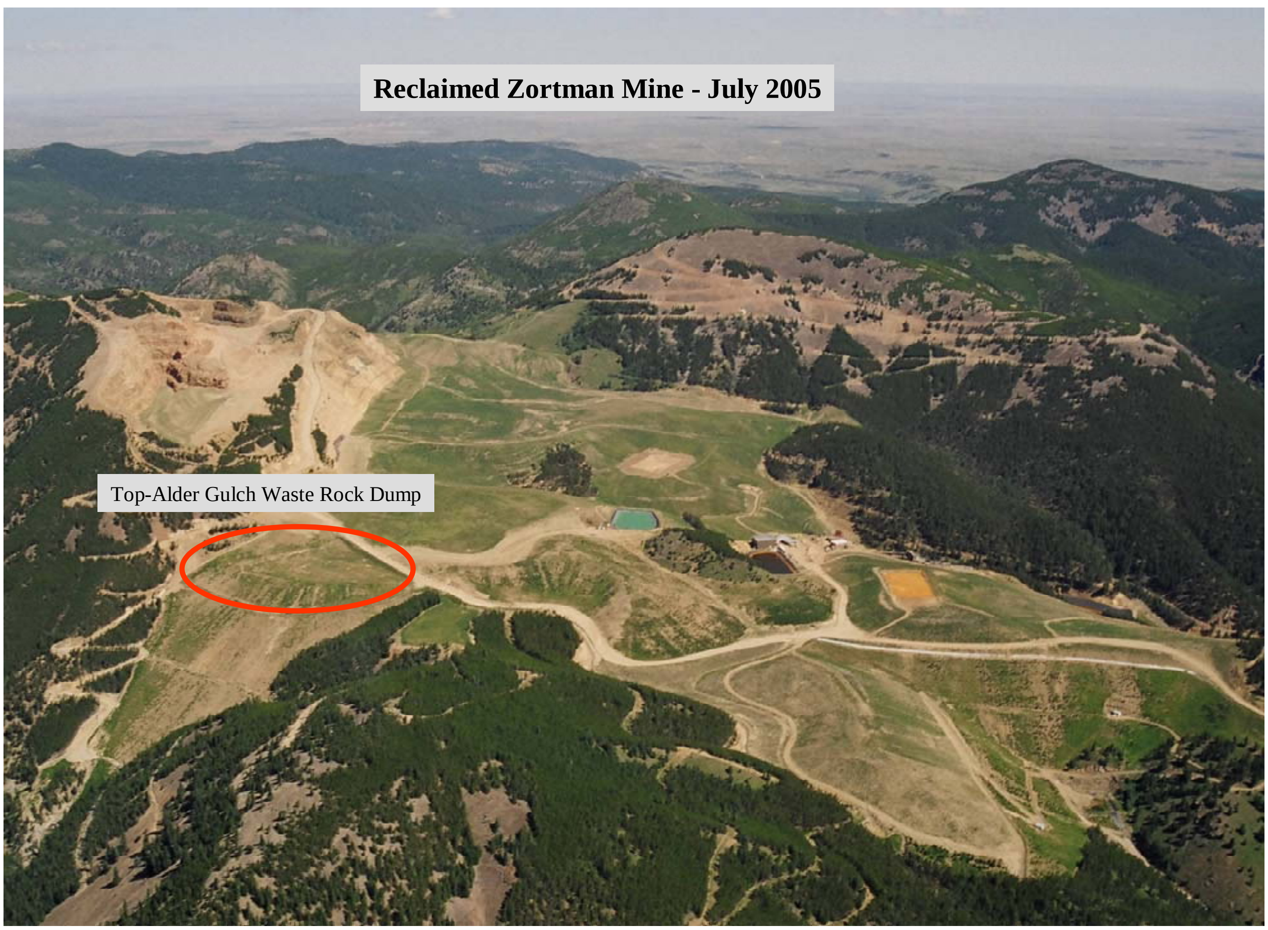
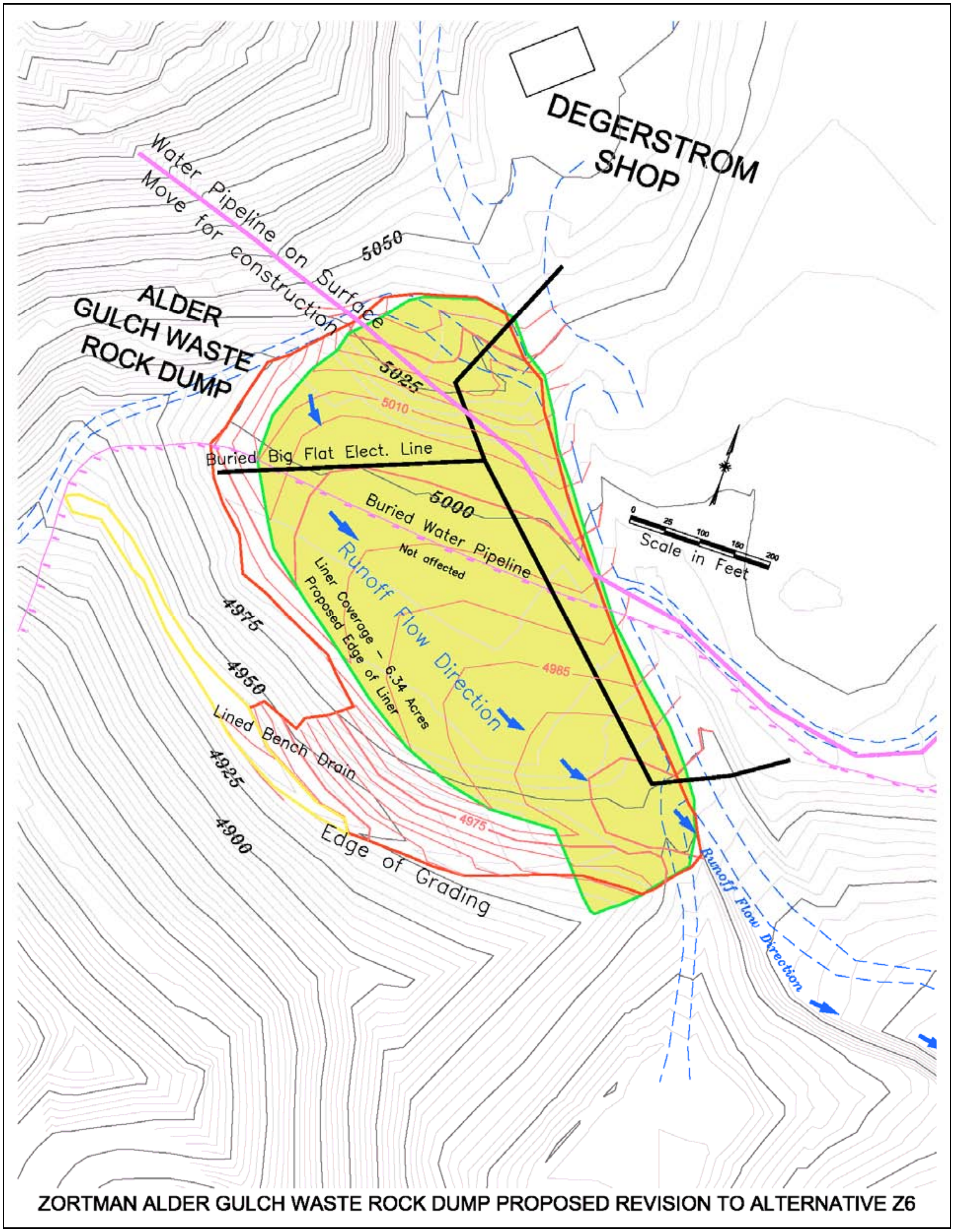


Figure 5 – Removal Action to Implement SEIS Reclamation Objective



3.1.7 Zortman Mine Capture Systems and Water Treatment Plant

Three capture systems were constructed to control mine-impacted seepage at the Zortman Mine. These systems capture and return seepage collected down-gradient of mine facilities located in Ruby Gulch, Alder Spur, and Carter Gulch. The source of seepage appears to be buried springs and seeps, as well as precipitation that percolates through waste rock. Although the quality of some seepage is apparently being impacted by passing through construction materials used for pad under-drains, buttresses, dikes, and repositories, heavily impacted groundwater also comes from two underground mine adits located near the southwest edge of the Z85/86 Leach Pad. For most of the year, these two adits only flow a few gallons per minute with 100% capture within the Ruby Pond. Before these openings were buried under reclamation backfill, HDPE drainpipes were installed in both adits and were run to the Ruby Gulch Capture Pond. Because the underground workings associated with the Zortman Mine extend deep into the sulfide zone and a considerable amount of broken ore was reportedly left in stopes prepared for block caving, the contribution that the historic underground workings make to acid rock drainage is significant.

Each capture system is comprised of a sump or collection area, storage tank and pumping system. Collected waters are transported via pipeline to the Zortman WTP where lime precipitation is used to improve the quality of the water. Process sludge is piped to a sludge pit on the Z89 Leach Pad for de-watering and disposal or to the new sludge pit located on the Z85/86 Leach Pad. Treated water from the plant is discharged into Ruby Gulch.

3.1.7.1 Zortman Mine Water Treatment Plant

This treatment plant was constructed by ZMI after it recognized an acid rock drainage problem associated with seepage below the Z85/86 Dike in Ruby Gulch. The plant was put into operation on June 30, 1994. It is currently operated about 72 hours per month to treat 56,000,000 gallons of water per year (current 5-year average). Treated water is discharged into the Ruby Gulch Pond at Outfall 667. Most of the water entering this plant from the capture systems is acidic and contains dissolved heavy metals. Hydrated lime and flocculent are mixed with the water to raise the pH of the water and to cause the dissolved metals to precipitate out of the water creating a sludge, which is pumped to a sludge disposal pit. During the process, ferric sulfate is used to remove arsenic from the discharge water. About 330,000 pounds of ferric sulfate (68% liquid) is consumed per year to remove arsenic from the discharge water at the plant at a cost of $36,000. The plant consumes about 381 tons of hydrated lime per year. Approximately 150,000 gallons of water are treated per ton of lime consumed. The high lime consumption rate is due to the high acidity of the influent.

Table 7 - Zortman Mine Water Treatment Plant Water Quality			
Parameter	**Typical Captured Water**	**Typical WTP Treated Water**	**Water Quality Standard**
Gallons per year	56,000,000	56,000,000	
pH (s.u.)	3.7	7.0	6.5 – 8.5
TSS (mg/l)	20	25	20
Sulfate (mg/l)	3000	2600	N/A
Cyanide (mg/l)	ND	ND	0.0052
Arsenic (mg/l)	0.227	0.0013	0.018
Copper (mg/l)	6.95	0.011	0.031
Cadmium (mg/l)	0.218	0.007	0.005
Iron (mg/l)	40	0.5	1.0
Lead (mg/l)	0.005	<0.003	0.015
Manganese (mg/l)	35	3.5	N/A
Mercury (mg/l)	ND	ND	0.00005
Selenium (mg/l)	0.012	0.009	0.005
Zinc (mg/l)	7.02	0.02	0.388

3.1.7.2 Sludge Disposal Pits

Turbidity and precipitates that settle out of the treated water (sludge) are pumped in slurry to either of two disposal pits. The older of the sludge pits is located on the Z89 Leach Pad. A new pit sludge pit was constructed on the Z85/86 Pad in 2005. The sludge does not test out as a hazardous material. Sludge disposal pits are large unlined pits excavated in the spent ore on the leach pad. After the slurry is pumped into a pit, the water slowly separates from the solids and either evaporates or infiltrates into the leached rock where it is ultimately captured by the containment system. Because the sludge is extremely fine grained (slime), dewatering rates are extremely slow. In order to avoid constructing additional disposal pits, the sludge deposited in the inactive pit is to be removed after it has dried and disposed of in the North Alabama Pit. The sludge will continue to be tested periodically. If high concentrations of mobile metals are identified, encapsulation or other corrective actions will be implemented.

3.1.7.3 Lined Ponds

The Zortman Mine water treatment plant has a 36-mil hypalon lined holding pond with a 4,786,000-gallon storage capacity. The Ruby Gulch Capture Pond has an 8,900,000 gallon storage capacity and is also lined with 36-mil hypalon with a GCL underliner.

3.1.7.4 Capture Systems

Ruby Gulch (80 to 100 gpm) Capture System – This facility consists of a pump station with a sump pump and two large centrifugal pumps with motors, pipe manifolds, pipes, pressure and overflow relief systems, flow measurement devices, and electric controls. One pump is rated at 300 Hp that can deliver 2500 gpm. The other is a 200 Hp pump that can deliver 1200 gpm. The station is enclosed in a building on a concrete slab at the toe of the Ruby Capture Pond. The under-drain that extends under the Ruby Capture Pond and Dike terminates below the pump station allowing the sump pump in the building to recover seepage collected below these facilities and to pump it into the collection manifold. A 10-inch diameter HDPE drainpipe runs from an outlet at the bottom of the pond and connects into the collection manifold. The pump station returns all water collected in the capture pond or under-drain back uphill to the Zortman Water Treatment Plant. Controls are provided to bypass the pumps and outlet any of the collected water directly into Ruby Creek. The 8,900,000 gallon capacity pond has a maximum depth of 38 feet and is equipped with an emergency spillway.

Alder Spur (10 to 16 gpm) Capture System – This capture system is located below the Z83 and Z84 leach pad dikes. It uses a cutoff dike and an interceptor trench that has been lined and filled with sized rock to capture and collect mine seepage. The pump control house and a separate slab, where two 18-inch sumps, two 8-inch drill casings, and the collection manifold are located on fill above the collection sump. The bottom of the sump is about 16 feet below the top of the slab. Two submersible pumps are operated inside the 8-inch casings. One submersible pump is operated inside one of the 18-inch sumps. The second sump is connected to a secondary capture well on the downstream face of the cutoff dike. The pump controls, a water level meter, a flow meter, and electrical box are located inside the pump control house. The pumps are automatically controlled to turn off and on at set water levels inside the sump. Two of the pumps are rated at 15 Hp and can each pump 84 gpm. The other pump is rated at 2 Hp and can pump 12 gpm. The sump is equipped with an overflow pipe to prevent water from rising above the top of the interceptor trench. This system has a capacity of 70,396 gallons.

Carter Gulch (11-28 gpm) Capture System - This facility is located below the Alder Gulch Waste Rock Dump. It uses a cutoff dike and an interceptor trench that has been lined and filled with sized rock to capture and collect seepage. The pump control house and a separate slab, where one 18-inch, three 8-inch drill casings, and the collection manifold are located on fill above the collection sump. The bottom of the sump is about 13 feet below the top of the slab. Two small submersible pumps are operated inside the 8-inch casings. One of these pumps is rated at 7.5 Hp and can pump 43 gpm. The other pump is rated at 3 Hp and can pump 17 gpm. A 60 Hp submersible pump with a capacity of 273 gpm is inside the 18-inch sump. The other casing is a spare. A secondary capture well on the downstream face of the cutoff dike connects to the manifold. The pump controls, a water level meter, a flow meter, and electrical box are located inside the pump control house. The pumps automatically turn off and on at set water levels in the sump. The sump overflow pipe prevents the water level from rising above the top of the interceptor trench. This system has a capacity of 50,011 gallons.

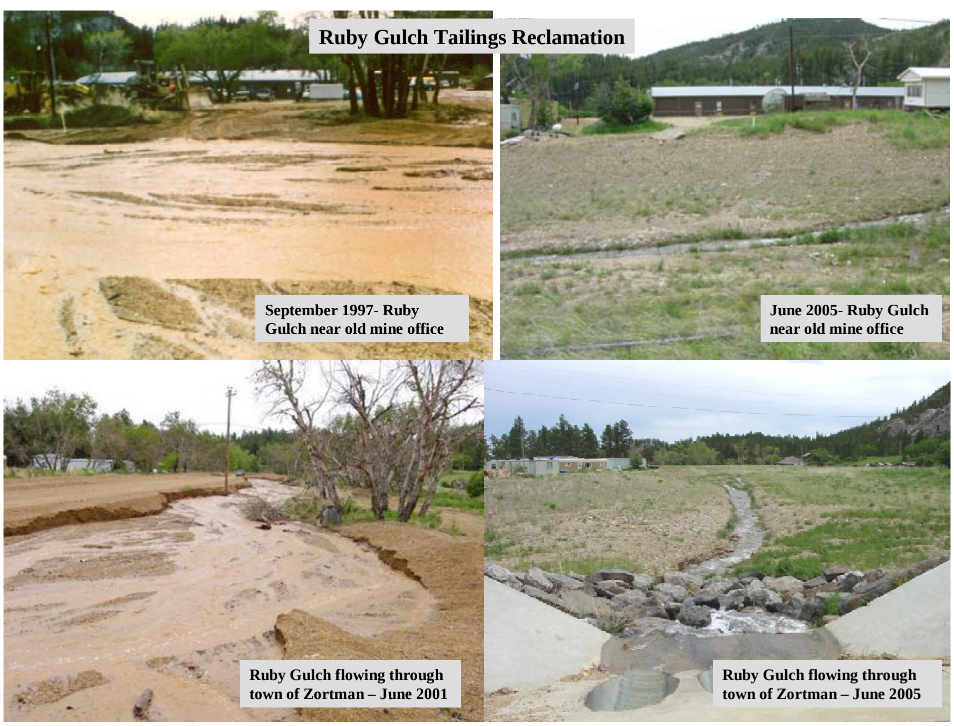
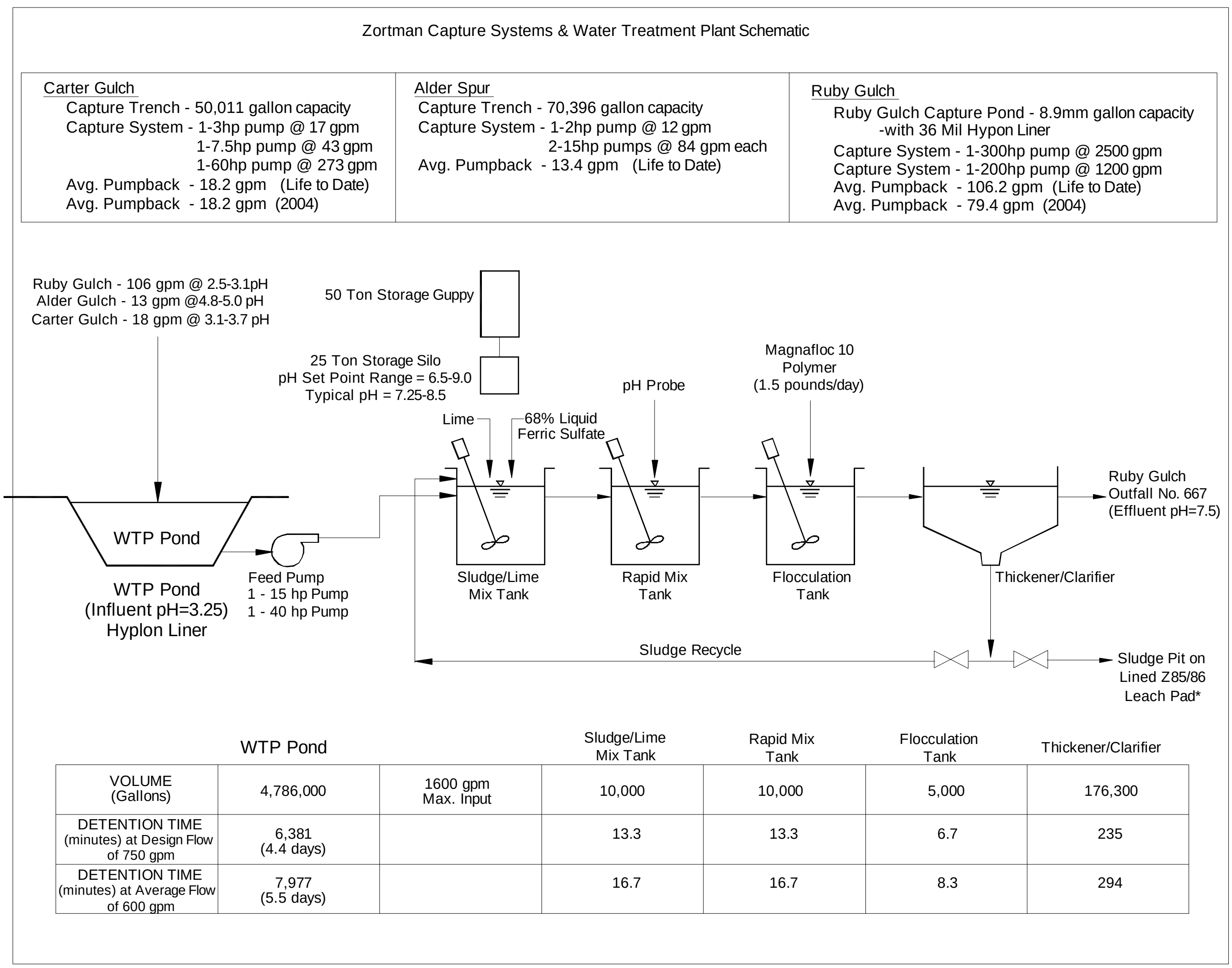


Table 8 - Summary of Yearly Zortman Mine Capture System Quantities				
	Precip	Captured Quantity (Million Gallons)		
Year	(Inches)	Alder Spur	Carter	Ruby
1994	3.29	2.66	3.94	13.00
1995	19.54	5.21	6.69	18.04
1996	18.63	5.70	7.26	11.22
1997	23.83	8.37	10.94	89.11
1998	23.95	7.07	11.25	66.89
1999	17.26	8.41	10.16	64.91
2000	16.39	4.85	6.70	41.09
2001	15.35	5.53	7.81	38.36
2002	20.44	8.73	10.54	51.06
2003	14.95	5.38	5.81	34.30
2004	14.40	7.55	9.57	41.74
2005	20.05	6.31	11.33	47.47

Figure 6 - Zortman Mine Water Treatment Plant Schematic

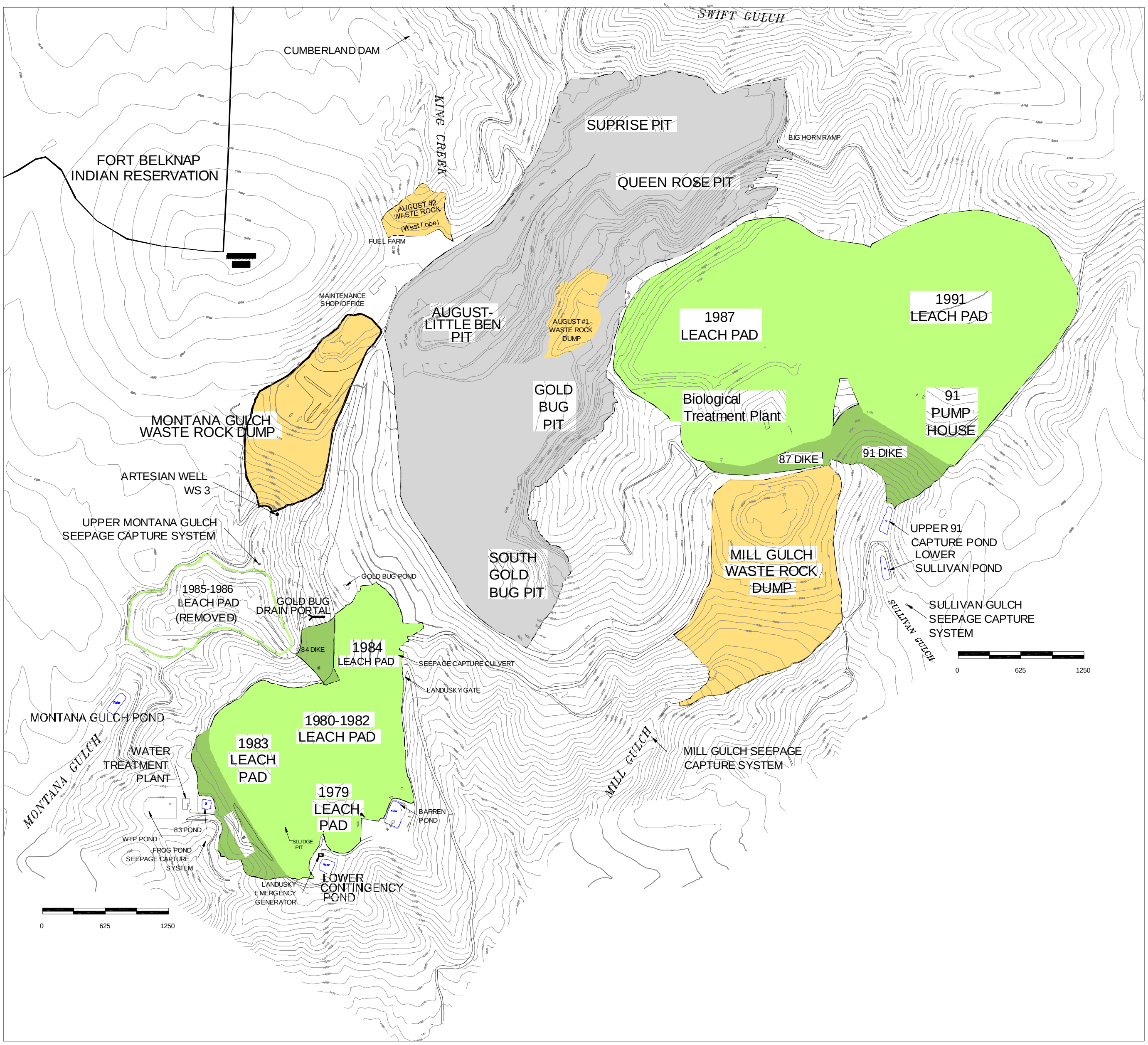


	WTP Pond		Sludge/Lime Mix Tank	Rapid Mix Tank	Flocculation Tank	Thickener/Clarifier
VOLUME (Gallons)	4,786,000	1600 gpm Max. Input	10,000	10,000	5,000	176,300
DETENTION TIME (minutes) at Design Flow of 750 gpm	6,381 (4.4 days)		13.3	13.3	6.7	235
DETENTION TIME (minutes) at Average Flow of 600 gpm	7,977 (5.5 days)		16.7	16.7	8.3	294

3.2 LANDUSKY MINE FEATURE CHARACTERIZATION

This section presents a brief summary of the individual Landusky Mine features. Between 1978 and 1996, the Landusky Mine consisted of several large open pits excavated along a ridge between the Rock Creek and Big Horn Creek drainages. The pits are identified from south to north as the South Gold Bug, Gold Bug, August-Little Ben, Suprise, and Queen Rose. The Landusky Mine Facility Map shows the layout of the mine features

Figure 7 - Landusky Mine Facility Map



Production from the Landusky Mine is shown on the following table.

Table 9 - Landusky Mine Production History						
YEAR	**ORE** Tons x 1000	**GOLD** Oz/Ton	**SILVER** Oz/Ton	**WASTE** Tons x 1000	**TOTAL** Tons x 1000	**STRIP RATIO** Waste/Ore
1979	458	0.038	0.12	11	469	0.02
1980	616	0.030	0.15	603	1,219	0.98
1981	1,084	0.025	0.18	1,024	2,108	0.94
1982	1,994	0.031	0.30	1,740	3,734	0.87
1983	2,021	0.033	0.25	1,452	3,473	0.72
1984	3,301	0.022	0.11	1,658	1,959	0.50
1985	NA	NA	NA	NA	NA	NA
1986	4,865	0.021	0.19	4910	9,775	1.01
1987	9,663	0.019	0.07	5,805	15,468	0.60
1988	10,376	0.019	0.09	4,567	14,946	0.44
1989	6,369	0.019	0.08	2,559	8,928	0.40
1990	12,895	0.016	0.31	4,558	17,453	0.35
1991	14,236	0.018	0.35	6,045	20,281	0.42
1992	12,974	0.015	0.08	5,853	18,827	0.45
1993	12,510	0.018	0.12	8,324	20,834	0.67
1994	14,843	0.017	0.13	10,965	25,808	0.71
1995	10,020	NA	NA	7,701	17,721	0.76
1996	139	0.015	NA	208	347	1.50
	108,890			**61,495**	**170,388**	

A discussion of each of the Landusky Mine features follows. Under each waste rock or ore facility heading is a discussion, if known, of the amount of sulfide material that might have been placed in that mine feature. The higher the percentage of sulfide minerals present the greater the potential for acid production and the development of ARD.

3.2.1 Open Pits

Efforts to backfill and reclaim portions of the mine pits began during mining with the placement of waste rock in the Gold Bug and Queen Rose pits. During mine reclamation from 1999 through 2005, materials from leach pads and waste dumps have been used to partially backfill and re-contour the pit complexes. Although backfilling has raised the pit floor throughout the pit complex and backfill measures have been used to cover the vast majority of the pit wall where sulfides were exposed, steep pit walls that are as much as 300 feet high remain around a portion of the pit complex. As of 2005, the preferred Alternative L4 reclamation plan from the BLM’s 2002 ROD had been completed.

Queen Rose Pit – The Queen Rose Pit is located in the northeastern section of the pit complex on the south slope of the Swift Gulch drainage basin. The pit floor in the Queen Rose pit area was backfilled and contoured in 2001. Then a wedge of limestone was placed along the bottom of the pit wall. Following grading, which was sloped to establish drainage toward the August-Little Ben pit area, a reclamation cover consisting of 6 inches of compacted clay, a GCL liner, 18-24 inches of non-acid generating material, and two feet of soil was installed over the backfill to limit storm-water infiltration. This area was seeded in 2003.

Suprise Pit – The Suprise Pit is located in the northwestern section of the pit complex. Its upper benches adjoin the west side of the Queen Rose Pit. However, the lower benches of the Suprise extended approximately 80 feet below the floor of the Queen Rose and formed a closed basin prior to reclamation. In the Suprise pit area, the benches along the rim of the pit were graded to drain into the pit. The floor of the Suprise was backfilled and graded to drain into the August-Little Ben area. Then a wedge of limestone (3000 cubic yards) was placed along the bottom edge of the wall in the Suprise pit. A reclamation cover consisting of 6 inches of compacted clay, a GCL liner, 18-24 inches of non-acid generating material, and two feet of soil was installed over the backfill. The pit walls surrounding the lined area in the Suprise area were covered with backfill material at the angle of repose to cover the sulfide-rich pit walls. Upper Suprise Pit benches had limestone placed against the pit walls (13,400 cubic yards). Accessible benches and the pit floor in the Suprise area were topsoiled and seeded in 2004.

August-Little Ben Pit – The August-Little Ben Pit complex extends south and west from the Suprise Pit. Reclamation of the August-Little Ben pit area was completed in the fall of 2004. This area was the deepest excavation in the pit complex. The bottom of this pit area was flooded until 2000, when it was drained by allowing artesian well, WS-3, to flow on a continual basis. Following dewatering, the pit floor was covered with five feet of limestone backfill. In 2003 and 2004, the pit area was partially backfilled with spent ore from the L85/86 Leach Pad. A drainage channel was extended down from the finished grade in the Suprise area to an underground mine opening that is exposed in the pit wall at the southwest end of the August-Little Ben Pit. The pit walls on the northwest side of the August-Little Ben were covered with backfill material and recontoured. The entire backfilled surface was lined with a minimum of 12-inches of clay, topsoiled and seeded in 2004. A 30-mil HDPE liner (6,552 square-yards) was installed over the runoff channel area to keep runoff from entering the backfilled spent-ore.

Gold Bug and South Gold Bug Pit – The Gold Bug Pit was excavated at the head of the King Creek drainage between 1981 and 1991. It is located above and to the south of the August-Little Ben Pit. Prior to 1993, the bottommost bench at the south end of the pit extended down to an elevation of 4650 feet. However, between 1993 and 1996, much of the pit was turned into a repository for potentially acid generation waste rock. About 13.4 million tons of waste rock was placed into the Gold Bug Pit before the mine ceased operation. (Refer to Gold Bug Backfill and Gold Bug Waste Repository)

During 2001, the waste rock in the unreclaimed portion of the pit was graded to slopes of 3H:1V or flatter. All depressions and lower benches were eliminated to produce a free draining surface. In addition, a 700-foot long section of highwall at the north end of the Gold Bug Pit was blasted to lower the top of the wall by about 50 feet. The blasted material was pushed over the pit wall to produce a scree slope in order to reduce the visual impact of the pit benches. Between 2003 and 2005, spent oxide ore from the L85/86 Leach Pad was backfilled along the remaining exposed pit walls to cover zones of sulfide bedrock. This large wedge of backfill was graded and covered with two feet of soil. The entire area was then planted with a mixture of grasses.

The South Gold Bug Pit was a southerly extension of the Gold Bug Pit that wrapped around the ridge into the Montana Gulch drainage. The South Gold Bug section of the pit complex contained lower benches with a floor elevation of 4925 feet. During the later stages of the mining operation, the mined out pit was used to stockpile limestone. After the limestone stockpile was removed between 2000 and 2002, this pit was almost completely backfilled with non-acid generating material from the L85/86 Leach Pad. This backfill project was completed in 2005 in conjunction with final backfilling in the Gold Bug Pit. Today, only a short section of the upper pit wall remains.

3.2.2 Waste and Topsoil

Waste rock from the open pit excavations was deposited in the August #1 Waste Rock Dump, the August #2 Waste Rock Dump, the Montana Gulch Waste Rock Dump, the Mill Gulch Waste Rock Dump, and the Gold Bug Pit backfill. Waste rock was also used extensively for pad and dike construction.

August #1 Waste Rock Dump – This dump was located above the southeast wall of the August-Little Ben Pit. 376,400 tons of rock was placed in this facility between the start of 1989 and the end of 1992. A large portion of this dump was removed to backfill portions of the Gold Bug Pit because it was non-acid generating. After the backfill was graded, the subgrade was tested to confirm that the material had excess acid neutralization potential. The remainder of the dump was either graded in place or pushed over upper benches in the August and Queen Rose pits. The remaining dump surface was graded and reclaimed in 2004.

August #2 Waste Rock Dump - ZMI constructed the August #2 Waste Dump within the King Creek drainage with material from the first mine benches that were excavated in the August Pit (11,000 cubic yards of oxides in 1979, and 603,000 cubic yards of oxides in 1980). The remaining material (239,200 cubic yards) came from both the August Pit and the Gold Bug Pit in 1981 and from the shop site excavation in April of 1984. The East Lobe of this dump covered 7.53 acres and contained 599,000 cubic yards of material. The West Lobe of this dump covered 5.06 acres and contained 254,200 cubic yards of material (total of 1,356,800 tons of material). It is likely that no sulfides were ever placed in the waste rock dump.

Between 2002 and 2004, the entire east lobe of the dump was removed and used as NAG to cover sulfide-rich pit highwalls. The uncovered native surface was covered with 12 inches of soil and revegetated in 2004. The west lobe was covered with 8-12 inches of soil and revegetated in May 1992. It now has a healthy stand of pine trees growing on the reclaimed dump slope.

Montana Gulch Waste Rock Dump – This valley fill waste repository was constructed from 1980 through 1988 at the head of Montana Gulch and covers the August drain tunnel. Waste rock was end dumped with no attempt to segregate materials by size, character, or placement within the repository. Perhaps as much as 15 percent of the material stored in this facility can be characterized as sulfide waste material. Prior to 1988, mostly oxide wastes from the August, Little Ben, and Gold Bug Pits were dumped here. Starting in 1986, a mixture of oxide and sulfide wastes from the Queen Rose Pit was placed in the Montana Gulch Dump. In the uppermost lift, over 20 percent of the material is sulfide in character. In total, 8,468,000 tons of waste rock was placed in this dump which covers 29.4 acres.

The face of the dump was covered with 8-12 inches of coversoil from the Montana Gulch Topsoil Stockpile and was reclaimed in May 1989 with 36 pounds of seed mix per acre, 100 pounds of fertilizer per acre, 1900 pounds of mulch per acre, and 125 pounds of tackifier per acre. No barriers were included in the reclamation cover. Trees were planted on the reclaimed dump in September 1989 and April 1990. In 2005, stockpiles and facilities on top of this dump were removed allowing the dump top to be reclaimed.

Mill Gulch Waste Rock Dump – This waste rock dump is located in Mill Gulch below the L87 Leach Pad Dike. Over 16.55 million tons of material was placed in this facility between 1989 and 1992. Over 20 percent of the material can be characterized as sulfide waste rock. Most of this material was mined from the Gold Bug and Queen Rose Pits. Production records indicate that the last 2 million tons placed into this facility was oxide waste from the Little Ben Pit. The dump covers 56.3 acres.

The entire dump was clay capped, then covered with 3-feet NAG, with benches every 200 feet which were lined with a synthetic liner (see also, 1996 Final EIS, Figure 2.505). The dump was covered with 8-12 inches of coversoil and reclaimed in May 1995 (38.31 acres) and October, 1996 (2.84 acres) with 33 pounds of seed mix per acre, 80 pounds of fertilizer per acre, 1900 pounds of mulch per acre, and 125 pounds of tackifier per acre. Following removal of the large topsoil stockpile located on the top bench of the Mill Gulch Waste Rock Dump, the footprint of the topsoil stockpile was graded, lined with clay, covered with 24 inches of topsoil, and seeded in 2005. The entire top of the Mill Gulch Waste Rock Dump, portions of the upper bench slopes and drainage areas on the lower benches are lined with either clay or PVC liner.

Gold Bug Pit Backfill and Gold Bug Waste Repository - The Gold Bug pit backfill was a designed waste repository with under-drainage provisions and a clay liner. Starting in October, 1991, the mined out Gold Bug Pit became a primary waste disposal area. Approximately 27,198,000 tons of waste was placed in this area and its associated stockpiles. The material was excavated from the August/Little Ben-Queen Rose pit complex.

The first stage of construction was designed to bring the top of the facility up to an elevation of 4900 feet. The base of the facility was constructed by placing a 3-foot deep layer of limestone and dolomite across the 4640 bench of the pit. An additional 100 tons of lime was distributed over the portion of the base that was in contact with the main Gold Bug shear. Above this base layer, sulfidic waste materials were selectively placed toward the interior of the facility. The margins were filled with “yellow” waste having an average net neutralization potential of near zero. At the 4740 level, a 6-inch clay barrier was installed over the top of the lower repository. This layer covers 14.25 acres and is inclined with a 2% grade that is contoured to direct leachate to the southwest. A collection trough was constructed to convey fluids to the repository toe at the southern end of the repository.

Slopes on the completed portion of the repository were reclaimed by placing a 6-inch layer of compacted clay over the graded waste along the outside of the facility. The clay barrier was covered with 2 to 18 inches of run-of-mine "blue" (non-acid generating) waste, which was intended to function as a capillary break. A final cover of 12 inches of soil was then placed over the layer of blue waste. Drainage off the main repository face was controlled by constructing benches every 100 vertical feet (200 horizontal feet). The benches were from 15 to 30 feet wide and sloped back into the repository at grades of 5 to 10%. The benches were also capped with clay. A drainage ditch, with an impermeable synthetic liner held in place by 6 inches of blue waste material, was constructed along the toe of the facility. Reclamation work on portions of the lower lifts of the mine waste repository in the Gold Bug pit backfill was completed in 1996.

In 2002, the upper area of the repository was backfilled with material from the August #1 Rock Dump and then graded in conjunction with the reclamation of other portions of the Gold Bug Pit. At that time, the upper 2 feet of the regarded pit and repository was sampled on a 100-foot grid to determine the Acid Base Account (ABA) value at each grid intersection. All grids lacking excess alkalinity were amended with lime prior to dressing the area with two feet of topsoil.

Between 2003 and 2005, the pit walls and the previously backfilled area along the base of the pit walls were backfilled with spent oxide ore from the L85/86 Leach Pad. This was done to cover a sulfide zone exposed in the pit wall. This large wedge of backfill was dressed with two feet of topsoil. The entire repository area has been planted with a mixture of grasses.

Coversoil - The available cover soil was salvaged prior to any significant disturbance. This material was stored in four large stockpiles. The Mill Gulch Topsoil Stockpile with 1,182,000 cubic yards of soil was located on the top bench of the Mill Gulch Waste Dump. The Montana Gulch Topsoil Stockpile with 180,580 cubic yards of soil was located on the edge of the Montana Gulch Waste Dump. The August/Little Ben Topsoil Stockpile with 349,000 cubic yards of soil was located adjacent to the August #1 Waste Rock Dump. The Gold Bug Topsoil Stockpile with 90,500 cubic yards of soil was located on the southwestern edge of the Gold Bug Pit. All stockpiled coversoil at the Landusky Mine has been used for reclamation. The stockpile footprints have been reclaimed.

3.2.3 Ore and Leach Pads

The ore removed from the pits was deposited on seven heap leach pads or pad complexes at the Landusky Mine. The heap leach pads were named according to the year they were constructed. The L79, L80-82, L83 and L84 leach pads were constructed on the ridge between Montana Gulch and Rock Creek. The L85/86 Leach Pad was constructed in the bottom of Montana Gulch. The L87 and L91 leach pad complex was constructed across the heads of Mill Gulch and Sullivan Gulch. The current quantity of ore within each leach pad is summarized in the following table.

Table 10 - Landusky Mine Leach Pad Ore Quantities			
LEACH PADS	**ACRES**	**TONS**	**LCY**
		(2000 lbs/ton)	**(16.5 cu ft/ton)**
L79 Leach Pad	1.92	458,000	279,800
L80/82 Leach Pad	25.27	4,524,000	2,764,200
L83 Leach Pad	15.46	2,021,000	1,234,800
L84 Leach Pad	11.96	2,499,000	1,526,900
L85/86 Leach Pad	0	0	0
L87 Leach Pad	94.08	48,866,000	29,857,100
L91 Leach Pad	97.44	55,387,400	33,841,700
	246.13	**113,755,400**	**69,504,500**

L79 Leach Pad – The L79 Leach Pad is a part of the complex of leach pads referred to as the lower leach pads located at the southwest corner of the mine. It contains 458,000 tons of oxide ore from the August Pit. It was reclaimed with 8 to 12 inches of soil and revegetated in September, 1991.

When this pad was operated and rinsed, the water was collected in a process pond located adjacent to the Barren Pond. Because reclamation grading on the L80-82 Pad pushed spent ore over the process pond, the drain from this pad was modified to empty into the Barren Pond.

L80/82 Leach Pad - Between five and ten percent of the total tonnage in the heap is sulfide ore (containing more than 0.2% sulfur). The heap was constructed with 4,524,000 tons of ore from the August Pit, the Gold Bug Pit, and the Little Ben Pit. Sulfide ores mined from the Gold Bug Pit are concentrated in a few isolated areas in the lower portion of the heap. In 1994, a mixture of oxide and sulfide ore from the Little Ben Pit was added to the top of this heap. However, detailed sampling on the surface of this heap found very low sulfur values. The buttress for this pad was constructed using a high percentage of sulfide waste from the Gold Bug Pit. The 829,700 tons of buttress and pad grading fill could possible contain greater than 20-percent sulfide material.

The pad was regraded from April to October of 2000. ABA testing on 100-foot grids took place and liming was completed. Topsoil placement took place from December 2000 through April 2001 with seeding taking place in May 2001.

L83 Leach Pad – This facility is located at the head of three small draws that drain toward Montana Gulch. The L83 Pad Dike, covering 9.1 acres, was constructed using a mixture of oxide and sulfide waste from the August Pit. The 1,635,000 tons of material in this dike probably contains less than 10 percent sulfide material. The grading fill used to shape the basin consisted of 487,600 tons of mixed oxide and sulfide waste from the Gold Bug Pit and the August Pit. This fill is estimated to contain about 15 percent sulfide material. The leach pad basin was covered with a thick layer of compacted clay and a synthetic liner before being filled with ore. Nearly the entire face of the dike was recontoured and reclaimed in 2001.

Probably less than two percent of the total 2,021,000 tons of ore in the heap is sulfide ore. The sulfide ores were mined from the August Pit and are concentrated in a few isolated areas in the lower portion of the heap. Detailed sampling on the surface of this heap found very low sulfur values. The pad was regraded from April to October of 2000. ABA testing was conducted on 100-foot grids before liming was completed. Topsoil was placed on the regraded leach pad from December 2000 through April 2001; and the area was seeded in May 2001.

L84 Leach Pad – The 2,499,000 ton L84 Leach Pad was built with oxide ore (less than 0.2% sulfur) from the August and Little Ben Pits. The records indicate that perhaps one percent of the material in this heap is sulfide ore. The 1984 Pad Dike, which contains 856,000 tons, and the pad grading fill, which required 260,000 tons, was constructed using a mixture of oxide and sulfide wastes from the August Pit. They probably contain 10 percent to 15 percent sulfide type materials.

The pad was regraded from April to October of 2000. ABA testing on 100-foot grids took place and liming the surface was completed. The L80-82, L83, L84 Pads surfaces were amended with 157.75 tons of lime. Topsoil was placed on the regraded leach pad from December 2000 through April 2001; and the area was seeded in May, 2001.

L85/86 Leach Pad - Before it was removed between 2002 and 2005, the lined area of the L85/86 Leach Pad covered 22.77 acres within Montana Gulch. The spent ore was removed to unblock two forks of the Montana Gulch drainage and placed as backfill in the August, Gold Bug, and South Gold Bug Pits. The ore heap was originally built with production from the Gold Bug Pit and the upper benches of the Queen Rose Pit. The vast percentage (98%) of material dumped on this pad was oxide ore. Only 79,000 tons of sulfide ore out of over 5.34-million tons were delivered to this pad. The sulfides were mined from the Gold Bug Pit and were placed in the lower portion of the heap. There is no indication that the 192,000 tons of fill used to construct the base of the pad or the 579,000 tons in the dike contained any sulfide type materials. In 2004 and 2005, the L85/86 dike and pad construction fill was excavated and used to build-out the L84 Dike area.

L87 Leach Pad – The L87 ore heap was built with production from the Gold Bug and Queen Rose Pits. Approximately 1.4-million tons of sulfide ore was mixed with about 37.9-million tons of oxide ore on this pad between 1987 and February of 1991. Hence, sulfides represent only about four percent of the total ore placed on the pad during this period. The 2,404,000 tons of grading fill and 4,217,000 tons of dike fill used to construct the pad were also low in sulfides. However, a high percentage of sulfide ore was used in the L87/91 Leach Pad extension. During the final years of production, sulfide ore was used to raise the top of this heap and to join it with the L91 Leach Pad on the northeast side.

The pad was regraded between November 2002 and November 2003. ABA testing was conducted on 100-foot grids. Grids lacking excess neutralization were limed. The contoured leach pad was covered with 24 inches of soil from the Mill Gulch Topsoil Stockpile in 2003 and seeded in the fall of 2003 and the spring of 2004.

L91 Leach Pad and the L87/91 Pad Notch - This facility was constructed at the current head of Sullivan Gulch. Sulfides were present in the 1,240,000 tons of pad construction fill. The top portion of the 2,643,000-ton L91 Pad Dike was constructed using sulfide waste. The dike covers 12.5 acres. The leach pad basin was covered with a thick layer of compacted clay and a synthetic liner before being filled with ore. While the inside face of the dike is covered with liner and ore, the outside face of the dike was reclaimed immediately after it was constructed with 8-12 inches of soil and vegetation. In 2004, a portion of the dike was removed to permit recontouring of the dike face as rills were developing in the soil cover on the 2H:1V slope.

The ore production that went into the L91 Pad and later into the area between the L87 and L91 Pads came from the lower benches of the mine, where sulfides were most prevalent. Approximately 64.9 million tons of ore were placed in the L91 Leach Pad and in the L87/91

Notch. The notch area drains to the basins in the L91 and the L87 Pads.

The pad was regraded between October 2000 and November 2002. ABA testing was conducted on 100-foot grids. The L87 and L91 Pads received a total of 3,745.65 tons of lime. Placement of 24 inches of cover soil from the Mill Gulch Topsoil Stockpile took place between April 2003 and September 2003. Seeding took place in fall of 2003 and the spring of 2004.

