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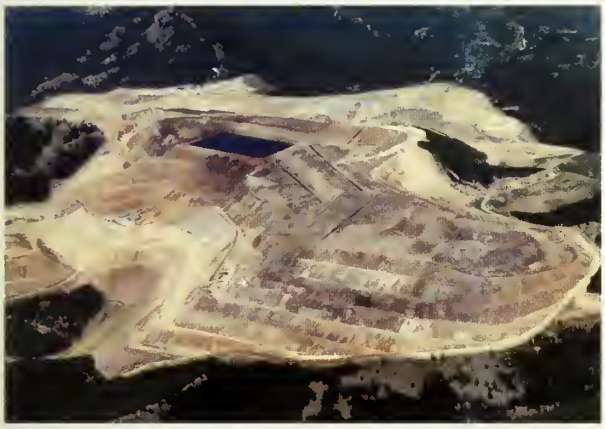
Draft
Supplemental Environmental Impact Statement for Reclamation of the Zortman and Landusky Mines

Phillips County, Montana



Prepared By:

Bureau of Land Management
Malta Field Office

State of Montana
Department of Environmental Quality

March 2001

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The Bureau of Land Management is responsible for the stewardship of our public lands. It is committed to manage, protect, and improve these lands in a manner to serve the needs of the American people for all times. Management is based upon the principles of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. These resources include recreation; rangelands; timber; minerals; watershed; fish and wildlife; wilderness; air; and scenic, scientific, and cultural values.

The Department of Environmental Quality's mission is to protect, sustain, and improve a clean and healthful environment to benefit present and future generations.

Cover Photos: Top photos show the L87/91 leach pads at the Landusky Mine. Top right photo shows interim reclamation grading along the east edge of the L91 leach pad. Bottom photos show the lower leach pads (L79-L84) at the Landusky Mine before and after interim reclamation grading. View is toward the northwest with Mission Peak in the background.

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April 2001

Dear Reader,

Enclosed is your copy of the Draft Supplemental Environmental Impact Statement (SEIS) on reclamation of the Zortman and Landusky Mines in northcentral Montana. This EIS is a draft supplement to the March 1996 Final EIS, *Zortman and Landusky Mines Reclamation Plan Modifications and Mine Life Extensions*. With the bankruptcy of the mines' operator, Zortman Mining, Inc., the Department of Environmental Quality