3.2.4 Historic Tailings in King Creek

Mill tailings from the pre-1941 mills in King Creek have also been cleaned-up. ZMI removed the tailings near the head of the drainage and used this material during the construction of several leach pads. In 2000, the EPA funded a project to remove the remainder of the tailings from the drainage based on a September 1999 EE/CA developed for the EPA/Corps of Engineers by IT Corporation. Materials removed during this project were hauled to the Landusky Mine and spread over the regraded surfaces of the L80-82, L83 and L84 Leach Pads as a subsoil. The tailings were subsequently covered with soil and seeded with a mixture of grasses. Vegetation is now well established over this area. Any water infiltrating through the tailings used to reclaim the leach pad surface is captured in the lined basins of the leach pads.

3.2.5 Landusky Mine Waters and Watersheds

The Landusky Mine area is drained by the Rock Creek drainage, which flows to the south, and the South Big Horn Creek drainage, which flows northwest onto the Fort Belknap Indian Reservation. About 876 acres of disturbance were created by the mining and reclamation operations and associated site facilities at the Landusky Mine.

3.2.5.1 Rock Creek Watershed

Rock Creek and its four tributaries, Montana Gulch, Mill Gulch, Sullivan Gulch, and Frog Pond Draw, drain nearly the entire site. Rock Creek and its tributaries are within the Missouri River drainage basin and are classified as C-3 by the State of Montana Surface Water Quality Standards (ARM 16.20.607[5]). There is a BLM campground located along Montana Gulch about half a mile downstream from the mine. Small brook trout populations exist in perennial segments of Rock Creek. Trout have recently been observed in the stream flowing through the Montana Gulch Campground located about a half mile below the Landusky Mine.

3.2.5.1.1 Rock Creek Upper Fork

This sub-basin extends northward from its confluence with Sullivan Gulch to the divide at the head of Swift Gulch. A relatively small area on the east-facing hillside of this gulch was disturbed by construction of the Antoine Butte road and construction of the L91 Leach Pad. It contains 50.3 acres of reclaimed leach pad and 2.6 acres of long-term access road disturbance. The north side of the L87/91 Leach Pad and the southeast-facing slope of the L91 Leach Pad drain into this basin.

3.2.5.1.2 August-Little Ben Pit (closed Drainage Basin)

This 363.1-acre enclosed drainage basin has been created by the open pit complex and the routing of diversions into the excavation. This area consists of 230.4 acres of reclaimed mine disturbance, 65.3 acres of undisturbed tree covered slopes, and 40.49 acres of unvegetated roads, road cuts, and pit walls. 14.87 acres of unvegetated scree backfill slopes covering pit walls are included in the 230.4 acres of reclamation. The bottom of the pit complex has been backfilled, graded, and lined with reclamation covers to control infiltration. All runoff reporting to the pit is routed into an underground drain (elev. 4700 feet) that is connected into the abandoned underground mine workings. Artesian well, WS-3, which is located at an elevation of 4484 feet in Montana Gulch and has a pressure head of 83 feet, is used to release this water. Water drawn from WS-3 is piped to the Landusky Water Treatment Plant.

The August-Little Ben Pit, the Suprise Pit, the Queen Rose Pit, the August #1 Waste Rock Dump the north side of the L91 Leach Pad, the northwest face of the L87 Leach Pad, the upper areas of the Gold Bug Pit Backfill Waste Repository and the South Gold Bug Pit are contained in this drainage area. Spent ore from the L85/86 Leach Pad and waste from the east lobe of the August #2 Waste Rock Dump were backfilled into the pit areas.

3.2.5.1.3 Sullivan Gulch

This gulch is the west branch of the Rock Creek headwaters. It drains the extreme southeast portion of the Landusky Mine site. The head of the gulch is covered by the L91 Leach Pad and Dike. Much of the pre-mining drainage area has been cut off and diverted. A seepage capture system is situated below the toe of the reclaimed L91 Leach Pad Dike. Captured seepage is stored in lined ponds until it can be pumped to the Landusky Water Treatment Plant. Below the capture facilities, the stream generally has a very low base flow. The drainage area consists of 26.5 acres of reclaimed leach pad and dike, and 5.1 acres of road disturbance, diversions, and capture facilities. The entire face of the L91 Dike face was reclaimed in 1991. However, the upper section was over-steepened to accommodate a haul road. In 2004, the width of the road was substantially reduced and an upper segment of the dike was removed allowing the upper portion of the dike to be recontoured to a 40-50 percent slope.

3.2.5.1.4 Mill Gulch

This gulch is a north branch of Rock Creek that is located above Frog Pond Draw and below Sullivan Gulch. It drains the south-central portion of the Landusky Mine. The pre-mining head of the gulch is covered by the L87/91 Leach Pad, the L87 Dike and the Mill Gulch Waste Rock Dump. In addition to storm water, Mill Gulch has a base flow, which is believed to originate from one or more seeps beneath the Mill Gulch Waste Rock Dump. This seepage and any seepage from the pads, dike, and dump are captured and pumped to the Landusky Water Treatment Plant. This drainage basin includes 183.1 acres of reclamation and 31.1 acres of active disturbance. Pumping facilities for the L87/91 Leach Pad, the Barren Pond, the Mill Gulch Seepage Capture System, and the Biological Treatment Plant are located in this basin. The south-facing slope of the L87/91 Leach Pad, the Mill Gulch Pipeline Road, portions of the Antoine Butte access road, the Mill Gulch Waste Rock Dump, portions of the L87 Dike, the Lower Contingency Pond, the L79 Leach Pad, the east side of the L80/82 and L84 Leach Pads, and the reclaimed lower facilities area are also contained within this basin.

In 2004, sulfide material excavated from the L91 Dike was deposited on the top bench of the Mill Gulch Waste Rock Dump. This area was graded and covered with a layer of clay. The entire top bench of the dump is covered with geo-synthetic liner or clay. Lined contour drains were installed on each bench to convey runoff to the southeast edge where a permanent diversion system and access road were constructed.

3.2.5.1.5 Frog Pond Draw

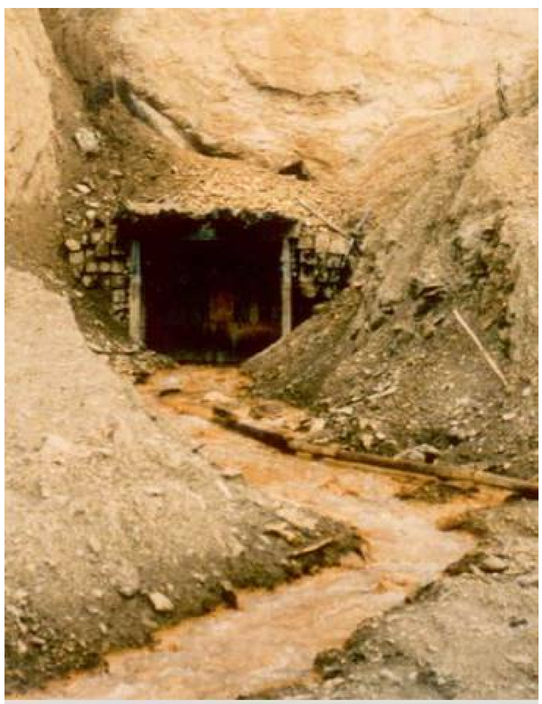
This draw is a northern branch of Rock Creek that is located above Montana Gulch and below Mill Gulch. It drains the southwestern corner of the Landusky Mine. Mine features within this drainage area include the Landusky Water Treatment Plant, the Sludge Pit, and the Frog Pond Capture, the L83 Pond, the L83 Leach Pad, portions of the L80-82 Leach Pad, part of the L84 Leach Pad, and part of the L79 Leach Pad. The Frog Pond Draw drainage basin includes 48.0 acres of reclamation and 8.5 acres of long-term facilities disturbance.

3.2.5.1.6 Montana Gulch

This gulch drains the western third of the Landusky Mine and is a tributary of Rock Creek. Prior to the era of large-scale open pit operations at the Landusky Mine, Montana Gulch was a perennial drainage fed primarily by drainage from underground mine openings situated in the gulch. The portion of the Montana Gulch drainage basin affected by the mine area comprises two forks of the gulch, which share Mission Peak as their headwater area. The 276.8 acres in the west fork of the gulch have been left largely undisturbed. However, this fork drains through the lower end of the reclaimed area where the L85/86 Leach Pad and Dike had been located. The east fork contains the shop, office and fuel storage facilities, the Montana Gulch Waste Rock Dump, the Upper Montana Gulch Seepage Capture System, portions of the Gold Bug backfill waste repository, portions of the L84 Leach Pad/Dike, the Gold Bug Adit Capture, and artesian well WS-3. The L85/86 Leach Pad, the L85/86 Dike, the West Fork Pond, and the Lower Montana Gulch Seepage Capture System were removed from the drainage between 2002 and 2005. Material excavated during dike removal was used to recontour steep slopes on the east and south sides of the pad removal area. A drainage channel that is protected by substantial rock checks was constructed along the bottom of the reclaimed area.

Below the Montana Gulch Pond, Montana Gulch has a perennial flow of about 580 gpm. Sources of water within the basin include the following:

- Flow from the historic Gold Bug Adit (elev. 4576 feet) - Prior to development of open pit operation, the Gold Bug Adit drained a steady flow of acidic water into the gulch. To control this discharge, the adit was sealed by ZMI. Collected water from inside the mine is piped 515 feet to the west to a capture system located at an elevation of 4540 feet. This water is routed by pipeline to the Landusky Water Treatment Plant for treatment.



Flow from the Gold Bug Adit, circa 1969

- Seepage from the base of the Montana Gulch Waste Rock Dump - This waste repository has an underdrain system that routes seepage to the toe of the dump where it drains for 600 feet down the native channel to the Upper Montana Gulch Seepage Capture System. Seepage averages around 10 gallons per minute, and is believed to originate principally from the August Drain Tunnel. When the Montana Gulch Waste Rock Dump was constructed, the entrance to the drain tunnel (located at an elevation of 4604 feet) was covered with several hundred feet of waste rock. Additional water may also originate from groundwater beneath the Montana Gulch Waste Rock Dump and from percolation of surface water through the repository. Water captured by the Upper Montana Gulch Seepage Capture System is piped to the Landusky Water Treatment Plant.

- Artesian well WS-3 - This well is located near the base of the Montana Gulch Waste Rock Dump. It has a collar elevation of 4484 feet and a pressure head of 83 feet (36 psi shut-in). In November 2005, it was flowing at the rate of 178 gallons per minute, which can be controlled with a valve. Groundwater levels in the August-Little Ben area are directly affected by the operation of WS-3. Discharge from the well is piped to the Landusky Water Treatment Plant.
- Runoff from largely undisturbed areas located mostly along the western edge of the site and in the West Fork of Montana Gulch.
- Water Treatment Discharge - The Landusky Water Treatment Plant and the Biological Treatment Plant discharge water into the lined Montana Gulch Pond. Because this pond is sub-excavated, excess water flows out through a lined channel leading to Outfall 597.
- Storm water runoff from active and reclaimed areas.

3.2.5.2 South Big Horn Creek Watershed

South Big Horn Creek and its tributaries, King Creek and Swift Gulch, drain the northern edge of the Landusky Mine. South Big Horn Creek is a tributary of Peoples Creek and is within the Milk River drainage basin. Waters within the Peoples Creek drainage basin are classified as B-1 in the State of Montana Surface Water Quality Standards (ARM 16.20.607[8][c]). Because South Big Horn Creek flows into reservation lands, reclamation in the northern part of the mine site has been designed to reduce the drainage area disturbed by mining to only 28.7 acres, which have been reclaimed. An additional 10 acres of undisturbed land drains onto the reclaimed area in this basin. There is a Tribal cultural and recreation use area located along South Big Horn Creek about a mile downstream of the northern portion of the Landusky Mine. Small brook trout populations exist in perennial segments of South Big Horn Creek/Little Peoples Creek, several miles downstream of the mine.

3.2.5.2.1 Swift Gulch

Swift Gulch is a southeastern branch of South Big Horn Creek that has a perennial flow fed by springs and seeps. Before part of the ridge on the south side of the gulch was mined as part of the Landusky Mine pit complex, and before the current diversion system was in place, the drainage area in Swift Gulch was approximately 715 acres. It is currently 667 acres. Because Swift Gulch drains toward reservation land, control measures have been implemented to minimize the amount of groundwater and surface water moving from mine areas into this drainage. Currently 28.7 acres of reclaimed mine disturbance associated with the Big Horn Ramp and scree slopes along the northern edge of the Queen Rose/Suprise Pit drain into the gulch. There is a wide area in South Bighorn Creek just upstream of the Reservation boundary that is covered with coarse placer mine tailings from the historic placer mining operation.

3.2.5.2.2 King Creek

King Creek is a southern branch of South Big Horn Creek that currently drains 576 acres in portions of four sections north and west of the Landusky Mine. Near the mine, it has been observed to flow only in response to rainfall and snowmelt events. However, downstream from the Cumberland Dam, King Creek flows to the northwest and supports a riparian shrub plant community. Construction of the open pit complex has effectively removed 96 acres of runoff from the upper reaches of this drainage. The area includes 24.8 acres of reclaimed mine disturbance, and 3.5 acres of access road disturbance. All runoff from the mine area within King Creek is detained behind the Cumberland Dam. If the capacity of the reservoir is exceeded, the dam releases water through an armored spillway at Discharge Point 596. Otherwise, the runoff seeps out at the toe of the dam. There are three sources of water, which converge, in the upper King Creek drainage:

- Storm water runoff from undisturbed slopes located on Mission Peak above King Creek;
- Storm water runoff from reclaimed and undisturbed slopes located at the current head of the King Creek; and,
- Seepage from beneath the reclaimed slopes of the August #2 Waste Rock Dump west lobe. This water flows into an interception trench. Water collecting in the lined sump is allowed to discharge as a seep, which is monitored at sampling point L-5.

The north rim of the August-Little Ben Pit and the August #2 Waste Rock Dump is located in this drainage. The east lobe of the August #2 Waste Rock Dump has been completely removed. The area still contains very substantial storm water and erosion control measures. Above the dam and its sub-excavated reservoir, there are three sediment basins in the drainage bottom. The sediment basins are spaced from 100 to 200 feet apart. Due to the excavation of historic tailings from this area, drainage from the side draws enter the constructed main channel on steep grades. These steep confluences are protected with rock riprap. A constructed channel with a plastic liner extends up the fork leading to the August #2 Waste Rock Dump.

3.2.6 Landusky Mine Regrading and Backfilling Reclamation (OU3)

About 718 acres inside the mine area have been reclaimed with some form of reclamation covering and a mixture of grasses and/or trees. An additional 15 acres have been reclaimed to scree slopes. 146 acres of land consisting of roads (cuts/embankments), facilities, and steep rock pit walls remain within the mine area. A haul road reclamation project, which eliminated several roads and reduced the average road-width of the retained road from 100 feet to approximately 24 feet, was completed in 2005.

In addition to the grading, capping, and revegetation work that has been accomplished, nearly all the plant buildings and processing equipment have been removed from the site. Haul roads on the site either have been reclaimed or have been reduced in width. Projects to reclaim exploration roads and drill holes associated with the mine have been completed. The Williams Clay Pit, which supplied clay for pad liner construction, has also been reclaimed. Only seven lined ponds, the warehouse/shop building, a fuel storage facility, portions of the mine diversion system, leach pad pumping facilities, several pipelines, ground water capture systems, 37 monitoring wells, and the water treatment plant remain in-place of the facilities that were constructed by ZMI.

There is an understanding that the amount and quality of impacted water reporting to seeps, the seepage capture systems, and the leach pad pumping facilities is influenced by the ability of precipitation to infiltrate through rock that was broken or exposed to oxidation by mining and processing. Consequently, reclamation efforts have focused on using grading, reclamation covers, vegetation, and diversions to reduce the overall amount of water that is available to percolate below the root zone. Where practical, storm water and snowmelt runoff are routed around reclaimed mine waste units. Although interim erosion prevention measures such as using dozer basins, check dams, and other devices that slow down and collect runoff are used on recently reclaimed areas, the long-term goal is to establish positive drainage that can be quickly channeled and routed off the reclaimed surface.

Work Remaining - The preferred reclamation alternative selected in the 2002 BLM ROD for the Landusky Mine is Alternative L4 from the 2001 SEIS. Reclamation under Alternative L4 was completed in the spring of 2005. The only remaining reclamation activity is monitoring.

3.2.7 Landusky Mine Capture Systems and Water Treatment Plant (OU1)

To control seepage from mine facilities, five capture systems were constructed during the mining operation. A sixth seepage capture sump was installed in King Creek. However, seepage collected in the King Creek capture has only been monitored and released. Following removal of the L85/86 Leach Pad and Dike from lower Montana Gulch, the Lower Montana Gulch capture system was dismantled to allow restoration of the drainage channel. The systems currently in operation capture and return seepage collected down-gradient of mine facilities located in Upper Montana Gulch (10 gpm), Sullivan Gulch (6-18 gpm), Mill Gulch (31-50 gpm), and Frog Pond Draw ($\geq$2 gpm). The source of seepage appears to be buried springs and seeps, and precipitation that percolates into waste rock and native rock. Functioning capture systems are comprised of a sump or collection area, a storage tank, and a pumping system.

Waters collected from the capture systems, the Gold Bug Adit capture facility (132-170 gpm), and artesian well WS-3 (178 gpm) are transported via pipelines to the Landusky Water Treatment Plant, where lime precipitation is used to improve the quality of the water. The discharge is routed through the Montana Gulch Pond, where it is released into Montana Gulch. Process sludge is piped to a sludge pit on the L83 Leach Pad for de-watering and disposal.

3.2.7.1 Landusky Mine Water Treatment Plant

Construction of this water treatment plant by ZMI was required by the 1996 Consent Decree between the mine operator, the State of Montana, the EPA, the Fort Belknap Tribes, and the Island Mountain Protectors, which resolved a complaint filed under the Federal Clean Water Act and Montana Water Quality Act over discharges from the mines. The Landusky Water Treatment Plant began operation on October 1, 1997. It is currently operated 24 hours per day, 363 days per year to treat 236,000,000 gallons of water per year (current 5-year average). Treated water is routed to the Montana Gulch Pond and enters Montana Gulch via Outfall 597. The water entering the treatment plant from the capture systems is slightly acidic and contains slightly elevated levels of dissolved heavy metals. During the process, hydrated lime and flocculent are mixed with the water to raise the pH of the water and to cause the dissolved metals to precipitate out of the water creating a sludge, which is pumped to the sludge disposal pit. Water from the treatment plant generally meets safe drinking water standards requirements.

Table 11 - Landusky Mine Water Treatment Plant Water Quality

Parameter	Typical Captured Water	Typical WTP Treated Water	Water Quality Standard
pH (s.u.)	5.0	7.7	6.5 – 8.5
TSS (mg/l)	20	7	20
Sulfate (mg/l)	991	900	N/A
$Cyanide_{(total)}$ (mg/l)	<0.005	ND	0.0052
Arsenic (mg/l)	0.15	0.008	0.018
Copper (mg/l)	0.11	0.004	0.031
Cadmium (mg/l)	0.04	0.002	0.005
Iron (mg/l)	18.8	0.3	1.0
Lead (mg/l)	0.004	<0.003	0.015
Manganese (mg/l)	7.6	3.0	N/A
Mercury (mg/l)	ND	ND	0.00005
Selenium (mg/l)	0.004	0.004	0.005
Zinc (mg/l)	1.72	0.07	0.388

The Landusky Mine Water Treatment Plant does not currently use a ferric sulfate circuit to assist with arsenic removal. Although the plant employed a ferric sulfate circuit for part of 2002, other modifications were made that provided better results than using ferric sulfate.

The water treatment plant consumes about 89 tons of hydrated lime per year. Approximately 2.65 million gallons of water are treated per ton of lime consumed. The low lime consumption rate is due to the pH of the influent being only slightly acidic.

3.2.7.2 Sludge Disposal Pit

Turbidity and precipitates settling out of the treated water (sludge) are pumped in slurry to a sludge disposal pit located on the L83 Leach Pad. The sludge is not considered chemically hazardous. The sludge disposal pit is a large unlined pit excavated in the spent ore on the leach pad. After the slurry is pumped into a pit, the water slowly separates from the solids and either evaporates or infiltrates into the leached rock where it is ultimately captured by the leach pad containment system. Because the sludge is extremely fine grained (slime), dewatering rates are extremely slow. The sludge will continue to be tested periodically for mobile metals.

3.2.7.3 Lined Ponds

The Landusky Water Treatment Plant has a 2.26 acre, polypropylene lined holding pond with a 12,500,000 gallon storage capacity. The lined Upper Sullivan Capture Pond with a storage capacity of 1,871,000 gallons and the Lower Sullivan Pond with a storage capacity of 1,768,000 gallons are both located in Sullivan Gulch immediately downstream of the L91 Dike. Two other ponds, the 83 Pond (927,000 gallon capacity) and the Lower Contingency Pond (2,997,000 gallon capacity) are also available for emergency storage.

3.2.7.4 Capture Systems

Upper Montana Gulch (10 gpm) Capture System – This facility consists of a pump house with three submersible pumps that discharge into a manifold feeding into a pipeline to the Landusky Water Treatment Plant. The two 7.5 Hp pumps and the one 15 Hp pump are housed inside a perforated HDPE sump that extends 21 feet down to the bottom of the lined underground collection area. The collection area is situated in the drainage channel below the toe of the Montana Gulch Waste Rock Dump. It is lined with HDPE and has a 97,243 gallon capacity. A dike downstream from the pump house at the bottom end of the collection area is employed as a cutoff barrier. The maximum water level is maintained 8 feet below the floor of the pump house. Pump controls and water flow/water level readouts are located on the control panels inside the heated pump house. Control valves are also located inside the pump house. The pumps deliver water to the Landusky Water Treatment Plant Pond through a buried 6-inch diameter HDPE pipeline which outlets in the northwest corner of the pond. Most of the original pipe was replaced in 2005. This facility was put into service on October 23, 1997. Until early 2005, artesian well WS-3 had been allowed to flow directly into this capture system. Artesian well WS-2 was plugged with a packer. However, seepage past the packer started in early 2005. Drainage from WS-2 is currently captured in the system.

Lower Montana Gulch (10 gpm) Capture System – This facility was dismantled in 2005 after the L85/86 Leach Pad and Dike were removed. The water that ran off the L85/86 facility now runs down Montana Gulch. Before it was removed, it consisted of a pump house with three submersible pumps that discharged into a manifold feeding a pipeline to the Landusky Water Treatment Plant. The pumps were inside a perforated HDPE sump that extends 13 feet to the bottom of the lined underground collection area. The collection area was in the drainage channel below the L85/86 Dike, above the Montana Gulch Pond. A dike downstream from the pump house at the bottom end of the collection area was employed as a cutoff barrier. This capture began operation on August 8, 1997 and was shutdown in February, 2005.

Sullivan Gulch (6-18 gpm) Capture System – This facility consists of a pump house with three submersible pumps that discharge into a manifold feeding a pipeline to the Landusky Water Treatment Plant Pond. The three 10 Hp pumps are housed inside a perforated HDPE sump that extends 13 feet down to the bottom of the lined underground collection area that has a 94,119 gallon capacity. The collection area is situated in the drainage channel below the downstream toe of the dam on the Lower Sullivan Pond. A dike situated downstream from the pump house and at the bottom end of the collection area is employed as a cutoff barrier. The maximum water level is maintained near the floor level of the pump house with overflow escaping though french drains and a pipe that drains down the face of the dike. Pump controls and water flow/water level readouts are located on control panels inside the heated pump house. Control valves are also located inside the pump house. This system works in conjunction with a lined capture pond, which is designated as the Lower Sullivan Pond. The pond is lined with Hyplon and has a 1,768,000 gallon capacity. A series of pumps and electrical controls are situated across the dike. The Sullivan Gulch Capture has been operating since September 19, 1997.

Upper 91 Capture Pond – This facility is located directly upstream from the Lower Sullivan Pond and extends to the toe of the L91 Dike. Seepage from the underdrain below the L91 Pad and Dike is collected in a pipe that gravity flows into the upper end of this pond. The pond is lined with Hyplon and has a 1,871,000 gallon capacity.

Mill Gulch (31-50 gpm) Capture System – This facility consists of a pump house with three submersible pumps that discharge into a manifold feeding a pipeline to the Landusky Water Treatment Plant Pond. The two 10 Hp pumps and the one 25 Hp pump are housed inside a perforated HDPE sump that extends 13 feet down to the bottom of the lined underground collection area with a 123,102 gallon capacity. The collection area is situated in the drainage channel below the downstream toe of the toe of the Mill Gulch Waste Rock Dump. A dike situated downstream from the pump house and at the bottom end of the collection area is employed as a cutoff barrier. The maximum water level is maintained near the floor level of the pump house with overflow escaping though french drains and a pipe that drains down the face of the dike. Pump controls and water flow/water level readouts are located on control panels inside the heated pump house. Control valves are also located inside the pump house. The Mill Gulch Capture has been operating since September 19, 1997.

Frog Pond Draw (1.4 gpm) Capture System – This facility is located below the toe of the L83 Dike. It consists of a lined underground collection area with a well extending into it. Collected water is periodically evacuated to the Water Treatment Plant Pond using a single 1 Hp pump.

King Creek Interception Trench – This trench is located below the toe of the August #2 Waste Rock Dump. This facility consists of a lined underground collection area with an observation well and a perforated HDPE sump extending into it. Pumps were not installed in this facility as water collected in the sump drains into the pond behind the Cumberland Dam where it evaporates. However, the water quality is been monitored. The construction of a passive treatment system below this trench is one of the alternatives under consideration in this EE/CA.

Gold Bug Adit Drainage Capture Facility (132-170 gpm) – This facility consists of a 12-inch PVC pipe that extends from inside the buried and plugged Gold Bug Adit and connects into an HDPE pipeline that flows by gravity to the Landusky Water Treatment Plant Pond. The upper segment of the pipeline is a 10-inch diameter HDPE pipe on a general downhill grade. The lower segment of the pipeline, which has an overall uphill gradient, is 12-inch diameter HDPE pipe. This segment connects to the pipeline from the Sullivan and Mill Gulch capture systems and outlets in the northeast corner of the pond. This pipeline was substantially rebuilt in 2005.

Artesian Well, WS-3 (178 gpm) – WS-3 was drilled to a depth of 243 feet in 1984. It was allowed to free flow until 1990. Between 1990 and 1995, it was only allowed to flow periodically. Late in 1995, it was shut in. The last mining blast occurred in the August-Little Ben Pit on

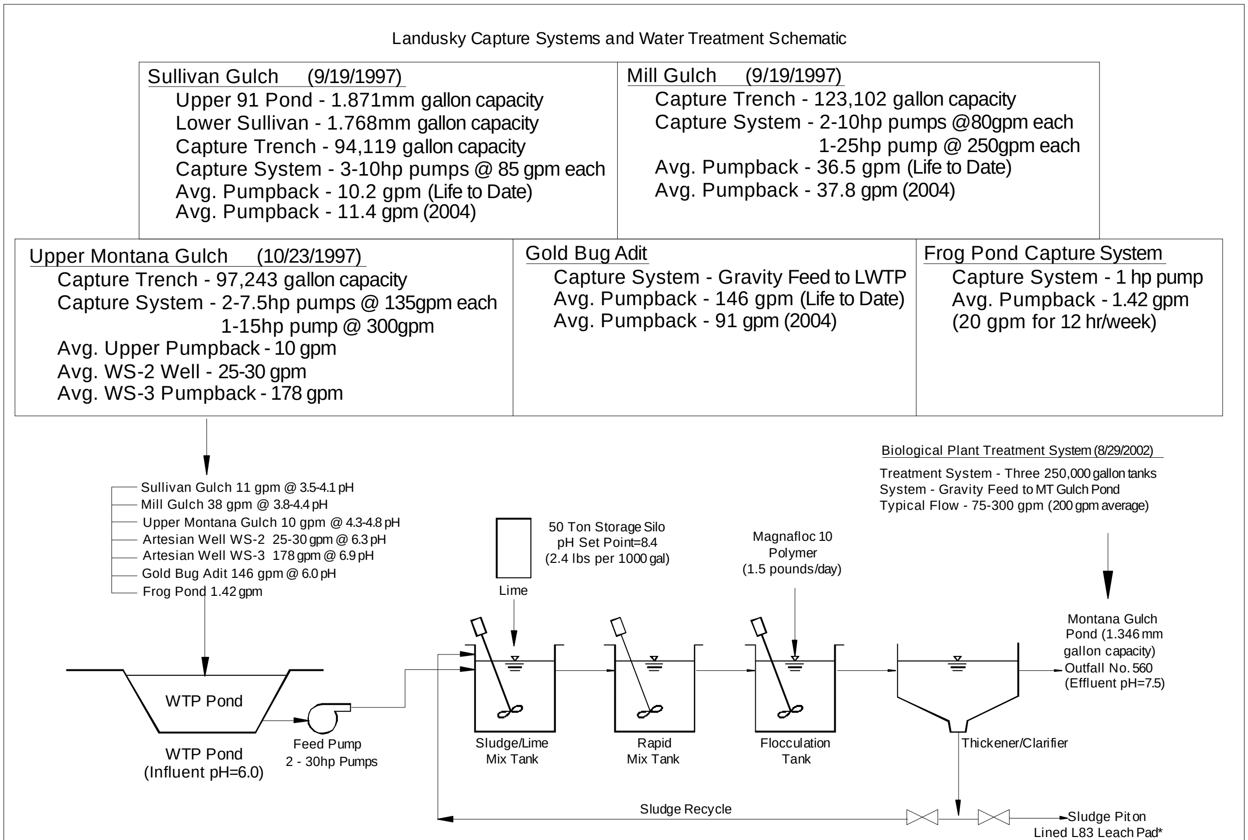
January 8, 1996. With WS-3 shut in, a pit lake started forming in late January 1996. This pit lake eventually covered 8 acres up to 15 feet deep within the pit. After the well was opened on October 27, 1999, the water level in the pit lake fell until it was completely dewatered by April 2000. A water level recovery test was performed for 30 days in November 2000. Thereafter, WS-3 has flowed by gravity to the Landusky Water Treatment Plant Pond via either direct pipeline or through the Upper Montana Gulch Capture System. In the spring of 2005, the seepage capture system was permanently bypassed by the installation of a new 8-inch HDPE pipeline between the well and the Landusky Water Treatment Plant Pond. The well was worked over in July 2003, due to steel casing corrosion, and received 220 feet of new schedule-80 stainless steel pipe. The well is capped and controlled with a valve attached to the cap.

Table 12 - Summary of Yearly Landusky Mine Capture System Quantities

		Captured Quantity (Million Gallons)			
Year	Precip (Inches)	Mill Gulch	Sullivan	Lower MT	Upper MT, Gold Bug, WS-3
1997	0.80	4.14	0.58	10.57	13.72
1998	22.03	24.84	6.55	41.63	139.79
1999	15.95	29.23	7.87	25.05	151.80
2000	16.51	18.41	2.86	13.38	239.07
2001	15.20	16.46	3.04	1.17	245.58
2002	21.25	19.13	5.83	0.70	226.15
2003	17.25	15.29	3.14	5.57	171.90
2004	15.25	19.89	5.97	4.45	146.81
2005	18.65	21.61	7.31	0.40	161.82

Inside the Landusky Mine Water Treatment Plant

Figure 8 - Landusky Mine Water Treatment Plant Schematic



	WTP Pond		Sludge/Lime Mix Tank	Rapid Mix Tank	Flocculation Tank	Thickener/Clarifier
VOLUME (Gallons)	12,500,000	700 gpm Max. Input	600	10,200	45,000	180,000
SIZE	250' x 360' x 30' deep				20 ft High, 20 ft Diameter	15 ft High, 45 ft Diameter
DETENTION TIME (minutes) at Design Flow of 600 gpm	20,833 (14.5 days)		1	17	75	300
DETENTION TIME (minutes) at Average Flow of 350 gpm	35,714 (24.8 days)		2	29	129	514

3.3 LEACH PAD WATER MANAGEMENT CHARACTERIZATION (OU2)

Water balance information collected since 1999 suggests that approximately 50% of the precipitation falling on the surface of leach pads eventually infiltrates and is captured in the lined leach pad basins. Yearly statistics show considerable variation in the infiltration percentage suggesting that the amount of infiltration is related to the type of precipitation event as well as the total amount of precipitation. This infiltration rate may decrease as the vegetation cover on the leach pads matures.

As water infiltrates through the spent ore on the leach pads it typically becomes more acidic and picks up dissolved sulfates and heavy metals from the ore, as well as, residual products from the cyanide leaching process. To prevent uncontrolled discharges of the impacted water, storage volumes must be maintained at safe levels by treating and releasing the water. Consequently, all Zortman and Landusky leach pad water is currently being pumped to the Biological Treatment Plant (OU2) for treatment.

The following pie charts illustrate the relative sizes of the leach pads at both mines and clearly show the dominance of the L87 and L91 leach pads at the Landusky Mine compared to all the others. Note that the L85/86 and the Z82 leach pads no longer exist as they were excavated and used for pit backfill.

Figure 9 - Remaining Leach Pad Sizes

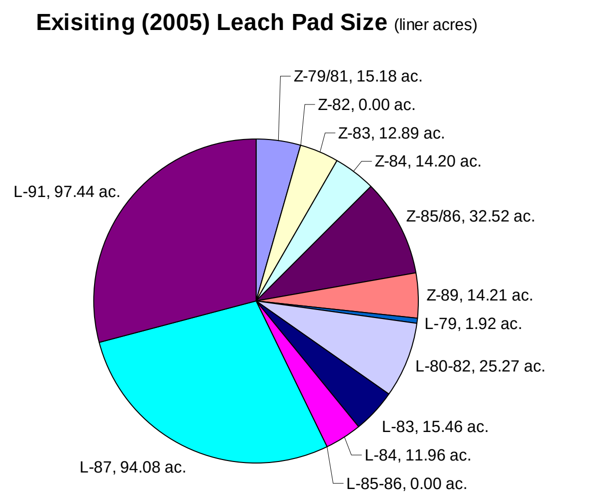


Figure 10 - Leach Pad Water Storage Capacity

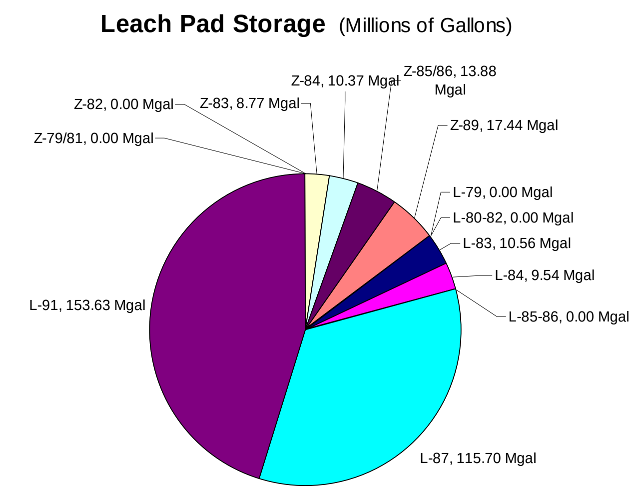
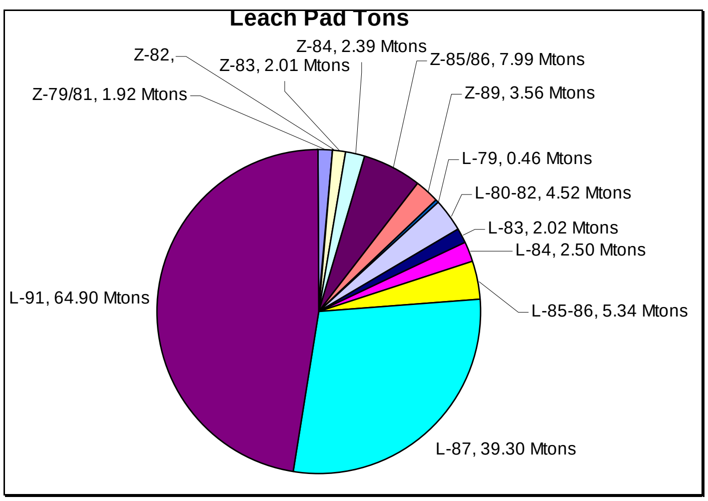


Figure 11 - Leach Pad Size (Tons Ore)



3.3.1 Zortman Mine Leach Pad Water Collection

Water is collected and stored in all of the remaining Zortman Mine leach pads. Each each pad was constructed as a lined basin with a limited storage capacity. In order to prevent uncontrolled discharges, each pad is equipped with a set of pumps that periodically operate to maintain the storage volume at a safe level. In the past, water removed from the pads has been treated and released by land application at the Goslin Flats LAD area. Beginning in 2005, water collecting in the leach pads (about 20 to 26 million gallons per year) was pumped to the biological treatment facility at the Landusky Mine at the rate of 200 gpm for three months.

Although all of the leach pads that still remain on the sites have been graded and covered with soil reclamation covers, a portion of the rainwater and snowmelt falling on these facilities will infiltrate through these covers, drain through the spent ore, and become trapped in their lined basins. Removal of the Z82 Leach Pad (used as backfill material in the O.K./Ruby Pit) reduced the total pad liner area to 89 acres. Given the recent five-year average precipitation of 17.04 inches per year, approximately 40-milion gallons of precipitation would fall on the reclamation covers over these areas in an average year. With the sludge pit contribution of about 3 million gallons per year and an infiltration rate of 50 percent, the leach pad collection system would accumulate about 24 to 27 million gallons in an average year without treatment and release.

With the exception of the Z79/81 complex, pad water is removed from the lined area through one or more casings that extend down to the bottom of the liner from a location on the dike. Submersible pumps that can be raised and lowered inside the casing are usually employed to pump the water. The water captured in these systems is typically acidic and contains dissolved heavy metals. Elevated levels of nitrates, carbonates, and various forms of cyanide that are residual products of the leaching operation can still be detected in the pad water.

Currently all pad water is pumped to the sludge pit on the Z89 Leach Pad or the new sludge pit on the Z85/86 Leach Pad, where it is run through the high pH sludge to raise its pH level. The pH-adjusted water is then collected in the basin of the Z89 Leach Pad. It is then pumped to the 5,064,000 gallon 82 Pond. From there, the pad water is pumped via pipeline to the pH Pond feeding the Biological Treatment Plant at the Landusky Mine.

Z79/81 Leach Pad – This pad complex has no water storage capacity. The 15.18 acre lined area on this pad is configured to drain directly into the Z89 Leach Pad.

Z82 Leach Pad – Before it was removed and used to backfill the O.K./Ruby Pit complex between 2001 and 2002, the lined area of the Z82 Leach Pad covered 10.68 acres.

Z83 Leach Pad – This pad has a water storage capacity of 8.77 million gallons. Water from the Z83 Pad is currently pumped via pipeline to the Z84 pump house. The lined area of the Z83 Leach Pad covers 12.89 acres. The site access road and a lined diversion ditch run along the edge of the lined area. Otherwise, upland runoff would not drain through this area.

Z84 Leach Pad – This pad has a water storage capacity of 10.37 million gallons. A 100 Hp pump is located in a pump house on the Z84 Dike. The lined area of the Z84 Leach Pad covers 14.20 acres. A diversion ditch routes upland runoff around the west edge of the pad. However, some runoff from the southeast face of the Z80/81 Pad does drain across the lined area.

Z85/86 Leach Pad - This pad has a water storage capacity of 13.88 million gallons. Its pad water is evacuated with a 15 Hp pump that is housed in a pump house on the Z85/86 Dike. A pipeline runs from the pump house to the sludge pit on the Z89 Leach Pad. The lined area of the Z85/86 Leach Pad covers 32.52 acres. This pad complex was constructed across an upper section of Ruby Gulch, so runoff from upland areas had to be diverted around the pad. With reclamation of the pad and the surrounding mine area, a large drainage area is now routed across the lined area of the pad. Runoff from the Ross Pit area, the northern two-thirds of the O.K./Ruby Pit area, and the South Ruby Rock Dump area now drains along the north edge of the pad in a lined diversion channel. However, the southern portion of the O.K./Ruby Pit drains into another unlined tipped-road channel.

Z89 Leach Pad – This pad has a water storage capacity of 17.44 million gallons. It is used as a reservoir to hold the water from the other Zortman Pads before being pumped to the 82 Pond and then transferred to the Biological Treatment Plant. Its 100 Hp pump is located in a pump house on the Z89 Dike. The lined area of the Z89 Leach Pad covers 14.21 acres. One of the Zortman sludge pits is located over the lined area of the pad. Diversion ditches route upland runoff around the north and west edges of the pad.

Table 13 - Summary of Zortman Mine Leach Pad Water Accumulation (Millions of gallons/year)

Year	**Zortman Pad Water** (M gal)	**Zortman Precipitation** (inches)
1999	35	17.26
2000	19	16.39
2001	25	15.35
2002	31	20.44
2003	9	14.95
2004	25	14.40
2005	20	20.05

3.3.1.1.1 Sludge Pit

The sludge pit on the Z89 Pad, which receives sludge from the Zortman Water Treatment Plant, is used as a treatment facility to raise the pH of the waters collected in the Zortman pads prior to transfer to the Biological Treatment Plant at Landusky. The sludge also reduces aluminum from over 1300 mg/l to less than 200 mg/l, and reduces the arsenic from over 3 mg/l to 0.001 mg/l. After running through the sludge pit, the water infiltrates through the spent ore on the Z89 Pad and collects in its lined basin. The water is eventually transferred to the Biological Treatment Plant at the Landusky Mine via the 82 Pond.

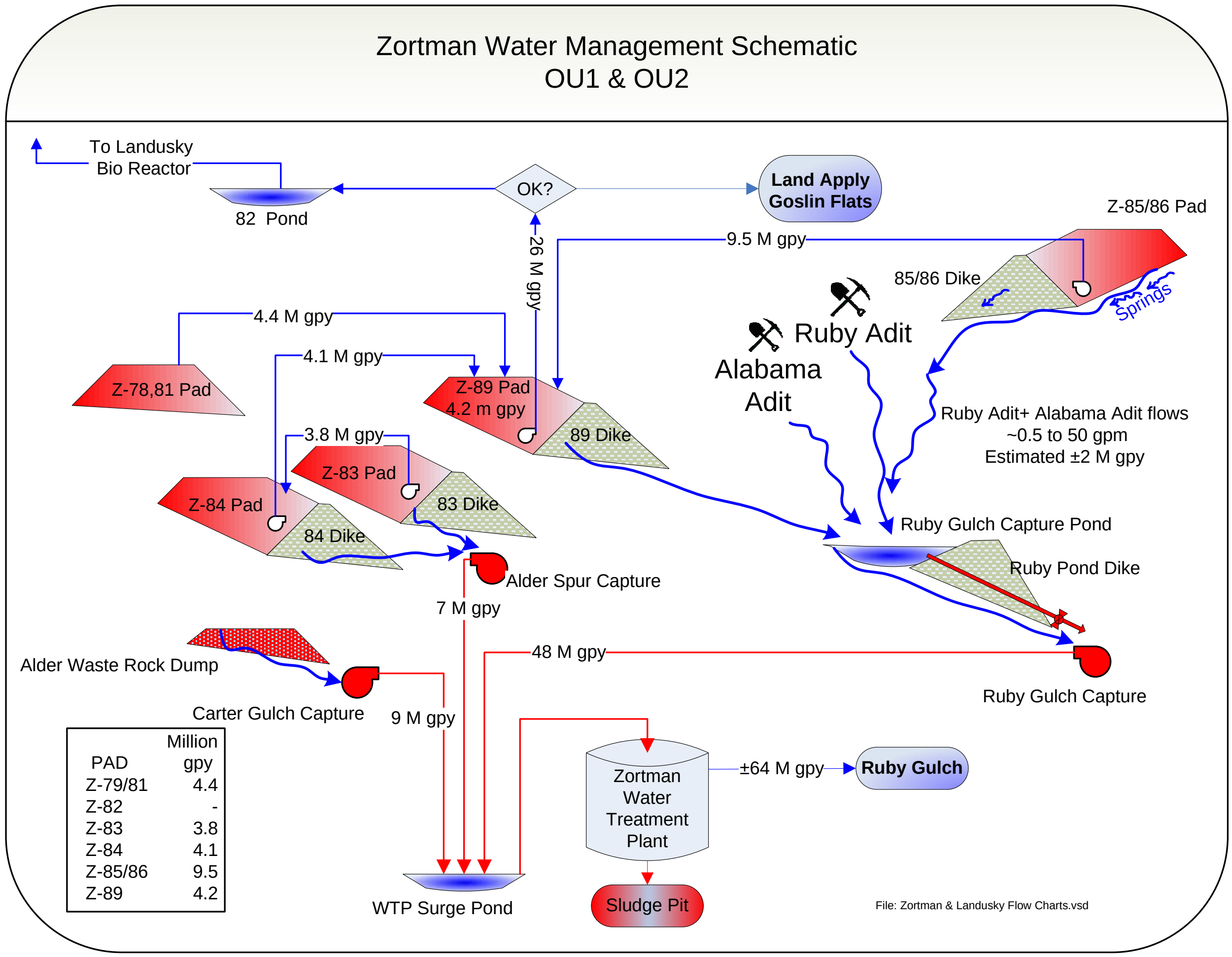
3.3.1.1.2 Hydrogen Peroxide Treatment

For a period, pad water was treated with hydrogen peroxide in the 82 Pond at the Zortman Mine. A mobile tank with a 50% hydrogen peroxide solution fed a metered amount of the 50% solution into the pond. Because hydrogen peroxide is a strong oxidizer, the mixing process converted available cyanide into cyanate. Hydrogen peroxide treatment was stopped in 2004 because it was determined to be ineffective on the remaining cyanide forms.

3.3.1.1.3 Zortman Pond Water Collection

The 82 Pond is used as the Zortman pad water collection and transfer facility. This pond is lined with hyplon and has a holding capacity of 5,064,000 gallons. It covers 0.99 acres and is fenced. All Zortman Mine pad waters are routed to this pond and are subsequently pumped to the Landusky Mine Biological Treatment Plant. A 100 Hp pump is employed at this facility.

Figure 12 - Zortman Mine Water Management Schematic



3.3.2 Landusky Mine Leach Pad Water Collection

There are currently five leach pad water collection systems at the Landusky Mine. The collection system below the L85/86 Pad was removed in 2005 when the entire leach pad was excavated and removed from Montana Gulch. Removal of the L85/86 Leach Pad reduced the total pad liner area to 246.13 acres. All of the leach pads that remain on the Site have been graded and covered with soil reclamation covers. Approximately 50 percent of the rainwater and snowmelt is estimated to infiltrate through these covers. Given the recent five-year average precipitation of 17.52 inches per year, approximately 117 million gallons of precipitation would fall on the reclamation covers over these areas in an average year. With the contribution of dewatering from the water treatment plant sludge of about 3 million gallons per year, the leach pad collection system would accumulate about 60 million gallons in an average year if not for treatment and release.

L79 Leach Pad –The L79 Pad process solution drains by gravity flow into the Barren Pond. The lined area of the L79 Leach Pad covers 1.92 acres. It is located in an area where there is no possibility of surface water run-on.

L80/82 Leach Pad - The L80/82 Pad drains by gravity into the Barren Pond. The lined area of the L80-82 Leach Pad covers 25.27 acres. It is located in an area where there is no possibility of surface water run on.

L83 Leach Pad – This pad has a process water storage capacity of 10.56-million gallons. Water from the L83 Pad is pumped to the Barren Pond before being transferred to the Biological Treatment Plant. Its 100 Hp pump is located on a bench above the Frog Pond Capture System. The lined area of the L83 Leach Pad covers 15.46 acres. The Landusky Water Treatment Plant's sludge pit is located over the lined area of this pad. In addition, the lined area receives surface water runoff from the southwest-facing slope of the L80/82 Pad.

L84 Leach Pad – This pad drains by gravity to the L83 Pad via a pipeline. A valve on the pipe controls the flow. When the valve is closed, 9,540,000 gallons can be stored in the pad basin. The lined area of the L84 Leach Pad covers 11.96 acres. However, surface water runoff from a larger area passes over the lined area. A lined diversion currently drains to the Gold Bug Pond. The stormwater plan calls for removal of this structure.

L85/86 Leach Pad - Before it was removed between 2002 and 2005, the lined area of the L85/86 Leach Pad covered 22.77 acres within Montana Gulch. It was removed to unblock two forks of the Montana Gulch drainage.

L87 Leach Pad - This pad has a storage capacity of 115.70 million gallons. The lined area of the L87 Leach Pad covers 94.08 acres. It is located in an area where there is little possibility of surface water run-on. It is equipped with two 30 Hp submersible pumps to lift water out of its storage basin for transport via pipelines to the Biological Treatment Plant. Its pumps are located near the Nutrient Building on the L87 Dike. The pumps feed into the pH Pond.

L91 Leach Pad and the L87/91 Pad Notch - This pad has a storage capacity of 153.63 million gallons. During reclamation, the lined area of the L91 Leach Pad was extended in a number of areas so that regraded spent ore could be kept on-liner. The leach pad currently covers 97.44 acres. It is located in an area where there is little possibility of surface water run on. It is equipped with two submersible pumps (one 30 Hp pump and one 10 Hp pump) to lift water out of its storage basin for transport via pipelines to the pH Pond at the Biological Treatment Plant. Its pumps are located on top of the L91 Dike, which extends down into Sullivan Park.

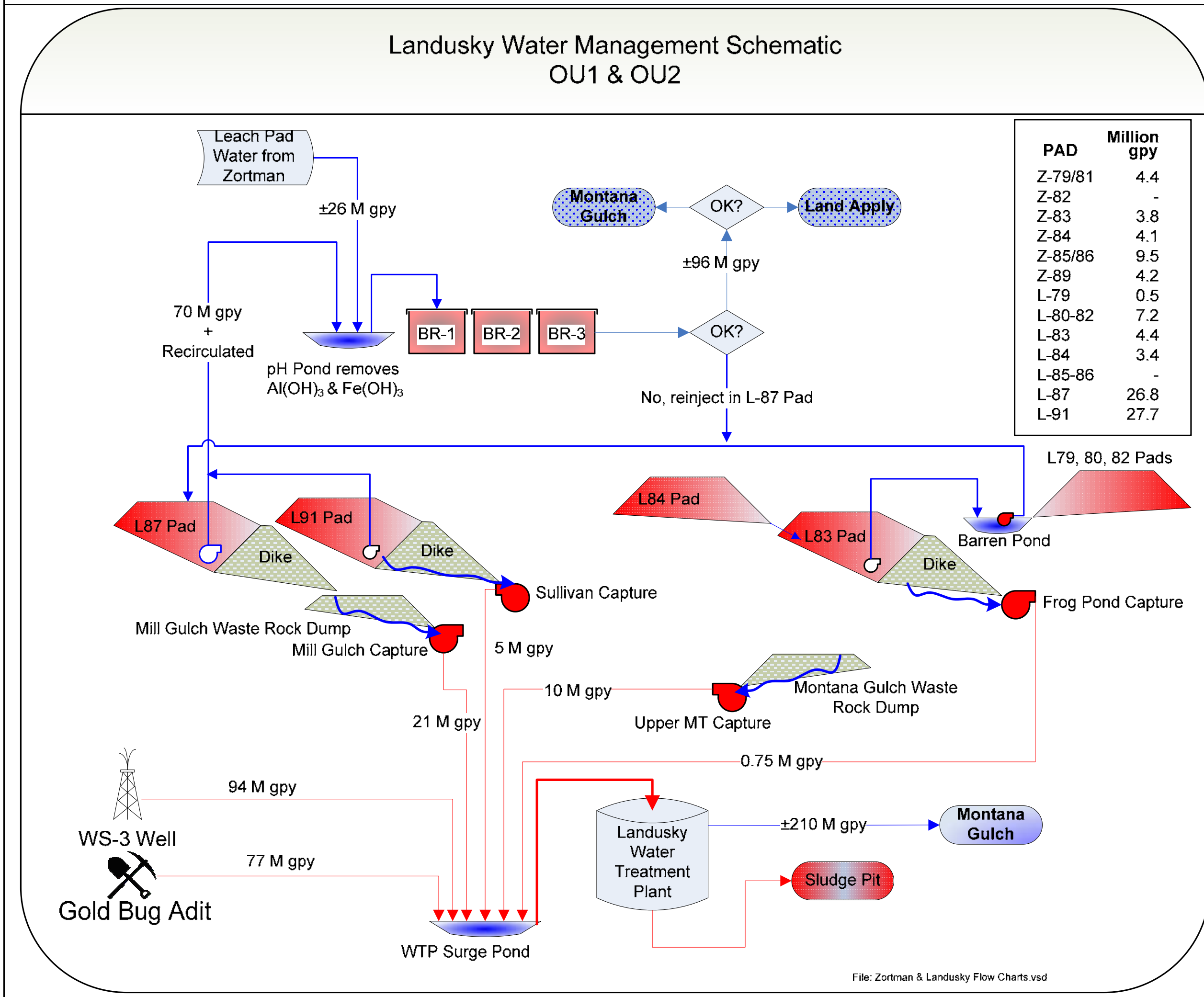
Table 14 - Summary of Landusky Mine Leach Pad Water Accumulation (Millions of gallons/year)

Year	**Landusky Pad Water** (M gal)	**Landusky Precipitation** (inches)
1999	35	15.95
2000	75	16.51
2001	49	15.2
2002	85	21.25
2003	108	17.25
2004	83	15.25
2005	76	18.65

3.3.2.1.1 Landusky Pond Water Collection

The Barren Pond serves as a leach pad water collection and transfer facility. This pond has a holding capacity of 4,604,000 gallons. All of the lower Landusky Mine leach pad waters are routed to this pond and are subsequently pumped, via a 75 Hp pump, to the Biological Treatment Plant.

Figure 13 - Landusky Mine Water Management Schematic



3.3.3 Biological Treatment Plant

The Biological Treatment Plant was built on a bench above the L87 Dike at the Landusky Mine. Treatment operations began on August 29, 2002. It was designed to remove cyanide, selenium, and nitrates from leach pad water using three processing tanks containing carbon bedding, bacteria, and nutrients. This treatment system is equipped with a holding pond where the pH is adjusted to precipitate a portion of the dissolved solids, and with a clarifier system to remove suspended materials from the water prior to entering the bioreactor tanks. Pipelines deliver leach pad waters from the L87 Pad, the L91 Pad, the Landusky Barren Pond (collection pond for the Landusky lower leach pads), and the Zortman 82 Pond (collection pond for the Zortman leach pads). The pH adjustment pond is a 1 million gallon facility where a 50% sodium hydroxide solution is combined with the pad water prior to biological treatment. After pH treatment, the water is clarified by filtering it through diatomaceous earth. This pre-filtering process is necessary to prevent clogging and to extend the functional life of the expensive carbon media in the bioreactor tanks.

The three reactors have a designed throughput capacity of 300 gallons per minute (gpm). However, the throughput is water quality dependent. Hence, the plant is typically operated in a range between 75 gpm and 200 gpm.

The processed water drains to the Montana Gulch Pond, where it is aerated prior to release into the Montana Gulch after being mixed with the water treatment plant discharge in the Montana Gulch Pond. The biological treatment process does not break the strongly bonded metal cyanide complexes. Treated water produced by the treatment facilities currently meets all human health standards at its discharge point. Although in some cases, this water does not meet all aquatic standards as it exits the Montana Gulch Pond. All standards are met at the Site boundary.

Figure 14 – Biological Treatment Plant Schematic (OU2)

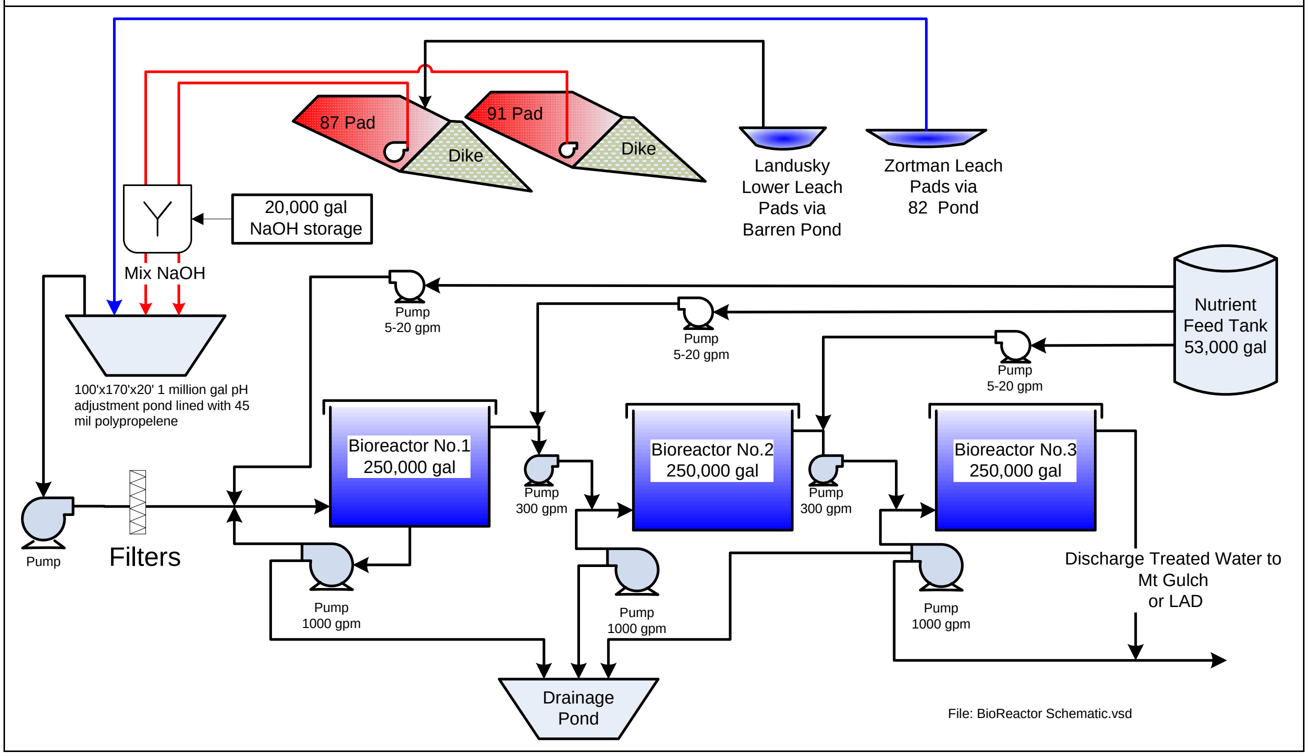


Table 15 - Biological Treatment Plant Quantities and Fate of Output				
Year	Total Water Processed (Gallons)	Biological Treatment Plant Output (Gallons)		
		Reinjected Into L87 Leach Pad	Discharge to Montana Gulch	Transfered to Landusky WTP Then MT Gulch
8/29/2002 – 12/31/2002	17,034,800	17,034,800	0	0
2003	60,679,700	60,679,700	0	0
2004	51,946,300	34,387,800	1,918,900	15,639,600
2005	44,963,100	6,312,000	37,515,800	1,134,500
Total Gallons	174,623,900	118,415,100	39,434,700	16,774,100

The biological treatment system has been successful at removing selenium and nitrates to very low levels. The biological system combined with the pH pre-treatment also removes other heavy metals. However, total cyanide reduction has not achieved the same level of success. This is because the bulk of the residual cyanide is bound up in metal complexes. Although most of these complexes can be digested with hot sulfuric acid allowing laboratory measurement of the cyanide content, biological treatment, as well as other natural processes, have little affect on these cyanide complexes.

Figure 15 – Average Bio Plant & Leach Pad Analyses for 2005

	BioPlant Effluent	L-79	L-81	L-83	L-84	L-87	L-91	Z-89	Average
GPM	182.6	1.0	13.7	8.4	6.5	51.0	52.7	49.5	182.6
As	0.000	0.102	0.073	0.000	0.000	0.023	0.125	0.000	0.048
Cd	0.012	0.035	0.000	0.010	0.066	0.402	0.595	0.388	0.392
CN_{total}	0.230	0.200	0.210	0.286	0.393	0.255	0.458	0.195	0.300
CN_{wad}	0.131	0.110	0.108	0.109	0.122	0.051	0.197	0.092	0.131*
Cu	0.115	1.050	0.014	0.017	0.095	5.074	8.460	1.563	4.291
N+N	0.3	284.00	382.00	81.20	105.00	178.40	238.00	94.20	181.6
Ni	0.144	0.190	0.000	0.140	0.640	3.084	5.010	4.000	3.420
Se	0.08	0.072	0.066	0.054	0.056	0.580	1.187	0.053	0.529
Zn	1.0	5.0	0.1	1.0	6.8	24.9	44.0	41.6	31.2

* Note that different pads are treated by the bioplant at different times of the year, so the averages are only approximate. The computed average feed CN_{wad} was 0.114 mg/L and the average effluent was 0.131, which is illogical. The discrepancy is because the effluent samples only represent the pads being treated that day, and do not reflect the weighted annual average of all pads. Z-89 represents all the Zortman Pads, because they are all run through this pad.

Nutrient Building - This 55 foot by 100 foot steel building houses a 10 foot high by 30-foot diameter (53,000 gallon) storage and mixing tank for the molasses-based Custom Nutrient BBC-L-100, which after being properly mixed is pumped into the bioreactors to feed the microbes. Storage and mixing have engineering controls that relieve the plant operator from handling the custom nutrient. Custom Nutrient BBC-L-100 is not hazardous unless it is allowed to ferment. Consequently, inspection and controls are required to prevent this from occurring. Nonetheless, the use of the nutrients gives all biologically treated water an unpleasant odor.

pH Adjustment Pond - This unit consists of a 1 million gallon, polypropylene-lined pond (100 feet by 170 feet by 20 feet deep) and a 20,000 gallon storage tank (12 foot diameter by 24 feet high) for the 50% sodium hydroxide solution, which is fed into the pond and mixed with leach pad water. The tank and the pond are outside facilities. Storage and mixing of the 50% sodium hydroxide solution have engineering controls to eliminate the need for the plant operator to handle this material. The 50% sodium hydroxide solution is used to raise the pH of the water enough to cause aluminum and some other minor heavy metals to drop out of solution and collect in the bottom of the pond. Sodium hydroxide is classified as a corrosive. The large lined pond is used to provide adequate holding time for pH adjustment and the precipitation of metals (primarily aluminum). Water from the pond is pumped into Bioreactor Number One after running through the clarifier.

Crystal Clarifiers - The Nutrient Building also houses the Crystal Clarifiers, pumps, and pipes that are used to filter pre-treatment water from the leach pads. Pallet storage for bags of Celatom FW-18 (Diatomaceous Earth Flux-Calcined), which is used as the filter media inside the Crystal Clarifiers, is also provided inside this building. Waste products from the clarifiers are pumped to a pit where residual water is allowed to drain out. The waste is then buried.

Bioreactors - There are three insulated bioreactors. Each bioreactor consists of a 250,000-gallon tank that is 43 feet in diameter and 24 feet high and is filled with carbon media and several types of microbes. Nutrients are periodically mixed and pumped to the bioreactors to feed the microbes. The pH adjusted water is pumped into the reactors where it resides for a period of time allowing the microbes to remove the selenium, nitrates, and residual WAD cyanide. After a number of years of use, the carbon media will become so laden with waste products that it will need to be removed and replaced. The used carbon media will be processed offsite.

3.4 GOSLIN FLATS LAD CHARACTERIZATION

In anticipation of the Zortman Mine expansion, proposed to include construction of a heap leach facility in the Goslin Flats area, ZMI purchased approximately 1167 acres from Square Butte Grazing Association in September of 1991. This land is approximately one mile south of the town of Zortman and is on the eastern flank of Saddle Butte. It includes most of Goslin Gulch and a section of Ruby Creek. By late 1994, ZMI recognized that this area might also be used for water disposal. ZMI developed a 55-acre Land Application Disposal area (LAD) within the Goslin Gulch basin and began operating it in 1998 to release waters accumulating in the leach pads. The land application area was expanded in 1999 to 96 acres. The LAD was expanded again to 410 acres during 2000. Although the ZMI bankruptcy trustee sold the Goslin Flats property back to Square Butte Grazing Association in 2001, rights for the continual use the property for any mine related function were reserved. Hence, LAD operations have continued after the sale and will continue in the foreseeable future.

Monitoring of the surface water, groundwater, soils, and vegetation in the LAD area is part of the removal action operating plan. Prior to expanding the LAD to 410 acres in 2000, the *Goslin Flats Land Application Disposal Expansion Assessment* was prepared. Modifications to the LAD operating plan have been made since 2000 in order to prevent the buildup of salts and selenium and the discharge of cyanide. The present LAD area covers 204 acres and includes 2687 spray heads that have been adjusted to provide zero surface runoff from the area. The water is conveyed down to the LAD site via pipeline where it is directed through smaller pipes to various application areas and sprayed over the ground by elevated sprinklers. The application areas are managed as irrigated hay fields that are either grazed or harvested as beneficial agricultural production. Because the native soils attenuate the migration of metals and other substances from the pad waters and the vegetation consumes the water, the soils and vegetation on the LAD site are monitored as part of the management plan. The DEQ has conducted a soils and vegetation LAD sampling program that has cost in excess of $200,000.

In the LAD area, a relatively thin layer of topsoil typically covers one to two feet of colluvium. Underlying alluvial deposits range in thickness from a few feet to 35 feet or more, with deposits greater than 48 feet found near Ruby Creek. The alluvium typically consists of variable amounts of gravel, sand, silt and clay. Older alluvium, overlying the bedrock formations, usually consists of gravels and cobbles with thin lenses of silty clay and stratified sand.

Below the alluvial material is the Thermopolis Shale Formation, which is typically calcareous with occasional siltstone and limestone beds. Under the Thermopolis shales are various shallow dipping, siltstone, sandstone, and shale units of the Kootenai Formation.

Prior to construction of the Biological Treatment Plant at the Landusky Mine, land application was employed as a primary method for disposal of water collected in the Zortman and Landusky leach pads. During 2005, all leach pad water was processed at the Landusky Mine Biological Treatment Plant and discharged in Montana Gulch.

Figure 16 - Goslin Flats LAD Area Schematic

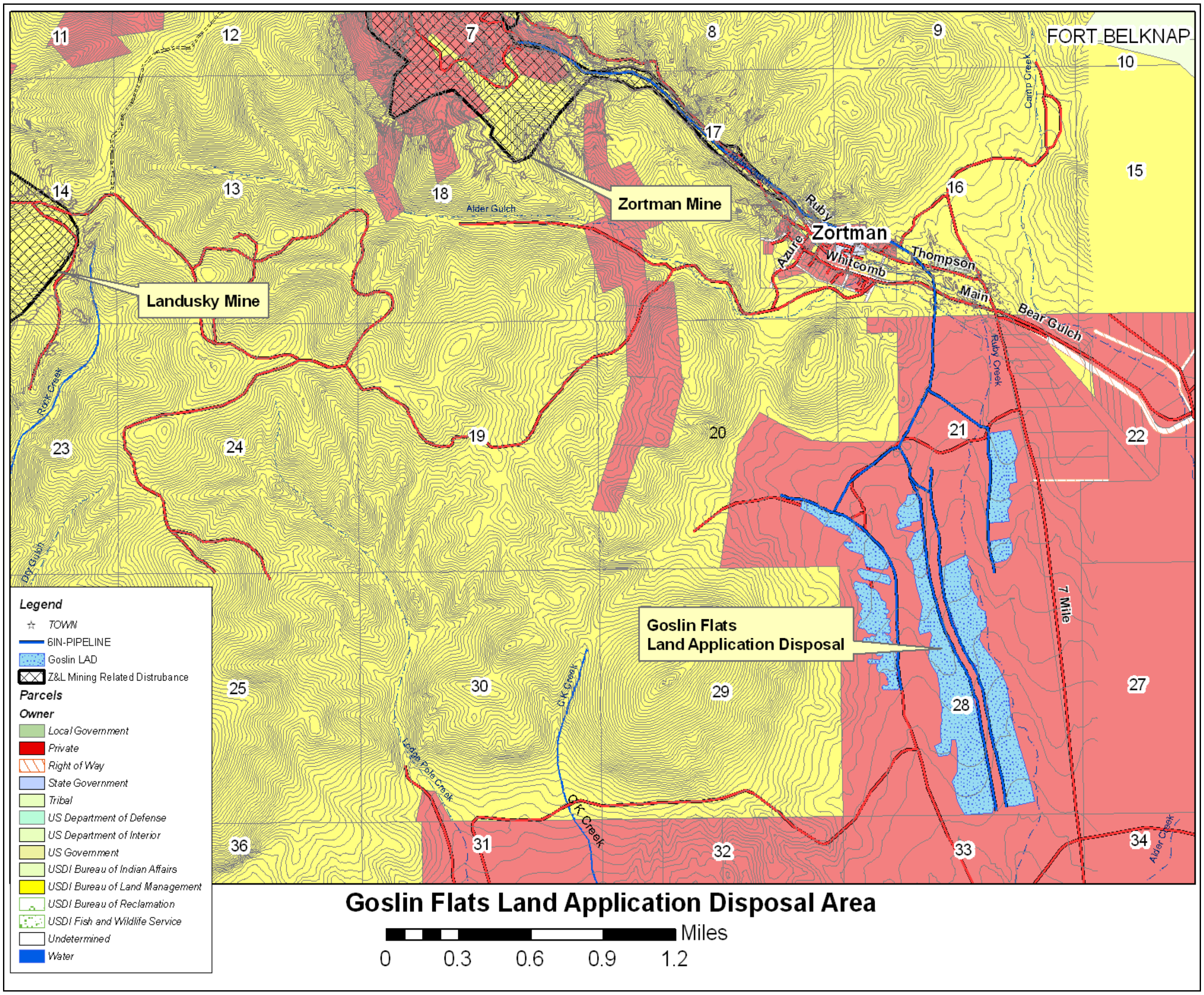


Table 16 - Summary of Goslin Flats LAD Disposal Quantities			
Year	Zortman Pads	Landusky Pads	Total Land Applied Water
June-Dec 1998	42,878,860	64,314,940	107,193,800
1999	36,733,600	70,831,399	107,564,999
2000	23,744,800	113,254,600	136,999,400
2001	23,201,905	116,563,395	139,765,300
2002	33,343,700	18,444,000	51,787,700
2003	13,746,000	81,905,100	95,651,100
2004	22,707,800	49,298,800	72,006,600
2005	0	0	0

Goslin Flats Land Application Disposal Area in Operation.

3.5 SAMPLING AND ANALYSES PLAN

The sampling and analyses plan is to be modified to reflect current site conditions. The plan is to continue the daily practice of monitoring the two mine drainage discharge points at site 591 (discharge from the Montana Gulch Pond) which indicates the discharge from the Landusky Water Treatment Plant and the Biological Treatment Plant and site 667 (discharge from the Zortman Water Treatment Plant). These discharges will be laboratory sampled monthly. All surface water sites will be sampled quarterly. All King Creek and Swift Gulch surface water will be sampled quarterly. Stormwater will be sampled when it occurs. The Zortman and Landusky mine primary groundwater wells will be sampled twice yearly. Wells of less importance will be sampled yearly. The Goslin Flats LAD will be sampled twice a year. Other sampling will be performed as required. Table 17 shows the sample sites, the sample frequency, and the parameters to be analyzed. Additional sampling will occur in Swift Gulch and King Creek as part of installation of OU4 and OU5, respectively. More intensive sampling will occur in response to adverse monitoring results or for general characterization purposes when needed.

Table 17 - Sampling and Analyses Plan

Sampling Locations and Frequency					
AREA / Category		Sites or Analytes	Surface Water	Ground Water	Sample Frequency
ZORTMAN MINE					
Groundwater Wells		AG-202 and ZL-323 (Alder Gulch) ZL-142 (Ruby Gulch) Z-8A (Zortman Town Water Supply) ZL-209 (Glory Hole Creek)		X	Twice per year
Surface Water Sites		Z-8 (Alder Gulch) Z-100 and Z-101 (Ruby Gulch) Z-5 and S-1 (Glory Hole Creek)	X		Quarterly
Mine Drainage		667 (ZWTP Discharge into Ruby)	X		Monthly
Capture System Overflows		695 (Carter Gulch Pumpback) 692 (Alder Spur Pumpback) 693 (Ruby Gulch Capture Pond) 696 (Ruby Gulch Pumpback)	X		Every occurrence
Stormwater Sites		609 (Carter Gulch) 606 and 607 (Alder Spur)	X		As occurred, once per year
LANDUSKY MINE					
Groundwater Wells		ZL-308 and ZL-310 (Rock Creek) ZL-136 (Mill Gulch) ZL-113, ZL-319, ZL- 124 (MT Gulch) ZL-315 (Swift Gulch) ZL-303 and ZL-139 (King Creek)		X	Twice per year
Surface Water Sites		RCSS-10 (Rock Creek) L-22 (Mill Gulch) D-7 (Montana Gulch)	X		Quarterly
Surface Water Sites (King Creek and Swift Gulch)		BKSP-2E, L-48A, L-48 (South Big Horn/Swift) L-39 (King Creek)	X		Monthly as weather permits, about 8 times per year
Mine Drainage		591 (MT Gulch Pond Discharge) (this includes the BR3 discharge)	X		Monthly
Capture System Overflows		595 (Sullivan Capture) 598 (Mill Gulch Capture)	X		Every occurrence
Stormwater Sites		520 (Rock Creek) 505 (Sullivan Gulch) 506 (Mill Gulch) 512 (Montana Gulch) 596 (King Creek)	X		As occurred, once per year

Sampling Locations and Frequency (continued)				
AREA / Category	Sites or Analytes	Surface Water	Ground Water	Sample Frequency
GOSLIN FLATS LAD				
Surface Water Sites	Z-22, Z-22C, R-22	X		Twice per year
Groundwater Wells	ZL-211, ZL-212		X	Twice per year
RESEARCH SITES-LANDUSKY MINE		Sampled for next couple of years		
Groundwater Wells	ZL-204, ZL-313, ZL-314 (N side Suprise Pit)		X	Quarterly
Surface Water Sites	BKSS-1, L-19, L-49 (South Big Horn/Swift) L-5 (King Creek) or as moved per new passive treatment system	X		Monthly as weather permits, about 8 times per year
ON-GOING OPERATIONS				
Leach Pads, Bio Plant, and capture systems	As required for operation including all Pads, WS-3, L-3, L-12, L-27, L-36, L-38, Z-13, Z-14, Z-37			Once per year, if needed.

Table 18 - Sampling and Analyses Plan
Laboratory Analyses

Category	Category	Analyte	Surface Water	Ground Water
FIELD PARAMETERS		Flow Rate	yes	yes
		Specific Conductance	yes	yes
		Visual Sheen	yes	yes
		pH	yes	yes
PHYSICAL PROPERTIES		pH	yes	yes
		Conductivity	yes	yes
INORGANICS		Alkalinity, Total as $CaCO_3$	yes	yes
		Acidity, Total as $CaCO_3$ if pH is < than 4.5	yes	yes
		Sulfate	yes	yes
		Cyanide-Total Manual	yes	yes
		Cyanide-WAD	yes if Total CN	yes if Total CN
		Hardness as $CaCO_3$	yes	yes
NUTRIENTS		Nitrogen, Ammonia as N	yes	yes
		Nitrogen, Nitrate+Nitrite as N	yes	yes
METALS, TOTAL RECOVERABLE			yes	no
METALS, DISSOLVED			no	yes
		Aluminum	no	yes
		Arsenic	yes	yes
		Cadmium	yes	yes
		Copper	yes	yes
		Iron	yes	yes
		Manganese	yes	yes
		Nickel	yes	yes
		Selenium	yes	yes
		Zinc	yes	yes

3.6 SITE COSTS

3.6.1 Labor and Management Requirements

3.6.1.1 Operation Times

Currently the Landusky Mine water treatment plant operates 24 hours per day, 7 days per week, 363 days per year with Christmas and Thanksgiving day off. The Zortman Mine water treatment plant operates 10 hours per day, approximately 6 to 31 days per month depending on the time of year. The biological treatment plant is scheduled to operate 24 hours per day, 7 days per week, 363 days per year.

3.6.1.2 Labor Requirements and Scheduling

The current operation has seven total personnel. This includes four certified waste water treatment plant operators, one electrician, one office clerk/water sampler, and one site manager. The four water treatment plant operators are scheduled with eight days on and six days off. This allows extra staffing (full seven people) every Wednesday to accomplish bigger tasks. Monday, Tuesday, and Thursday there are five people on site. Friday, Saturday, and Sunday there are two people on site. The detailed job descriptions for the staff is presented in the Appendix.

3.6.1.3 Labor Costs

For 2006, labor costs are 42% of the total operating cost of the entire operation. The $632,462 includes the operation reduction to 7 employees in February 2006.

3.6.2 Chemicals

3.6.2.1 Chemicals Used to Treat Water

- Hazardous-Corrosive and/or Toxic
  - Hydrated Lime $Ca(OH)2$ - Both Water Treatment Plants
  - Sodium Hydroxide 50% - pH Pond
  - Ferric Sulfate 68% Liquid - Zortman Water Treatment Plant
- Heath Risk- Lungs and/or Ingestion
  - Celatom FW-18 (Diatomaceous Earth Flux-Calcined)
  - Magnafloc 10 - Both Water Treatment Plants (Contains 0.1% 2-propenamide)
- Storage/Handling Precautions
  - Molasses Based Custom Nutrient BBC-L-100 – Biological Treatment Plant Nutrient Building
  - Carbon Media - Biological Treatment Plant
  - Microbes - Biological Treatment Plant Reactors
- Flammable/Explosive
  - Petroleum Based Lubricants, Oils, and Gear Oils
  - Petroleum Based Fuels (Diesel and Gasoline)

- o Propane - Landusky Water Treatment Plant, Zortman Water Treatment Plant, Shop/Office complex, and Fuel Farm

3.6.2.2 Process Generated Materials

- **pH Pond Water** - Sodium Hydroxide 50% solution is added to untreated water at the biological treatment plant pond causing aluminum to precipitate out and collect in the bottom of the pond.
- **Spent Clarifier Filter Material** - Leach pad water is filtered though Celatom FW-18 (Diatomaceous Earth Flux-Calcined) to remove suspended solids prior to being sent to the bioreactors in the Biological Treatment Plant. The spent material is buried.
- **Spent Reactor Media** - After many years of service the carbon media in the reactors will need to be removed and replaced. The carbon will contain heavy metals and will be shipped off-site for processing.
- **Water Treatment Plant Sludge** - This is a slurry created by mixing the treatment plant precipitate with process water. Various compounds containing the heavy metals are precipitated out of solution during the treatment process. The addition of Magnafloc 10 helps these compounds fall out of suspension.

3.6.2.3 Chemical Costs

The chemical costs account for $329,516 or 22% of the total annual operating costs for the Site.

3.6.3 Power and Heat

Power is supplied by Big Flat Electric Cooperative and gas, diesel, and propane is supplied from Ezzie's Wholesale. The power and heating costs for 2006 are estimated at $269,112. This is 17.9% of the $1,500,000 overall Site budget.

3.6.4 Other Expenses

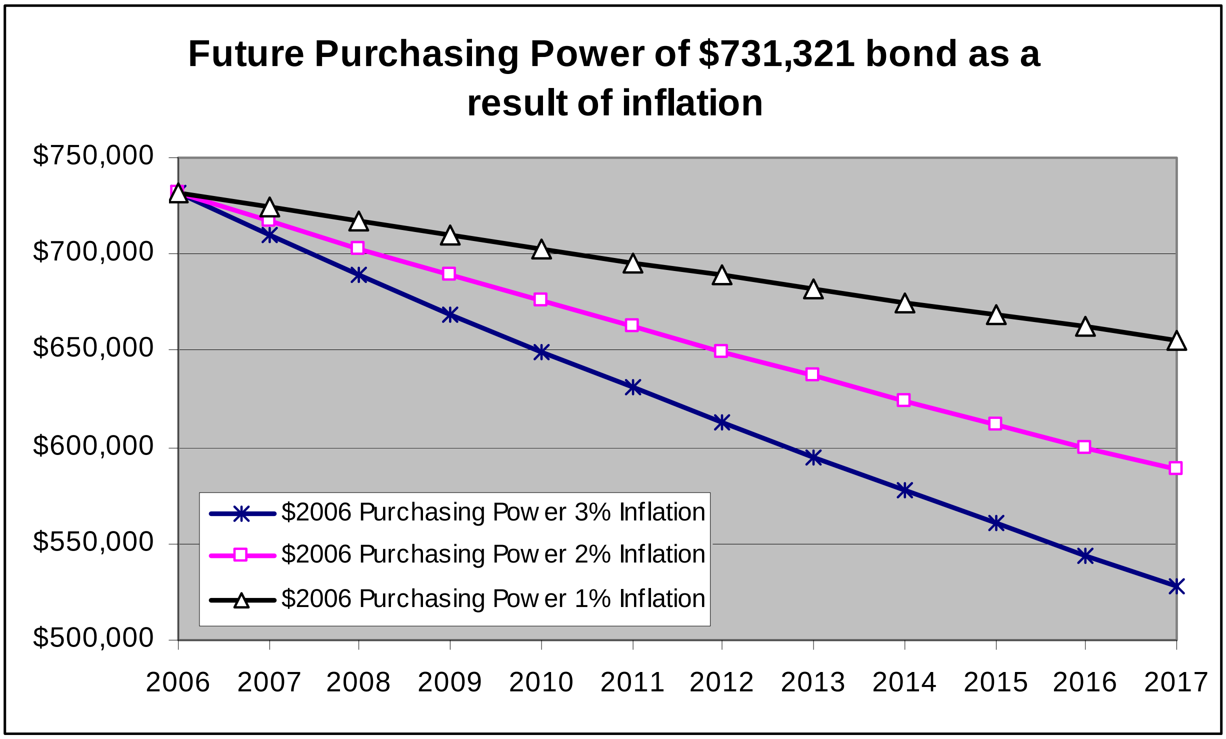
All of the other expenses include tools, parts, supplies, equipment repairs, general office, phone, and lab analyses. This totals $268,970 or 17.9% of the Site budget.

3.7 ISSUES OF CONCERN AND RISK ASSESSMENT

3.7.1 Funding

Presently, the cost to continue to operate the water monitoring, collection and treatment systems at the Zortman and Landusky mines is approximately $1,500,000 per year (in $2006). The available annual funding (water treatment bond) through year 2017 is $731,321, leaving an annual unfunded deficit of about $769,000. The funding payment from the reclamation bond is fixed, not adjusting for inflation. Inflation will cause the purchasing power of the annual bond payment to erode each year as illustrated below.

Figure 17 – Decreasing Value of Existing Bond

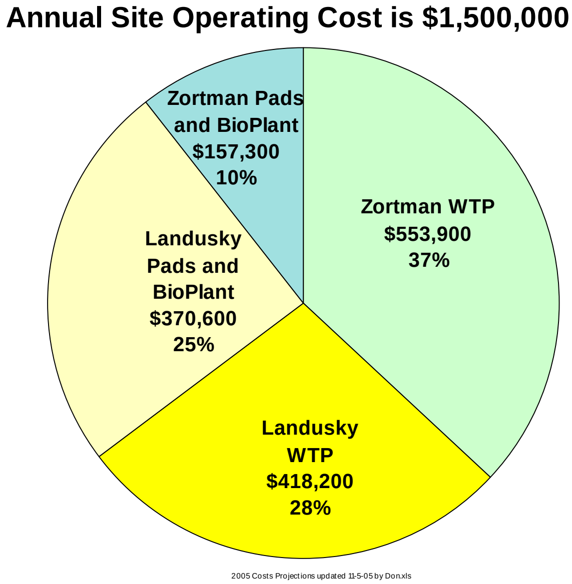


The 2006 tasks requiring funding are:

- Zortman Water Treatment Plant, capturing and treating the acidic seeps and two adit flows for numerous metals including arsenic and low pH with conventional hydrated lime style water treatment and a ferric sulfate circuit
- Landusky Water Treatment Plant, capturing and treating the acidic seeps, one adit flow and one artesian well for numerous metals and low pH with conventional hydrated lime style water treatment
- Biological Treatment Plant, capturing and treating water from five Zortman Mine each pads and six Landusky Mine leach pads for elevated nitrates, selenium, and WAD cyanide. pH adjustment is required to raise the pH and precipitate aluminum and other metals.

The 2006 annual budget needed to perform each of these current tasks is summarized in the pie chart below:

Figure 18 – Base Case Operating Cost



In order to stay within the $731,321 funding, and recognizing that the purchasing power of this money will drop every year, two of the three functions must be either eliminated or completely revamped.

In the long-term, beginning in year 2018, the surety funding, RIT funding, and House Bill 379 trust fund will provide for a $33.9 million trust fund beginning on January 1, 2018. This trust fund is to pay for water treatment in years 2018 and beyond. This trust fund can provide perpetual funding if the funds earn an annualized average return of 8%, inflation stays at no more than 2.39%, and operating constraints/conditions are more or less stable. If the net difference (average return minus inflation) is less than 5.61% (8%-2.39%), then there will eventually be a shortfall in funding. Achieving real interest rates greater than about 3% will require investing in non-government backed securities.

3.7.2 Leach Pad Waters

An innovative biological treatment plant was constructed at the Landusky Mine. This biological treatment plant does a good job treating discharge from the leach pads, but as the pads became more acidic the chemistry caused aluminum and iron hydroxide precipitates to foul the bioreactors. The solution to this problem has been to neutralize the water by adding NaOH into a pond to precipitate the metals before the water enters the first reactor. As many of the leach pads continue to become more acidic, their chemistry is approaching the chemistry of the acid seeps that are treated in the conventional lime water treatment plants.

At the Zortman Mine, the pH of all the leach pads is being amended by passing the pad water through the caustic water treatment plant sludge on the Z89 leach pad. Lab testing shows that the sludge is chemically stable down to about 3.8 pH. Spectrum Engineering is carefully monitoring this practice, since there is a risk that running acid water through the sludge will remobilize the metals in the precipitates. On the other hand, the ferric hydroxides in the sludge are reducing the arsenic from 3 to 0.001 ppm, and the practice is also reducing many of the other metals. Consequently, when the Zortman leach pad water is run through the biological treatment plant at the Landusky Mine, the plant operates more efficiently than when running leach pad water from the Landusky Mine. Since all the Zortman Mine water passed through the sludge is captured in the Z89 leach pad, there is no risk to the environment and the practice is reducing both the operating costs and the arsenic content.

One of the benefits of the bioreactors is their ability to reduce many of the heavy metals such as arsenic, cadmium, nickel, and zinc in addition to its intended goal of reducing nitrates and selenium. Since the plant was not designed to reduce these other metals, Dr. Adams (the designer of the plant) believes that the performance might be improved by adjusting some of the operating parameters.

The water quality from the leach pads and the water treatment plants are summarized in Tables 2 and 3. Note the reduction in the heavy metals from the leach pad solution after they are passed through the pH pond and bioreactor. This suggests that biological processes do a reasonably good job reducing the metals. But since the water is pretreated at a high pH to precipitate the aluminum and iron it is not known what proportion of the metals is being removed by the pretreatment and what is being removed biologically. This would require additional analytical testing and monitoring.

The point discharge from the bio and water treatment plants does not always satisfy the most stringent component of Montana's WQB-7 standards (which is usually the chronic aquatic standard). Although the treatment plants regularly meet all the primary human health standards, Thallium (which is not regularly assayed) appears to be fluctuating around 0.003 mg/l and the chronic human health standard is 0.00024 mg/l.

Discharge from the Landusky Mine water treatment plant as it enters the Montana Gulch Pond slightly exceeds the aquatic standards for total cyanide, selenium and zinc. During November, 2005, surface water samples were taken at the following locations: Water treatment and biological treatment discharge into the Montana Pond (site 591); below the Montana Gulch Pond (site L-16); near the Montana Gulch Campground (site L-47); near the Francis Kolczak ranch (site L-1); Rock Creek at Warm Springs; Rock Creek at Highway 191; and the JD Reservoir outflow (pond south of Highway 191). The analyses shows that the water satisfies all ARARs before it exits the Site Boundary.

If the leach pads are allowed to drain by puncturing the liners or letting them overflow their embankments, most of the water would report to the capture systems where the flows would exceed the capture system capacity. Some of the water would report to the water treatment plant (increasing the power and chemical consumption) and some would run down the drainages and either report to groundwater or contribute to a small surface flow of acidic noncompliant nitrates, selenium, and other metals.

Uncaptured and untreated leach pad water could expose humans to contaminants by affecting shallow domestic water supply wells in the town of Landusky. It is not know what effect leach solutions would have on the Zortman town well.

3.7.3 ARD Water

Acid rock drainage with elevated levels of heavy metals and sulfates exist. The major acid sources are the L87 and L91 Leach Pads at the Landusky Mine, the Z85/86 Leach Pad at the Zortman Mine (all the pads are acidic, but the Z85/86 is the worst), the Sullivan Gulch, Mill Gulch, Montana Gulch, Carter Gulch, Alder Spur, and Ruby Gulch capture systems that collect acidic water from the dike embankments and possibly from acidic materials used to construct the pads. In addition, acid rock drainage drains from the Ruby and Alabama adits at the Zortman Mine and the Gold Bug Adit at the Landusky Mine.

Uncaptured and untreated ARD is subject to human exposure by contamination of shallow domestic waster supply wells in the town of Landusky and would have an unknown effect on the Zortman town well.

3.7.4 Natural Acidic Water

Naturally acidic water and water with naturally elevated metals is present on and near the Site. Ferricrete deposits, which indicate ancient to historic events of pyrite oxidation, are present in many drainage on or near the Site. Ferricrete deposits occur in Alder Gulch, Mill Gulch, Sullivan Gulch, and Swift Gulch to name a few examples. Most of the water from artesian well WS-3 is an example of naturally occurring mineralized or acidic water.

The water chemistry in Swift Gulch, as measured at L-19, began to decline in 1998. A recent study was made to try and determine the baseline conditions in this drainage (HydroSolutions, 2005). The results were inconclusive as to the relationship between the naturally occurring acid generating-ferricrete system in the drainage, and the influence of recent or historic mining operations. Additional monitoring and studies are planned for 2006 and possibly 2007.

The water quality from an artesian well (WS-3) has slightly declined recently, indicating a mining (or reclamation) related influence. This well could be plugged, but the consequences of plugging it might include creating other water quality problems such as in Swift Gulch.

3.7.5 King Creek

The current OU1 system at the Landusky Mine does not include capture or treatment of water that drains north towards the Fort Belknap Indian Reservation in King Creek. Although virtually all of the King Creek tailings and their associated concentrations of lead, arsenic, selenium, and cadmium have been removed from the drainage, there remains on-going concern regarding the water flowing to the northwest. Selenium, at sample site L-39 on the Reservation boundary, has ranged from 0.001 to 0.048 mg/L (4/1998) with the most recent sample being 0.008 on 5/9/2005. Nitrates typically are close to 20 mg/L at sample site L-5.

Two mine-related structures remain in King Creek. First, when ZMI removed the upper tailings in 1993, they also removed and rebuilt the Cumberland Dam on bedrock after removing the tailings under it. This dam serves as a sediment trap and water energy dissipation structure. The second structure is an interception trench. Located 875 feet upstream from the Cumberland Dam, it was installed by ZMI after agency approval of the modified design plans submitted by William E. Payne and Associates in September, 1996. Surface sample site L-5 is the overflow from this small interception system.

This is little to no risk of exposure by allowing this uncaptured and untreated water to flow down King Creek.

3.7.6 Previous Investigations

Previous studies, as well as, the 1996 EIS and the 2001 SEIS looked at the water issues and other site problems. See also Section 9, References.

3.7.6.1 Waters Flowing North

In September 1995, the Fort Belknap Indian Community Council petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the Landusky and Zortman, open-pit, cyanide heap leaching, gold mines located adjacent to the south end of the Fort Belknap Reservation. The Council believed the mines posed a health hazard to the people of the reservation by releasing toxic substances into the environment, especially into drinking water supplies. Concerns were raised by community residents in the petition letter and subsequent meetings with ATSDR representatives about the quality of the drinking water and pollution of surface water, sediments, and air on the Reservation. During November, 1995, ATSDR conducted a site visit to Fort Belknap Reservation to meet with the Fort Belknap Community Council about its concerns and then again in 1996 to conduct public availability sessions in

Hays, Lodgepole, Landusky, Fort Belknap Agency, and Malta. The results of the ATSDR investigation were presented to the Fort Belknap Community Council in May, 1996.

Data from the drainages flowing in the direction of Fort Belknap and groundwater were reviewed to determine what contaminants were present at concentrations above the ATSDR comparison values. The levels detected do not pose a health threat, and subsequent sampling failed to show any contamination. Private well water has elevated levels of naturally occurring salts and minerals, however the levels are not expected to cause adverse health effects.

Based on the data reviewed, ATSDR concluded that the gold mining operations were no apparent public health hazard to the residents of Fort Belknap (ATSDR, 1999).

There are no leach pads, solution-holding facilities, or impoundments that contain contaminated water located in drainages where a release would flow to the north. All the leach pads, capture system ponds, water treatment plants, and LAD area are in drainage basins that flow south.

3.7.6.2 Cyanide Spills

There have been several releases of cyanide solutions from the Zortman and Landusky mines.

- A leach pad pipe broke in 1982, causing the release of about 50,000 gallons of cyanide solution into Alder Gulch. Following the spill, cyanide was detected in the Zortman trailer court water supply, which consisted of a cistern located in the alluvial stream channel of Alder Gulch. As a result, ZMI had a community well drilled that now supplies the entire Zortman community (Pegasus Gold, 1993).
- Ore slippage in 1985 on the Z85/86 heap leach pad resulted in a breach of the lining system, resulting in a loss of cyanide solution. Low concentrations of cyanide were then detected in Ruby Gulch (Pegasus Gold, 1993).
- The Landusky Mine barren cyanide solution pond experienced a liner leak in 1988 and cyanide was detected in a monitoring well adjacent to the pond (Pegasus Gold, 1993).
- A seam failure occurred on a process pond liner installed for ZMI in 1993 by a third party contractor, leading to a release of cyanide. Because of the release, ZMI monitored private wells in Landusky. No cyanide was reported to be detected in those samples (ATSDR, 1995a).

Based on an evaluation of site monitoring data, no removal action is required to address the above releases. The operator's initial response to the spill event, and the natural cyanide degradation that has since occurred, have reduced the affect of these releases to levels that do not warrant further action.

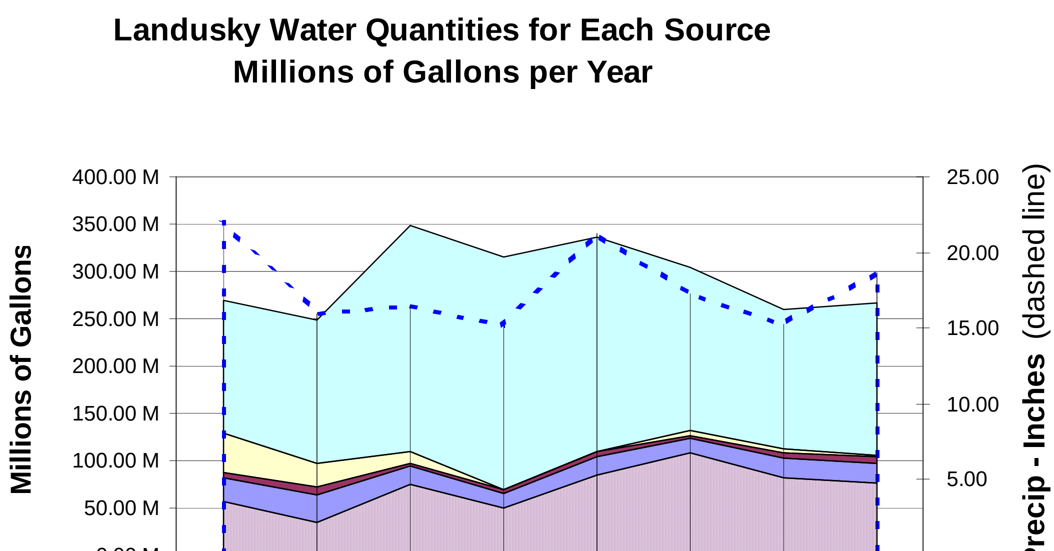
No commercial cyanide products are currently stored or utilized at the mines. All processes that employed cyanide were discontinued prior to the bankruptcy of ZMI. Only trace quantities of residual cyanide remain from the leaching process.

4.0 SOURCES, NATURE AND EXTENT OF CONTAMINATION

4.1 SUMMARY OF QUANTITY AND QUALITY OF WATER BY SOURCE

The quantity of water by source for each of the two mine areas is shown in the figures below. In general, the amount of water captured and treated appears to be related to the amount of precipitation. The aberration in this relationship during 2000 and 2001 at the Landusky Mine is due to the fact that the artesian well WS-3 was opened and permitted to flow freely on October 27, 1999 until November 6, 2000 at an uncontrolled rate of about 290 gpm. The flow in December 2005 was approximately 180 gpm. The 110 gpm difference is 58 million gallons per year and seems to account for the increased flow rate during the low precipitation years 1999 - 2001.

Figure 19 - Landusky Mine Water Quantities



	1998	1999	2000	2001	2002	2003	2004	2005
Gold Bug & WS-3 & Upper MT	139.79 M	151.80 M	239.07 M	245.59 M	226.15 M	171.90 M	146.81 M	161.82 M
Lower Montana	41.62 M	25.05 M	13.38 M	1.17 M	0.70 M	5.56 M	4.45 M	0.40 M
Sullivan Gulch	6.55 M	7.87 M	2.86 M	3.04 M	5.83 M	3.14 M	5.97 M	7.31 M
Mill Gulch	24.84 M	29.23 M	18.41 M	16.46 M	19.13 M	15.29 M	19.89 M	21.61 M
Leach Pads	56.74 M	35.31 M	75.46 M	49.37 M	84.75 M	108.15 M	82.55 M	75.76 M
Precip. Inches	22.03	15.95	16.51	15.20	21.25	17.25	15.25	18.65

Underground mining, surface mining, and ore processing have affected surface and ground water at the Zortman and Landusky mines. These operations and their residual effects have and are continuing to degrade water quality by producing:

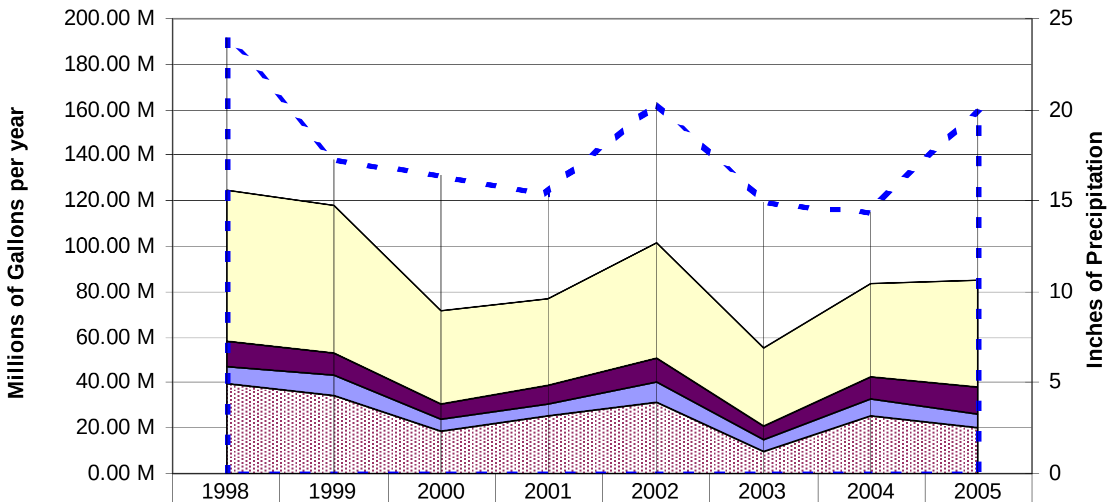
1. Acid Rock Drainage, characterized by low pH, elevated heavy metals, high sulfate content, and high dissolved solids, which is associated with breaking rock and exposing sulfide minerals to weathering.
2. Elevated selenium levels due the breaking of rocks during mining and construction, which exposed selenium minerals to weathering and flushing. Also, high selenium is associated with the clay that was mined near Landusky and then used during mining to

line leach pads, repositories, ponds, and channels. Some of the clay liners were later excavated and used for sub-grade infiltration barrier material. Unlike ARD, selenium is mobilized at an alkaline not an acidic pH.

3. Elevated levels of nitrates due to blasting, cyanide decomposition in leach pads, and application of nitrogen fertilizer for revegetation.
4. Elevated levels of cyanide (CN) due to heap leaching with sodium cyanide.

Figure 20 - Zortman Mine Water Quantities by Source

Zortman Water Quantities by Source



	1998	1999	2000	2001	2002	2003	2004	2005
Ruby Gulch	66.89 M	64.91 M	41.09 M	38.36 M	51.06 M	34.30 M	41.74 M	47.47 M
Carter Gulch	11.25 M	10.16 M	6.70 M	7.81 M	10.54 M	5.81 M	9.57 M	11.33 M
Alder Spur	7.07 M	8.41 M	4.85 M	5.53 M	8.73 M	5.38 M	7.55 M	6.31 M
Leach Pads	39.71 M	34.60 M	18.98 M	25.32 M	31.35 M	9.44 M	25.09 M	20.12 M
Precip Inches	23.95	17.26	16.39	15.35	20.44	14.95	14.4	20.05

Opinions vary regarding the source of the arsenic in WS-3 and the Gold Bug adit discharges. Most experts agree that, considering the solubility characteristics of arsenic at various pH's, the solubility tends to decrease as the pH drops from 7 to about 5.5 and then it stabilizes. Therefore, one can conclude that the arsenic in these two sources is not related to acid conditions, but appears to be more closely related to the natural background in the mineralized shear zones that predate the mining.

Although ARD and selenium transport also occur at much lower rates due to natural processes, disturbance of the host deposits by mining greatly increase the rate of production and transport. Assessments of the rock at both mines indicate that most of the mined rock contains sufficient sulfide materialization to produce ARD. The acid generating potential ranges from fairly high at the Zortman Mine to very slight in some areas of the Landusky Mine. Actual generation of acidic drainage depends upon the location of the material with respect to water, oxygen, and potentially neutralizing rock material.

Chemicals that were brought to the mines for use in mining and mineral processing have left residual cyanide and nitrate contamination. Although large quantities of sodium cyanide, blasting agents, and nitrogen fertilizer were used, the quantities are finite and their harmful constituents ultimately break down or are converted by natural process into products that are considered benign.

Water balances for the two mines show that the annual volume of groundwater discharged from the Landusky Mine is approximately 2.8 times greater than at the Zortman Mine. However, contaminant loads are not always proportional to the amount of groundwater. In comparing the contaminant loads at the two mines, the Zortman Mine has the greater loads of arsenic, iron, manganese, and of some of the cationic metals; while the Landusky Mine has the greatest loads of nitrate and selenium. In general, contaminants are more concentrated at the Zortman Mine than at the Landusky Mine. The groundwater acidity data indicates that the acidity load at the Zortman Mine is approximately ten times greater, in spite of the nearly three times smaller total groundwater discharge. This is probably due to the greater exposure of sulfides to weathering processes and the more advanced state of geochemical evolution at the Zortman Mine.

Although the present-day concentrations of most contaminants are greater at the Zortman Mine, contaminant production from the Landusky Mine is expected to increase over time to greater levels than at the Zortman Mine. The Landusky Mine has additional neutralization potential, given the presence of the Emerson shale and other carbonate rocks; however, once that is 'swept' out of the system, water quality (in particular metals and sulfate) at the Landusky Mine will become similar to the Zortman Mine today. This is already happening in the Landusky 87/91 Leach Pads that have become very acidic and high in sulfates, aluminum and heavy metals.

4.1.1 Acid Rock Drainage Overview

Acid rock drainage (ARD) is the result of sulfide oxidation, a natural chemical weathering process that is accelerated up to 1000 fold by certain bacteria. When rock is broken, exposure of the sulfide minerals to the weathering agents is increased by orders of magnitude. The main sulfide mineral at the Zortman and Landusky Mines is iron pyrite or "fool's gold" (FeS_2). When exposed to oxygen and water, pyrite oxidizes and produces sulfuric acid (H_2SO_4). It is not the acid, in and of itself, that degrades water quality. Humans, animals and plants are very tolerant of acids (vinegar and Coke are both very acidic). The real problem is that acidic water dissolves metals from the adjacent rock. This solution can then migrate into surface water, groundwater, or the soil profile, where it can produce toxic effects.

The pH scale is used to measure acidic concentrations. The lower the pH the higher the acidity. Because it is a logarithmic scale, the acidity increases by a factor of 10 for every unit decrease in the pH value. While acid water, by definition, is water with a pH below 7, it is not until the pH is below approximately 4.5 that dissolved metals become problematic. Rainwater, for instance, typically has a pH in the range of 5.5 to 5.8, making it a very weak acid that does not dissolve significant concentrations of metals. Similarly, much of the oxide material at the mines has pH values of 5 and above, representing very weak acidic conditions with little potential to dissolve metals. As the pH decreases below 4.5, the ability to dissolve metals increases rapidly. By the time the pH is below 3, the metal concentrations are generally high.

As soon as rock is broken, it is exposed to air, starting the oxidation process. The rate of oxidation is slow. Initially, any acid produced is neutralized by alkali minerals in the rock, or alkali minerals added to the rock piles (i.e. as caustic soda during leaching in the leach pads, or as lime amendment used during reclamation). This neutralization process consumes any acid that is produced, preventing a drop in the pH of the waste. If the amount of neutralizing minerals is sufficient to neutralize all the acid that can be produced by the sulfides in the waste rock, then the waste material would not become acid. However, even neutralized ARD can contain contaminants such as sulfate, dissolved solids, and metals such as selenium or arsenic, which may degrade water quality. When the amount of neutralizing minerals is less than the acid that is produced, the neutralizing mineral would eventually be consumed, and any additional acid produced would then cause the pH of the waste to drop. The potential for waste rock to "go acid," and the time it takes to go acid is, therefore, dependent on three things:

1. The amount of sulfides;
2. The nature of the sulfides (how quickly they oxidize); and,
3. The amount of neutralizing minerals.

The condition of the mined rock evolves as oxidation progresses. Waste materials that have little or no sulfides and those with excess neutralizing minerals do not become acidic, while rocks with rapidly oxidizing sulfides and few neutralizing minerals become acidic very quickly. This evolution of acidic conditions can take tens of years to develop. As more and more acidic conditions develop, the concentrations of metals in the runoff and groundwater flowing over and through these wastes increases, thereby increasing the pollution potential. Wastes that have reached their maximum acidity condition are referred to as 'mature' with respect to acid rock drainage.

As acid is produced and subsequent reactions take place within the mine facilities, other minerals precipitate from the waters infiltrating through the rocks. These minerals are typically readily soluble and can be seen coating the surfaces of the rocks. These minerals are also referred to as 'stored oxidation products. When they are redissolved, they add contaminants such as iron, copper, zinc, arsenic, nickel and cobalt to the water. At both mines, the chemical reactions that have occurred over time have produced a significant storage of these types of minerals on the rock surfaces. Over the same time period, water moving through the material has developed flowpaths along which it tends to migrate. Along these flowpaths, there are limited amounts of secondary minerals. Many of the stored oxidation products, however, are currently sitting in 'dry pockets' within the rock and have not been redissolved. When the materials are moved or water levels are allowed to fluctuate, short-term water quality impacts are created when new flowpaths are made available and secondary oxidation products are flushed from the new flowpaths.

Contaminant concentrations will continue to increase until the final or "mature" state is reached. As oxidation proceeds and acid is generated, the pH decreases until the sulfides in the rocks are nearly all oxidized. The acid being produced is also being continuously leached out by infiltrating water. If the rate at which acidity is being leached exceeds the rate at which it is being generated, then there would be a net decrease of the acidity at the source rock. Once that happens, the pH would slowly increase again up to some "equilibrium" value (possibly around pH of 6).

As the sulfides oxidize, sulfuric acid is produced. Neutralized sulfuric acid produces sulfate. Thus, the concentration of sulfate (S04) can be used to indicate if the ARD reaction is occurring, even when the runoff pH is near neutral. As with pH, the sulfate concentration would change over time, being at its highest concentration at full ARD "maturity". Once the sulfides are gone, the concentration of sulfate would again begin to decrease to some background level. When oxidation is essentially complete and the acidity has been leached away, the rocks left are the oxide rocks that no longer leach contaminants. These oxide rocks occur naturally near the surface at the mine sites because the ARD reaction process occurs naturally as part of chemical weathering. It is anticipated that the full cycle from oxidation initiation to finally reaching the "oxide" state would take tens to hundreds of years.

Data collected over the years show that there are different stages of ARD evolution at the mines and that there are considerable differences in the conditions at each mine, with some isolated zones that are at full maturity and some zones that are still very immature. In general, the leach pad materials are less mature than the waste dump and in-pit materials due to the lime that was added during the gold leaching process. The Landusky Mine materials are less mature than the Zortman Mine materials due to a greater prevalence of alkaline minerals in the rocks that occur naturally around the mine (for example in the Bighorn dolomite and the Emerson shale).

A great deal of water quality data has been collected from the monitoring stations at the mines since the 1996 FEIS was completed. This data, together with the geochemical characterization results, confirms the FEIS assessment that even with water barrier and water balance covers, water collection and treatment would be required at both mines for a very long time.

4.1.2 Geochemical Testing

Over two thousand samples of ore, spent ore, waste rock and other unmineralized local rock types from both mines were tested for the 1996 FEIS. Rock types include Tertiary syenite porphyry and monzonite, Precambrian amphibolite and felsic gneiss, Paleozoic sedimentary rocks, and quartzites and breccias. Since the FEIS testing program, the materials on site have continued to weather and their associated geochemistry has continued to evolve. A follow-up geochemical characterization program was conducted in 1999 and 2000. This program consisted of a widespread surface sampling program and a drilling program to test material from within the leach pads and dikes. In general, the results from this program agree with or help refine the conclusions made in the FEIS. The results of the ongoing water-monitoring program also suggest that ARD is continuing to develop as the available neutralization potential is used.

Acid generating samples from mine facilities typically have low pH values and higher TDS (total dissolved solids) values. The high TDS values reflect the presence of soluble oxidation products stored on the rocks. Those samples, which have been exposed for ten or more years with neutral pH results and low TDS values are typically, considered non-acid generating. There is, however, an exception to this trend for material that has been leached on the leach pads. In the gold extraction process using cyanide, the pH of the leaching solution is kept high (around 10.5) by adding lime or caustic soda (alkali) to the leaching solutions. Therefore, many of the samples on the leach pads had a near neutral to slightly alkaline pH with high TDS as a result of the alkali minerals, which remain as coatings on the leached ore.

Modified Acid-Base Accounting (ABA) tests were also used to assess the ARD potential of the mine facilities. These tests involve a measurement of the acid production potential (AP) and the neutralization potential (NP). The balance or difference between the NP and the AP indicates the net tendency for a material to either produce or consume acid. Theoretically, if the potential to produce acid is equal to the potential to neutralize acid, the sample would not result in ARD. In reality, an excess of neutralization potential is typically required to ensure acidic conditions do not arise. Those samples with excess acid potential would be classified as either currently acid generating (such as the pit wall samples) or potentially acid generating (such as most of the leach pad samples). Again, the information shows that most of the material is either currently or likely to become acid generating.

In general, there is very little neutralization potential in the vast majority of materials on-site. Nearly all samples (excluding the leach pad samples) with total sulfur contents greater than 0.2% have field paste pH values less than 5.0. This percentage of sulfur is far less than would be visible with the naked eye. In other words, a sulfur cutoff value of 0.2%, as proposed by ZMI in 1993, is not necessarily protective of the environment. This is the same conclusion that was reached in the 1996 FEIS.

Geochemical findings from the 1996 Final Environmental Impact Statement (FEIS) and the 2001 Supplemental Environmental Impact Statement (SEIS) include the following:

- ARD is currently being generated from pit walls and floors, leach pads and pad foundation (L91 Leach Pad), and waste rock piles at the Zortman and Landusky Mines. However, not all leach pads should be considered acid-forming. The lower leach pads at the Landusky Mine and the Z83, Z84, and Z89 Pad materials are only very slightly acid generating.

- The groundwater in the Thermopolis shale at Goslin Flats has naturally high TDS, alkalinity and sulfate. This area is unlikely to be a source of acid due to its fine-grained nature, relative impermeability and inherent neutralization potential.
- Ore produced as a result of the past mining operations has acid producing potential. Leachates from spent ores initially have alkaline pHs, relatively high TDS and nitrate concentrations, and high concentrations of elements mobile at alkaline pHs such as arsenic, selenium and molybdenum. However, as remnant sulfides react, subsequent leachates will likely become acidic and contaminated with dissolved metals. Certain leach pads have already become acidic (e.g. Z85/86 Leach Pad, which has a leachate with 2.6 pH).
- For waste rock at both mines, there is a direct relationship between percent sulfur and net neutralization potential (NNP). Almost all sulfur is reactive. Excluding the limestone, amphibolite, shale and dolomite, the waste rock has very little neutralization potential.
- Where the paste pH was 6.0, or above, acidic pHs in humidity cell leachates were not produced. Samples with a paste pH less than 6.0 identified low sulfur rock types, which had already gone acid or contained stored oxidation products. Therefore, use of paste pH as a parameter for classifying waste is appropriate.
- All low to medium sulfur, 0.8 weight percent or less, amphibolite appears to be non-acid forming.
- Syenite waste rock containing less than or equal to 0.2 percent sulfur does not generate acid in sufficient quantities to affect vegetation, but could affect water quality.
- Breccia and monzonite rock types, designated as 'blue waste' by ZMI (i.e. percent sulfur less than 0.2) may generate acid or contain oxidation products sufficient to generate low pH conditions. The 'blue waste' comprised of Emerson shale, however, is an excellent NAG source.
- For other rock types, trachyte, quartzite and felsic gneiss, static data indicated that these rock types did have the potential to generate net acidity. However, kinetic test data was inconclusive. Additional field and lab testing confirms the results of earlier static testing, i.e. that these rock types are largely acid generating.

4.1.3 ARD Migration Overview

At the initiation of open pit mining at the Zortman and Landusky Mines in 1979, it was determined that ARD would not be a significant issue because mining would occur in the oxide portion of the deposit. However, as mining progressed, water quality analyses showed that geological materials at both mines were generating acidic waters. Data from the early 1990's indicates that most of the major southern flowing drainages were showing some degree of impact from mining-related activities. Once detected, monitoring programs were developed to detect and track the ARD migration in the surface and groundwater. Because a large percentage of the mined rock is contained in lined basins (leach pads), ARD impacts from the mines have been limited to areas beneath and immediately downgradient of pits, rock dumps and leach pad dikes. Seepage capture systems, which have proven to be very effective, were constructed below these mine facilities in all of the gulches that drain southward from the sites. Since 1996, when the seepage capture systems were completed, practically all the recharge to groundwater over the mine areas has been captured and treated. Although ARD-neutralized zones and low level/occasional mine-related contaminants extend downgradient of these facilities, the amount of ARD that migrates downstream from the mines is minimal, particularly in those drainages with capture systems.

Subsequent studies and the success of the capture systems indicate that the majority of groundwater from the mine sites flows along shallow and intermediate flowpaths that discharge to capture systems. There does not appear to be a significant deep flowpath.

Shear zones and associated underground workings are the major controllers of surface and groundwater flow at both mine sites. Groundwater flows laterally into the shear zones. The shears act as long lateral sinks that contain significant amounts of groundwater in storage, and discharge primarily through the underground workings out the old mine adits. Underground and open pit blasting and mining activities may have further enhanced the permeability of the shears. Additionally, underground workings following the shear zones below the water table may connect otherwise discontinuous and unconnected fractures, enhancing groundwater movement along and through the shear zones. These zones have relatively high hydraulic conductivity compared to the surrounding areas. This is evident by the relatively flat potentiometric surface near the Ruby-Ross shear zone at the Zortman Mine and near the August, Niseka, Suprise and Gold Bug shear zones at the Landusky Mine.

High conductivity shear zones are not observed outside of the mining areas, except for the Suprise shear zone, which extends from the north end of the Suprise pit across Swift Gulch to the north. Some drainages appear to be aligned with major faults, which may collect groundwater flowing toward the drainage and facilitate its movement along the drainage. High conductivity discrete fracture zones were observed in some wells outside of the mined shear zones, which do not appear to correlate directly to any mapped geologic faults or other structures. These zones are isolated and of limited extent, producing water mostly from storage within the rock. It should also be noted that the sulfide rock in the shear zones has been subject to chemical weathering and that the location of the water level in the shear zone is a controlling factor in determining the zone where conditions are right for active chemical weathering to occur.

A year-long test of artesian well WS-3 at the Landusky Mine demonstrated that the single well could control groundwater levels throughout the shear zone of the Landusky Mine. The aquifer test confirmed the high permeability and storage capacity of the shear zone, and that groundwater outside the shear zone in syenite or Paleozoic aquifers is relatively isolated from that in the shear zone. Water level data did reveal most of the groundwater within the shear zone is migrating along the shear zone to the southwest toward Montana Gulch. Groundwater studies found that groundwater flows beneath the Landusky Pit complex are divided between Montana Gulch and Swift Gulch, but not substantially toward King Creek. Flow toward Swift Gulch, instead of King Creek, was substantiated when the August Pit filled after artesian well WS-3 was closed and groundwater levels rose in well ZL-313 and ZL-315.

Likewise, a long-term (approximately three-month) aquifer test of well ZL-302 at the Zortman Mine showed the hydraulic connection between wells located in the shear zone. At the Zortman Mine, it is unlikely that groundwater levels will increase significantly above year 2000 levels, due to the relatively high permeability of the shear zone and the presence of extensive underground workings that serve to transmit water relatively quickly to discharge points.

Without the capture systems in place, conditions on the Site could affect water quality and aquatic habitat below the Site. Impacts to the Madison Group aquifer would only occur by seepage of poor quality surface water into the Madison subcrop, which is located downstream of the mine areas. Poor quality water could only infiltrate where the limestone was not discharging to the drainage. Since the subcrop is located below the capture systems, a small amount of uncaptured groundwater bypassing the capture system, as well as water treatment plant discharges in Ruby Gulch and Montana Gulch, are currently components of recharge to the Madison Group aquifer.

There are two types of contaminants in these migrating waters: (1) those that do not attenuate and tend to concentrate along a migration path; and (2) those that do attenuate along a migration path, typically decreasing in concentration with distance and time. Sulfate and nitrate usually do not attenuate, whereas metals such as zinc, copper, cadmium, and iron would attenuate along the migration path. Data collected to date shows that a great deal of attenuation occurs downstream of both mines. A variety of attenuation mechanisms can occur. The most common and likely mechanisms are those of pH control and absorption/co-precipitation of metals with minerals such as iron-oxyhydroxides (rust colored minerals). In general, if the pH of the water downstream of the mine sites is maintained above approximately 5 to 5.5, it is unlikely that significant concentrations of metals contaminants would occur. Exposures of the Paleozoic limestone in the area drainages serve to raise the pH and promote metal precipitation.

4.1.4 Domestic Well Contamination

This EE/CA assesses the risk associated with each alternative being considered. Under some of the alternatives, untreated discharges of water would occur down the drainages surrounding the two mine areas. The following three figures shows the location of the domestic water wells within or adjacent to the Site boundary.

The community of Hays to the north has two primary water wells, which fed two water tanks. In addition, many people have their own wells. No documented contamination has been shown to extend onto the Fort Belknap Reservation where it could affect these water supplies. Thus, downstream flow should not affect the community of Hays.

The town of Zortman has a community water supply well to the east-southeast of town labeled Z-8A. This well is 738 feet deep and is completed in the Madison Limestone. It is unlikely that any untreated discharges would affect this well due to the significant geologic structure that prevents groundwater movement between the Madison outcrop in Ruby Gulch and the Zortman community well located near Camp Creek. However, without detailed flowpath studies, it is impossible to definitely conclude that no contamination could occur. No impacts to this water supply for the town of Zortman have occurred or are anticipated in the future.

The town of Landusky has nineteen shallow wells. There is no community well, each landowner having their own source of water. There have been varying degrees of mine-related affects to the shallow wells used by Landusky residents. The four wells sampled (TP-l, TP-2, TP-3, and TP-4) have all had some affect. Wells TP-l and TP-2 were affected by neutralized mine drainage and metals until late 1997-1998, when the Mill Gulch and Sullivan Gulch capture systems became operational. Since then, sulfate levels have been in decline, although still above background concentrations. The data for well TP-3 indicate a general lack of mine impacts, except for occasionally elevated iron and a couple of elevated arsenic samples prior to mid-1997. Since elevated iron but not other ARD indicator metals occurs in all these wells, it may be due to natural conditions. Uncaptured discharges down Sullivan or Mill Gulch would affect each of these supply wells. The capture systems in Sullivan Gulch, Mill Gulch and Montana Gulch are the primary reclamation components responsible for maintaining acceptable water quality in the Landusky town site wells.

Figure 21 – Zortman Domestic Wells

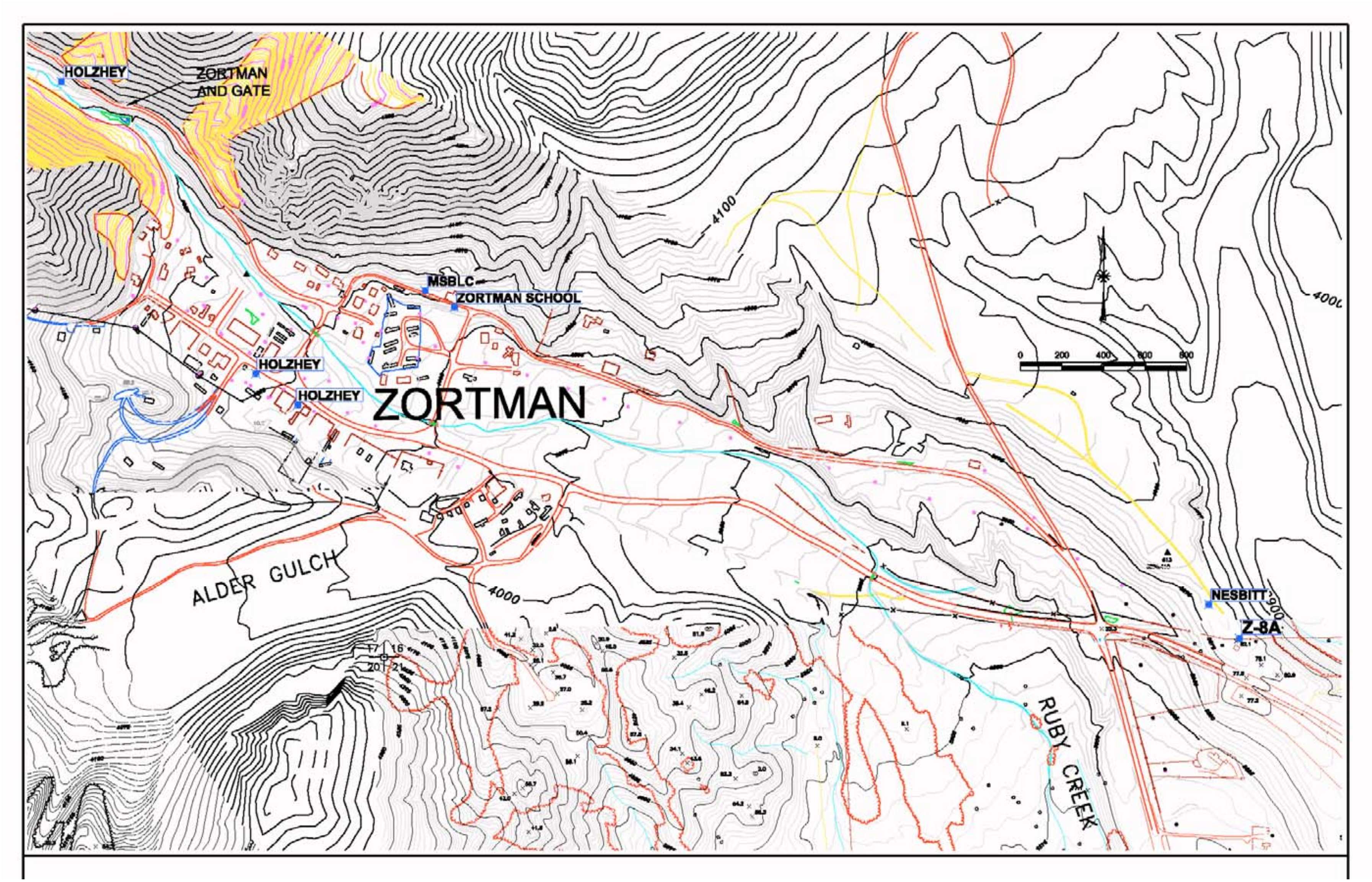


Figure 22 – Landusky Domestic Wells

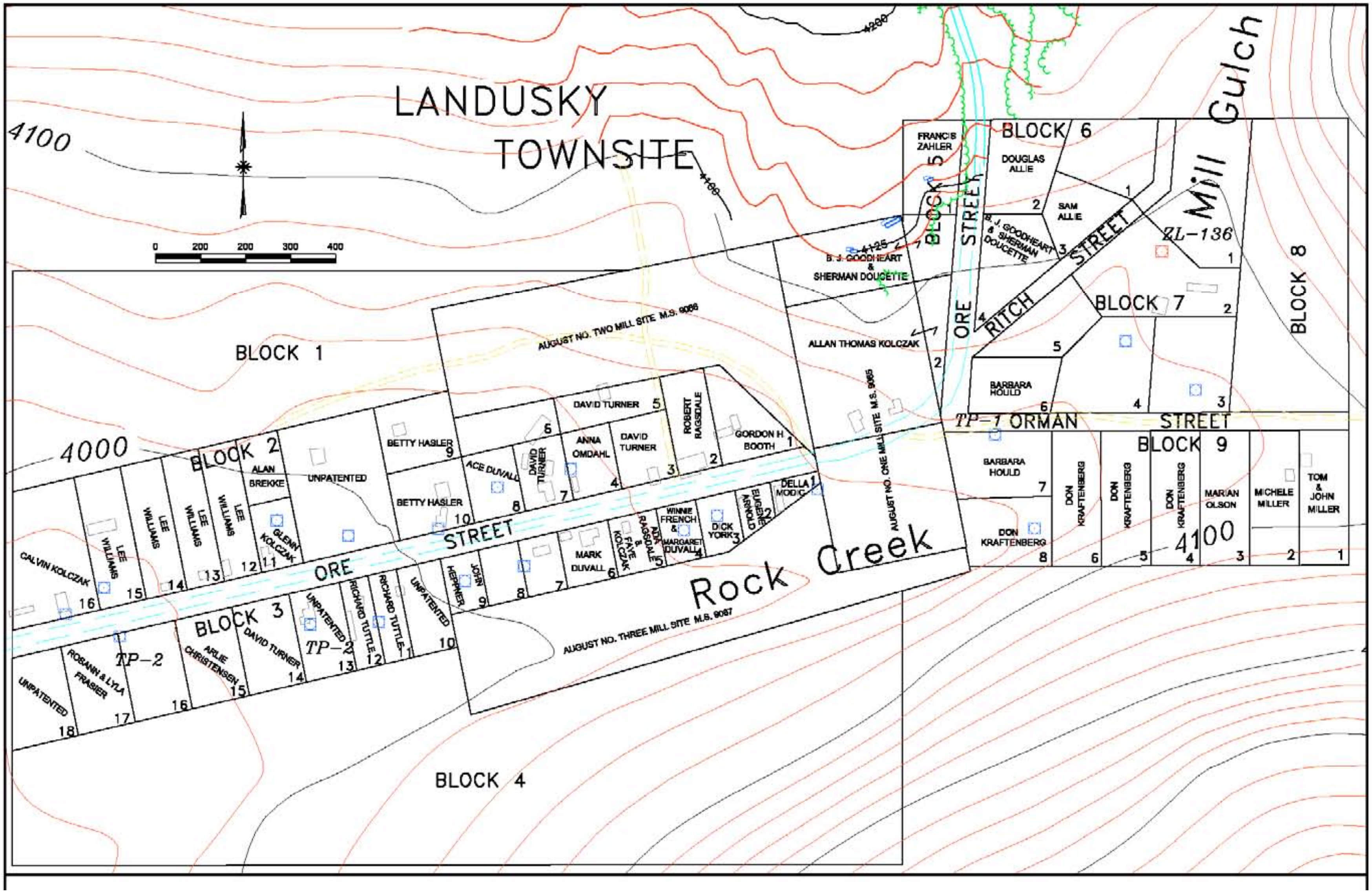
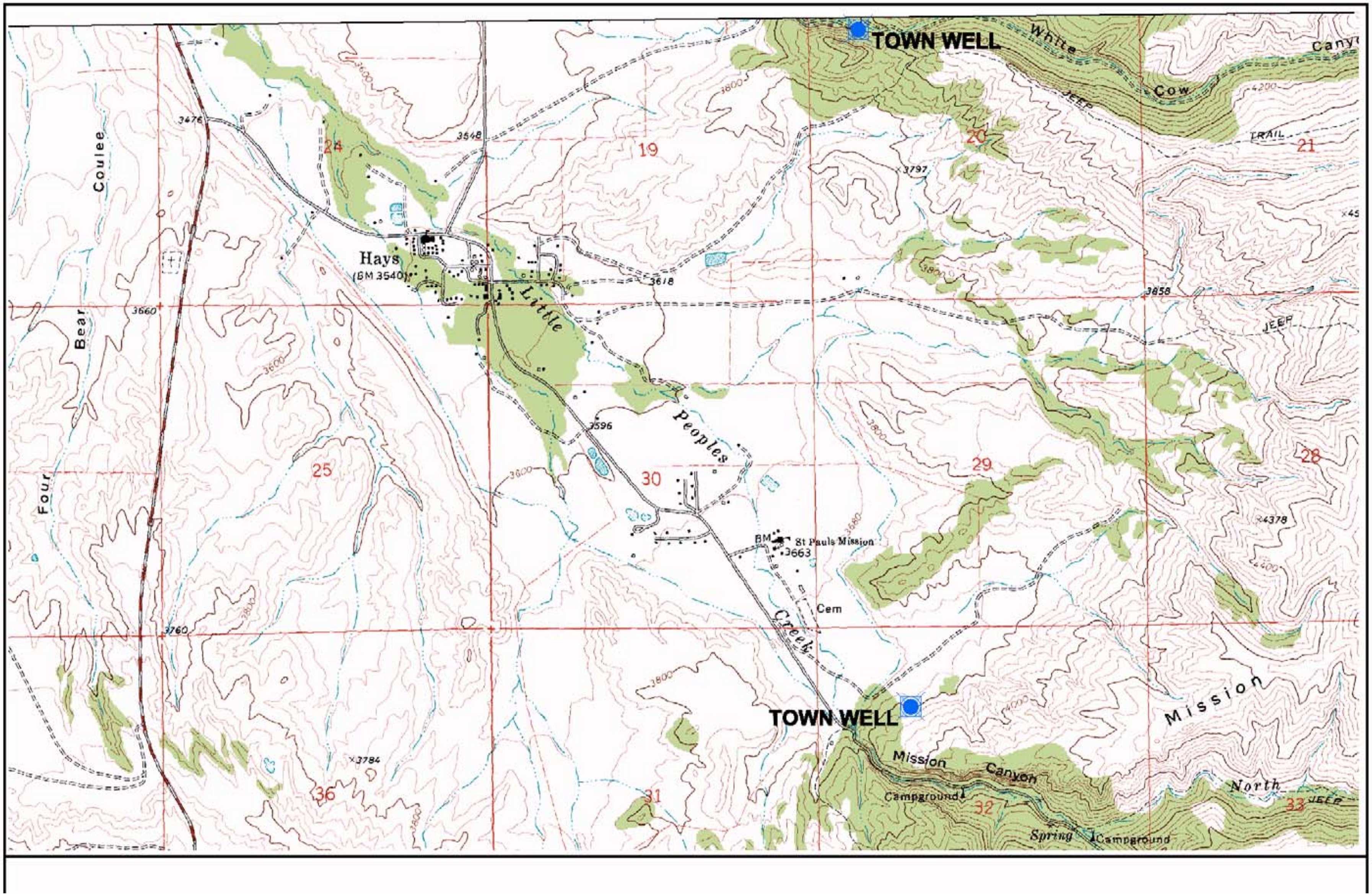


Figure 23 – Hays Domestic Wells



4.1.5 Aquatic Resources

Fisheries habitat in the Little Rocky Mountains is limited because most drainages are intermittent. Beaver Creek and Lodgepole Creek support a limited brook trout population. Both brook trout and rainbow trout have been recorded in Little Peoples Creek. The dominant taxa is the area are fly larvae (Chironomidae and Simuliidae), mayflies, stoneflies and flatworms.

Streams in the Zortman area are relatively small, providing limited habitat. Near the mine site, streams have narrow channel widths, shallow water depths and low flows. The lower part of Alder Gulch, lower Beaver Creek and lower Lodgepole Creek have wider, deeper water channels with slightly higher flows. Downstream locations on Beaver Creek and downstream locations on Lodgepole Creek have fish populations. Brook trout *(Salvelinus fontinalis)* was the only species present at both locations.

Streams in the Landusky area are generally small with narrow, shallow channels and low flows. Montana Gulch and Rock Creek downstream of Montana Gulch have larger channels with somewhat higher flows. In 2000, the lower portion of Rock Creek was the only segment where brook trout was present. Recently, trout were observed in the Montana Gulch Campground. Untreated discharges down Montana Gulch would affect the Montana Gulch campground. While the well in the campground is closed, the stream flow is still an exposure pathway to humans.

4.2 ZORTMAN MINE SOURCES AND EXTENT

4.2.1 Waste Dumps, Leach Pad Dikes and Pad Construction Fill (OU1)

During the period of open pit mine operations at the Zortman Mine, ZMI removed approximately 13.5 million tons of waste rock, which was placed into waste dumps, stockpiles, backfill areas, leach pad dikes, leach pad basin construction, and roads. Because waste materials with as little as 0.2 percent sulfide content can produce acid if there is negligible buffering capacity, most of the materials that were mined are potentially acid producing.

Table 18 - Zortman Mine Sulfide Waste Deposition Locations				
Facility	**Tons**	**Tons**	**Tons**	**Tons**
	Oxide	**Sulfide**	**Mixed**	**Total**
Pad and Dike Construction				
Z79/81 Pad	523,840	0	0	523,840
Z82 Pad	0	0	321,425	321,425
Z83 Pad	1,358,002	0	0	1,358,002
Z84 Pad	1,533,753	43,561	0	1,577,314
Z85-86 Pad	375,893	77,886	940,795	1,394,574
Z89 Pad	1,572,969	118,750	279,898	1,971,617
Totals	**5,364,457**	**240,197**	**1,542,118**	**7,146,772**
Waste Rock Dumps				
Alder Gulch	1,957,328	236,792	1,757,873	3,951,993
O.K. Waste	281,152	0	923,976	1,205,128
South Ruby	514,583	0	387,150	901,733
82 Sulfide Stockpile	31,500	11,690	0	43,190
Ruby Sulfide Stockpile	0	221,600	0	221,600
Totals	**2,784,563**	**470,082**	**3,068,999**	**6,323,644**

Ore grade and sulfide data was collected for each blast hole that was drilled. The sulfide content was determined by a rough visual inspection. The Zortman Sulfide Waste Deposition Locations table presents a breakdown of the tonnages placed in each area and identifies areas where rock with at least a 10 percent sulfide content was placed. This information was compiled from mine production records, mine planning records, and blast hole data (Spectrum, 2001). Those quantities identified as “Sulfide” on the table represent large discrete blocks of sulfide waste. The category “Mixed” refers to blocks of predominately oxide waste that contained isolated areas of high sulfides. Quantities lacking specific sulfide quality information, which were mined from areas where sulfide zones were likely, are also lumped into the “Mixed” category. The quantities presented in this table were calculated from drill hole and truck-count information and have not been reconciled with the other calculated quantities.

Note that the terms ‘oxide’, ‘sulfide’ and ‘mixed’ are terms used during operations and do not necessarily reflect the material’s potential or propensity to generate acid. Much of the material defined as ‘oxide’ at the mine is indeed considered potentially acid generating.

Developing acidic conditions associated with modern day mining were first noted in Ruby Gulch in 1992. By 1994, ZMI had constructed the Zortman Water Treatment Plant and had removed a large section of sulfide-rich waste rock from the downhill face of the Z85/86 Dike. The 1996 FEIS noted declining surface water quality in the upper Ruby Gulch drainage, mostly due to deepening of the pits into areas where sulfides were more prevalent. It also noted that before installation of the Ruby Gulch Capture System, impacts to water quality were seen downstream from the town of Zortman after an extreme storm event in 1993.

Alder Gulch Waste Rock Dump - The 1996 FEIS noted impacts in Alder Gulch due to seepage from this waste rock dump. Impacts included decreasing pH and elevated sulfate, TDS concentrations. Water quality in Alder Gulch improved after construction of the capture systems in 1997. Data through 2000 indicate that alluvial groundwater near the mouth of Alder Gulch (AG-20 1, AG-202) did not exhibit impacts from mine activities, nor did groundwater in the deeper limestone aquifer. The FEIS concluded that groundwater (160-200 feet bgl) under the Alder Gulch Waste Rock Dump was not impacted by seepage from the dump.

The Carter Gulch Seepage Capture System, which is located near the toe of the dump, intercepts about 9,600,000 gallons of ARD per year. The leachate has a pH of about 3.5 with a high concentration of metals, high sulfate content, and high total dissolved solids. The selenium is moderately high, exceeding aquatic standards. Nitrates are also moderately high with values between 10 mg/l and 33 mg/l. Values from cadmium are exceptionally high. Sample values reflect great seasonal variations.

Surface water in the main stem of Alder Gulch, downgradient from the Carter Gulch and Alder Spur confluence (Z-8), is typical of unimpacted nonmineralized water quality. Data from this area indicate that with the exception of occasional elevated iron concentrations, surface water is of good quality with pH values between 7 and 8, low SC, low metals concentrations, and no nitrate detections. Based on monitoring results, the underlying syenite groundwater is not impacted by vertical migration of contaminants from surface water. There is no evidence of vertical migration of mine-impacted alluvial water to the limestone aquifer.

O.K. Waste Rock Dump - Sulfide information is not available for most of the tonnage delivered to this dump. However, pre-reclamation sampling indicated that it contained mixed partially oxide material. One sample taken in the lower portion of the dump had a paste pH of 5.1 and a low conductivity value of 280. This dump was reclaimed by grading a large portion of the material downhill and over an adjacent steep slope to the south.

Water seeping through the waste rock either drains into the Z85/86 Pad or drains under the pad and is trapped by the capture system in Ruby Gulch. Information on seepage quantity and quality for this facility is not collected.

South Ruby Waste Rock Dump - Pre-reclamation sampling indicated that some of the waste rock had acid generating potential. During reclamation, the upper 439,000 cubic yards of this dump was removed and used to backfill portions of the O.K./Ruby Pit and the Mint Pit. The lower portion of the dump was graded in place.

Most of the water seeping through the graded waste rock and Mint Pit backfill probably follows the loose rock down to the bottom of the Mint Pit. It is likely that the pit drains below the L85/86 Leach Pad and that the water is ultimately trapped by the capture system in Ruby Gulch.

Z79/81 Dike and Pad Construction – The 523,700 tons of waste placed in this area were characterized by the mine records as oxide rock. Most of the material was placed at the base of the pad and was then covered with a thick layer of clay followed by an impermeable liner. Exposed slopes on the buttresses around these pads were subsequently covered by the lined basins of adjacent leach pads. Consequently, little of this rock is exposed to weathering, except for some minor peripheral drainage that might collect and flow under the pad liners.

Z82 Dike and Pad Construction – This facility was constructed on the ridge dividing Ruby Gulch, Carter Gulch, and Alder Spur. The 321,400 tons of mixed sulfide and oxide waste placed in this area was used for grading fill after spent ore and lining materials were removed from the pad in 2001 and 2002. Most of this material was used to contour a steep slope, which extends down into the Ruby Gulch drainage and is on the northeast side of the pad area. The fill is above the Ruby Gulch Capture System. Therefore, any impacted drainage through this fill, which might collect in the alluvial system would be collected by this facility.

Z83 and Z84 Dike and Pad Construction – About 44,000 tons of highly sulfide waste was placed in the Z84 fill. (Drilling in 2000 tested the Z84 Dike and located layers of moderately acid generating material.) The two large dikes, which are about 150 feet high, meld together and wrap around the top of the draw.   Approximately 1,275,000 tons of material was placed at the base of these pads and was then covered with a thick layer of clay followed by an impermeable liner. The remaining 1,660,000 tons is located in the dikes, which are steep exposed fills extending to the bottom of the draw.

The 2001 supplemental EIS stated that water quality in Alder Gulch had improved since construction of the capture systems. 1997-2000 data indicate that alluvial groundwater near the mouth of Alder Gulch (AG-200, AG-202) does not exhibit impacts from mine activities, nor does the groundwater in the deeper limestone aquifer. With the exception of one slightly elevated nitrate value, deeper groundwater in Alder Spur is representative of nonmineralized syenite background water quality.

Recent data from the Alder Spur Seepage Capture System indicates that about 7.5-million gallons per year of impacted water is being collected from the drainage below the Z83 and Z84 dikes. The leachate has a pH of between 4.8 and 5.0 with elevated concentration of aluminum, cadmium, copper, manganese, nickel, and thallium. The sulfate content (1710 mg/l), and total dissolved solids (1330 mg/l) also reflect ARD conditions. Selenium and nitrate values meet all applicable standards. No detectable cyanide reports to this capture system.

Z85/86 Dike and Pad Construction – At least 78,000 tons of the rock used in pad and dike construction were high in sulfides. The vast majority of the waste rock contained some sulfides. When ZMI realized that the dike was generating acid and contributing to a growing acid problem in Ruby Creek, it removed a substantial portion of the dike and stockpiled this material in the mine. In 1999, surface reconnaissance sampling of the remaining section of dike, which contains about 375,000 tons of waste rock, characterized the dike material as essentially unoxidized and recorded paste pH's of 2.6 and 3.1 at the top of the dike. In 2002, the dike face was built out with non-acid generating material.

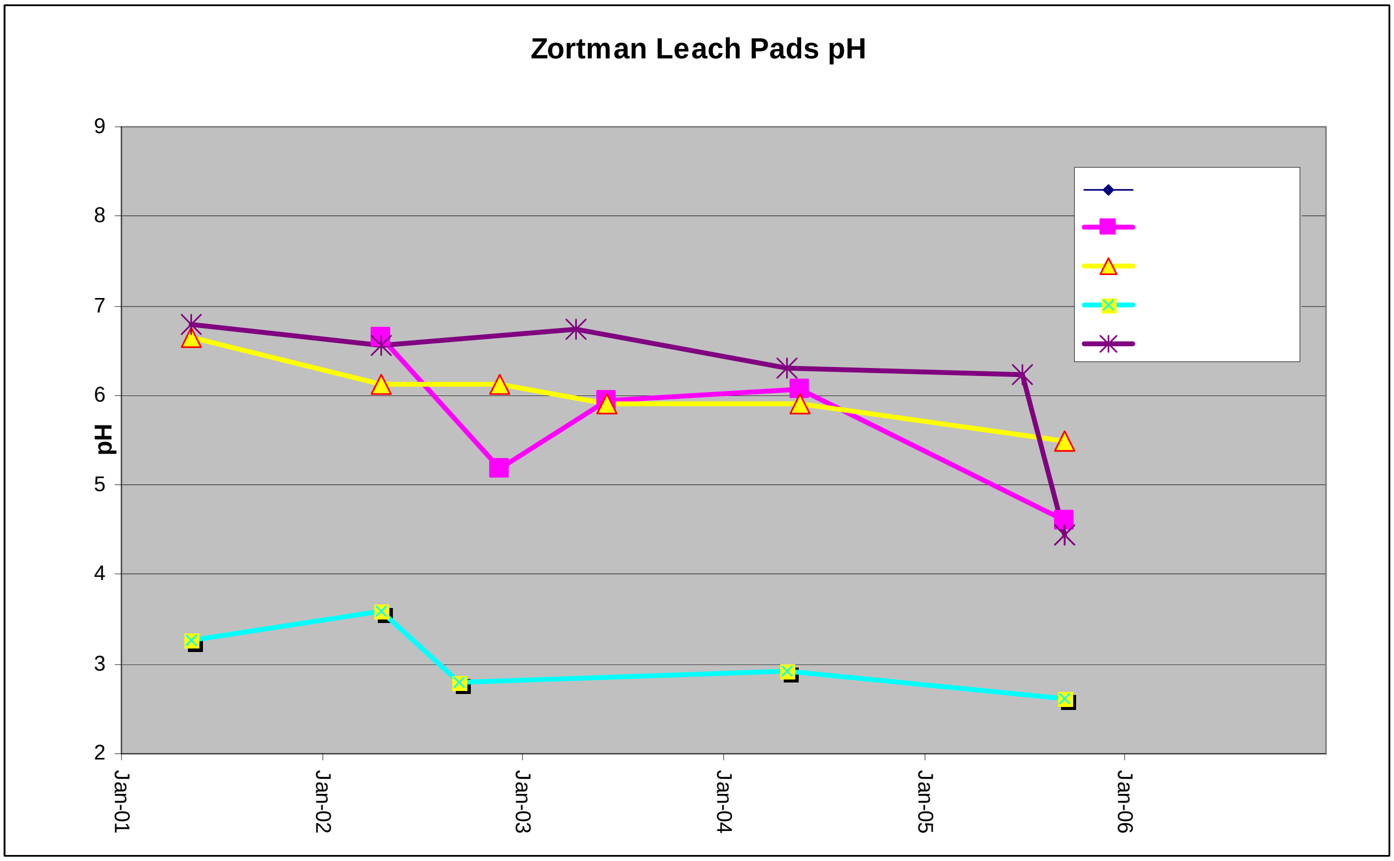
Much of the sulfide rock used to construct the basin is covered by clay and an impermeable liner. The pad also had french drains installed along the buried channels to act as underdrains. However, this pad was constructed in a drainage bottom where several springs were located. So portions of the fill are constantly in contact with water from the seeps. In addition, two mine adits drained along the south edge of the pad. This water was not contained in a pipe and routed around the pad area until 2003. Prior to that time, the water drained into a sump that seeped under the liner. Because the pad blocks a drainage, upland areas drain toward the pad. Water seeping into the ground from these upland areas also comes in contact with the waste rock below the pad.

The 2001 Supplemental EIS concluded that seepage from the Z85/86 Pad underdrain, buried springs and/or discharge from the buried mine adits represented the most concentrated ARD on either mine site. Since 1995, the captured seepage quality has remained generally stable, with only a slightly increasing sulfate trend. Elevated metals concentrations were evident in two post -1995 runoff events.

Historical data from the Ruby Seepage Capture System indicates that over the life of the capture system about 56 million gallons per year of ARD has been collected and pumped to the Zortman Water Treatment Plant. However, since 2000, the average has been 41 million gallons per year. This quantity includes all contributions to the capture system of which the Z85/86 Dike and Pad is just one source. The combined leachate from all sources has a pH of between 2.5 and 3.1 with elevated concentrations of aluminum, arsenic, cadmium, chromium, copper, iron, manganese, nickel, selenium, thallium, and zinc. The sulfate content (4440 mg/l), and total dissolved solids (4860 mg/l) also reflect ARD conditions. Nitrate values meet all applicable standards. No detectable cyanide reports to this capture system.

Z89 Dike and Pad Construction – Because the pad and dike are located above the Ruby Gulch Capture System, any impacted drainage would be collected by the capture system.

Figure 24 - Zortman Mine Leach Pad pH Trend



4.2.2 Zortman Mine Leach Pads (OU2)

The neutralization potential in the leach pads has been augmented by the addition of alkalinity during the leaching process. It is anticipated that once the alkalinity in the leach pad samples is exhausted, the spent ore on the pads will also follow the apparent natural trend of the other materials on site and become acid generating over time.

Cyanide compounds continue to be washed from the spent ore on all of the pads. However, recent samples from the Z79/81 Leach Pad complex, which are the oldest pads, indicate that the cyanide content has now fallen below the most stringent regulatory standards. All of the pads currently meet human health standards for cyanide content. Analysis shows that at least half of the residual cyanide is tightly bound up in compounds that require distillation with hot sulfuric acid to free the cyanide.

Water infiltrating through the spent ore on all of the pads is still accumulating nitrate from blasting residue, cyanide decomposition, and nitrogen fertilizer applications. The Z79/81 Leach Pad complex has the lowest nitrate values at almost 60 mg/l.

Selenium mobilization remains a problem to varying degrees in all of the pads. The Z85/86 Leach and the Z83 Leach Pad (0.084 and 0.075 mg/l, respectively) have the highest values, which exceed human health standards for ground and surface water. Although concentrations are much lower in all other pads, levels are still above standards for surface water.

The 10,650,800 cubic yards of spent ore at the Zortman Mine are contained on synthetic liners, which are bedded on thick clay underliners. All of the pad water is currently captured and treated prior to release. The leach pads cover 89 acres. In an average year, they collect approximately 20+ million gallons of water from precipitation and recycle approximately 3 million gallons of treated Zortman Mine water treatment plant water due to sludge disposal.

Z79-80-81 Leach Pad - The Zortman 79-80-81 pads are currently characterized as acidic with pH values around 4 s.u., SO4 concentrations > 2600 ppm, Al ~ 80 ppm, Cu ~ 1.2 ppm, Ni ~ 0.7 ppm, Zn ~ 11 ppm, Nitrite+Nitrate ~ 60 ppm, and low Fe and CN (0.2 ppm). The majority of parameters show improving water quality since the late 1990's with a reduction in concentrations on the order of 50 percent or greater to values seen prior to extensive reclamation.

The water chemistry suggests that the pH and much of the chemistry is currently controlled by precipitation of $Al(OH)_3$ minerals, which tend to buffer between pH values of ~ 4 and 5. It might be expected that with the predominance of Al in the solutions that these conditions may prevail for some time into the future.

Z83 Leach Pad - The Zortman 83 pad's most recent water quality data shows acidic pH values (~ 4.8 s.u.). The pH of this solution has been gradually decreasing from alkaline values near 8 since the late 1990's as would be expected when precipitation replaces the alkaline leach solutions. Sulfate concentrations however are elevated at ~ 6350 ppm. The sulfate concentrations suggest that sulfide oxidation has been occurring at some level within the pad. Because the pad waters, until the most recent sampling, have been generally buffered, most concentrations of metals such as Al, Cu, Fe, etc. were low until this fall when concentrations increased to approximately 300 ppm Al, 5.8 ppm Ni, and 52 ppm Zn. Nitrite and Nitrate are elevated in this pad (recently ~ 125 ppm), although generally decreased since the late 1990's.

While water levels in this pad change seasonally, the variations (i.e. highs and lows) have remained very similar throughout the monitoring period and are, therefore, not considered a significant factor in the changing water chemistry over the same timeframe.

As only one monitoring sample (the most recent) has indicated a moderately acidic solution, it is not clear whether this is indicative of a long term trend towards water qualities more similar to the Z82 or Z85/86 Pads (i.e. strong ARD conditions) or whether it is a reflection of recent reclamation efforts and the disruption of flowpaths and flushing of new flowpaths.

Z84 Leach Pad - The leachate chemistry of the Z84 Leach Pad is similar to the Z83 Leach Pad with relatively recent pH measurements of ~ 5.5 s.u., SO4 concentrations just below 4000 ppm, elevated Al concentration of ~ 70 ppm and generally low concentrations of Cu and Fe. Concentrations of Ni and Zn are elevated (1 and ~ 20 ppm, respectively) due to their greater solubility at these pH values than most other metals. Recent values of total CN are ~ 0.1 ppm and N+N concentrations are ~ 95 ppm. While concentrations are indicative of sulfide oxidation to some extent within the leach pad, it is not clear whether long term water qualities will become more acidic, or whether recent pH values of 5.5 are a 'stabilization' of conditions more indicative of a rinsed pad (i.e., pH conditions similar to precipitation values). Given the similarity in geochemical characteristics between material in Z83 and Z84 and the recent degradation of pad leachate in Z83, it is anticipated that a stronger signature of acid generation will become evident in this pad in the relatively short term.

Z85/86 Leach Pad - Water quality in the Z85/86 Leach Pad is an order of magnitude worse than any of the other leach pads. Recent sampling indicates that the pH is 3.2 with high concentrations of aluminum, arsenic, cadmium, chromium, copper, iron, manganese, nickel, selenium, thallium, and zinc. The sulfate content (12,800 mg/l) and total dissolved solids (15,800 mg/l) also reflect ARD conditions. Nitrate values are still at 72.5 mg/l. Total cyanide values are 0.137 mg/l.

The leachate in this pad is strongly affected by sulfide oxidation and still contains residual cyanide at relatively elevated levels compared to other Zortman Mine leach pads.

Z89 Leach Pad – Since the sludge disposal pit was installed on the Z89 Leach Pad in 1999, waters from the Z79/81, Z83, Z84, and Z85/86 pads plus sludge from the Zortman Water Treatment Plant have been circulated through this leach pad. The leachate that is produced by this mixing can be characterized as having near neutral pH. Sulfate concentrations have increased recently from around 4500 ppm to 6000 ppm, recent Al concentrations of ~ 190 ppm, Cu of ~ 0.3 ppm, Fe ~ 0.2 ppm, Ni of ~ 4.9 ppm and Zn ~ 52 ppm. Total CN concentrations recently monitored were approximately 0.06 ppm and N+N concentrations were about 95 ppm. In addition, the leachate is high in Ca (~ 530 ppm) reflecting the interaction of the various pad waters with the lime based water treatment sludge in the sludge pit. Due to the introduction of previously impacted waters and of sludge from the treatment plant, water quality sampling during this period is not reflective of the chemistry inside the Z89 Leach Pad.

4.2.3 Historic Mine Water Discharge (OU1)

The USGS topographic map of the area shows 11 mine adits near the Zortman Mine pits (some of these adits were mined out since publication of the map). Numerous other adits are shown in the surrounding area (e.g. Alder Gulch, Shell Butte, Antoine Butte). Most of these adits are above the current groundwater surface elevation and do not exhibit any groundwater drainage.

There is, however, a large network of underground mine workings at the Zortman Mine. The available maps, which are not complete, show levels developed between the elevations 4550 feet and 5270 feet. Stoping extends between the underground levels and towards the surface. Large glory holes broke through the surface in several areas. During the final phase of underground mining, an area was developed for block caving. However, the attempt at block caving failed when the draw points choked and could not be freed (Hoffman 2001).

According to Bryant (1953), significant water was encountered near the 600 Level at an elevation of 4675 feet. At the 700 Level (elevation 4550 feet) water production was reported to have reached a steady flow rate of 1,600 to 1,800 gpm. According the underground maps, these deep workings at the 600- and 700-foot levels are limited in extent and are present only below the South Alabama Pit and the north end of the Ruby Pit.

The workings in Ruby Gulch include two mine adits, which are located in the draw at the south end of the O.K./Ruby Pit. One adit has a portal elevation of 4742 feet and was driven on a northwestern bearing toward workings situated beneath O.K./Ruby Pit. The other adit was driven on an east-southeastern bearing toward workings beneath the South Alabama Pit. This adit is located at an elevation of 4775 feet. Both adits drain water and respond to precipitation events. If the adits and their associated workings are located within a zone of groundwater fluctuation, oxidation products would form when the water level is low and would mobilize in the groundwater system with rising levels, causing a decline in water quality. This has been noted in samples from the Zortman Mine water quality monitoring wells located in the shear zone.

In 2003, both of the adits were buried when the O.K. Waste Rock Dump and the Z85/86 Leach Pad were graded. Prior to being covered with backfill, drainpipes were installed in the adits and the openings were sealed with clay bulkheads. The drain pipes extended through the bulkheads and were connected to a pipeline running down to the capture system in Ruby Gulch. Together the adits have a base flow of around 3 gpm. However, following precipitation events, this flow increases upward toward 100 gpm. The adit that was driven toward the South Alabama Pit has the heavier flow. The base flow is highly acidic with a pH of 2.2 and a specific conductance of 1682. The January 2006 flow was 0.5 gpm. The flow in June 2002, when the two adits were plugged with clay and a HDPE pipe installed into the entrance of each adit, was about 15-25 gpm from the Alabama Adit with the Ruby Adit being dry. The flow was 120 gpm in April 2006.

4.3 LANDUSKY MINE SOURCES AND EXTENT

4.3.1 Waste Dumps, Leach Pad Dikes and Pad Construction Fill (OU1)

During the period of open pit mining operations at the Landusky Mine, ZMI removed approximately 68-million tons of waste material, which was placed into waste dumps, stockpiles, backfill areas, leach pad dikes, leach pad basin construction, and roads. Kinetic testing done to support the 1996 EIS shows that rock with as little as 0.2% sulfide content can produce acid. Hence, most of the materials that were mined are potentially acid producing. The main distinction between waste and ore is their gold and silver content. In some areas, the waste might have been more oxidized and barren than the typical ore.

ZMI was concerned about sulfide content during the early years of the operation because oxide ores typically leach better and cost less to leach than sulfide ores. This meant that sulfide rock was often classified as waste rock even when its precious metal content was the same or slightly higher than oxide rock.

The following table presents a breakdown of the tonnages placed in each area and identifies areas where rock with at least 10 percent sulfide content was placed. This information was compiled from mine production records, mine planning records, and blasthole data (Spectrum 2001). Those quantities identified as "Sulfide" in the table represent large discrete blocks of sulfide waste as determined by visual examination. The category "Mixed" refers to materials that were mined without any record of sulfide content. "Mixed" also refers to blocks of predominately oxide waste that contained isolated areas of high sulfides. The quantities presented in this table were calculated from drill hole and truck count information, and have not been reconciled with the other calculated quantities.

Table 19 - Landusky Mine Sulfide Waste Deposition Locations

Facility	Tons Oxide	Tons Sulfide	Tons Mixed	Tons Total
Pad and Dike Construction				
L80-82 Pad	321,365	60,890	447,400	829,655
L83 Pad	1,432,387	124,710	565,483	2,122,580
L84 Pad	543,825	0	572,170	1,115,995
L85-86 Pad	477,960	2,000	291,830	771,790
L87 Pad	6,476,809	144,191	0	6,621,000
L91 Pad	2,632,510	507,315	743,000	3,882,825
Totals	**11,884,856**	**839,106**	**2,619,883**	**15,343,845**
Waste Rock Dumps				
August #2	614,000	0	0	614,000
Montana Gulch	6,991,935	1,014,340	46,075	8,052,350
Mill Gulch	8,609,923	2,401,435	3,907,561	14,918,919
Gold Bug Repository	466,500	0	13,862,200	14,328,700
Gold Bug Backfill/August #1 Dump	523,500	0	10,301,817	10,825,317
Roads	1,471,060	193,680	269,930	1,934,670
Topsoil	2,669,200	0	0	2,669,200
Totals	**21,346,118**	**3,609,455**	**28,387,583**	**53,343,156**

Gold Bug Waste Repository - Any groundwater collecting in the backfill interval between the bottom of the pit and the water barrier at the 4740-foot elevation of this facility drains into either the Gold Bug Shear or the Suprise Shear. Water reaching underground workings probably drains into the Gold Bug Adit where it is captured.

Water infiltrating through the surface of the rock dump and the adjacent pit backfill runs down to the water barrier at the 4740-foot elevation and to the solid rock benches around it. Water reaching the barrier or feeding onto the barrier from the surrounding benches and pit walls drains toward the southwest face of the repository area. Because the collection trough extending along the toe of the water-barrier layer was buried below 20 to 50 feet of backfill when this area was reclaimed in 2002, the lined trough has been reduced to a low capacity French-drain reporting to a seepage capture culvert located on the southeast face of the L84 Leach Pad. Leachate escaping the collection trough either infiltrates into one of the shear zones or drains into or under the L84 Leach Pad. *RGC Report No. 075001/,2* dated March 20, 2000, speculated that water in the L84 Leach Pad was affected by an outside source, probably the Gold Bug backfill. The quality and quantity of leachate produced by this repository are unknown.

August #1 Waste Rock Dump – Any runoff from the graded area or water infiltration through the waste dump material drains into the pit complex.

August #2 Waste Rock Dump – Any runoff or seepage from the west lobe of the August #2 Rock Dump ends up in the Cumberland Dam. Shallow groundwater (less than 40 feet) in King Creek is typical of neutralized ARD, as evidenced by elevated TDS and sulfate. In addition, nitrate is elevated, probably due to residual blasting agents and fertilizer used on the August #2 Waste Rock Dump. Trend data indicate generally stable pH, alkalinity, TDS, and sulfate, with stable, low metals concentrations. Groundwater quality as deep as 80 feet exhibits neutralized ARD quality and elevated nitrate. Groundwater quality in the deeper aquifer (145-165 feet bgl) is representative of background nonmineralized syenite aquifer water.

Mill Gulch Waste Rock Dump - Investigations for the 1996 EIS found that shallow groundwater quality near the toe of the Mill Gulch waste rock dump was ARD impacted with low pH and high sulfate, TDS and metals. To combat this situation, ZMI constructed the Mill Gulch Seepage Capture System below the toe of the dump. In addition, the entire dump was capped with clay and 3-feet of non-acid generating material. Liners were installed on all of the dump benches and surface drainage controls were installed to collect and route runoff away from the dump. This barrier cover was intended to prevent infiltration and eliminate the need for capture and treatment. Even with this extensive barrier cover, some 21 million gallons of seepage from infiltration and run-on is captured annually at the Mill Gulch Capture System.

Montana Gulch Waste Rock Dump - The Upper Montana Gulch Seepage Capture System was built by ZMI in 1997 at the toe of the dump. Annual seepage from the dump is about 5 million gallons of water with elevated sulfate, TDS, and metals. The leachate contains no cyanide and is relatively low in selenium. On occasion, samples exceed the standard for nitrates.

L79, L80/82, L84, L85/86 Pads and Dikes – To date, there has been no indication that the materials used to construct the basins or the dikes at these facilities make any contribution to water quality problems at the sites. However, approximately 61,000 tons of sulfide rock were used in the construction of the L80/82 Dike and basin.

L83 Dike and Pad Construction – In 1997, the Frog Pond Capture System was constructed near the toe of the dike in one of the three draws covered by the facility. Although only 12,500 gallons of seepage is captured per year, this is intensely ARD water with a pH of 3.3, high metals, high TDS, and 9440 mg/l of sulfate.

L87 Dike and Pad Construction – A minor amount of high sulfide waste rock was used to construct this facility. Later the Mill Gulch Waster Rock Dump was constructed over the face of the dike. It is unknown whether this facility makes any contribution to the quality or quantity of water captured below the toe of the dump at the Mill Gulch Seepage Capture System.

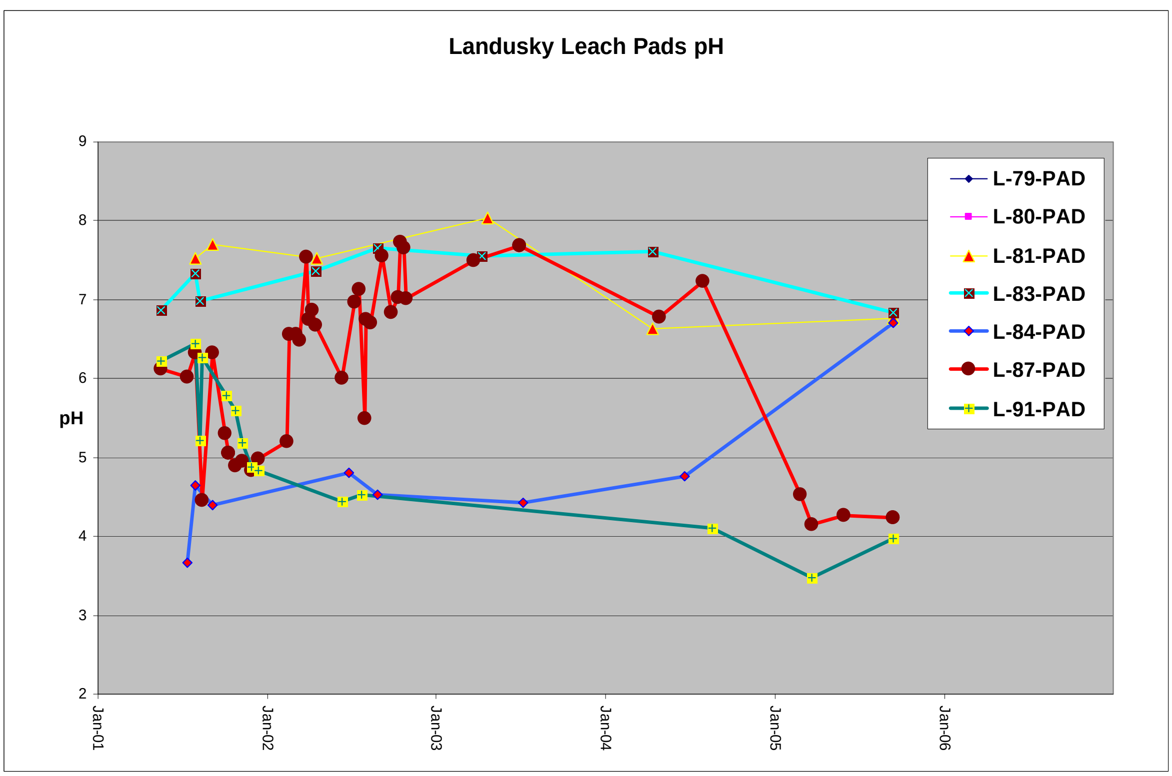
L91 Dike and Pad Construction – Before the Sullivan Gulch Capture System was installed in 1997, surface water quality downstream of the L91 Leach Pad was affected by ARD, as evidenced by low pH and elevated concentrations of sulfate, high total dissolved solids and high specific conductance. The FEIS concluded that alluvial and bedrock groundwater in upper Sullivan Creek were impacted by ARD from the L91 leach pad dike or underlying acid generating bedrock. This was determined by samples from alluvial well ZL-132 and bedrock well ZL-131.

The Sullivan Gulch Capture System handles about 5 million gallons of water per year. The Upper 91 Capture pond collects water from a spring at the toe of the dump. The Sullivan Gulch Seepage Capture System intercepts the entire thickness of alluvial aquifer. Captured water is sent to the Landusky Water Treatment Plant. Water quality trends indicate gradually worsening ARD characteristics in 1997 and 1998, with more stable conditions to the present. At its confluence with Rock Creek, Sullivan Gulch water quality is typical of the unmineralized syenite aquifer. There may be a slightly increasing trend in sulfate and TDS, but metals are stable. pH and alkalinity appear to be slightly increasing.

Bedrock groundwater does not show mining-related impacts at existing downstream monitoring stations. Groundwater quality above the confluence with Mill Gulch is characteristic of natural groundwater for the alluvial and bedrock aquifers. The Groundwater Study (WMCI, p. 199) identified a vertically upward gradient in the Madison Group limestones above the Landusky townsite. Therefore, impacts to groundwater in this aquifer are not likely.

4.3.2 Landusky Mine Leach Pads (OU2)

Figure 25 - Landusky Mine Leach Pad pH Trend

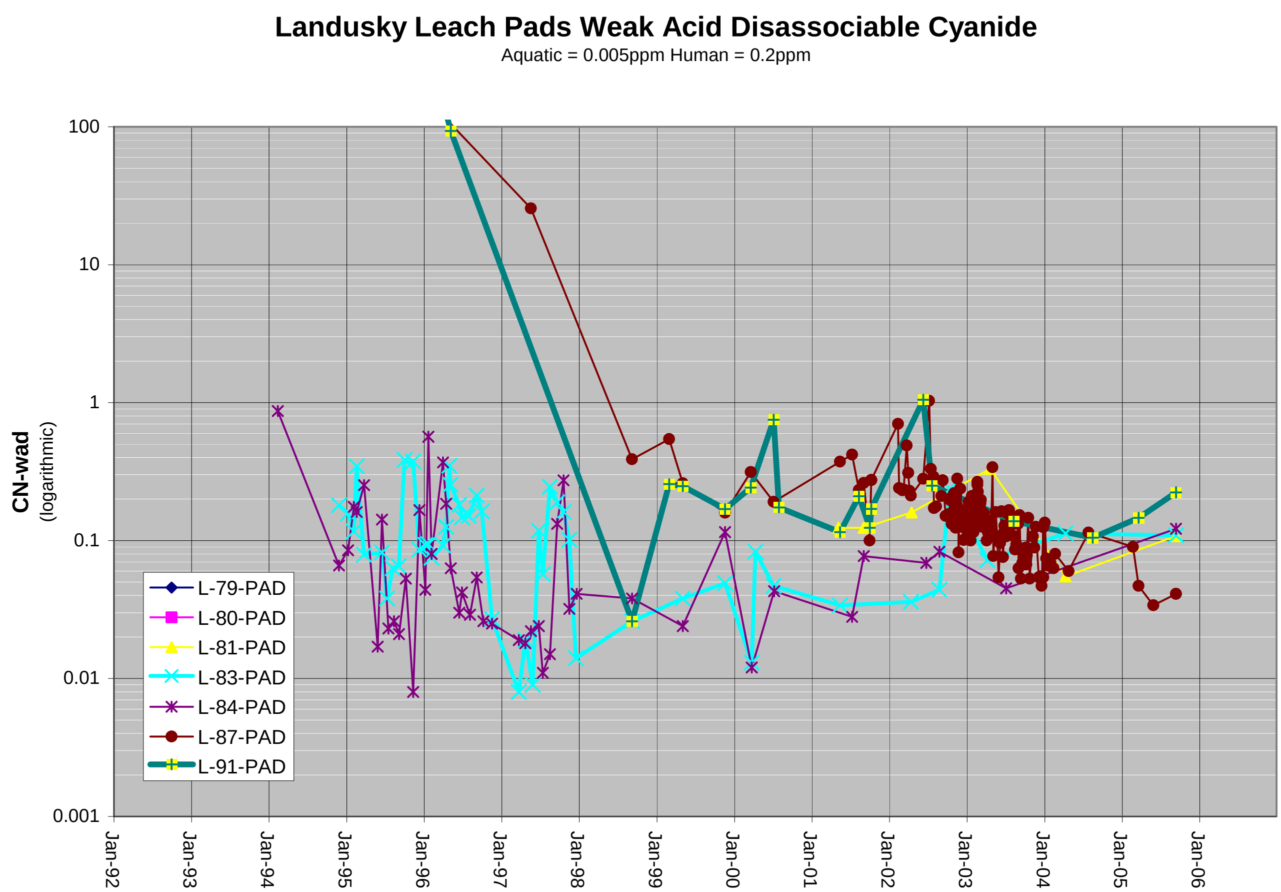


Neutralization potential in the leach pads was augmented by the addition of alkalinity during the leaching process and later during the reclamation process. When the ore was placed on the pads, ZMI added a set amount of quicklime to each truckload of ore before the load was dumped on the leach pad. This was done to conserve the cyanide in the process leach solution.

When the leach pads were reclaimed, the upper 2 feet was amended with lime prior to topsoiling. In order to determine the lime amendment requirement, the upper two feet of the subgrade was sampled on a 100-foot grid. Soil samples taken at each grid intersection were analyzed to determine their Acid Base Account (ABA). Areas with a net Acid Potential (AP) of 0-7.5 were limed with 19 tons of lime per acre. Areas with a net AP of 7.5-15 were limed with 37 ton of lime per acre. In addition, areas with a net AP of greater than 15 were limed with 74 ton of lime per acre.

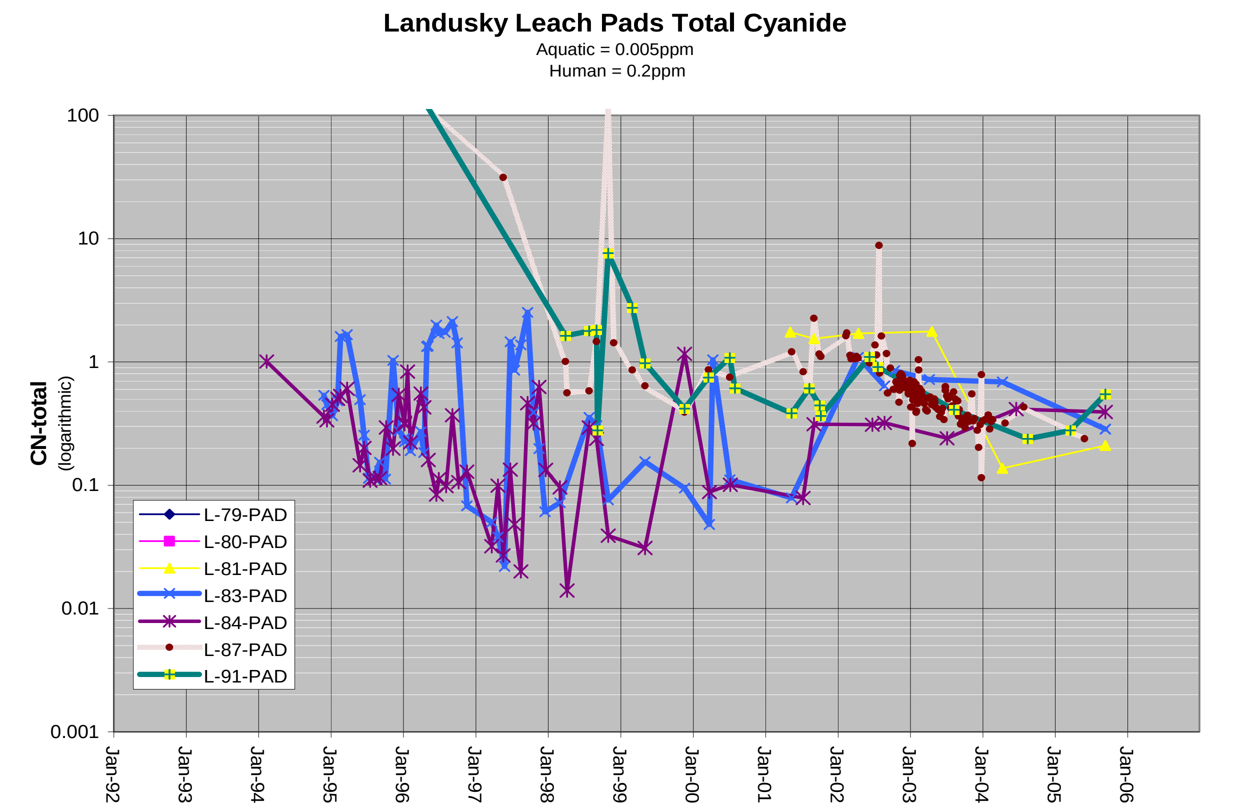
It is anticipated that once the alkalinity in the leach pads is exhausted, much of the spent ore on the pads will also follow the apparent natural trend of the other materials on site and become acid generating over time. The L91 Leach Pad is currently highly acid generating. The L87 Leach Pad is currently acidic (field pH of 4.24) and is becoming more acidic. However, it appears that the entire lower leach pad complex L79 through L84 will be only very slightly acidic with respect to acid drainage development. The L85/86 Leach Pad, which contained excess alkalinity, was removed and used as a source of non-acid generating material for pit backfill.

Figure 26



Cyanide compounds and nitrate continue to be rinsed from the spent ore on all of the leach pads with the L91 Leach Pad being the major contributor. Analysis shows that at least half of the residual cyanide is tightly bound up in compounds that require distillation with hot sulfuric acid to free the cyanide. Cyanide levels are generally less than 1 ppm; compared to the 300 to 500 ppm concentrations present during leaching operations.

Figure 27



Problems with selenium mobilization occur primarily in the L87 and L91 leach pads (1.04 and 1.05 mg/l, respectively). Although concentrations are much lower in all other leach pads, selenium levels within the leach pads are still above the chronic aquatic standard (0.005 mg/l).

The 63,698,800 cubic yards of spent ore in the L87/91 Leach Pad complex and the 5,805,700 cubic yards of spent ore in the lower leach pad complex are contained on synthetic liners, that are bedded on thick clay underliners. All of the impacted water is currently captured and treated prior to release. The Landusky Mine leach pads cover 246 acres. In an average year, they collect approximately 60 million gallons of water.

4.3.3 Historic Mine Water Discharge (OU1)

Prior to the beginning of surface mining in 1979, gold and silver bearing zones, which typically followed shear zones, were extensively mined underground. Although maps of the underground workings are far from complete, the available maps indicate that the underground workings ranged in elevation from about 4576 feet to 4910 feet. The principle mines were the August and Gold Bug. The Little Ben Mine was also worked this area. The underground workings are concentrated in the August, Niseka, and Gold Bug shear zones. Because most of the subsequent surface mining concentrated on these shear zones, underground workings in the August, Little Ben, Suprise, and Queen Rose area were nearly completely removed. Most of the underground workings in the Gold Bug Pit area were also removed as the bottom of this pit extended down to the 4650-foot elevation. It is believed that only some development workings at the bottom of these mines remain. When the surface mine was abandoned, all of the known ore reserves had been exploited. Only two mine adits with significant impact on drainage were not removed by the surface mining operations.

Prior to large-scale surface mining, ARD impacted water was draining from the Gold Bug Adit. Mine openings and the underground workings they access not only serve as conduits for the passage of groundwater, they also expose sulfide zones and allow airflow. When mines are abandoned, chutes and stopes can be left full of broken rock. Subsequent caving of the workings breaks more rock and exposes more rock surfaces to oxidation. Although little ARD production can occur in portions of the underground mine that are located below the oxygenated portion of the water table, fluctuation in the water table or a dropping water table can encourage the production of ARD and can flush oxidation products from the system.

The August drain tunnel (elevation 4604 feet) is buried beneath the Montana Gulch Waste Rock Dump. This adit was developed to evacuate groundwater from the underground mine workings. Notes on maps of the August Mine and oral accounts of miners indicate that groundwater was not a problem on the King Creek side but was a major problem as mining approached the Montana Gulch side. Drain tunnels are typically constructed on a slight upward grade and are positioned at the very lowest level of the mine to avoid pumping. This tunnel has been partially collapsed since April 1959. When ZMI drilled and shot the August pit floor after removing the last bench of ore in January 1996, it is likely that the tunnel was collapsed even further. Any flow from the August drain tunnel is captured by the Upper Montana Gulch Seepage Capture System. Water collecting in this system is heavily ARD impacted with a pH of 4.7, 1890 mg/l of sulfate, 2300 mg/l of total dissolved solids, and elevated heavy metals. Very little selenium and no cyanide are present in the water collecting in this system.

Although flow from this drain tunnel cannot be segregated from the total flow at the toe of the dump, aquifer testing shows that the discharge from the Montana Gulch waste rock dump is reduced when artesian well WS-3 is flowing and increases again when WS-3 is closed. Based on the fact that the drain tunnel did not stop the August Pit from flooding, the quantity of water captured by the Upper Montana Gulch Capture System, and the area reporting to this capture system (about 42 acres), it is likely that the contribution of the drain adit is less than 10 gpm.

The Gold Bug adit (elevation of 4576 feet) was located approximately 1,700 feet to the south of the August tunnel portal and about 28 feet lower in elevation. Discharge from the Gold Bug adit has varied over a wide range depending on the year, season, and method of measurement. It currently discharges at a rate of between 132 gpm and 170 gpm, making it a major conduit for groundwater flow. Reportedly, flow from the August drain tunnel decreased significantly after construction of the Gold Bug adit, which suggests a hydraulic connection between the August and Gold Bug underground workings. The Gold Bug adit has been sealed and water behind the seal is piped to the Landusky Water Treatment Plant Pond. Water from the adit is mildly ARD impacted with a pH of 6.0, 485 mg/l of sulfate, 758 mg/l of total dissolved solids, and elevated heavy metals. However, the Gold Bug discharge does not contain any selenium or cyanide. This adit currently discharges about 80 million gallons of water per year.

4.3.4 Artesian Wells (OU1)

Artesian well, WS-3, was drilled in 1984 to supply water for dust suppression. It is located near the toe of the Montana Gulch Waste Rock Dump in upper Montana Gulch. This well was drilled to a depth of 243 feet in the syenite porphyry aquifer within the same shear zone occupied by the August Pit, which is about 0.52 miles from the well. The top 160 feet of the borehole was cased. This artesian well initially yielded an estimated 1,000 gpm but reportedly tapered off to a couple hundred gpm. After this well was shut in during late 1995, the groundwater level began to rise and began flooding the pit by the end of January 1996. The water level in the pit continued to rise slowly until it reached a maximum depth of about 15 feet. During this period, water levels for the northern shear zone wells also increased approximately 10 feet.

On October 27, 1999, a test of WS-3 and the syenite aquifer was initiated. The well head was opened and allowed to flow continuously until November 6, 2000, at an uncontrolled rate of about 290 gpm. The August Pit lake began to decline approximately one week after the start of the test, and was completely dry by early April, 2000. Periodic water level and water quality samples were collected from WS-3 and a network of wells around the Landusky Mine area. Water quality in the pit lake was typical of neutralized ARD, while discharge from WS-3 was representative of naturally mineralized groundwater. This indicated that pit lake water was either altered geochemically or diluted along the flowpath.

On November 6, 2000, WS-3 was closed and a network of wells was measured for water level response. Groundwater levels responded within 30 to 45 minutes at the two closest wells lying along the strike of the shear zone. Other wells on the north side of the shear zone that are over 6,000 feet northeast of WS-3 showed measurable recovery within 48 hours. Wells offset or outside the main shear zones showed a delayed response, or no response in the first two weeks of recovery, demonstrating that groundwater outside the shear zone in the syenite or Paleozoic aquifers is relatively isolated from that in the shear zone.

The WS-3 tests demonstrated the dominance of the shear zones in controlling groundwater flow. The sustained discharge of WS-3 throughout the year is evidence of relatively large groundwater storage capability of the shear zone and associated underground workings. Additionally, the flow test of WS-3 did not measurably affect the flow of the Gold Bug adit. Since it is believed that these two points are hydraulically connected by shear zones, fractures and mine workings, it suggests that recharge to the area was great enough to supply the observed flows without much interference. Nonetheless, unregulated flow of WS-3 shifted the groundwater divide zone north through the Suprise and Queen Rose pits.

WS-3, which has a surface elevation of 4484 feet, flows at a rate of between 150 and 170 gpm and has a shut-in pressure of 36 psi. It is currently discharging in excess of 84 million gallons per year into an 8-inch diameter HDPE pipeline that reports to the Landusky Water Treatment Plant Pond. Water discharging from the well is somewhat characteristic of the naturally mineralized zones of the syenite aquifer with a pH of 6.9, 505 mg/l of sulfate, 962 mg/l of total dissolved solids (TDS), and elevated arsenic, manganese, and iron. However, the high sulfate load, the high TDS, and a specific conductance value of 1149 suggest some neutralized ARD. The well discharge does not contain any selenium or cyanide. Runoff and seepage from the August/Little Ben/Suprise/Queen Rose pit complex is currently discharged through WS-3. Surface water runoff from the Gold Bug Pit and South Gold Bug Pit is also routed into the August Pit and discharged via WS-3. The original casing in this well was augmented with a stainless steel casing insert after the upper portion of the original casing rusted out.

Well WS-2 was drilled at a distance of 7.5 feet from WS-3. However, this well was abandoned and plugged with a packer before completion. During abandonment, a 1-inch diameter pipe was cemented into the top of the casing allowing the release of seepage from around the packer. In 2005, the pipe releasing seepage was broken allowing a 25- to 30-gpm flow from this pipe to drain into the Upper Montana Gulch Seepage Capture System. The pH, iron precipitation, and specific conductance (1291) of the flow contained ARD reaction products. The well was permanently plugged in May 2006.

August Pit, October 1999 - Before Draining Pit Lake

August Pit, July 2005 - Reclamation Work Complete

Note: Red line to the right in each photo shows the same pit wall elevation.

4.4 GOSLIN FLATS LAD

Since 1998, a land application and disposal (LAD) facility has been operated to dispose of the leach pad water. The LAD site is located on Goslin Flats, about one mile south of the town of Zortman. The water is conveyed down to the 410-acre LAD site via pipeline where it is sprayed over the ground by elevated sprinklers. The application areas are managed as irrigated pastureland that is grazed in the winter. Because the native soils attenuate the migration of metals and other substances from the pad waters and the vegetation consumes the water, the soils and vegetation on the LAD site are monitored as part of the management plan. The location and operation of the land application area is described in detail in the report entitled Goslin Flats Land Application Disposal Expansion Assessment and 2000-2001 Plan of Operations (HSI and Spectrum, 2000).

Through 2005, nearly 711 million gallons of water have been land applied at the Goslin Flats LAD area. Until mid-2004, the LAD remained the primary disposal facility for leach pad water. In 2005, the only water applied came from the Zortman water treatment plant discharge for a short duration attempt to rinse the area with treated water. However, the high sulfate level in the treated water left a white residue on the vegetation and soil causing a suspension of this activity.

The application of the leach pad water has affected the shallow groundwater in the LAD area. Elevated levels of cyanide, nitrate, selenium, and heavy metals are apparent in seeps and ponds in the area. Because water is applied during the growing season, plants utilize the water, nitrate, and dissolved minerals. The biomass that is produced is monitored and is either burned or fed to livestock. Springs, ponds, soil, vegetation, and groundwater are all monitored by DEQ. From the assessment available, there does not appear to be a metal-loading problem in the soil or vegetation. Consequently, no removal action is required. Future use of the LAD area should not cause additional loading or further problems for the area soils or vegetation.

5.0 REMOVAL ACTION OBJECTIVES

This section of the EE/CA presents the scope of Removal or Response Actions to address the identified issues and risks present. Response Action objectives and goals that are intended to meet applicable or relevant and appropriate requirements (ARARs).

5.1 SCOPE AND PURPOSE

The removal action objective is, to the extent practicable, to only discharge water from the Site that satisfies the ARARs, which means in this case the primary State water quality standards (Circular DEQ-7). The Site boundary is shown in Section 2, Figure 2.

5.2 JUSTIFICATION FOR THE RESPONSE ACTION

Collection and treatment of water is necessary to meet ARARs and to protect public health and the environment; including the residents of Zortman, Landusky, Fort Belknap, and visitors to the BLM campground in Montana Gulch.

Concentrations of total cyanide, selenium, nitrate, and metals in the mine drainage and residual heap leaching solutions at the site present a threat to public health or welfare and the environment. These conditions meet the criteria for a Removal Action under 40 CFR § 300.415(b)(2) of the NCP.

The Site contaminants of concern include:

- Arsenic;
- Aluminum;
- Cadmium;
- Copper;
- Cyanide;
- Nitrates;
- Selenium; and,
- Zinc.

Toxicity profile summaries from the Risk Assessment Information System website for the Site contaminants of concern are at the following link: http://risk.lsd.ornl.gov/tox/rap_toxp.shtml. These are also reproduced in Appendix 5. Other constituents may be added as contaminants of concern if identified during monitoring or characterization studies at levels that present a threat to public health, welfare, or the environment.

5.2.1 Threats to Public Health or Welfare

Without a removal action, the threat of direct exposure exists through the ingestion of cyanide, nitrates, selenium, and heavy metal compounds that may expose the human population to the toxic effects. The following factors from § 300.415 (b)(2) of the NCP form the basis for our determination of the threat presented, and the appropriate action to be taken:

(i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;

(ii) Actual or potential contamination of drinking water supplies or sensitive ecosystems;

(iv) High levels of hazardous substances, pollutants, or contaminants in soils largely at or near the surface, that may migrate;

(v) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released; and,

(vii) The unavailability of other appropriate federal or state response mechanisms to respond to the release.

5.2.2 Threats to the Environment

Mine drainage derived from the leach pads, waste rock piles, leach pads dikes, and mine pits, if not captured and treated potentially affects several groups of ecological receptors. The first group includes aquatic life and plants in or adjacent the local streams emanating from the mining area. The second group of receptors includes wildlife that may ingest water in area streams with elevated metal content that could bio-accumulate, potentially reaching toxic levels. The third group of potential receptors is individuals recreating or engaging in traditional ceremonial practices at or near streams impacted by mine drainage. Because the communities of Zortman, Landusky, and the Montana Gulch Campground are all located within a mile of the potential releases, residents or visitors could come in contact with water containing elevated metal content. Streams on the north side of the mountains have fewer mine facilities, receive less mine drainage or runoff, and experience greater dilution or attenuation prior to reaching recreation areas or communities.

Several ecological receptors are potentially affected by residual contaminants in treated heap water associated with the LAD. The first group includes aquatic life associated with local streams located down gradient of the LAD areas in Ruby and Goslin drainages. The second group of receptors is native terrestrial plants whose ability to grow in LAD area soils may be limited by relatively high concentrations of nitrates, selenium, metals and salts in the land-applied water. Some plants that grow on the land application area, or near waterways subject to untreated mine drainage, may concentrate metals. These may include plants of importance to Native Americans for purposes of traditional use. Depending on the plant species and use, exposure to high metals could occur through ingestion or inhalation of such plants. The third group of receptors are cattle or wildlife that forage in the LAD area and may be exposed to on-site contamination either through direct contact with contaminated soil, plant forage, standing water, and sediments, or indirectly through consumption of organisms (algae, aquatic insects, or animals) feeding in the area.

Cyanide, selenium, and metals are found on-site in elevated levels, are hazardous substances as defined in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended, Section 101(14), and are listed in 40 CFR Section 302.4 "List of Hazardous Substances and Reportable Quantities".

5.3 IDENTIFICATION OF ARARS

Table 20 - Montana Water Quality Standards				
	Montana Water Quality Aquatic		Montana Water Quality Human Health	
	Acute	Chronic	MT DEQ-7 Surface Water	MT DEQ-7 Ground Water
	Standard mg/l	Standard mg/l	Standard mg/l	Standard mg/l
Aluminum	0.75	0.087	NA	NA
Antimony	NA	NA	0.006 mg/l	0.006 mg/l
Arsenic	0.34	0.15	0.01 mg/l	0.01 mg/l
Barium	NPP	NPP	2 mg/l	2 mg/l
Beryllium			0.004 mg/l	0.004 mg/l
Cadmium	0.009	ND76	0.005 mg/l	0.005 mg/l
Chromium (total)			0.100 mg/l	0.100 mg/l
Copper	0.052	0.030	1.300 mg/l	1.300 mg/l
Cyanide (total)	0.022	0.0052	0.140 mg/l	0.200 mg/l
Iron *(2ndary)*		1.000	0.300 mg/l	0.3 mg/l
Lead	0.477	0.019	0.015 mg/l	0.015 mg/l
Manganese (2ndary)			0.05 mg/l	0.05 mg/l
Mercury (inorganic)	0.0017	ND9	ND05 mg/l	0.00200 mg/l
Nickel	1.5160	0.1690	0.010 mg/l	0.100 mg/l
Nitrate as N+N			10 mg/l	10 mg/l
pH (EPA 2ndary)			6.5-8.5	6.5-8.5
Selenium	0.02	0.005	0.05 mg/l	0.05 mg/l
Silver	0.041	NA	0.100 mg/l	0.100 mg/l
Sulfate (EPA 2ndary)			250 mg/l	250 mg/l
Thallium			0.00024 mg/l	0.002 mg/l
TDS (EPA 2ndary)			500 mg/l	500 mg/l
Zinc	0.388	0.388	2.000 mg/l	2.000 mg/l

In accordance with the National Contingency Plan [40 CFR 300.415(j)], on-site removal actions conducted under CERCLA are required to meet ARARs "to the extent practicable, considering the exigencies of the situation." ARARs include only federal and state environmental laws or regulations. Action-specific ARARs are usually technology or activity based requirements or limitations on actions taken with respect to hazardous substances, or other particular circumstances at a site.

The State of Montana standards are similar to the EPA drinking water standards with the exception of weak acid dissociable (WAD) and total cyanide, and are the defined ARARs for this site. The toxicological difference between the free and total cyanide is significant, since cyanide that has formed complex compounds such as $Cu_2Fe(CN)_6$, $Zn_3Fe(CN)_6$, $Ag_4Fe(CN)_6$ or $Fe_4(Fe(CN)_6)_3$ with iron and other metals is not as toxic. For example, vitamin B-12 (cyanocobalamin) is a cobalt cyanide complex. Whereas the EPA's water quality standards recognize this difference, the State water quality standards do not differentiate between the total and free cyanide. Therefore, BLM anticipates acceptable environmental impacts, even if levels of total cyanide in the effluent exceed the criteria, provided that WAD cyanide levels are acceptable. Drinking water standards are met by the present water treatment operation.

July 2000 - L87/91 Valley-Fill Leach Pads. Contains 112 million tons of spent ore, over 150 million gallons of residual cyanide solution and covers over 200 acres.

June 2006 - L87/91 Leach Pad After regrading, topsoil placement and seeding. Third year vegetation.

L85/86 Leach Pad Removal from Montana Gulch

1993

2003

2006

6.0 RESPONSE ACTION TECHNOLOGIES AND DEVELOPMENT OF ALTERNATIVES

6.1 TECHNOLOGY IDENTIFICATION AND SCREENING

Given the fact that the site produces contaminated water, which cannot just simply be turned off, the management challenge is to find a feasible balance of water chemistry, technology, and cost that is protective of human health and the environment.

Presently, mine-contaminated water is being captured and treated. The acidic capture system water is being treated in conventional lime water treatment plants at the Zortman and Landusky mines. The Leach Pad water is being collected and treated in the biological treatment plant located at the Landusky Mine. In general, these treatment plants do an excellent job eliminating the acidity and removing most of the heavy metals, selenium and nitrates.

6.1.1 Prevent the Water from Becoming Contaminated

The ideal water treatment solution would be to prevent the water from becoming contaminated so that treatment would not be necessary. However, this is not possible to achieve in practice because the sources of the groundwater flowing from the adits such as the Gold Bug, Ruby and Alabama, are disperse and likely derived from groundwater recharge occurring over square miles of surface area. It would not be technically possible to totally prevent infiltration across such an area even if funding were not a limiting factor.

It is theoretically possible to use clay and other low permeability cover materials such as PVC or High Density Polyethylene (HDPE) to completely cover the leach pads and waste dumps. This alternative is not only very costly but may run into technical difficulties considering the steep slopes on some of the mine facilities and the limited room left for regrading.

One of the requirements of impermeable covers is that they must be protected by a fine grained bedding material to guard the liner from being punctured by rock. Finding, creating, and installing this bedding material is not only expensive, but provides no performance guarantee. If moisture gets under the liner, the oxidation process continues, and, even though the volume of water flowing through the system is less, the concentration of metals tends to increase, which results in a smaller volume of more concentrated acid and metals.

Due to the technical limitations to installing a site-wide barrier cover, the existing ARD reaction products already present in the leach pads, and the large area providing recharge to the groundwater system, some contaminated water would still remain. Therefore, this alternative is not viable without provisions for collection and treatment.

6.1.2 Conventional Water Treatment Systems

Presently, the acidic water from various springs, seeps, waste dumps, and leach pad dikes is collected in interception trenches and pumped to the Zortman and Landusky water treatment plants, where lime is added to raise the pH and precipitate out the heavy metals. At the Landusky Mine treatment plant, the groundwater from artesian well (WS-3) and the Gold Bug adit (81% of total WTP volume) is mixed with the more acidic capture system water to help raise the pH. This reduces the amount of lime that needs to be used and lowers the operating cost of the plant. The Landusky water treatment plant treats 210 million gallons per year compared to 64 million gallons per year at the Zortman water treatment plant, yet the annual operating costs at the Landusky treatment plant are lower.

6.1.2.1 Active Treatment

The most effective and most common acid mine water treatment method is the method being used at both the Zortman and Landusky mine water treatment plants. It involves adding hydrated lime (or other alkaline chemicals) to the water to raise the pH, which causes metal hydroxides such as iron hydroxide and aluminum hydroxide to precipitate as a sludge. This neutralizes the acidity and removes a large portion of the heavy metals, but not all of them. Each metal hydroxide will begin to precipitate at a different pH, and each has a different pH "sweet spot" where the maximum amount of metal removal will occur. If the pH is above or below this optimal level, some metals may not precipitate, or may go back into solution. This principle is illustrated in the solubility charts in Figure 28 on the following page.

This process produces a substantial volume of precipitates called sludge that must be collected and managed. During periods of high flow (spring runoff), the capacity of the Zortman water treatment plant is taxed because the high through put does not allow sufficient time for settling some of the gypsum that forms when the calcium in the lime reacts with the sulfates in the acid rock drainage.

This conventional water treatment method works very well, which explains its popularity and the fact that ZMI chose to install it at both mines. However, it is relatively expensive, because it requires constant maintenance and chemical consumption, and a large volume of sludge is generated that must be managed. At the Site, additional expenses are incurred because the capture systems are usually located below the elevation of the treatment plants, hence pumping must be employed. Gravity alone cannot be used in most cases.

6.1.2.2 Aeration/Oxidation

If the water is oxidized by introducing air, aluminum and iron will generally precipitate at lower pH values, thus reducing the alkaline chemical consumption. This system works when the iron is in the ferrous form and the water is alkaline. If sufficient alkalinity and high enough pH exists, sometimes only aeration is needed to increase the pH and precipitate the iron. Chemical oxidants such as hypochlorite, hydrogen peroxide and potassium permanganate have been used occasionally to complete the oxidation process, enhance metal hydroxide precipitation, and to reduce metal floc volumes[3].

6.1.2.3 In-situ Biological Treatment

Depending on the oxidation state and pH, bacteria can reduce metals and precipitate them from aqueous solution. Activated charcoal can absorb metals from aqueous solution and act as a high surface area host for the bacteria. This is the basis for the present biological treatment plant that successfully reduces the selenium, nitrates and other metals from the leach pad water. The present OU2 system uses pumps to move the water and feed the nutrients to the bacteria, so this must still be considered an active system even though it uses bacterial process to reduce the metals.

One alternative is to use the bacteriological solutions from the bioreactor and re-inject them into the leach pads and rock dumps to reduce or eliminate the bacteria responsible for most of the acid conditions. This concept could significantly reduce acid generation from the sulfide rock, but it is not a permanent solution, and there is no assurance it will work well enough to eliminate the need for the biological treatment plant. Pilot scale testing would be needed before any confident recommendation could be developed. A continuous source of nutrients would need to be introduced to the pads to feed the bacteria. One source of nutrients that would work is

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3 Handbook of Technologies for Avoidance and Remediation of Acid Mine Drainage

manure from a feedlot operation on top of the pads (that could also help create topsoil). A concern is that imported grass, alfalfa, and grains could introduce weeds.

6.1.2.4 Reverse Osmosis

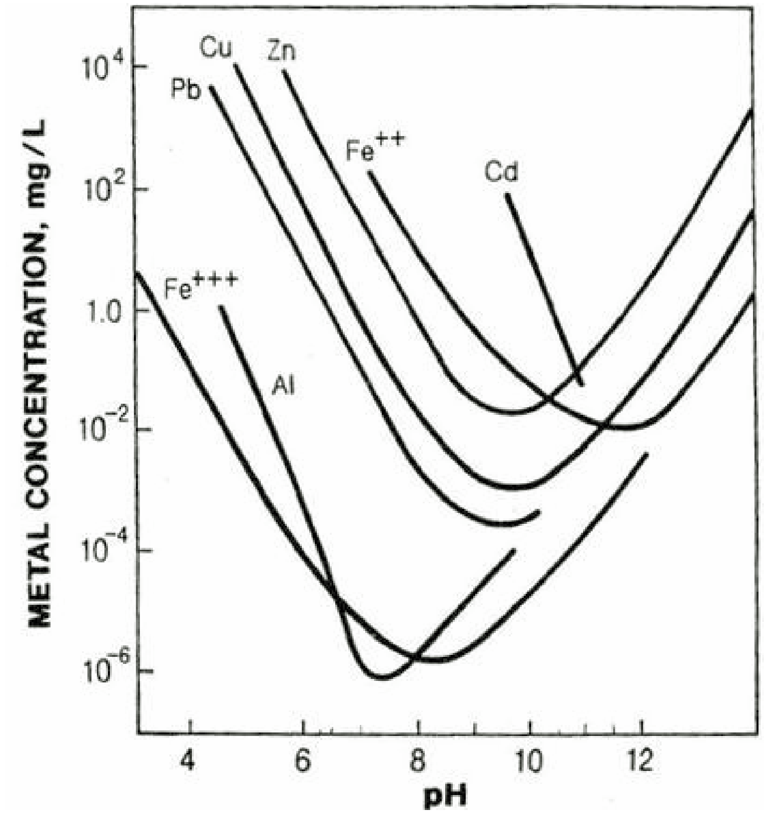
Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration. Osmosis is a special case of diffusion in which the molecules are water and the concentration gradient occurs across a semi-permeable membrane. The semi-permeable membrane allows the passage of water, but not ions such as Fe^{++}, Al^{+++}, Cu^{++} or larger molecules. Osmosis can be slowed, stopped, or even reversed if sufficient pressure is applied to the membrane from the “concentrated” side of the membrane.

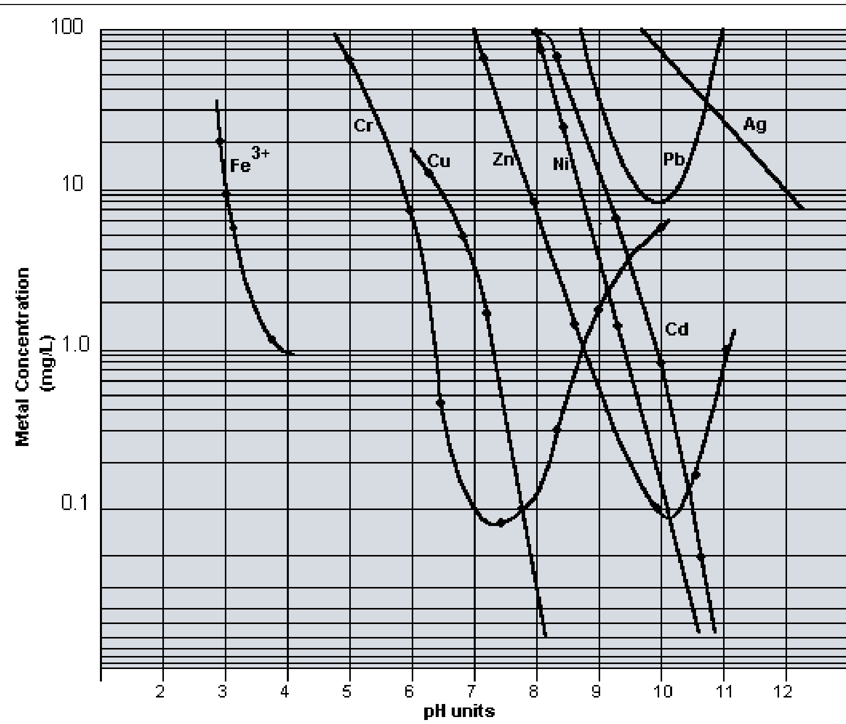
Reverse osmosis occurs when the water is moved across the membrane against the concentration gradient, from lower concentration to higher concentration. To illustrate, imagine a semi-permeable membrane with fresh water on one side and a concentrated aqueous solution on the other side. If normal osmosis takes place, the fresh water will cross the membrane to dilute the concentrated solution. In reverse osmosis, pressure is exerted on the side with the concentrated solution to force the water molecules across the membrane to the fresh water side, leaving the larger ions and molecules on the high pressure side of the membrane. Several systems have been developed to flush or vibrate the concentrate off the membrane to prevent it from plugging. The concentrate must then be collected and disposed of. This can be done by drying it in solar ponds or with heaters, or it can be slurried or transported to a lined disposal site for burial as hazardous waste. In both cases, the disposal will be difficult and expensive for a large site like the Zortman and Landusky mines.

Reverse osmosis is expensive because the semi-permeable membranes tend to plug up or wear out, each membrane can only process a small amount of water, and the concentrated waste must be collected and managed. Typically, the waste product stream is about 15 percent of the total volume treated. If the water is highly acidic the pH must still be adjusted before the water can be released.

The capital cost for an R/O unit capable of handling water at the mines is about $250,000 for each 50 gpm treated (± 20 gpm depending on water temperature). The annual operating cost would be about $40,000 per year per 50 gpm, plus power and operating labor. The performance of reverse osmosis is sensitive to the viscosity of the water, which is a function of the water temperature. The capacity of an R/O unit will double if the water temperature is increased from 10°C to 50°C. One manufacturer suggested that it is often more economical to heat the water than to purchase twice as much R/O capacity. Technically, reverse osmosis will produce clean water, but it is usually only economical in a commercial operation. For the Site, it is technically possible to use but is much more expensive than the current treatment systems. Total capital costs of an R/O unit are estimated at $3,000,000 with annual operating costs of $2,100,000.

Figure 28 – Solubility of Metals at different pH





6.1.3 Passive Treatment Systems

The active treatment systems described above are all relatively expensive and require constant management and supervision. Proponents of passive or semi-passive treatment systems suggest that the success of the biological treatment plant indicates that a less expensive, more passive system will be feasible. The problem with passive systems is that they require a considerable amount of flat ground that does not exist in the mountains, and most of the literature suggests that the flow rate must be less than 100 gpm. The average total flow from the Zortman Mine is about 170 gpm, and the average from the Landusky Mine is about 545 gpm.

It has been observed that natural systems frequently remove acidity and metals from water. For example, the copper and gold deposits near Cooke City, Montana were discovered when naturally occurring bog iron and bog copper were discovered in the wetlands below the mineralized deposits. The ferricrete deposits in Swift Gulch, to the north of the Landusky Mine, formed by naturally occurring mineralized water seeping from the mineralized shear zones. Ferricrete deposits when iron naturally oxidizes and precipitates out as iron oxyhydroxides.

In recent years, a variety of passive treatment systems have been developed that do not require continuous chemical inputs and take advantage of naturally occurring chemical and biological processes to clean contaminated waters. The primary passive technologies include constructed wetlands, anoxic limestone drains (ALD), successive alkalinity producing systems (SAPS), limestone ponds, open limestone channels (OLC), and Sulfate Reducing Bioreactors (SRBR).

A considerable amount of research, including a variety of trial and error testing, has been done in the last two decades to try to understand the bio-geochemistry that permits natural processes to remove the acidity and the heavy metals. Before the chemical and biological processes were understood, many of these artificial wetlands failed. As more knowledge is gained, the success rate has increased. Most of the research to date has focused on adjusting pH and reducing iron, aluminum and sulfates from acid coal mine drainage.

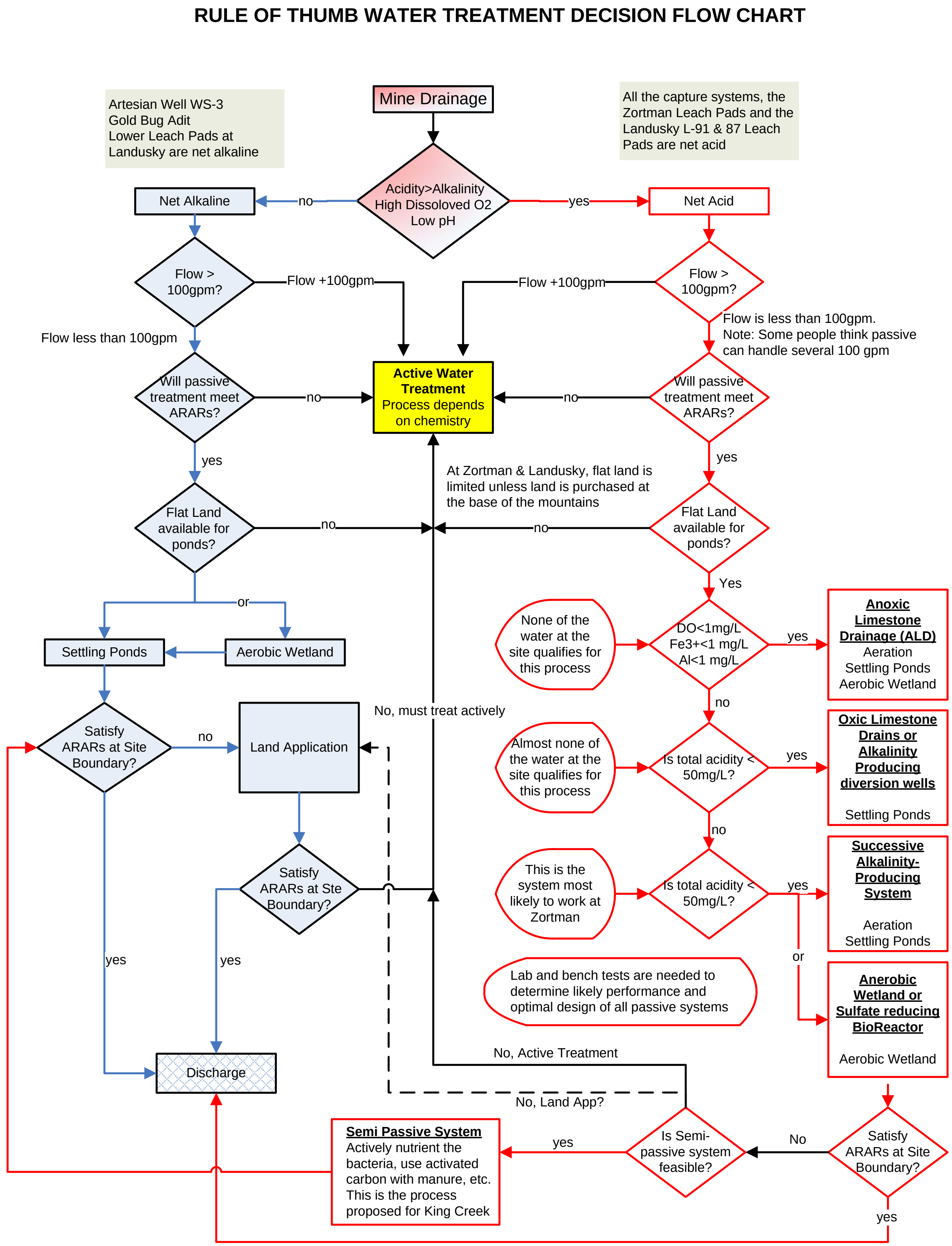
Researchers have developed some preliminary rules that indicate whether or not different types of passive systems may be applicable as a function of the flow rate (which dictates the size), the availability of flat land for large ponds, the dissolved oxygen content of the water, the amount of ferric ions and aluminum, and whether the water is alkaline or acidic. Other considerations that go into the design of the passive systems include how variations from seasonal flows during rain storms and spring run-off will affect the passive system, and whether it will function properly at high altitude or below freezing.

The Zortman and Landusky mines are located in steep terrain with very little flat land available for ponds, the winters are very cold, and many of the sources of water have highly variable seasonal flow rates and water chemistry. These are all factors that put the feasibility of large scale passive treatment systems in doubt.

6.1.4 Release Untreated Waters

The immediate problem is to find a way to either fund the deficit or find a less expensive way to satisfy the ARARs. Releasing untreated water at certain locations during a portion of the year is an option, but would have to be done in a manner that did not contaminate drinking water aquifers. This is not possible near the Landusky Mine due to the presence of numerous shallow domestic wells. At the Zortman Mine, it is possible but the savings potential is extremely small. The labor force cannot be hired and fired and rehired so the personnel are present whether the water treatment plant operates or not. Much of the power costs are fixed and continue whether pumps operate or not. Some chemicals costs could be saved. Estimated savings are less than $50,000 per year and ARARs would be exceeded.

Figure 29 - Rule of Thumb Water Treatment Flow Chart



File: Rule of Thumb Water Treatment Method Flowchart.vsd

6.1.5 Cost Reduction Measures

Some potential options to reduce the costs are:

- Additional automation. Some automation has already been implemented at the Landusky water treatment plant. The labor for the 24-hour Landusky operation has been reduced to 10 hours/day of manned labor with warning systems that automatically notify the site manager at home 24 hours/day 365 days per year if problems are detected. It is doubtful if the Zortman water treatment plant can be fully automated due to some capture systems being too low to connect with a radio link. Further reductions in the amount of time the plants are staffed, reduce the monitoring and sampling, and reduce the amount of diligence used to ensure that all the capture systems are operating properly to ensure zero untreated water pollutes the environment. Seven people (reduced from eight on 2/1/2006) are presently employed to operate the Landusky WTP 24/7/363 and to regularly check and maintain the capture systems, to operate the biological treatment plant and to intermittently operate the Zortman WTP and regularly check the Zortman Mine capture systems. If the labor force is reduced to only one shift per day, 4 days per week, then one additional job could be eliminated. This could save about $81,000 per year, but during peak flows when the Zortman WTP needs to operate 24 hours per day and when problems arise overtime rates will need to be paid, which will reduce the savings. The chances that untreated water being released would increase. Servicing and inspecting some of the capture and pumpback sites cannot be done safely with only a single operator.

  Based on recent experience with trespassing, theft and vandalism, any money saved by reducing on-site personnel may result in significant losses due to theft and vandalism that might also compromise the operation.

- A semi-passive technology such as Sulfide Reducing BioReactors might be deployed, but the performance and true cost cannot be accurately determined without lab and pilot scale testing, and a significant amount of capital would be required to purchase the land and construct the facilities. The high aluminum and iron content of the water will require special consideration, and there is no guarantee that a passive or semi-passive system will satisfy ARARs. A passive system might be useful for polishing the water treatment effluent, but it will add to the cost. Lab and pilot scale testing of passive systems would be required and a source of funding is necessary before this can be done.

- Wind turbines could be installed to offset a significant portion of the $260,000 annual electricity costs.

- Eliminate the use of ferric sulfate. This would save about $36,000 per year. The arsenic content in the discharge from the Zortman Water Treat Plant in Ruby Gulch would potentially increase. ARARs would most probably be met as the water reached the town of Zortman. A January-April 2006 test of the Zortman Water Treatment Plant without the use of ferric sulfate was completed. The lab results gave a 0.001 mg/l result for arsenic and no change in the other analytes. It is possible that the ferric sulfate in needed only during the 2-3 months when the plant is run at 1200 gpm and not during the 9-10 months when it is operated a few days per month at 600 gpm. Additional testing is ongoing in order to minimize the use of ferric sulfate.

More than half the removal action costs for OU1 and OU2 are fixed and can only be reduced if an entire cost center is eliminated. Labor is the largest cost component and has already been substantially reduced. The cost to operate each of the three treatment systems is approximately the same depending on how the supervision and overhead costs are allocated. If one of the operations was shut down, the cost would still exceed the $731,321 funding. It is not possible to shut down the leach pad and biological treatment collection and treatment, because most of the water from the leach pads would report to the capture systems and would be sent to the water treatment plants. Land Application Disposal was used before the leach pads became so acidic, but the high level of dissolved salts and the acid water are not amenable to long-term land application without prior treatment. The materials, power and chemical costs alone for the current operations now cost $867,600 per year. Therefore, even if labor was eliminated, site operations would still exceed the funding from 2007 through 2017 by $136,300 annually.

Bioreactor on the L87 Leach Pad Dike, pH pre-treatment pond in the foreground.

7.0 ANALYSIS OF ALTERNATIVES

7.1 EVALUATION CRITERIA

The following three criteria are used to evaluate removal action alternatives for the Zortman and Landusky Mine Site.

1. Effectiveness - According to EPA guidance for removal actions (EPA, 1993), the effectiveness of an alternative should be evaluated by the following criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness.
2. Implementability - Implementability addresses the technical and administrative feasibility of implementing an alternative.
3. Cost - Evaluation of alternative costs consists of developing cost estimates based on existing practices.

7.2 IDENTIFICATION OF ALTERNATIVES

The main issues of concern are the water quality and the lack of funding to implement the treatment of water to satisfy ARARs. The alternatives are identified in Table 23 – Alternatives Matrix.

Effective removal technologies have already been implemented at the Site. The alternatives consider impacts, benefits, and cost savings of modifying these operations or discontinuing their operation and of replacing the in-place control measures with alternative controls. Alternatives that would shut down an individual capture system or an individual leach pad leachate collection system were considered. Many variations had minimal cost savings compared to the Base Case (current operating procedure).

A total of 14 alternatives were considered for the removal actions associated with the Zortman Mine and a total of 10 alternatives were considered for removal actions associated with the Landusky Mine portion of the Site. These are labeled Z-100 through Z-1300 and L-100 through L-1000 respectively. Most of these are not viable and do not meet ARARs. In addition, three alternatives were considered for Swift Gulch (SG-100, SG-200, SG-300), two alternatives were considered for King Creek (KC-100 and KC-200), and three alternatives were considered for the Zortman Alder Gulch Waste Rock Dump (AG-100, AG-200, and AG-300).

The following table depicts the volume and quality of water from various site sources before treatment in comparison to the water quality standards. If this water was released without treatment, it is doubtful ARARs would not be met at the downstream Site boundaries.

Table 21 - Untreated Water Quality

(This is the quantity and quality that would be released from each source if not captured and treated)

	DEQ-7 Standards				Landusky Mine				Zortman Mine		
	Aquatic Acute (mg/l)	Aquatic Chronic (mg/l)	Human Health Surface Water (mg/l)	Human Health Ground Water (mg/l)	Landusky Capture	Landusky Pads	Total Landusky Untreated	Units	Zortman Capture	Zortman Pads	Total Zortman Untreated
Average gpm (365 days/yr, 24 hrs/day)					380 gpm	130 gpm	510 gpm		120 gpm	50 gpm	170 gpm
Gallons/year					200 M	70 M	270 M		64 M	26 M	90 M
pH					5.00	4.19	4.62		3.7	3.05	3.39
SC					1,194	8,270	3,028		1,087	4,341	2,028
AL	0.750	0.087			33.5	385.9	124.9	mg/l	254.0	607.1	434.0
As	0.340	0.150	0.010	0.010	0.150	0.012	0.114	mg/l	0.227	1.205	0.451
Cd	0.009	0.001	0.005	0.005	0.040	0.516	0.160	mg/l	0.218	0.507	0.291
CN	0.022	0.022	0.200	0.200	<0.005	0.289	0.075	mg/l	<0.005	0.130	0.041
Cu	0.052	0.030	1.30	1.30	0.11	6.46	1.76	mg/l	6.95	8.60	7.89
Fe		1.00	0.30	0.30	18.8	139.7	50.2	mg/l	40.0	206.5	118.0
Mn			0.05	0.05	7.6	77.0	25.6	mg/l	35.0	72.5	51.5
N+N			10.00	10.00	1	204	54	mg/l	5	85	29
Ni	1.57	0.17	0.010	0.100	0.29	4.12	1.28	mg/l	2.12	4.71	2.87
Se	0.02	0.005	0.050	0.050	0.004	0.673	0.177	mg/l	0.012	0.055	0.025
SO4	250	250	250	250	991	7,335	2,636	mg/l	3,000	7,648	5,629
TDS	500	500	500	500	1,328	9,365	3,412	mg/l	5,283	10,086	6,672
THrd					671	2,078	1,036	mg/l	1,404	1,822	1,525
Tl			0.00024	0.0020	-	0.003	0.001	mg/l	-	-	-
Zn	0.39	0.39	2.00	2.00	1.72	34.93	10.33	mg/l	7.02	50.92	19.62

Note: Flow rates and chemistry fluctuate year to year and seasonally
Flow rates represent annual volume 365 days/year, 24 hrs/day

Table 22 - Actual Water Quality Discharged from Both Mines

	Contaminants												
	GPY	AL	As	Cd	CN	Fe	Mn	N+N	Ni	Se	SO4	Tl	Zn
Aquatic Acute (mg/l)		0.8	0.34	0.01	0.02				1.57	0.02	250		0.4
Aquatic Chronic (mg/l)		0.1	0.15	0	0.02	1			0.17	0.005	250		0.4
Human Health Surface Water (mg/l)			0.01	0.01	0.2	0	0.1	10	0.01	0.05	250	0.00024	2
Human Health Ground Water (mg/l)			0.01	0.01	0.2	0	0.1	10	0.1	0.05	250	0.00024	2
Site													
Zortman-ZWTP (2005)	64			0.022	-			5.5			2,450		0.06
Zortman-ZWTP (since 2003)			0	0.004	0.011	0.3	5.6	4.78	0.05	0.01	2,251		0.02
Landusky WTP Discharge (2005)	200		0.007	0.002	-	0.1	2.7	1.16	0.050	0.006	882		0.02
Landusky WTP Discharge (since 2003)	200	0.5	0.008	0.001	0.003	0.4	2.8	1.58	0.051	0.008	755	0.003	0.05
BioReactor Discharge (2005)	96	2.7	-	0.008	0.195	0.7	59	0.3	0.12	0.02	6,390		1.36
BioReactor Discharge (since 2003)	96	0.7	0	0.019	0.230	1.0	24	0.3	0.26	0.08	4,588	0.003	1.0
Combined Landusky Discharge	296	0.6	0.006	0.007	0.077	0.6	9.7	1.1	0.1	0.035	1,998	0.003	0.4
Note: zero indicates non-detect, blank is no data													
Exceeds Human Health Std													
Exceeds Aquatic Chronic Std													
Exceeds Aquatic Acute Std													

Sullivan Gulch seepage capture system

Table 23 – Alternatives Matrix

	Case	Treat in Zortman WTP	Treat in Landusky WTP	Treat in Landusky Bioplant	Goslin LAD	Passive or Semi Passive Treatment	Release untreated	Satisfy ARARs?	Comment
Zortman Capture	Z-100	XXX						Yes	Base Case. Operate ZWTP similar to current operation.
Zortman Capture	Z-200		XXX					Yes*	Shut down Zortman WTP, pump to Landusky WTP. Requires all season acid resistant pipeline.
Zortman Capture	Z-300					XXX		No	Passive or semi passive have some potential, but high aluminum and iron and lack of available space are major constraints.
Zortman Capture	Z-400						XXX	No	No treatment. Allow upper captures to run down Ruby Gulch and lower captures to run down Alder Gulch
* Except during spring flows when LWTP capacity would be exceeded.									
Zortman Leach Pads	Z-500			XXX				Yes	Base Case. Operate Landusky Bio Plant similar to current.
Zortman Leach Pads	Z-610	XXX						No	Treat pad water in ZWTP, then discharge down Ruby Gulch with elevated nitrates, selenium, and cyanide.
Zortman Leach Pads	Z-620	XXX						Yes	Treat pad water in ZWTP, then pump to Landusky biological treatment plant for additional treatment.
Zortman Leach Pads	Z-630	XXX						Yes	Treat pad water in ZWTP, then land apply on Goslin Flats LAD.
Zortman Leach Pads	Z-700		XXX					No	Treat pad water in Landusky WTP. If Zortman WTP is closed, the pipeline must be replaced with HDPE acid resistant pipe. Nitrate, selenium, and cyanide will exceed ARARs until they are washed out of the system.
Zortman Leach Pads	Z-800				XXX			Yes	Take pad water to the Goslin LAD. Placing acid water on the LAD is probably unsustainable.
Zortman Leach Pads	Z-900					XXX		Maybe	Treat pad water in external passive or semi passive system. High aluminum and iron and lack of available space are major constraints.
Zortman Leach Pads	Z-1000						XXX	No	No treatment. Allow upper pads to run down Ruby Gulch and lower pads run down Alder Gulch.
Seal all areas	Z-1100	Cover all leach pads, dumps, and mined areas with an impermeable cover to seal out the water.						Not without treat-ment	Cap the mine features. This would cost more than the base case of collecting the water and treating it. Plus, it would not stop all the seeps and water draining from old workings.
* For case Z-200, the Landusky WTP can not handle both Landusky and Zortman flows during spring runoff. A portion of the Zortman captures would need to be released.									

Table 23 – Alternatives Matrix										
	Case	**Treat in Zortman WTP**	**Treat in Landusky WTP**	**Treat in Landusky Bioplant**	**Goslin LAD**	**Passive or Semi Passive Treatment**	**Release untreated**	**Satisfy ARARS?**	**Comment**
Wind Power	Z-1200	Generate electricity with a wind turbine.							This will work for up to about 40% of the power. Economics look favorable only if capital is "free".
Zortman Water Treatment Plant Variation	Z-1300	XXX						Yes	Base Case Alternative Z-100 modified with elimination of ferric sulfate circuit.
Landusky Capture	L-100		XXX					Yes	Base Case. Operate LWTP similar to current operation.
Landusky Capture	L-200	XXX						Yes, most of the time	Close the Landusky WTP and pump all captures to Zortman WTP. This is not as economical as pumping Zortman to Landusky WTP, so is not feasible and was not analyzed. ZWTP capacity exceeded 2-3 months per year and ARARs would not be met.
Landusky Capture	L-300					XXX		No	Passive or semi passive have some potential, but high aluminum and iron and lack of available space are major constraints.
Landusky Capture	L-400						XXX	No	No treatment. Close the Landusky WTP and let all the captures run freely. Either let artesian well WS-3 run freely or plug it. Plugging it may increase Swift Gulch flows.
Landusky Leach Pads	L-500			XXX				Yes	Base Case. Operate Landusky Bio Plant similar to current.
Landusky Leach Pads	L-600		XXX					No	Shut down the bioreactor and treat all pad water in LWTP. Nitrates, cyanide and selenium would exceed ARARs until they are washed out of the system.
Landusky Leach Pads	L-700				XXX			No	Pump Landusky Pads to Goslin LAD. This will probably overload the LAD and exceed ARARs.
Landusky Leach Pads	L-800						XXX	No	No treatment. Allow pads to overflow or else puncture them. In both cases the water will report to the capture systems. If the WTP is running, then this would be a variation of L-5, otherwise the water will contaminate Rock Creek and the Landusky townsite water wells.
Seal all areas	L-900	Cover all leach pads, dumps, and mined areas with an impermeable cover to seal out the water.						Yes, with treat-ment	This would cost more than the base case of collecting the water and treating it. Plus, it would not stop all the seeps and water draining from old workings like the Gold Bug Adit.
Wind Power	L-1000	Generate electricity with a wind turbine.							This will work for up to about 40% of the power. Economics look favorable only if capital is "free"

Table 24 – Alternatives Matrix

	Case	Treat in Zortman WTP	Treat in Landusky WTP	Treat in Landusky Bioplant	Goslin LAD	Passive or Semi Passive Treatment	Release untreated	Satisfy ARARS?	Comment
King Creek	KC-100						XXX	Yes	No action alternative. Slightly elevated nitrates and selenium will continue to flow down King Creek.
King Creek	KC-200					XXX		Yes	Install passive system below the current interception trench. Should satisfy all ARARs and address nitrate and selenium issues.
Swift Gulch	SG-100						XXX	Yes	Monitor only.
Swift Gulch	SG-200						XXX	Yes	Continue to monitor and conduct studies on drainage paths.
Swift Gulch	SG-300						XXX	Yes	Continue to monitor and conduct studies on drainage paths. Plus build settling ponds in the old placer tailings at the Bighorn-Swift Gulch confluence. This will decrease the chance of contaminants leaving the Site during extreme runoff.
Alder Gulch Waste Rock Dump	AG-100							Yes	No action alternative. Leave the dump as currently reclaimed.
Alder Gulch Waste Rock Dump	AG-200							Yes	Regrade and recap the top portion of the Alder Gulch Waste Rock Dump with RIT grant of $300,000.
Alder Gulch Waste Rock Dump	AG-300							Yes	Remove top of dump and place into North Alabama Pit. Regrade and recap the top portion of the Alder Gulch Waste Rock Dump and North Alabama Pit. Total cost of $2.2 million.

All of the treatment options are illustrated graphically with the next four figures. First, the Zortman Mine Captures Systems options are presented, followed by the Zortman Mine leach pad options. Then the Landusky Mine Capture Systems options are presented, followed by the Landusky Mine leach pad options.

Figure 30 – Zortman Mine Capture Options

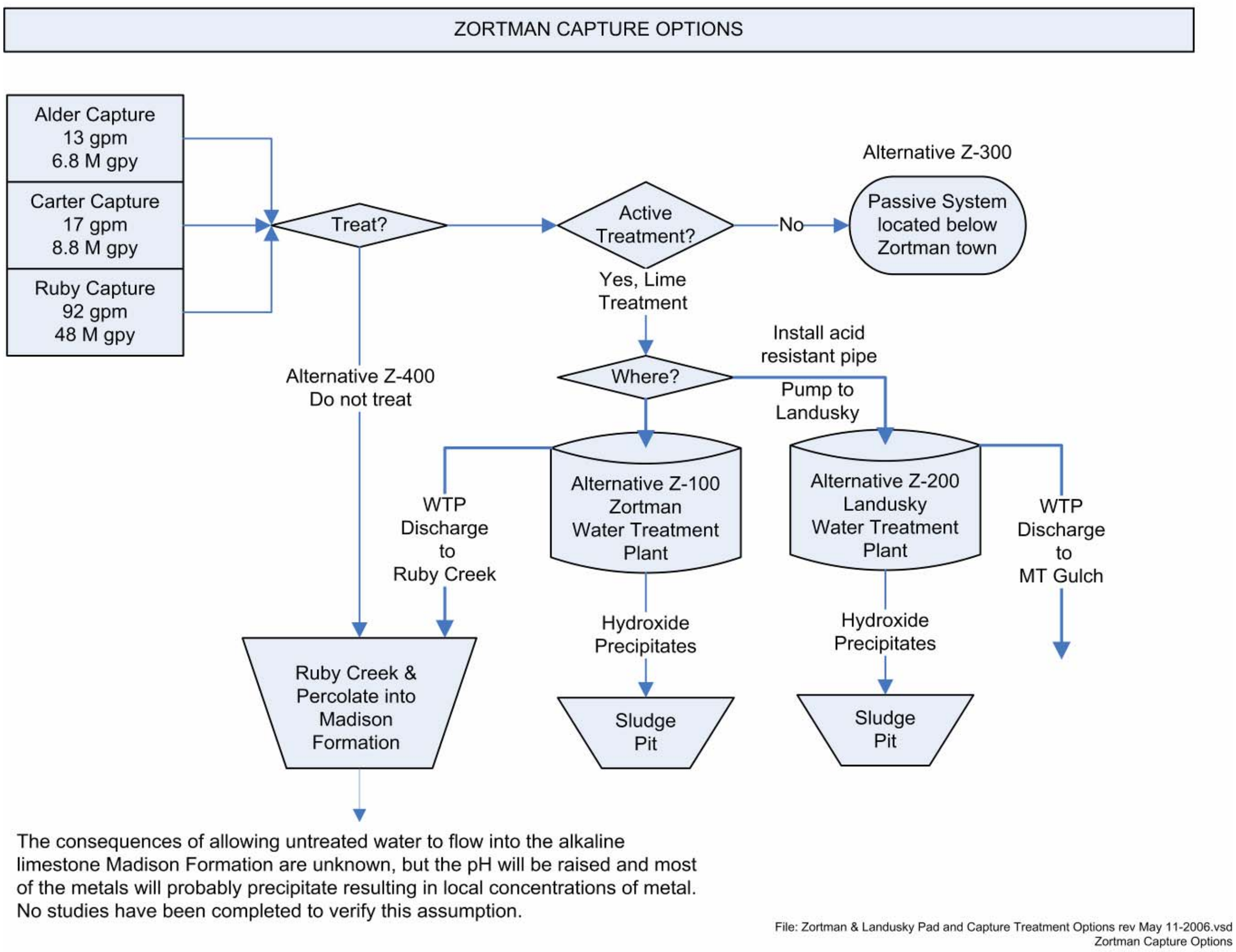


Figure 31 – Zortman Mine Leach Pad Options

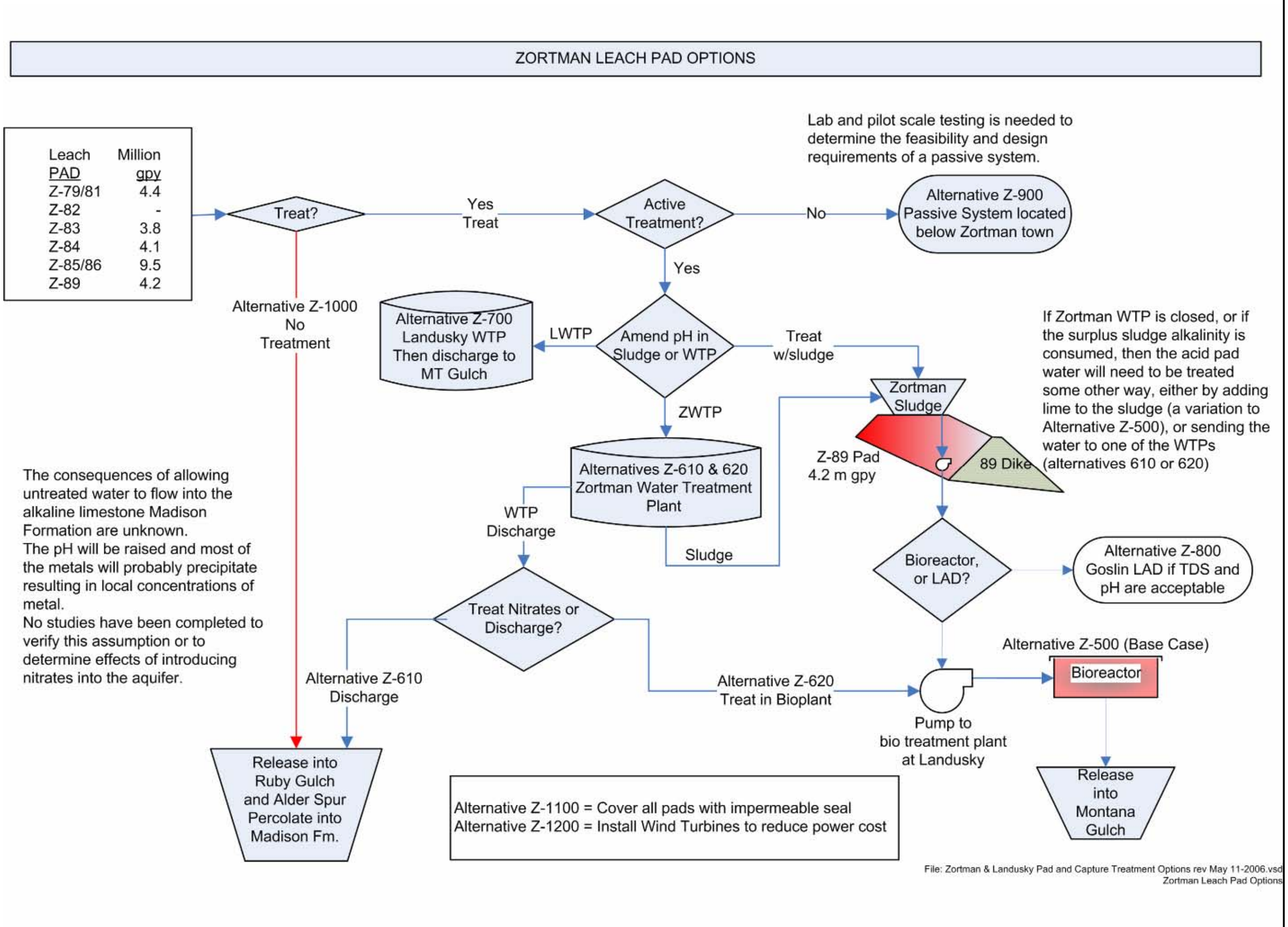


Figure 32 – Landusky Mine Capture Options

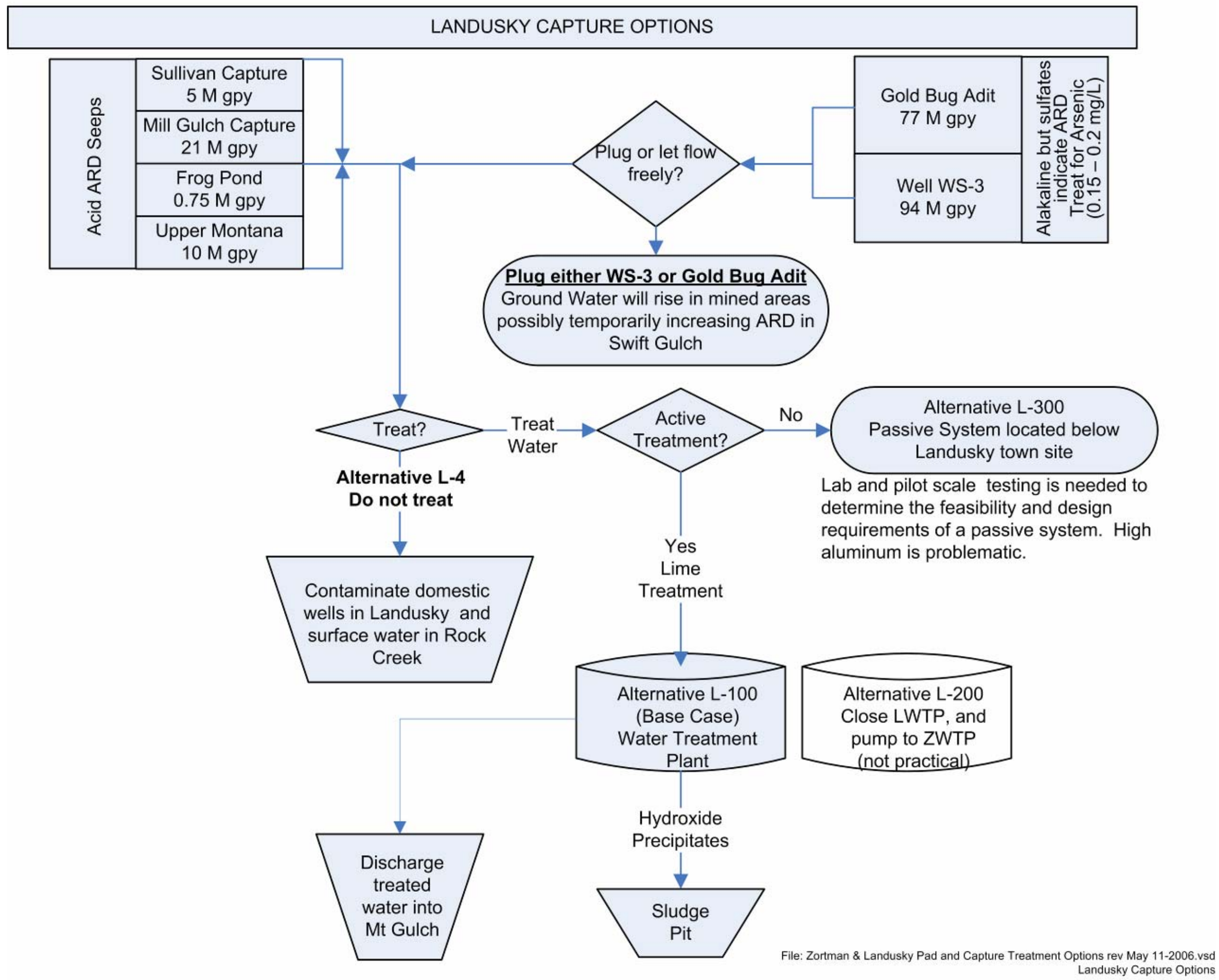
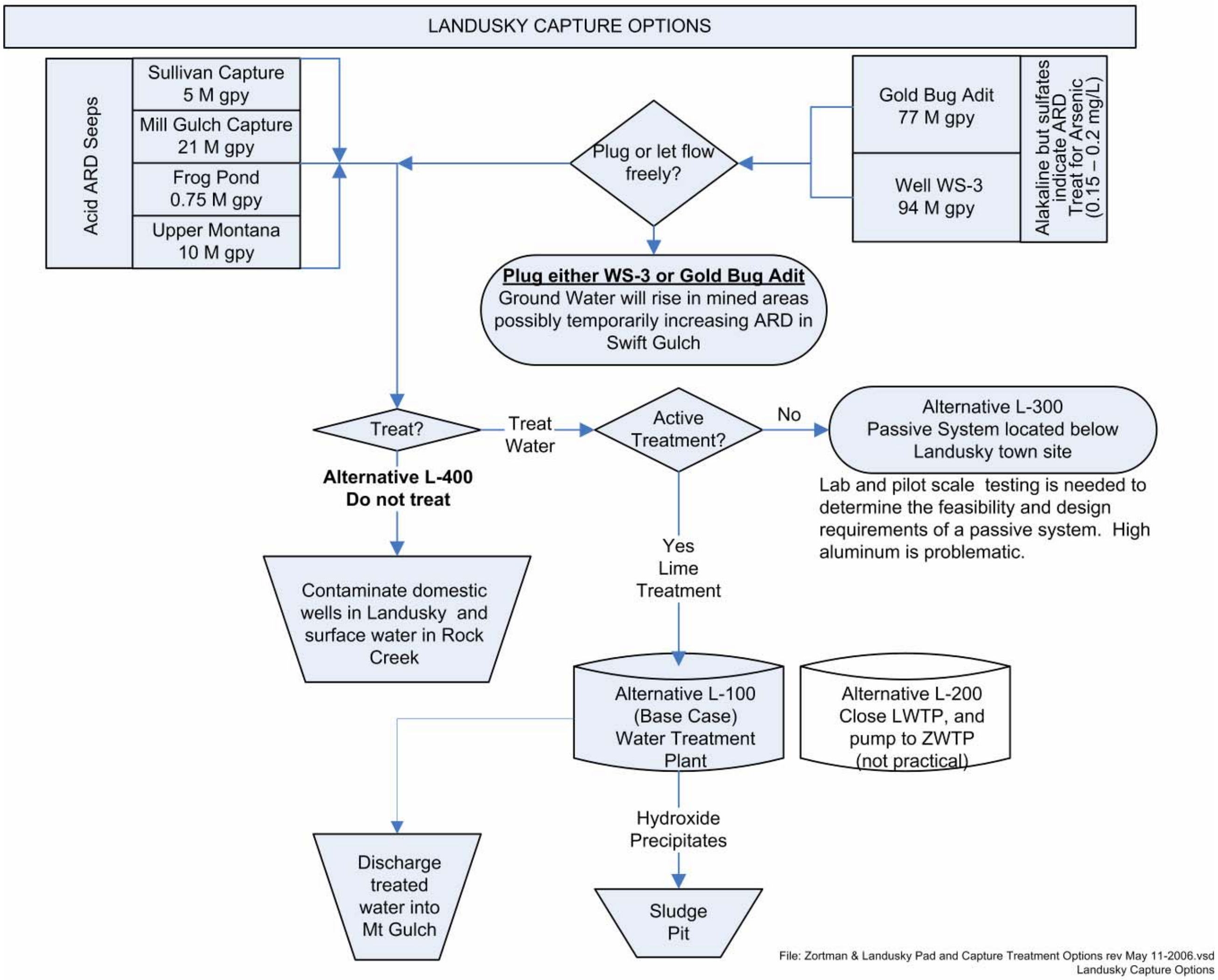


Figure 33 – Landusky Mine Leach Pad Options



7.2.1 Zortman Mine Alternatives

The current treatment operation is a combination of Alternative Z-100 (the existing capture and water treatment plant) and Alternative Z-500 (run all the leach pad waters through the Z-89 pad and then pump to the bioreactor at the Landusky Mine). Each alternative is evaluated for Effectiveness, Implementability, and Cost.

7.2.1.1 Alternative Z-100 (Base Case - Continue to Operate Zortman Mine Capture Systems and ZWTP)

Capture Systems - The three seepage capture systems operate very well. There is no evidence that any contaminated water gets past them. All the captured water is treated in the Zortman Water Treatment plant. The Ruby capture system collects 75% of the water (92 gpm average) consisting of water from two adits and seeps from beneath the Z85/86 Leach Pad. The Carter capture system collects about 18 gpm that is seeping from the toe of the Alder Waste Rock Dump. It is not clear whether all the seepage is from the dump, or whether some seepage is also being contributed from a buried mine adit or spring. The Alder Spur capture system collects about 13 gpm from the Z83 and Z84 dike faces and underdrain.

Zortman Mine Water Treatment Plant - The Zortman water treatment plant only operates ±1200 hours per year. It must run 24/7 during spring run off at approximately 1200 gpm, but during the remainder of the year, it is operated intermittently at 600 gpm. Design capacity is 750 gpm. Presently there is no automation or remote management capability. It is unknown whether every capture system could be automated due to location. The treated discharge then flows down Ruby Gulch and during most of the year percolates into the bedrock. During periods of high flow and during spring run off, the water from the water treatment plant will flow down Ruby Gulch past the Zortman town site. The Madison formation is an important potable water aquifer throughout the State and is the source of drinking water for Zortman. A monitoring well in the Madison Formation down gradient from the site does not show any mining impacts.

The lime mixing system can not properly mix the lime so limey scale builds up in the thickener and gypsum precipitates are escaping the thickener/clarifier during peak flows. An additional mixing tank is being installed to attempt to solve this problem.

Since labor is a major cost, various changes to the operating schedules to reduce the labor costs are under consideration. Unlike the Landusky plant, the Zortman plant and capture systems are not automated and the capture systems are monitored on a daily basis. Costs could be reduced by reducing the inspection frequency and operating less frequently. This increases the chances of an intermittent release of contaminated water, but it could save $81,000 annually. If the labor is to be reduced, then automation and telemetry need to be installed so that the systems can be monitored remotely and so that warnings can be transmitted to someone if pumps fail. (Based on Landusky experience, this would cost approximately $100,000 for automation).

It may be possible to reduce or eliminate the ferrous sulfate ($36,000 per year) by more closely monitoring the arsenic in the feed, and by increasing the density and quantity of ferric hydroxide precipitates that are recirculated. Colorimetric testing can be used to periodically check the chemistry on a regular basis to better tune the operation, especially during high flows when the plant is running above capacity. However, testing required an operator. Tests are on-going on changes to this subsystem.

Benefits:	This is a proven technology and is working well right now.
Consequences:	The current system costs more than the current funding.
Effectiveness:	This alternative is very effective at overall protection of human health and the environment. There is 100% certainty this alternative functions well.
Implementability:	This alternative is currently being implemented.
Costs:	The Zortman Capture and WTP costs $553,900/year, contributing 36.9% to the total $1.5M annual cost, and 76% of the $731, 321 available.

7.2.1.1 Alternative Z-100 (Base Case - Continue to Operate Zortman Mine Capture Systems and ZWTP)	
Ability to Meet ARARs:	The Zortman water treatment plant discharge nearly always satisfies ARARs at the point of discharge. The only exception is the aquatic acute standard for cadmium and secondary standards for iron and manganese. All ARARs are met at the Site boundary.
Recommendations:	Find additional funding for the shortfall. Continue making improvements that lower the costs. These include: ▪ Fine tuning the water treatment plant circuits to reduce chemical consumption ▪ Adding automation and telemetry to potentially reduce operating labor costs ▪ Changing the operating schedules to reduce labor costs, recognizing that this may result in occasional water discharge violations and increased vandalism. ▪ Investigate ways to reduce or eliminate the ferric sulfate circuit. ▪ Continue to limit public access to the mine area in order to protect public health and safety, provide for worker safety (especially during hunting season), prevent vandalism, and protect the reclamation covers from damage due to off road vehicle traffic.

7.2.1.2 Alternative Z-200 (Shut Down Zortman Water Treatment Plant - Treat at LWTP)	
This alternative requires that the Zortman Water Treatment Plant be completely shut-down and that the water normally treated be pumped over the hill to the Landusky Water Treatment Plant (after replacement of the over-the-hill line with an HDPE pipeline). The water would still be treated most of the time. Heavy precipitation may require release of some waters due to the capacity of the Landusky Water Treatment Plant being exceeded.	
Benefits:	This eliminates one complete plant and its associated costs.
Consequences:	The 124 gpm of ZWTP water plus the current 368 gpm of LWTP water puts the LWTP at almost 500 gpm. The design capacity is 600 gpm and this will not allow much leach pad water to go through the LWTP.
Effectiveness:	This alternative is effective at overall protection of human health and the environment. This alternative only functions when the LWTP does not exceed design capacity.
Implementability:	This alternative could be implemented after installation of a HDPE over-the-hill pipeline. There is 2-3 months per year where full implementation could not be achieved.
Costs:	Operating costs would be $335,000 per year for a savings of $120,000 per year. The upfront capital cost for purchasing and burying an HDPE pipeline from Zortman to the LWTP is estimated at $1 million.
Ability to Meet ARARs:	This alternative would satisfy ARARs when water is treated. During the spring rains, the Landusky WTP would exceed its design capacity and water would need to be discharged without being treated. The ZWTP runs at 1200 gpm for about 2-3 months and the LWTP has a design flow of 600 gpm. Therefore, about half the flow would not meet ARARs during this 2 to 3 month period.
Recommendations:	This option has limited savings and is not recommended.

7.2.1.3 Alternative Z-300 (Passive or Semi Passive Treatment of all Capture Systems)	
Passive systems will theoretically work for some or all of the capture systems and some of the leach pad water. They probably would not save any money and might cost more if they do not meet ARARs. In addition, continued active treatment is required. The major current cost is the cost of staffing and operating the water treatment plants. At Zortman, shutting off one or two captures and replacing them with a passive system would still require the operation of the Ruby Capture and the water treatment plant. The other problem with a passive system is finding a suitable location. It might be possible to build a passive system on top of some of the leach pads, but this would require continuing to operate the pump backs. Without lab and pilot scale testing, it is risky to assume that a passive system will work with several hundred mg/l aluminum and iron. If gravity systems are used, then the capture systems must be modified for gravity flow, which would require constructing at least two miles of frost-free piping along Alder Gulch to somewhere below town.	
Benefits:	Operating costs could be lower if it works.
Consequences:	Passive systems cannot handle the quantity and wide range of flows from all capture systems. Shutting down one or two of the smaller captures and installing local small passive systems on each one saves very little money, in fact might cost more.
Effectiveness:	This alternative relies on unknown or unproven technology, especially at the design flows. It may not be good at overall protection of human health and the environment. This alternative is unproven to work for this Site.
Implementability:	This would be difficult to implement.
Costs:	The cost would be $58,000 per year with a yearly savings of$323,000. New capital costs are estimated to be ±$2,000,000.
Ability to Meet ARARs:	Not likely until the acidity drops and the iron and aluminum drop.
Recommendations:	If suitable flat real estate could be obtained, and if the iron and aluminum could be removed with some type of simple pretreatment in the pads or ponds, then perhaps a passive system could be used to polish the water. Lab and pilot plant testing are needed to determine whether this is possible and to provide the data needed to design and size the passive system. Considering the lack of funding and the complex nature of the various ARD sources, the performance of passive systems are risky and are not recommended.

7.2.1.4 Alternative Z-400 (Shut down Zortman Water Treatment Plant – no Capture)	
This alternative requires that the Zortman Water Treatment Plant be completely shut-down and that the water normally treated be allowed to flow down Ruby and Alder Creek.	
Benefits:	All costs associated with treatment would be gone.
Consequences:	ARD contaminated with heavy metals would flow freely down Ruby and Alder Gulches creating the problems that the capture and water treatment plants were built to prevent. Most of the Ruby Gulch flow would seep into the limestone Madison formation, a major drinking water aquifer.
Effectiveness:	This alternative does not protect human health or the environment. Contaminated water would be allowed to flow through the town of Zortman. It is possible that the town water supply may be affected.
Implementability:	This alternative is easy to implement.
Costs:	Operating costs will be $15,900 per year for site maintenance. This alternative has a cost savings of $359,000 per year.
Ability to Meet ARARs:	ARARs would be exceeded for all heavy metals of concern at the Site boundary.
Recommendations:	This alternative is not recommended due to effect on the environment. If it comes to a choice between shutting down the Zortman water treatment or the Landusky water treatment (Alternative L-400), then this alternative is more favorable than Alternative L-400.

7.2.1.5 Alternative Z-500 (Base Case for Zortman Mine Leach Pads – Collect and Pump to Biological Treatment Plant at Landusky Mine)

Leach Pads - The leach pad water is collected, the pH is amended, and the water is stored in the Z89 Pad before being seasonally pumped over the mountain to the biotreatment plant at Landusky (3 months at 200 gpm in 2005). As the pads become more acidic, the current practice of amending the pH through the WTP sludge will need to be changed because the metals remobilize when the pH drops below 3.8. As the alkalinity added by ZMI declines, the leach pads at Zortman are all becoming acidic and beginning to look more like the acid seeps being treated in the water treatment plant than the historic leach pad water where the only concerns were cyanide, nitrates and selenium. This has created two problems. First, the low pH high metal content and high TDS water should not be directly land applied without being treated. Second, the low pH solutions will dissolve steel pipes, so they cannot be pumped over the mountain to the biotreatment plant unless the pH is raised or the piping is replaced. Both these problems are being temporarily managed by running all the Zortman leach pad water through the water treatment plant sludge pit on the Z-89 leach pad, and then storing the water in the pad before it is pumped either to the bio plant or LAD. The surplus alkalinity in the sludge increases the pH precipitating heavy metals as hydroxides. The ferric hydroxide in the sludge adsorbs the arsenic, reducing it from more than 2 ppm to 0.001 ppm.

This cannot continue indefinitely without consuming the surplus alkalinity in the sludge and remobilizing the metal hydroxides. Titration testing indicates that several years of use still remains before consuming the existing alkalinity. In the future, there are three options available. Continue the current practice and add more lime as needed, run the water though the WTP and then send to the bioplant or discharge depending on nitrates, or replace the steel pipe with acid resistant pipe and treat at the bioplant. For now, the best solution is to continue the current practice of running the pad water through the sludge and then pumping it to the bioreactor. The sludge effectively removes the aluminum, iron, and arsenic and is clear enough to be run through the bioplant at 200 gpm (compared to only 75 to 125 gpm for the Landusky pad water).

At some point, it is anticipated that the nitrogen in the leach pads will diminish to a level where the pads can be treated in the WTP. The incremental cost to run the leach pad water through the WTP will be less than pumping it to the bioplant. Previous tests of treating leach pad water in the WTP resulted in plugged pipes, so some testing and design work is needed before pad waters can be mixed with capture system water.

All the leach pads at Zortman have become acidic and the acidity is still increasing. The acidity causes the aluminum, iron, cadmium, manganese, nickel, sulfate, TDS, and zinc to increase well beyond the ARARs. The N+N in the pads is ranging around 70 to 125 ppm.

Benefits:	The nitrates are removed. Most of the metals are removed to below ARARs.
Consequences:	The system works well with no negative consequences.
Effectiveness:	This alternative is very effective at overall protection of human health and the environment. There is 100% certainty this alternative functions well.
Implementability:	This alternative is currently being implemented.
Costs:	Current cost is $157,300 per year for the base case.
Ability to Meet ARARs:	Human health ARARs are satisfied after being diluted with water treatment water at the Montana Gulch Pond at the point of discharge. All ARARs are satisfied at the Site boundary.
Recommendations:	Careful monitoring of the sludge is recommended.

7.2.1.6 Alternative Z-610 (Treat Pad Waters through ZWTP and Discharge to Ruby Gulch)	
It is possible to treat the acidic pad water in the lime water treatment plant, but the lime plants do not treat selenium, nitrates, or cyanide. The Zortman water treatment plant has the capacity to easily treat all the Zortman pad water.	
Benefits:	This eliminates the need to pump the 20 to 26 million gallons from the Zortman pads to the biological treatment plant
Consequences:	Elevated nitrates in discharge. There is no significant cyanide or selenium content in the Zortman leach pad waters.
Effectiveness:	This alternative is not as effective at overall protection of human health and the environment as the base case.
Implementability:	This alternative is fairly easy to implement. Some fouling of pipes inside the ZWTP happened the last time leach pad waters were taken through the plant on its way to the LAD. This issue would need to be solved.
Costs:	The cost will be $110,000 per year. This yields a $40,300 savings on an annual basis.
Ability to Meet ARARs:	The nitrates will not be removed, but the metals should meet ARARs. Cyanide might not meet aquatic standards. ARARs would likely be satisfied at the Site boundary.
Recommendations:	Previous attempts to mix pad and capture water have resulted in plugged pipes. This is probably happening when the higher pH pad water is mixed with the lower pH capture water causing the capture water iron and aluminum to precipitate and plug the pipes. The piping needs to be rearranged to resolve the problem. This may require some trial and error testing and monitoring. As nitrates in the leach pad water declines this alternative becomes more viable.

7.2.1.7 Alternative Z-620 (Treat Pad Waters through ZWTP and then Pump to Landusky Mine Biological Treatment Plant)	
It is possible to treat the acidic pad water in the lime water treatment plant, but the lime plants do not treat nitrates. As long nitrates exceed ARARs, the Zortman pad water must then either be pumped over the hill to the biotreatment plant, disposed in the LAD (after the pH is amended), or sent through a passive treatment system (after the water treatment plant). The Zortman water treatment plant has the capacity to easily treat all the Zortman pad water, so if the nitrates eventually drop to an acceptable level the pads could be treated in the WTP and released.	
Benefits:	None, unless the pH cannot be amended in the sludge pit.
Consequences:	Possible problems blending the different types of water in the ZWTP. If the waters are run separately, the plant operating hours will increase and the amount of lime needed will increase. Previous attempts to treat the pad water in the WTP resulted in plugged pipes.
Effectiveness:	While human health is protected, there are other alternatives which are more effective and cost less to implement.
Implementability:	This is not easy to implement.
Costs:	The annual cost will be $146,000. This alternative is $32,000 per year more expensive than the base case (Alternative Z-500).
Ability to Meet ARARs:	This option will meet ARARs.
Recommendations:	This is more expensive than the base case, and is more expensive than adding lime to the sludge pit, so it is not recommended.

7.2.1.8 Alternative Z-630 (Treat Pad Waters through ZWTP and then Land Apply on Goslin Flats LAD)	
It is possible to treat the acidic pad water in the lime water treatment plant, but the lime plants do not treat nitrates. As long nitrates exceed ARARs, the Zortman pad water must then either be pumped over the hill to the biotreatment plant (Alternative Z-620), disposed in the LAD (after the pH is amended), or sent through a passive treatment system (Alternative Z-900). The Zortman water treatment plant has the capacity to easily treat all the Zortman pad water, so if the nitrates eventually drop to an acceptable level the pads could be treated in the WTP and released.	
Benefits:	None, unless the pH cannot be amended in the sludge pit.
Consequences:	Possible problems blending the different types of water in the ZWTP. If the waters are run separately, the plant operating hours will increase and the amount of lime needed will increase. Previous attempts to treat the pad water in the WTP resulted in plugged pipes.
Effectiveness:	Human health is protected.
Implementability:	This is fairly easy to implement.
Costs:	This alternative is $20,000 per year more expensive than the base case (Alternative Z-500).
Ability to Meet ARARs:	This option will meet ARARs.
Recommendations:	This is more expensive than the base case, and is more expensive than adding lime to the sludge pit, so it is not recommended.

7.2.1.9 Alternative Z-700 (Pump Zortman Leach Pad Water to Landusky WTP)	
The logic for this case is the same as treating the water in the ZWTP. The nitrates and cyanide would not be treated, but the cost of operating the biological treatment plant would be avoided.	
Benefits:	Only operate one WTP.
Consequences:	If the Zortman WTP water were also being pumped to Landusky, then it would be necessary to install an acid resistant pipe and bury it below the frost line. The lime costs would increase at the Landusky WTP because of the added acidity and because some of the WS-3 alkaline water would be displaced. This alternative would only make sense if the ZWTP was shut down, so the Landusky WTP would be receiving Landusky capture water, Zortman Capture Water, and Zortman Leach Pad water. Given the wide range of chemistry there will be some serious operational issues in the plant that will need to be resolved. This may involve separate holding ponds for each source, and some way to blend the waters without causing plugging of pipes that now occurs whenever Pad and capture waters are mixed. If the plugging issues are not resolved before this is implemented, the result will be undesirable.
Effectiveness:	This alternative does protect human health and the environment.
Implementability:	This is not difficult to implement.
Costs:	The cost will be $110,000 per year, yielding a net savings of $198,000 per year. The installation of a HDPE buried pipeline would have a initial capital cost of about $1,000,000.
Ability to Meet ARARs:	The ARARs will not be met for nitrates.
Recommendations:	Need to research how blending the different types of water will affect the plant performance. Need to develop a new operating procedure to make it work.

7.2.1.10 Alternative Z-800 (Pump Zortman Leach Pad Water to Goslin LAD)	
Experience at the Goslin Land Application Disposal site proves that land application works, but it requires continuous maintenance and can only be used during the growing season. Before the leach pads became acidic, land application disposal worked well. Low pH with high TDS material should not be land applied. So as the leach pads become more acidic, direct land application without some form of pre treatment is becoming a less viable alternative for the surplus water from the site. This alternative assumes that the leach pad waters are pH amended prior to any land application.	
Benefits:	The biological treatment plant needs to average 200 gpm to stay even with the influx of waters from both Zortman and Landusky based on 2005 infiltration. By taking the Zortman pad water to the LAD, this frees up bioreactor capacity and lowers the average down to 160 gpm required to be taken through the biological treatment plant to maintain steady-state.
Consequences:	Presently the surplus alkalinity in the Z-89 pad is providing a pH amendment for "free", but this might not last forever, and definitely will not last if the ZWTP is shut down.
Effectiveness:	This is an effective method for disposal of water. There is no risk to human health. Overloading the LAD with metals could be detrimental to the cows grazing there.
Implementability:	This is easy to implement and has been done in the past.
Costs:	Annual cost will be $114,000, yielding a net savings of $44,000 per year.
Ability to Meet ARARs:	Depends on whether the pH is amended and whether Landusky pads are also land applied.
Recommendations:	This option is feasible if only Zortman leach pads are land applied, and provided the pH is amended prior to application.

7.2.1.11 Alternative Z-900 (External Passive Treatment of Some or all Zortman Leach Pad Water)

On the average, the Zortman leach pads produce ~49 gpm and the capture systems collect ~122 gpm of contaminated water. The literature suggests that passive systems should be kept to less than 100 gpm. The Zortman Mine does not have flat land available to construct treatment ponds, so additional real estate would be needed below the town of Zortman. The two largest sources of water contain about 1000 mg/l of aluminum, which will rapidly precipitate and plug any system that raises the pH without including some method of settling or filtering the aluminum hydroxide precipitates. Therefore, additional testing including a pilot scale test would be needed before any type of passive or semi-passive system could be seriously considered.

One option is to pass all the pad and capture water through the water treatment plants, and then use a passive or semi passive system to polish the nitrates and selenium, and any other heavy metals. If sufficient land were available, this might be feasible. However, a biological treatment plant at Landusky is already available. The additional cost to pump the leach pad water from Zortman to Landusky is about $6,000 per year and the cost of nutrients, etc to treat the Zortman water is about $20,000 per year, so any passive system at Zortman would need to cost less than $26,000 per year and still be able to perform as well.

Benefits:	Insufficient data to determine if there will be any benefits. In general, if a passive system works and can be gravity fed, the O&M costs will be lower than the active treatment.
Consequences:	This analysis only considered Zortman. No savings result if the biological treatment plant is still operating to treat the Landusky water.
Effectiveness:	This alternative relies on unknown or unproven technology, especially at the design flows. It may not be good at overall protection of the environment. This alternative is unproven to work for this Site.
Implementability:	This alternative is difficult to implement.
Costs:	Average cost of $189,000 per year. This is $31,000 per year more than the base case. In addition, the upfront capital is estimated to be $1,500,000.
Ability to Meet ARARs:	It is unknown if ARARs can be met without more testing.
Recommendations:	Additional lab and pilot testing is needed for several years duration to determine the feasibility and the size and type of system. The sizing will be a challenge considering the large seasonal flow rate fluctuation. This is experimental and is not recommended.

7.2.1.12 Alternative Z-1000 (Abandon Pads - Allow All Zortman Leach Pad Waters to Flow Freely)

The leach pad waters would not be contained (if the capture systems are shut-down) or treated. Waters would be allowed to flow down Ruby and Alder drainages.

Puncture the Liners - In several major gold producing States, the standard procedure for abandonment of non-ARD producing cyanide heap leach pads is to rinse the spent ore approximately three times with good quality water, test the evacuated water to insure that cyanide levels have dropped below a set value, and then drill holes through the bottom of the liner to prevent future accumulation of water in the collection basin. The "No Action" Alternative in the 1996 FEIS states that the tasks associated with reclamation of the heap leach facilities would include detoxification, surface reclamation, and liner perforation. Heap detoxification would continue until the solutions returning from the heap maintained less than 0.22 mg/l WAD cyanide for a six-month period. Then all remaining solutions would be pumped out. After detoxification, the pad liner would be perforated to reduce storage of precipitation and surface water run on within the heap. Approximately three to four 6-inch diameter holes would be drilled through the liner and into the underlying drainage system to provide an exit for water entering the heap. The boreholes would be filled with drain rock to an elevation at least 5 feet above the liner. The holes would be positioned in the lowest part of the pad collection basin. Although this was the proposed plan, ZMI had committed to monitor leach pad effluent for a 10-year period prior to perforating any liner. Consequently, none of the pad liners were actually perforated. One of the conclusions of the 1996 FEIS was that the liner perforation plan would result in a short period of alkaline drainage followed by an acidic, metalliferous seepage requiring capture and treatment in the long-term.

If a leach pad liner were to be perforated, water collecting in the lined basin would drain through the holes and into the waste rock used to contour the floor of the basin. Since a high percentage of this material contains sulfide mineralization, additional material would produce ARD. From the rock at the bottom of the basin, the seepage would infiltrate into the leach pad dike and then drain out the toe flushing oxidation products from the material in the dike. The majority of drainage escaping the toe of the dike would follow colluvial and alluvial materials into and down the drainage courses where the impacted water would be captured in one of the existing seepage capture systems.

Consequently, preservation of the integrity of the pad liners is considered beneficial to site water management for the following reasons:

- Puncturing liners would increase the demand on the existing seepage capture systems;
- Puncturing liners would introduce more sulfide waste materials to ARD production;
- Puncturing liners would release poor quality water that at a minimum would require land application (but puncturing the liners would force the water to the capture systems, which are set up to deliver contaminated water to the lime treatment plants);
- Leach pads are located well above the capture systems and are generally closer in elevation to the treatment facilities; and,
- The leach pad liners provide storage capacity and add redundancy to the capture systems.

Although puncturing liners is known to be an acceptable and economical management method for final closure of a decommissioned leach pad, it is only appropriate when the quality of the water to be released has reached an acceptable level. If a decision were made to puncture the liners, it would be done by pulling the pumps and drilling through the existing well casings.

Allow the Pads to Overflow - Given the fact that the dike side of the pads is always the lowest elevation, it is highly probable that the water could be captured as it overflows the dikes, or allowed to infiltrate the dikes (sources of ARD) and report to the capture systems. Unless the water can be captured as it overflows the dike, the problems will be similar to puncturing the liners. If the water is captured, then it must be treated, so rather than saving money, the costs would increase because new capture, pumping, and plumbing systems would need to be installed.

Benefits:	No real environmental benefits.
Consequences:	Very acidic water with elevated nitrates would be discharged down Ruby Gulch and Alder Gulch.
Effectiveness:	This alternative does not protect human health or the environment.

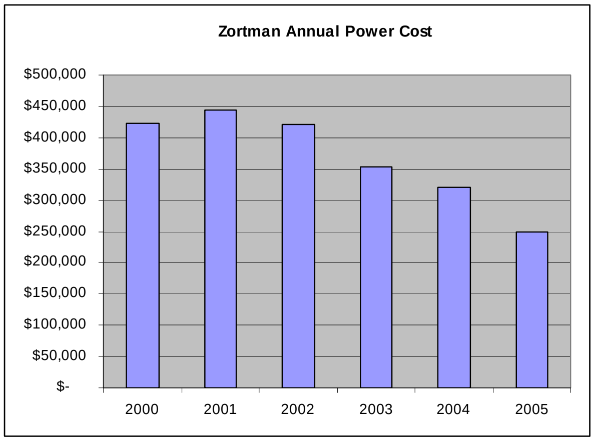
7.2.1.12 Alternative Z-1000 (Abandon Pads - Allow All Zortman Leach Pad Waters to Flow Freely)	
Implementability:	This is easy to implement.
Costs:	Annual cost will be $7,400 per year for analysis and overhead. The savings will be $145,000 per year.
Ability to Meet ARARs:	ARARs would be exceeded for some metals of concern as well as nitrates.
Recommendations:	This alternative is not recommended.

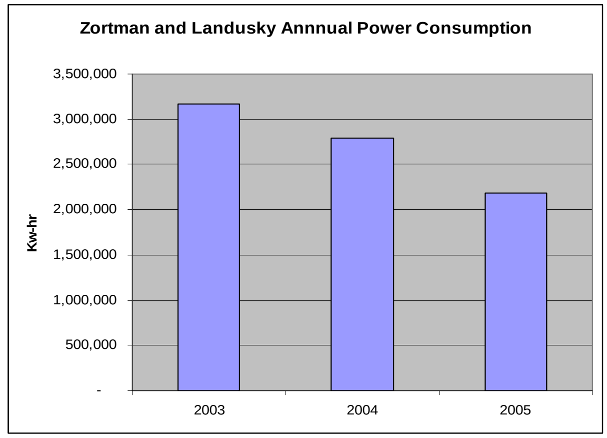
7.2.1.13 Alternative Z-1100 (Cover All Pads, Dumps, and Mine Areas with Impermeable Seal)	
Dumps and Dikes -Since most of the water reporting to the Ruby Capture system is believed to be coming from old mine workings, springs, and fracture zones that are beyond the area mined by ZMI, it would still be necessary to operate the Ruby Capture System (75 percent of current quantity treated) and the Zortman WTP. Therefore, no matter what is done on the surface, it will still be necessary to operate the water treatment plant. **Pads** - It would be difficult to successfully cover all the Zortman leach pads with an impermeable liner because of the terrain, but the most acidic pad, Z85/86 can be capped for an estimated $2.5 million.	
Benefits:	There will be less total water to treat.
Consequences:	Capping will not eliminate the need for treatment.
Effectiveness:	This provides no additional protection to human health or the environment.
Implementability:	This is very difficult to implement.
Costs:	Z85/86 Pad will cost $2.4 million to cap. The Z83, Z84 and Z89 Pads will cost approximately $2.7 million to cap. The Alder Gulch Waste Rock Dump is too steep to cap all but the top, which is estimated at $0.3 million (SEIS Alternative Z6 new option under consideration). The leach pad dikes are all too steep to cap. Annual cost savings are less than $20,000 per year after capping.
Ability to Meet ARARs:	Same as without the cap. Any water will still require treatment to meet ARARs.
Recommendations:	This alternative is not recommended. The cost is high and the positive results are limited.

7.2.1.14 Alternative Z-1200 (Install Wind Turbines to Generate Electricity for both Mines)

The total site power demand has been reduced from 3.4 to about 2.2 MW-hr per year. This works out to an average of 388 kw (520 hp) constant demand. Since pumps are running intermittently, the instantaneous demand is considerably higher.

Figure 34 - Power Cost and Consumption





In 2005, the total power cost was $252,546. The cost has been reduced from over $400,000 per year by renegotiating some of the fixed costs associated with renting the transformers and power lines from Big Flat, by replacing some larger pumps with smaller pumps, which reduces the demand charge, and by rerouting power to two leach pads. Not all the large pumps have been replaced yet, so some incremental savings are still possible. Big Flat reduced some of the fixed costs as part of an agreement for the site to use its emergency generators to provide power for Big Flat in case of an emergency, bringing the annual fixed payment to $56,934.

Big Flat will not further reduce this payment unless some of the oversized transformers at either mine can be sold.

Wind Resources – The Landusky Mine is very windy, but the average wind speed is very site dependent. Wind data from the Zortman Mine collected during the permitting process showed the wind at Carter Butte was highly variable. Recent wind studies suggest the L87 Pad area is one of the better locations in Montana for wind energy. Wind monitoring suggests an average wind speed of 17 mph and additional monitoring will continue. Options exist to use wind power to reduce the cost to operate the pumping and water treatment facilities. One option is to use wind power to generate a portion of the power (or only use it to pump leach pads intermittently). Backup power would still be required from Big Flat or local diesel generators (but the diesel option is very expensive).

If wind energy is used to generate sufficient power to satisfy all or a portion of the 2.2 Mw-hr needed on site, arrangements must be made with Big Flat to buy or use Big Flat's power lines and for Big Flat to provide power when the wind is not blowing.

The economics of wind power are improving every year, especially for larger turbines and large wind farms. The amount of energy a wind turbine can generate is proportional to the length of the blade squared and the wind velocity cubed. For example, doubling the blade length quadruples the amount of power generated. Increasing the average wind speed from 12 to 19 mph also quadruples the amount of power generated. The capital cost of a wind turbine (per mega watt of capacity) is similar or slightly lower than the capital cost of a new coal fired power plant, but the fuel cost is free. In this regard, the marginal cost of large wind power systems is lower than the marginal cost of coal, and much lower than the cost of gas turbine generated electricity.

7.2.1.14 Alternative Z-1200 (Install Wind Turbines to Generate Electricity for both Mines)

Wind power is economical in today's market provided that it can be distributed to a buyer and provided that another source of power is available during the 60% to 70% of the time the wind isn't blowing within the operating envelope required by the turbine. This is the immediate problem facing wind power generation at Landusky.

Even though wind power is renewable and environmentally clean, it does have some social and environmental concerns. Wind generators can be visually disruptive and may have impacts on birds or area bats depending on the type and size of generator used.

Wind Economics - To generate the power needed on site would require 400 kw running constantly and a peaking capacity of about 1200 kw when some of the big pumps are starting up (this could be reduced by purchasing more smaller pumps). A single moderately large turbine (750kw) could theoretically generate most of this power. Since the two mines are not presently connected, it would be better to consider several smaller units at each site. As the units become smaller however, the cost per kilowatt increases and the benefit is reduced.

Since the wind is an intermittent power source, arrangements must be made to supply critical operations when the wind is not blowing, and to provide peaking capacity if only a portion of the power is generated on site. The best way to do this would be to make arrangements with Big Flat. However, if a Big Flat agreement cannot be reached, then the two diesel generators could be used, but the cost would be higher than purchasing power.

Including the fixed costs, the average cost of power in 2005 was about $0.075/kw. The cost to generate wind power varies depending on the size of the installation and the average wind speed. Most of the literature suggests that the capital costs are about 70% of the cost of wind power, and O&M the other 30%. The +100MW Judith Basin Wind project recently entered into long term contracts to sell power for $0.035/kw. This price includes capital, O&M and profit. A smaller sized operation suitable for generating power at Zortman or Landusky would probably have a total cost of about $0.05 to $0.07/kw depending on the size. The operating costs would be about $0.01/kw. The cost savings would depend on how the capital cost is treated and whether the wind power can be exchanged for purchased power.

If the capital were provided by a grant or specific appropriation, then the operating cost would be about $0.01/kw for all the energy generated. Since the wind does not always blow, and often it blows slower than needed to generate all the rated power, another power source must always be available. For example, if wind power generated 35% of the power, and the marginal cost was $0.01, then the annual savings would be 35% of 2.2 million Kw-hr x (0.075-0.01) = $50,000 per year. A preliminary study prepared by CTA in 2004 suggested purchasing five used 65kW (325 kw) wind generators that could generate about 0.85 Mw-hr or about 1/4 of the total requirement. The capital cost to install this system is about $400,000, but arrangements need to be made for the remaining 65% of the power needed.

Produce All Power On Site Using Diesel Generators And Wind Power - There are two 1200kw diesel generators, one at each mine. According to "Mine and Mill Equipment Costs" the fuel, maintenance and overhaul costs for a 1350 kw diesel generator is $213/hour assuming diesel is $2.40/gallon). This equates to about $0.16 per kw-hr if all the power were generated by the diesel generators. These generators were used when purchased by ZMI, so the remaining useful life is not known.

As a practical matter, wind power can be generated about 35% of the time. Assume that the wind turbines can only generate power 30% of the time, requiring the generators to operate 70% of the time. Assume the wind generators and all electrical systems needed to disconnect from Big Flat are purchased and installed as a gift to the project (so the capital cost can be ignored), and that it costs $0.01/kw-hr to operate and maintain the wind generators. Then the combined cost of generating power using wind and diesel will be $0.11/kw-hr. The current cost is $0.075/kw-hr.

7.2.1.14 Alternative Z-1200 (Install Wind Turbines to Generate Electricity for both Mines)

Combined Wind & Diesel Generated Power Cost

	Cost	% of time operated
Diesel Power	$0.16/kw-kr	65%
Wind Power	$0.01/kw-kr	35%
Average	**$0.11/kw-kr**	

If the capital cost of purchasing and installing the wind generators and purchasing and installing power lines is included, the cost will be approximately $0.13/kw-hr or about double the present cost. This analysis shows that it is not economical to generate all the power on-site.

This remains a potentially excellent site for commercial wind power generation. Some money could be saved if a wind turbine could be installed that would generate at least 1200kw 30% or more of the time, but this would require an agreement with Big Flat.

Benefits:	If wind turbines were installed and the capital costs were provided by a grant and not included in the total cost, power costs could be reduced as much as $50,000 to $74,000 per year (for both mine sites) provided that Big Flat Electric did not increase it's rates to offset the lost revenue.
Consequences:	Few, if any negative consequences.
Effectiveness:	This provides no further human health or environmental protection. This would be a cost savings measure only.
Implementability:	This is fairly easy to implement.
Costs:	If the capital cost is considered, there will be no cost savings if only sufficient capacity is installed to meet the Zortman demand, because the smaller wind turbines cost more to own and operate than the current price paid to Big Flat. Larger turbines could be cost competitive, but the surplus power must be sold on the outside market. If the capital costs are ignored, then 30% to 40% of the power could be generated for about $0.01 to $0.02/kw-hr compared to the $0.075 paid to Big Flat. Preliminary capital costs to purchase sufficient capacity to satisfy the site demand will be about $500,000, but additional electrical engineering and wind analysis studies are needed to firm up this estimate. Annual cost savings are estimated at $50,000 to $75,000 per year for both mines combined.
Ability to Meet ARARs:	Not applicable. If wind power can reduce the costs, then more money might be available to improve the ability of the system to satisfy ARARs.
Recommendations:	Since Zortman and Landusky are electrically isolated from each other, turbines would need to be installed on each site or a connection must be installed. A more detailed wind monitoring and electrical engineering design is required before any commitments can be made. Details need to be worked out to handle the cases where the wind is blowing enough to generate power, but not enough to satisfy all the instantaneous demands. Arrangements also need to be worked out to dynamically switch between the wind energy and Big Flat.

7.2.1.15 Alternative Z-1300 (Alternative Z-100 with Elimination of Ferric Sulfate Circuit)	
The Zortman Water Treatment Plant currently uses a ferric sulfate circuit to reduce the arsenic. A total of 230,000 pounds of ferric sulfate was used in 2005 with a yearly cost of $36,000.	
Benefits:	The elimination of the ferric sulfate would reduce the sulfates and lower the costs.
Consequences:	Potentially higher arsenic could be discharged.
Effectiveness:	This alternative would still provide for effective treatment of acidic and metal-bearing waters to protect human health and the environment.
Implementability:	This is very easy to implement.
Costs:	Annual cost savings are $36,000.
Ability to Meet ARARs:	ARARs will be met.
Recommendations:	This alternative is being investigated. Assuming ARARs can be met, it is highly recommended.

Sludge from the water treatment plants is place in shallow ponds on top of the lined leach pads to solidify.

7.2.2 Landusky Mine Alternatives

7.2.2.1 Alternative L-100 (Continue to Operate Landusky Mine Capture Systems and WTP)

Capture Systems -The Frog Pond Capture is only pumped about 12 hours per week at 20 gpm (average of 1.42 gpm if pumped continually). Due to the extremely low flow, there is minimal expense associated with this site and thus no reason to consider alternative treatment.

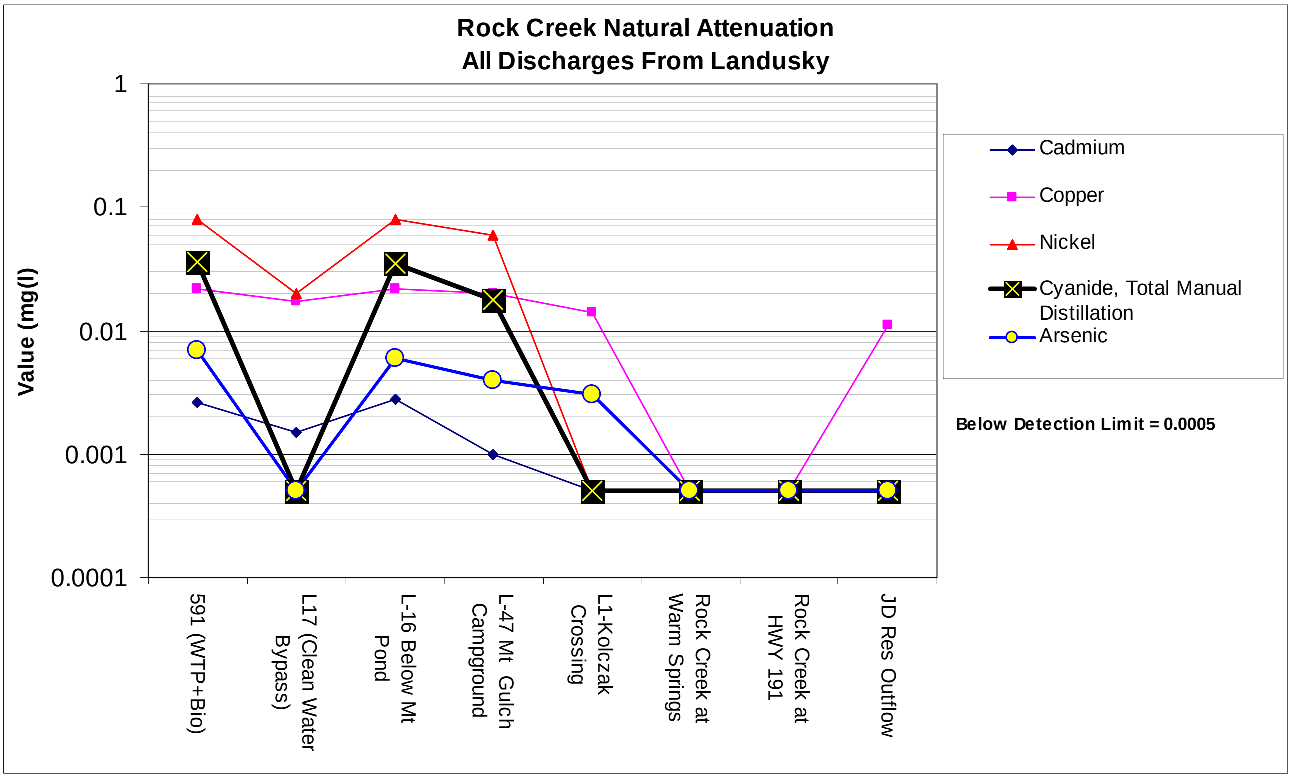
The Sullivan and Mill Gulch capture systems appear to be working very efficiently. There is no evidence that any ground water get past the captures, but they have overflowed during high precipitation events.

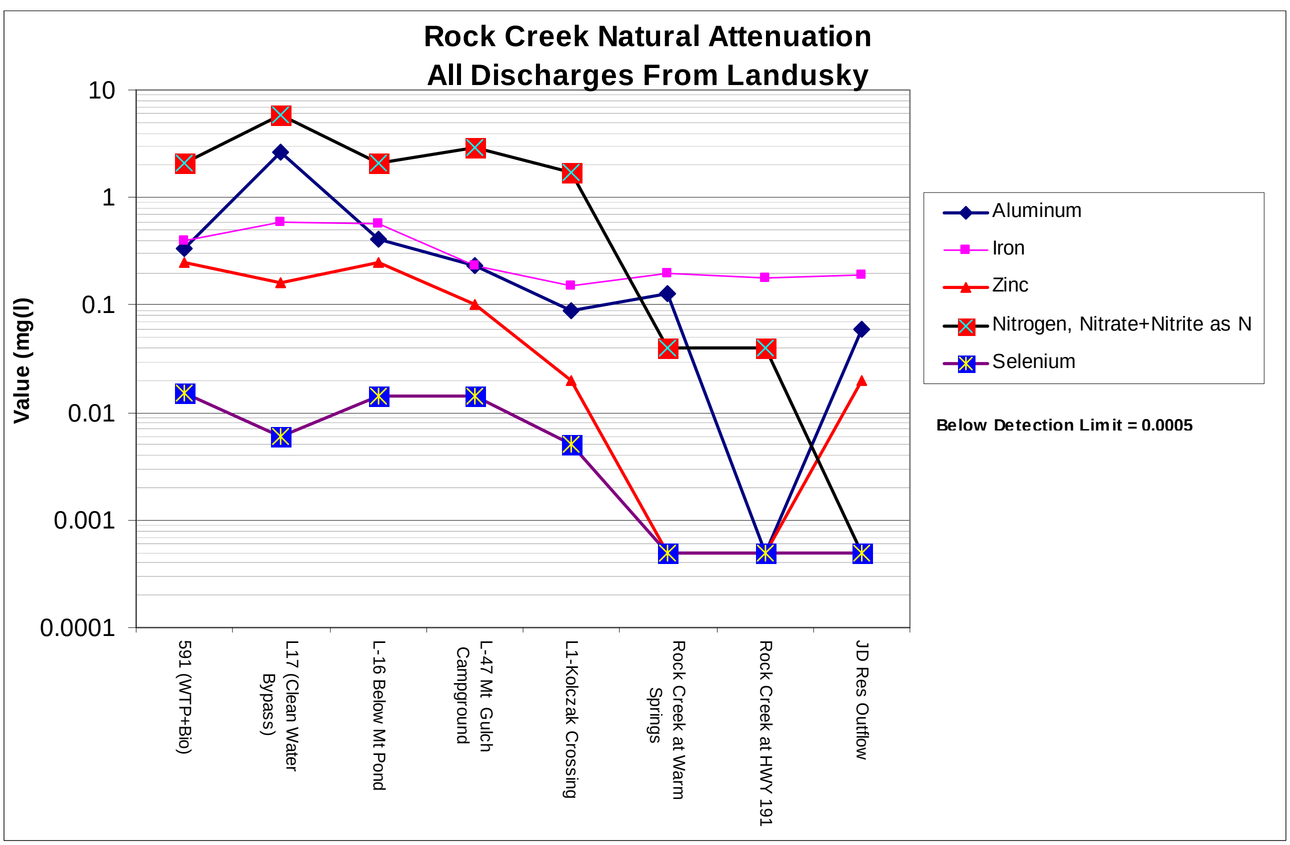
Landusky Water Treatment Plant – The design capacity is 600 gpm. Current flow through the LWTP is 368 gallons per minute. The plant can handle another 232 gpm before exceeding design capacity. The plant currently operates 363 days per year, 24-hours per day, 7-days per week.

Benefits:	This is a proven technology and is working well in its current mode of operation.
Consequences:	The cost of operating the plant was reduced when the alkaline water from the artesian well, WS-3 was added. This substantially increases the flow, but reduces the amount of lime needed to adjust the pH. If WS-3 is plugged, then the lime requirements will more than double. Only 20% of the water being treated at Landusky is from the ARD seeps. The other eighty percent is the combined flows from the relatively alkaline WS-3 and Gold Bug adits. They both contain elevated arsenic, and the pH is beginning to drop and the sulfates are increasing. The alkalinity from these sources reduces the amount of lime needed to treat the capture system water, and the ferric hydroxide precipitates that are recirculated into the feed do a good job removing the arsenic. There is no need to change the system in the foreseeable future. The largest leach pads at Landusky have become very acidic and also contain elevated selenium (up to 1.5 mg/l) which must be treated in the bioplant. If the selenium and nitrates dissipate sufficiently, then at some point the bioplant can be shut down and the acid pad water run through the WTP.
Effectiveness:	This alternative is very effective at overall protection of human health and the environment. There is 100% certainty this alternative functions well.
Implementability:	This alternative is currently being implemented.
Costs:	The Landusky Capture and WTP costs $418,200 per year, contributing 27.9% to the total $1.5M annual cost.

7.2.2.1 Alternative L-100 (Continue to Operate Landusky Mine Capture Systems and WTP)	
Ability to Meet ARARs:	Water from the Landusky Lime Water Treatment plant is combined with the bio treated water (combined Zortman and Landusky Leach Pad water) and discharged from the Montana Gulch Pond. The Landusky water treatment plant nearly always satisfies Montana DEQ-7 human health standards for drinking water and only slightly exceeds aquatic standards at the discharge points. Brook Trout have been observed living in the effluent as far upstream as the Montana Gulch Campground. As shown in the table below, the combined discharge from the plants meets Human Health standards for everything except thallium (which is slightly exceeded) but doesn't meet chronic aquatic standards for cadmium, total cyanide, or selenium. The water treatment plant does a good job removing the arsenic from the artesian well WS-3 and the Gold Bug adit. In November 2005, samples were taken below the Montana Gulch Pond at various intervals for several miles downstream to determine how natural attenuation occurs in the stream. There was a concern that selenium might accumulate in the JD Reservoir below Highway 191, but below Kolczak Crossing no selenium is detectable. The results are summarized in Figure 35 - Natural Attenuation Downstream from Landusky on the following page that shows all ARARs are met at the Site boundary
Recommendations:	The current operation is functioning well. Assuming additional funding can be secured, the currently operation is recommended. Continue to limit public access to the mine area in order to protect public health and safety, provide for worker safety (especially during hunting season), prevent vandalism, and protect the reclamation covers from damage due to off road vehicle traffic.

Figure 35 - Natural Attenuation Downstream from Landusky Mine





7.2.2.2 Alternative L-200 (Close Landusky WTP and Pump Water to Zortman WTP)	
Close the Landusky WTP and pump all captures to the Zortman WTP. This is not as economical as pumping Zortman to the Landusky WTP and as such was not considered in detail.	
Benefits:	None.
Consequences:	Zortman WTP exceeds design capacity part of the time. Water rights issues could develop.
Effectiveness:	This alternative is totally ineffective.
Implementability:	This alternative is difficult to implement.
Costs:	This alternative was not studied in detail. This would cost at least an additional $100,000 per year above the base case.
Ability to Meet ARARs:	Probably, except when plant capacity is exceeded.
Recommendations:	This alternative does not accomplish anything worthwhile, is more expensive, and was not studied in detail.

7.2.2.3 Alternative L-300 (Build Passive or Semi-Passive Systems to Treat Capture System Water. Replace the LWTP with Passive Systems)	
Passive systems will theoretically work for some or all of the capture systems. But they probably would not save any money and might cost more if they do not meet ARARs. The high amounts of aluminum and iron make the success of the passive systems doubtful unless the pH can be amended. This is now being accomplished in the lime water treatment plants and the pH pond. Passive systems could be used to treat the Gold Bug Adit and WS-3 water, but this would not result in any cost reduction because the alkalinity of these two sources actually reduces the cost of operating the WTP today. The ARD captures contain up to 700 mg/l aluminum, which will cause problems unless the aluminum is pre-treated in either the WTP or something similar to the existing pH pond.	
Benefits:	Operating costs could be lower if it works.
Consequences:	Passive systems cannot handle the quantity and wide range of flows from all capture systems and shutting down one or two of the smaller captures and installing local small passive systems on each one saves very little money, in fact might cost more. There is no space available for a passive system above the Landusky town site,
Effectiveness:	This alternative relies on unknown or unproven technology, especially at the design flows. It may not be good at overall protection of human health and the environment. This alternative is unproven to work for this Site.
Implementability:	This alternative is difficult to implement.
Costs:	The annual cost is $104,000 for a $296,000 operating savings. This alternative has an upfront capital cost of $2,500,000.
Ability to Meet ARARs:	Not likely until the acidity drops and the iron and aluminum drop.
Recommendations:	Considering the lack of funding and the complex nature of the various ARD sources, passive systems are not recommended.

7.2.2.4 Alternative L-400 (Close the Captures and WTP, Allow the Water to Flow Down Sullivan Gulch, Mill Gulch, and Montana Gulch)	
This alternative closes the Landusky water treatment plant and allows all capture water to free flow down Sullivan Gulch, Mill Gulch and Montana Gulch. The artesian well WS-3 could be allowed to free-flow or it could be shut-in. Shutting WS-3 would likely increase the flows into Swift Gulch. The Gold Bug Adit could be cut back but probably could not be closed totally.	
Benefits:	This would save money.
Consequences:	The water wells in Landusky townsite would be contaminated with ARD and heavy metals. Rock Creek would be contaminated.
Effectiveness:	This alternative does not protect human health or the environment.
Implementability:	This alternative is very easy to implement.
Costs:	The annual operating cost is $5,300 with a projected saving of $313,000 per year.
Ability to Meet ARARs:	Elevated levels of arsenic, cadmium, copper, nickel, and zinc would be released. ARARs would not be met.
Recommendations:	This alternative is not recommended.

7.2.2.5 Alternative L-500 (Landusky Leach Pad Base Case, Treat in Bioreactor)	
Biological Treatment Plant – The plant has a design capacity of 300 gpm. It is currently operated about 320 days per year (about 90% operational efficiency). It is currently treating Landusky pad water at the rate of 75 to 175 gpm.	
Benefits:	The biological treatment plant does an excellent job of removing selenium, nitrates and heavy metals.
Consequences:	The carbon will eventually become fully loaded and either have to be replaced or regenerated. Current operation needs to be closer to 160 gpm to stay even with the influx of new water infiltrating the Landusky leach pads and 200 gpm from both mines.
Effectiveness:	This alternative is very effective at overall protection of human health and the environment. There is 100% certainty this alternative functions well.
Implementability:	This alternative is currently being implemented.
Costs:	The bioreactor for leach pad water treatment costs about $370,600 to operate, or 24.7% of the total $1,500,000 annual cost.
Ability to Meet ARARs:	Most ARARs are currently met at the discharge, and all ARARs all met at the Site boundary as illustrated above in Figure 35 - Natural Attenuation Downstream from Landusky.
Recommendations:	In order to increase the biological treatment of Landusky leach pad waters to the same level as the Zortman leach pads, an investment in two baffle curtains has been made. This has allowed the pH pond to help settle out the aluminum hydroxide precipitates and to reduce the turbulence caused by high winds that stir up the precipitates. The NaOH used to increase the pH causes a low density floc that is difficult to settle. Investigate switching to CaO which is less expensive and creates a higher density floc. If these improvements are not implemented it will be necessary to start land applying some of the Zortman pad water.

7.2.2.6 Alternative L-600 (Shut Down the Bioreactor and Treat all Landusky Water in LWTP)	
This alternative requires that the Landusky Biological Treatment Plant be completely shut-down and that the leach pad water normally treated be taken through the Landusky Water Treatment Plant.	
Benefits:	This eliminates one cost center.
Consequences:	The LWTP does not remove selenium, nitrates, or cyanide.
Effectiveness:	This does not protect the environment.
Implementability:	This is fairly easy to implement and was done in the past.
Costs:	Shutting down the biological treatment plant saves $109,000 per year.
Ability to Meet ARARs:	ARARs for selenium, nitrates, and cyanide will not be met.
Recommendations:	This alternative is not recommended at this time. This might work after the nitrates and cyanide have been rinsed from the Landusky pads.

7.2.2.7 Alternative L-700 (Shut Down the Bioreactor and Pump all Pad Water to Goslin LAD)	
If the bioreactor was shut down, and the Landusky pad water was pumped to the Goslin Flats LAD without treatment, the LAD would become saturated and overloaded with the high metal and acidity in the applied water. Land applying both Zortman and Landusky pad waters is no longer a viable option.	
Benefits:	Shutting down the bioreactor would save money.
Consequences:	The LAD area would become contaminated with ARD, heavy metals, Se, Al, Fe, and nitrates.
Effectiveness:	This is not effective. The environment is not protected when elevated metals are land applied.
Implementability:	This is fairly easy to implement. This procedure was followed for several years.
Costs:	The cost savings would be $69,000 per year over the base case.
Ability to Meet ARARs:	ARARs do not apply to the LAD. Discharges from the LAD would be subject to ARARs and would not be met.
Recommendations:	This alternative is not recommended.

7.2.2.8 Alternative L-800 (Abandon all Landusky Mine Leach Pad Capture and Treatment. Either Puncture Liners or Allow Pads to Overflow and Flow Freely)

This alternative would let the leach pad water flow freely down Mill Gulch, Sullivan Gulch, or Montana Gulch.

Puncture the Liners - In several gold producing states, the standard procedure for abandonment of non-ARD producing cyanide heap leach pads is to rinse the spent ore approximately three times with good quality water, test the evacuated water to insure that cyanide levels have dropped below a set value, and then drill holes through the bottom of the liner to prevent future accumulation of water in the collection basin. The "No Action" Alternative in the 1996 FEIS states that the tasks associated with reclamation of the heap leach facilities would include detoxification, surface reclamation, and liner perforation. Heap detoxification would continue until the solutions returning from the heap maintained less than 0.22 mg/l WAD cyanide for a six-month period. Then all remaining solutions would be pumped out. After detoxification, the pad liner would be perforated to reduce storage of precipitation and surface water run on within the heap. Three to four 6-inch diameter holes would be drilled in the lowest part of the collection basin through the liner and to the underlying drainage system; and filled with drain rock to an elevation at least 5 feet above the liner. Although this was the proposed plan, ZMI had committed to monitor leach pad effluent for a 10-year period prior to perforating any liner. Consequently, none of the pad liners were actually perforated. One of the conclusions of the 1996 FEIS was that the liner perforation plan would result in a short period of alkaline drainage followed by an acidic, metalliferous seepage requiring capture and treatment in the long-term.

If a leach pad liner were to be perforated, water collecting in the lined basin would drain through the holes and into the waste rock used to contour the floor of the basin. Since a high percentage of this material contains sulfide mineralization, additional material would produce ARD. From the rock at the bottom of the basin, the seepage would infiltrate into the leach pad dike and then drain out the toe flushing oxidation products from the material in the dike. The majority of drainage escaping the toe of the dike would flow through alluvial materials down the drainage where the impacted water would be captured in one of the existing seepage capture systems. However, if the Landusky lower pads were punctured, water could escape into a number of uncontrolled areas and probably report to Montana Gulch, Mill Gulch or Rock Creek depending on where the holes were drilled. Only the L83 pad would be captured by the Frog Pond Capture.

Consequently, preservation of the integrity of the pad liners is considered beneficial to Site water management for the following reasons:

- Puncturing liners would increase the demand on the existing seepage capture systems;
- Puncturing liners would introduce more sulfide waste materials to ARD production;
- Puncturing liners would release poor quality water that at a minimum would require land application (but puncturing the liners would force the water to the capture systems which are set up to deliver contaminated water to the lime treatment plants);
- Leach pads are located well above the capture systems and are generally closer in elevation to the treatment facilities;
- The leach pad liners provide storage capacity and add redundancy to the capture systems; and,
- Water with different quality and treatment requirements can be kept segregated in the leach pads.

Although puncturing liners is known to be an acceptable and economical management method for final closure of a decommissioned leach pad, it is only appropriate when the quality of the water to be released has reached an acceptable level. If a decision were made to puncture the liners, it would be done by pulling the pumps and drilling through the existing well casings.

Allow the Pads to Overflow - The present cost for pumping leach pad water at the Landusky Mine is $152,000 per year. Given that the dike side of the pads is always the lowest elevation, it is highly probable that the water could be captured as it overflows the dikes, or allowed to infiltrate the dikes (sources of ARD) and report to the capture systems. Unless the water can be captured as it overflows the dike, the problems will be similar to puncturing the liners. If the water is captured, then it must be treated, so rather than saving money, the costs would increase because new capture, pumping, and plumbing systems would be needed.

7.2.2.8 Alternative L-800 (Abandon all Landusky Mine Leach Pad Capture and Treatment. Either Puncture Liners or Allow Pads to Overflow and Flow Freely)	
Benefits:	The costs of pumping and operating the pumps and biotreatment plant can be avoided.
Consequences:	Depends on whether the WTP is also shut down. If the WTP and captures are operating, most of the pad water will report to the captures and then be treated in the WTP. Some of the overflow will escape the captures and run down Mill Creek, Rock Creek, and Montana Gulch.
Effectiveness:	This alternative provides no human health or environmental protection.
Implementability:	This is easy to implement.
Costs:	The annual costs would be $2,100 per year. The net operating savings are projected to be $375,000 per year.
Ability to Meet ARARs:	Depends on the scenario, but ARARs for nitrates and selenium will not be met. If the ARD escapes the capture systems, ARARs for many heavy metals will not be met, and the Landusky town water wells will be contaminated.
Recommendations:	This alternative is not recommended.

7.2.2.9 Alternative L-900 (Cover all Leach Pads, Dumps, and Mine Areas with Impermeable Covers to Prevent Water from Infiltrating)

Dumps and Dikes - More than 80% of the water being treated in the Landusky WTP comes from the artesian wells (WS-2 and WS-3) and the Gold Bug Adit. It would be possible to shut in the artesian wells, but there is some doubt whether the Gold Bug Adit can be sealed. In both cases, if they are sealed, the water table will rise and the water will begin seeping out elsewhere. If the Gold Bug Adit cannot be sealed, then the water treatment plant must continue to operate regardless of whether all the other seeps can be stopped by sealing the Montana Waste Dump, the Mill Gulch dump face and the L87 and L91 pad dikes. There are springs beneath the Montana Dump, so even if the dump were sealed, the seeps may not stop.

In all cases, it would be very expensive and not technically feasible to cover the steep dike and dump faces. Unless the water treatment plant can be shut down, the economics do not favor capping the dumps because the incremental cost to operate each capture and pump back is relatively small compared to the cost of tearing out the existing reclamation and regrading and capping the dumps and dikes.

Leach Pads – There are two types of leach pads at Landusky. The lower pads which are all approaching neutral pH but still contain elevated metals and nitrates, and the L87/91 Pads that are very acidic and also contain elevated nitrates and selenium.

The lower leach pads do not contain any selenium, so once the nitrates are low enough, they can be treated in the WTP and released, saving the cost of pumping them 900 ft vertically to the biological treatment plant.

The upper pads are problematic. The L91 Pad aluminum and iron exceed 1000 mg/l (combined), and when the pH is raised copious amounts of hydroxides precipitate. This causes problems with any type of passive system and also causes problems with the bioplant, forcing the addition of the pH pond to remove the hydroxide precipitates.

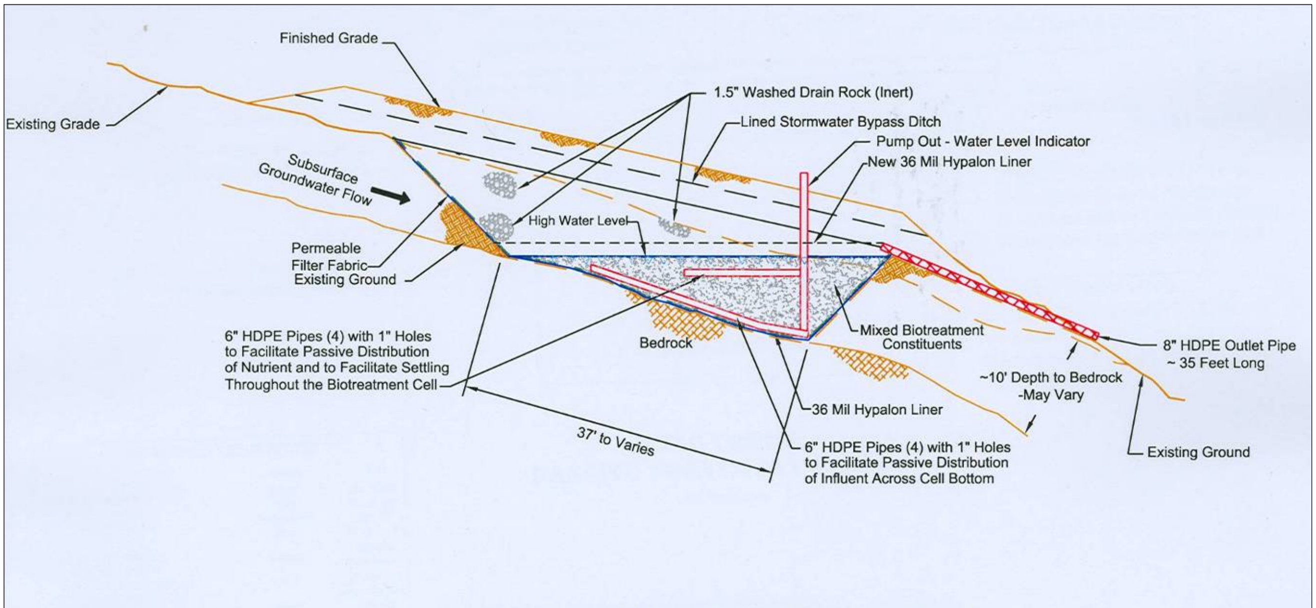
The cost to cover the L87/91 Leach Pad complex with an impermeable liner wiould be about $31.4 million so in the long run it is more economical to continue treating than to cover. In the short term, the water must be run through the bioplant in order to remove the nitrates and selenium. In the long run, it is difficult to know how the selenium will dissipate, but if the selenium and nitrates dissipate to acceptable levels and the pads are still generating ARD and heavy metals, they will continue to require some form of treatment. This will be either in the water treatment plant or in a constructed passive or semi-passive system. A passive system is probably not going to work so long as the aluminum and iron remain so high, so it is most likely that the pads will need to be treated in the WTP.

Benefits:	There will be less total water to treat.
Consequences:	Capping will not eliminate the need for treatment.
Effectiveness:	This alternative provides no further protection of human health or environmental protection.
Implementability:	This is very difficult to implement.
Costs:	L87/91 Pad total cost is $31.4 million to cap. The L79, L80-82, L83 and L84 would cost approximately $3.6 million. The leach pad dikes are all too steep to cap. This leach pad capping will only reduce the amount of water to be treated and will not eliminate the need for operating the treatment facilities. The annual cost savings are projected to be $208,000 over the base case.
Ability to Meet ARARs:	Same as without the cap. Any water will still require treatment to meet ARARs.
Recommendations:	This alternative is not recommended. The cost is very high and the environmental benefit is limited. This will not eliminate the need to treat water.

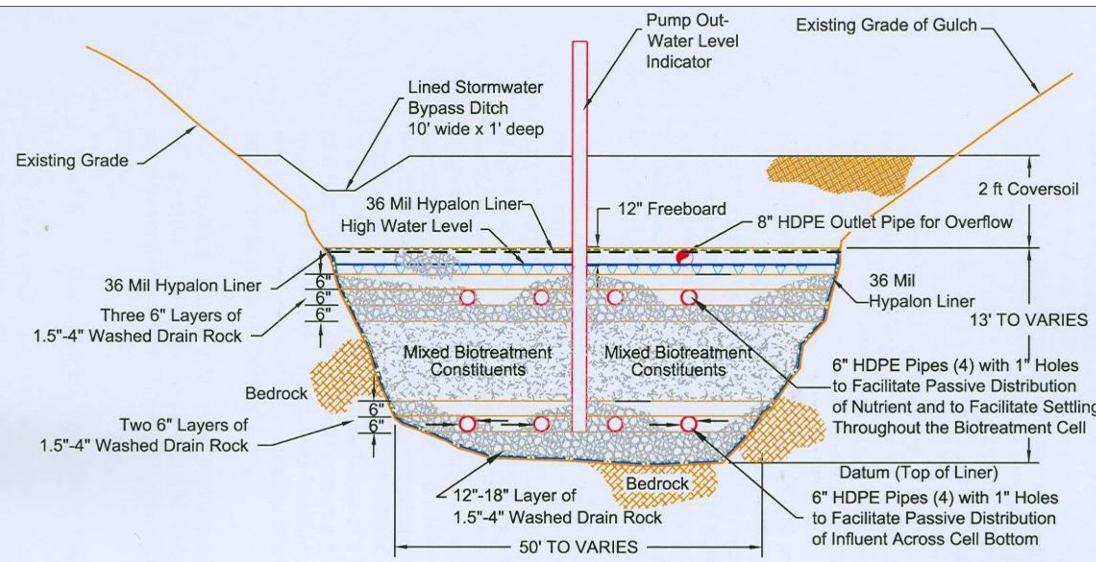
7.2.2.10 Alternative L-1000 (Install Wind Turbines to Generate Electricity or operate Wind Pumps)	
This is similar to the wind powered electricity generation discussion under Zortman Alternative Z-1200.	
Benefits:	The Landusky Mine has more consistent and stronger wind speeds and is more likely to be able to sustain a wind generation system than Zortman. Plus, the majority of the power consumption is on the Landusky side.
Consequences:	See Alternative Z-1200.
Effectiveness:	This alternative provides no further human health or environmental protection.
Implementability:	This is fairly easy to implement.
Costs:	See Alternative Z-1200. The power costs for small scale wind power is very dependent upon a free source (grant) of capital to purchase the units.
Ability to Meet ARARs:	No change in ability to meet ARARs. Would provide power to whatever treatment or pumping system requiring it.
Recommendations:	See Alternative Z-1200.

7.2.2.11 Alternative KC-100 (Monitoring in King Creek)	
This alternative is to leave King Creek alone as is with continuing monitoring.	
Benefits:	No real benefits. Monitoring would be used to determine if a removal action was required in the future due to changes in contaminant levels.
Consequences:	Marginally elevated nitrates and selenium continue to flow down King Creek.
Effectiveness:	The current interception trench provides limited reduction in nitrates and selenium but no positive effect on the environment. There are no human health effects.
Implementability:	This alternative is currently being implemented.
Costs:	None.
Ability to Meet ARARs:	ARARs are not met at discharge point L-5. ARARs are met at the Site boundary.
Recommendations:	This alternative is not recommended.

7.2.2.12 Alternative KC-200 (Install Passive System in King Creek)	
This alternative consists of constructing a trench or cell that intercepts the normal flows below the existing interception trench and takes these flows into an anaerobic biotreatment system for metal reduction and denitrification. The passive treatment system would be constructed as a vertical flow semi-passive treatment cell in which captured waters are directed to the bottom of the system and flow upward through rock and organic substrates. After excavation of a 45-foot by 80-foot cell, the inside will be lined with a 36 Mil Hypalon or 45 Mil Polypropylene liner. The trench's bottom will contain a 24 to 30-inch layer of washed gravel with several buried (at a 12-inch depth) perforated six inch HDPE pipes, with one inch holes, laid in a manner to aid in the passive distribution of the influent across the cell bottom as the organics are broken down (Figure 7-2). The influent migrates through the bottom washed gravel/distribution system and moves upward through a rock-organic substrate mixture for anaerobic treatment. Biofilm support substrate mixture materials include 24% gravel (1.5-inch to 4-inch aggregate) mixed with 18% woodchips, 18% sawdust, 26% hay, 6% manure, and 14% activated carbon such that there will be free flow of waters up through the system without a formal distribution system. Activated carbon, already in use at the Landusky bioreactor, should be treated to establish a high density of metal reducing and denitrifying microbes, and used to substantially increase microbial densities and overall system robustness. The microbial inoculum will be obtained from the effluent waters from the Landusky bioreactors. The inoculum would be a mixture of both bottom and top bioreactor waters in order to increase microbial diversity. A draw-down system consisting of a vertical pipe is initially used for pumping trench inoculum/incubation waters from the bottom to the top and later used for a water level indicator. This pipe is linked to the influent water distribution system and used to pump waters from the bottom to the top to settle and compact trench fill materials. This same pipe could be used to pump Landusky bioreactor nutrient into the system if at some point the organics appear to be limited in the system.	
Benefits:	Removal of contaminants of concern with minimal cost. Upfront capital is provided for under a separate surety bond.
Consequences:	A passive system is predicted to treat the low flows with elevated nitrates (taking the 20 ppm influent down to 1 ppm) and selenium (taking the 0.045 ppm influent down to 0.01 ppm).
Effectiveness:	A biological system is currently treating nitrates and selenium with great success. This passive system should have similar results. This will improve the environment. There are no human health effects.
Implementability:	This is fairly easy to implement.
Costs:	The upfront capital cost is project to be $130,000. This annual operating costs are projected to be $5,000 or less.
Ability to Meet ARARs:	ARARs will be met well upstream of the Site boundary.
Recommendations:	This alternative is recommended.



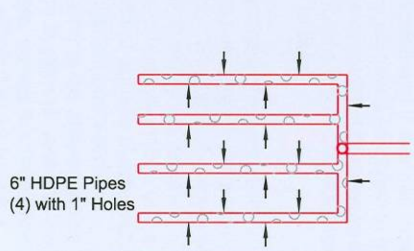
KING CREEK PASSIVE TREATMENT SYSTEM
CROSS SECTION
Not To Scale



BIOTREATMENT CELL QUANTITIES

	Quantity	Size
Coversoil-Salvage & Stockpile	780 CY	70' x 150' x 2'
Liner Bedding	70 CY	45' x 80' x 6"
Liner for Bottom-36 Mil Hypalon	14400 SQ FT	90' x 160'
Washed Gravel on Bottom	200 CY	45' x 80' x 1.5'
6" HDPE Pipe-Install 4 Laterals with 1-Inch Perforation Holes	200 Feet	6-Inch Dia. Evenly Spaced
Washed Gravel-Place Over HDPE Pipe	70 CY	45' x 80' x 0.5'
Place Mixed Biotreatment Constituents		About 8 Feet Thick
Washed Gravel	240 CY	1.5-4" Dia.
Wood Chips	180 CY	81,000 Lbs
Sawdust	180 CY	81,000 Lbs
Hay/Alfalfa	200 CY	54,000 Lbs
Manure	60 CY	45,600 Lbs
Activated Carbon	85 CY	66,120 Lbs
Washed Gravel-Place Over Bio Material	100 CY	55' x 90' x 0.5'
6" HDPE Pipe-Install 4 Laterals with 1-Inch Perforation Holes	250 Feet	6-Inch Dia. Evenly Spaced
Washed Gravel-Place Over HDPE Pipe and Above Pipe	200 CY	55' x 90' x 1'
8" HDPE Outlet Pipe	45 Feet	
Liner for Top-36 Mil Hypalon Plus Bypass Ditch Lining	13500 SQ FT	70' x 150' + 15' x 200'
Coversoil-Replace Stockpile	780 CY	70' x 150' x 2'
Stormwater Bypass Ditch	200 Feet	
EkoCompost-Downstream Passive	112 Dry Tons	About 370 CY

KING CREEK
PASSIVE TREATMENT SYSTEM
Not To Scale



DRAIN DISTRIBUTION DETAIL
Not To Scale

SPECTRUM ENGINEERING
1413 4th Ave. North
Billings, MT 59101
Phone: (406) 259-2412
August 2005

LANDUSKY MINE
RECLAMATION PROJECT
Blaine and Phillips Counties, Montana

KING CREEK PASSIVE TREATMENT SYSTEM

FILE NAME: Intercept Trench with Bio

FIGURE 7-2

7.2.2.13 Alternative SG-100 (Monitoring in Swift Gulch)	
This alternative is to continue with monitoring only in Swift Gulch.	
Benefits:	Monitoring would be used to determine if a removal action was required in the future due to changes in contaminant levels and better understand the hydro-geologic relationships in the drainage.
Consequences:	Water with high metals and acidity could continue to migrate downstream toward the Reservation boundary.
Effectiveness:	There are no negative human health effects.
Implementability:	This alternative is currently being implemented.
Costs:	Current monitoring costs are $6,900 per year.
Ability to Meet ARARs:	ARARs are met at the Site boundary.
Recommendations:	This alternative is not recommended.

7.2.2.14 Alternative SG-200 (Monitor with Characterization Study in Swift Gulch)	
This alternative is to continue monitoring in Swift Gulch plus complete a characterization study.	
Benefits:	Additional studies on drainage paths will help understand the waters flowing in Swift Gulch.
Consequences:	The contaminated water could continue to migrate downstream toward the Reservation boundary.
Effectiveness:	The collected data would help to better understand the situation in Swift Gulch so that it could be determined if a removal action was warranted to protect human health. At this time there are no negative human health effects.
Implementability:	This would be easy to implement.
Costs:	Current monitoring costs are $6,900 per year. A characterization study could cost from $100,000 to $300,000.
Ability to Meet ARARs:	ARARs are met at the Site boundary.
Recommendations:	This alternative is recommended over Alternative SG-100.

7.2.2.15 Alternative SG-300 (Monitor with Characterization Study Plus Construct Settling Basins or Ponds in Swift Gulch)	
This alternative continues monitoring in Swift Gulch, completes a characterization study, and builds setting ponds or basins in the old placer tailings at the Bighorn-Swift Gulch confluence.	
Benefits:	Additional studies on drainage paths will help understand the waters flowing in Swift Gulch. The settling basins will either slow or eliminate downstream progression of contaminants.
Consequences:	No negative consequences other than minor disturbance in the Swift Gulch/Bighorn drainage.
Effectiveness:	This may help protect the environment. There are no negative human health effects.
Implementability:	This is easy to implement.
Costs:	Current monitoring costs are $6,900 per year. A characterization study could cost from $100,000 to $300,000 and tailings reconstruction could cost from $100,000 to $300,000.
Ability to Meet ARARs:	ARARs are met at the Site boundary.
Recommendations:	This alternative is recommended over Alternative SG-200.

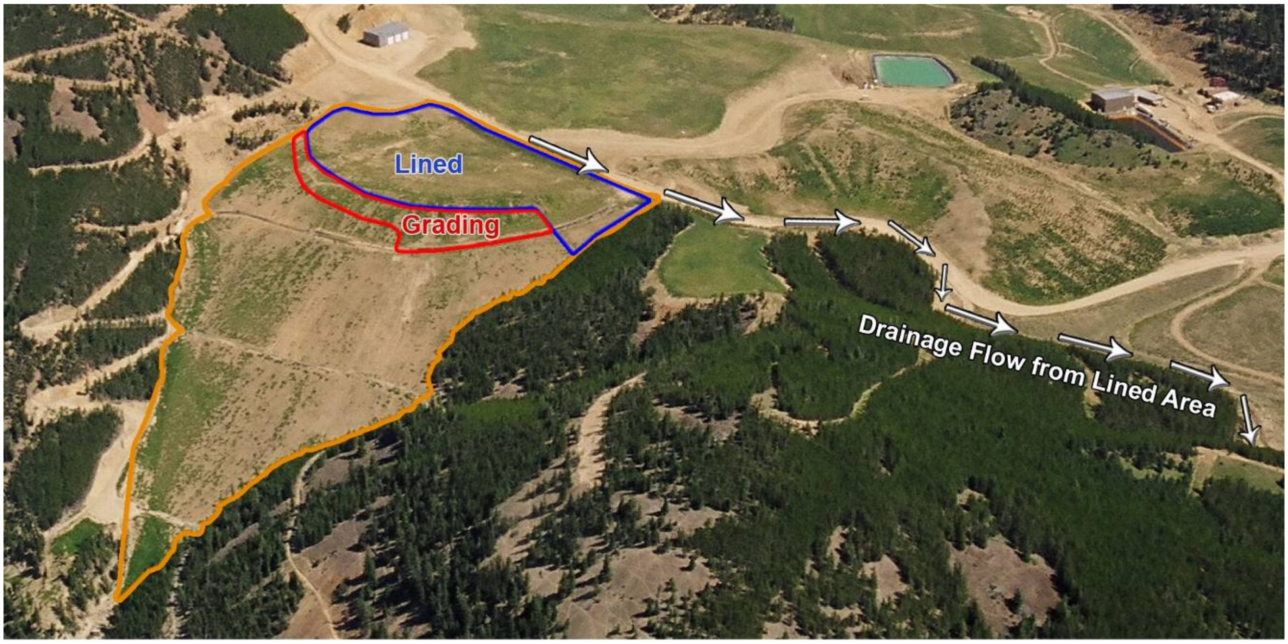
Iron seep in Swift Gulch

Iron-rich sediment deposits in Swift Gulch

Natural outcrop of acid generating rock in Swift Gulch

7.2.2.16 Alternative AG-100 (No Action on Zortman Mine Alder Gulch Waste Rock Dump)	
This alternative leaves the current reclamation of the Zortman Mine Alder Gulch Waste Rock Dump in its current state of completion. Seepage would continue to be monitored, captured, and treated.	
Benefits:	No benefits.
Consequences:	No negative consequences.
Effectiveness:	There are no negative human health or environmental effects.
Implementability:	This alternative is currently being implemented.
Costs:	There are no costs.
Ability to Meet ARARs:	ARARs are met at the Site boundary.
Recommendations:	This alternative is not recommended.

7.2.2.17 Alternative AG-200 (Regrade and Recap the Top of the Zortman Mine Alder Gulch Waste Rock Dump)	
This alternative completes the intent of SEIS reclamation Alternative Z6. It requires regrading and recapping the top of the dump.	
Benefits:	This reduces the flow being captured in the Carter Gulch Capture System.
Consequences:	No negative consequences other than minor disturbance of existing reclamation.
Effectiveness:	There are no positive or negative human health or environmental effects.
Implementability:	This is fairly easy to implement.
Costs:	The construction cost is estimated at $300,000.
Ability to Meet ARARs:	ARARs are met at the Site boundary.
Recommendations:	This alternative is recommended over AG-100.



Alder Gulch Waste Rock Dump showing cover and drainage under Alternative AG-200.

7.2.2.18 Alternative AG-300 (Complete the SEIS Alternative Z6)	
This alternative takes the top of the Alder Gulch Waste Rock Dump and places it into the North Alabama Pit (SEIS Alternative Z6). Then both the North Alabama Pit and the Alder Gulch Waste Rock Dump get capped.	
Benefits:	This reduces the flow being captured in the Carter Gulch Capture System.
Consequences:	Possible negative consequences as sulfides get placed into the North Alabama Pit and acid generation becomes possible.
Effectiveness:	There are minimal human health or environmental effects.
Implementability:	This is fairly difficult to implement.
Costs:	The construction cost is estimated at $2,200,000.
Ability to Meet ARARs:	ARARs are met at the Site boundary.
Recommendations:	This alternative is not recommended over AG-200.

7.3 ALTERNATIVES CONSIDERED AND DISMISSED

7.3.1 Pipe Leach Pad Water to the Missouri River

One alternative proposed by Terry Mudder, Ph.D. and Mike Botz, M.S., P.E. as part of the RFQ in July, 2000 for professional qualifications for leach pad nitrate, cyanide, and selenium reduction, was to pipe all leach pad waters to the Missouri River. They stated that "this alternative as a viable alternative to water treatment. While discharging the solution into the Missouri River may be unpopular, environmentally it could be conducted to maintain high-quality water in the river at a minimal long-term cost to the State of Montana and taxpayers. The construction of such a pipeline could also provide welcome employment for local people. Furthermore, as the quality improves over time, the water being conveyed to the river could be drawn off and used for irrigation along the pipeline route." Since the initial proposal, the leach pad waters have become increasingly acidic and would require some treatment prior to release. This concept, while technically feasible, has been eliminated from further consideration.

7.3.2 New Landusky LAD

Potential LAD sites on land south of the town of Landusky were investigated before the bioreactor was constructed and rejected because of the additional cost. At this point, it would be more environmentally sound and economical to adjust the bioreactor pH treatment and precipitate problem than to construct a new LAD area.

7.4 COMPARATIVE ANALYSIS OF ALTERNATIVES

There are very few large scale changes or alternatives to the present solution management practices. The processes being used on site today are the result of several years of incremental analysis and development, and were carefully analyzed before they were implemented. The current practices meet ARARs for the two mine sites. Any significant cost savings will only be realized by completely shutting down the treatment at one of the two mines or shutting down all the treatment and installing passive systems. Very few opportunities still exist to improve the efficiencies within the existing system, and these are being pursued.

The power cost to move water and operate the treatment plants is about $260,000 per year. A large component of this cost is fixed because Big Flat Electric owns the transformers and wires and charges a monthly rental. The Site has an average wind speed of 17 mph and has great potential for wind generation that could be used to reduce the power costs.

Theoretically, passive or semi passive systems will work, but they cannot be justified at this site without extensive testing and then detailed engineering. The analysis would be different if two lime water treatment plants and a biotreatment plant were not already constructed and successfully treating the water. It is unlikely that replacing the existing system with a passive system would produce the same water quality. Aluminum fouling must be addressed and resolved before a semi-passive system can be considered technically feasible. Installing a passive or semi-passive system will not eliminate the water management task, but it would reduce or eliminate the water treatment plant labor costs.

Consideration of passive/semi-passive systems should not be totally dismissed, because, they might prove more economical than operating with a large deficit. A pilot plant would be required and additional lab scale testing to get the data necessary to determine the size of the passive systems, the relative cost and performance of the passive and semi-passive systems, and the number of bioreactors needed in series to meet ARARs since it is unlikely that only one passive bioreactor will remove aluminum, iron, nitrates, selenium, nickel, cadmium, and arsenic.

8.0 RECOMMENDED ALTERNATIVE ACTION

The following three criteria were used to evaluate alternative actions to the present Zortman and Landusky OU1 and OU2 treatment systems: effectiveness, implementability, and cost. Numerous options were considered and only the current base case or existing conditions met ARARs. The following recommendations are only minor potential changes to current practices. The cost for the current operation is $1,500,000. There is no way of meeting the existing funding limitation of $731,321 annually, without shutting down all but one of the operating systems.

8.1 ZORTMAN MINE RECOMMENDATIONS

8.1.1 Zortman Mine Water Treatment Plant and Capture Systems

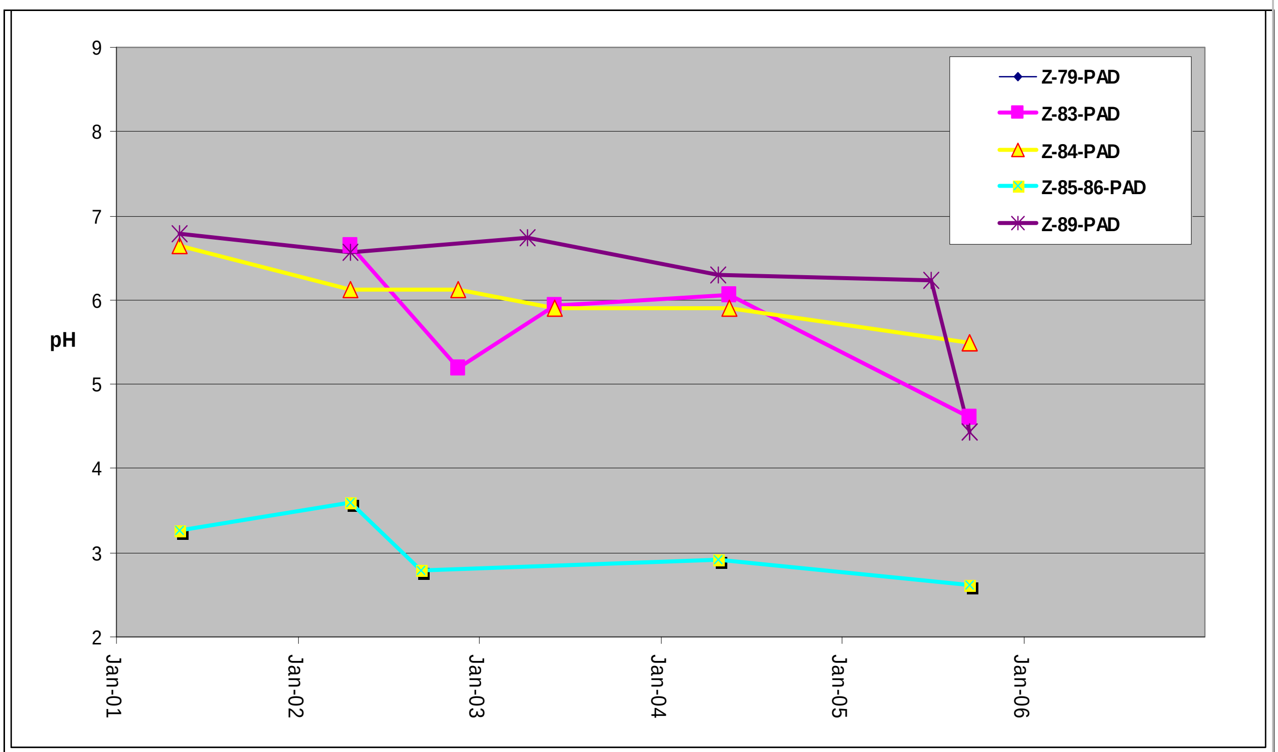
The recommendation is to continue current practices (Alternative Z-100).

Investigations for reducing the labor costs by changing the operating schedules should be considered. It may be possible to reduce the ferric sulfate costs if the sludge recirculation is increased. Completely shutting down the ferric sulfate circuit reduces the costs by $36,000 per year and would still meet ARARs.

8.1.2 Zortman Mine Leach Pads

The current operation (Alternative Z-500) is recommended. All the Zortman Leach pads are acidic, and they are slowly trending more acidic.

Figure 36 – Zortman Mine Leach Pad pH Trend



The present procedure of pumping the pad water through the water treatment pad sludge is working very well because it removes the aluminum, iron and other heavy metals, and does a very good job reducing the arsenic. Testing is in process to determine how long this can be done before the alkalinity is consumed, and to determine whether to replenish the alkalinity in the sludge or perhaps to treat the acid pad water in the water treatment plant.

The acidic pad water cannot be pumped directly to the Biotreatment plant because the acid would dissolve the steel pipes. If acid resistant pipes (HDPE) were installed, then acidic water could be pumped to the Landusky Mine where it would still need to be treated using the current methods. Zortman Mine leach pad water can be run through the Biotreatment plant at up to 200 gpm whereas the Landusky Mine leach pad water can only be treated at 75 to 125 gpm. At some later date, when the nitrates have sufficiently diminished, it will be feasible to route all the Zortman Mine leach pad water through the lime treatment plant and then discharge it into Ruby Gulch.

8.1.3 Zortman Mine Regrading and Backfilling

The Zortman Mine SEIS reclamation alternative Z6 has been completed except for the removal of the top of the Alder Gulch Waste Rock Dump. This action would not have eliminated the need for capture and treat in Carter Gulch. The price to complete the 2002 ROD Z6 plan is $2.2 million. The action would affect water quality and would have limited affect on water quantity. Completion of Alternative Z6 should only be completed if additional funding becomes available outside of the funding needed to treat water through 2017.

A more efficient variation to the Z6 reclamation plan for the Alder Gulch Waste Rock Dump has been developed that would keep all sulfides contained within the existing dump area. The variation is estimated to cost about $300,000. The top of the dump would be graded to drain to the east into the Alder Spur drainage. Surface water and seepage captured on the lined area would flow into the existing diversion system that carries water to Outfall 607, which is located on the east side of Carter Butte. The grading would be limited to 31,000 cubic yards of excavation required to shape the drainage area. All of this cut would be placed along the southwest edge of the bench. A 30-mil PVC liner would be installed over the 6.34 acre area, graded with maximum of 4H:1V slopes. Most of the area would have 5-10 percent slopes. The reclaimed North Alabama Pit would not receive any excavated waste rock and would not need to be capped as previously planned.

Implementation of the SEIS Z6 will have no effect on the Site ability to meet ARARs,

8.2 LANDUSKY MINE RECOMMENDATIONS

8.2.1 Landusky Mine Water Treatment Plant and Capture Systems (OU1)

Continuing the current operation (Alternative L-100) is recommended. The existing system is working well and does not need to be changed to meet ARARs.

8.2.2 Landusky Mine Leach Pads (OU2)

Continuing the existing operation (Alternative L-500) is recommended. The bioreactor is performing well as long as the influent is pretreated to prevent plugging with aluminum and iron hydroxide precipitates.

During the days when it is relatively calm, the pH pond works well. However, when the wind blows the precipitates are stirred up and the plant capacity is reduced. On very windy days the plant must be shut down. It is recommended that this problem be solved by blocking the wind, by covering the pond with something that does not allow the waves to form, or by installing a mechanical clarifier.

The lower leach pads are near neutral pH but still contain elevated nitrates. Once the average N+N in the lower pads drops below 140 mg/l, it is recommended that the pad water be run through the WTP to remove the metals and dilute the N+N sufficiently to meet ARARs. This will save pumping 29 gpm vertically 900 feet to the biotreatment plant.

8.2.3 Landusky Mine - King Creek (OU4)

A semi-passive treatment cell is recommended to treat nitrates and selenium from the small seep in King Creek per Alternative KC-200.

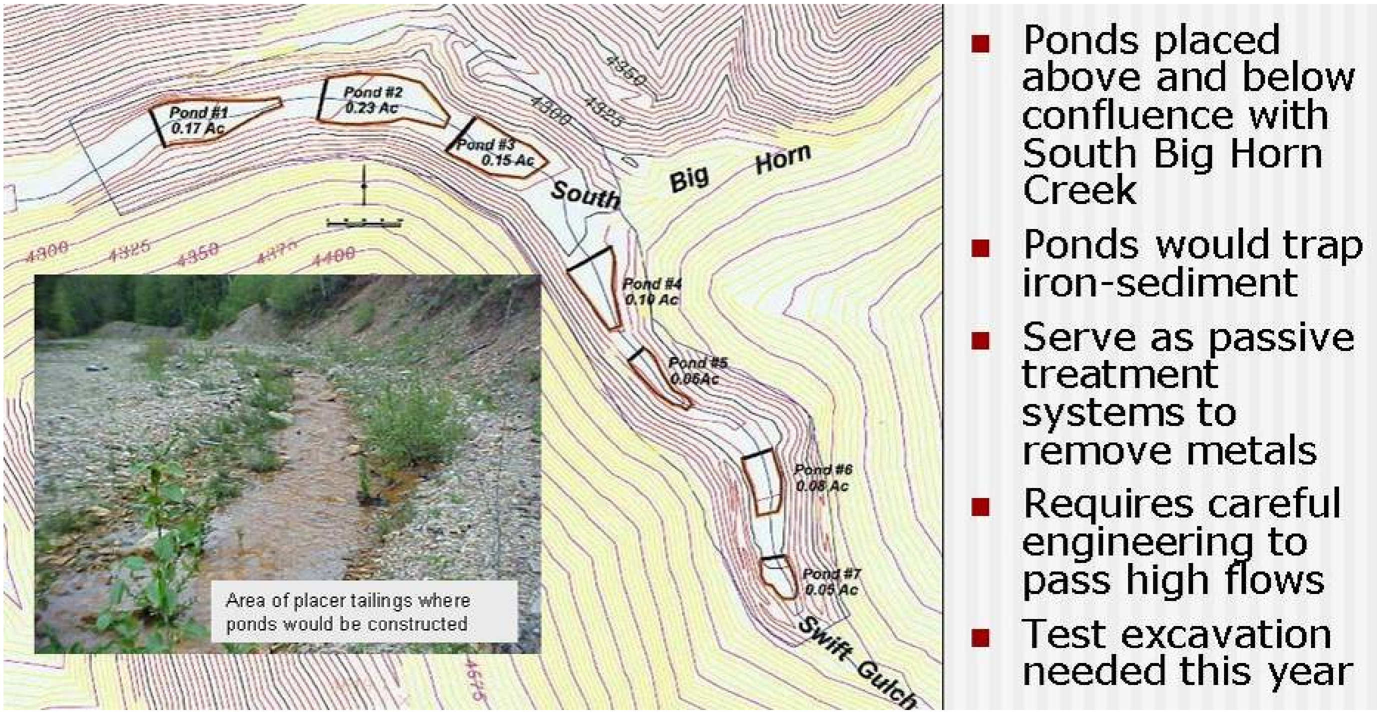
8.2.4 Landusky Mine - Swift Gulch (OU5)

It is recommended that continued monitoring and additional hydro-geologic studies be conducted in the Swift Gulch drainage basin to identify the sources of the iron seeps that are contributing to the decline in water quality observed since 1998.

In the interim, it is recommended that a series of settling ponds/passive treatment ponds be constructed in the bottom of Swift Gulch, near its confluence with South Bighorn Creek, as part of an effort to reclaim the old placer dredge tailings at this location. The ponds would provide for settling of iron-rich muds in case a large runoff event mobilized these deposits from their upstream location. This would provide a barrier to the downstream migration of contaminants, limiting their potential to leave the site and possibly impact water quality on the Fort Belknap Reservation.

8.3 ALTERNATIVE COMPARISON

A summary table of alternatives considered has been prepared. It lists the consequences of turning off treatment systems and whether ARARs would be met. The summary of Alternatives table in found in Section 7. The existing base case of the combination of Alternatives Z-100 (Zortman captures systems), Z-500 (Zortman leach pads), L-100 (Landusky capture systems) and L-500 (Landusky leach pads) is the most cost effective while satisfying ARARs.



Map view of Swift Gulch/South Big Horn Creek confluence showing the location where the Alternative SG-300 ponds would be built.

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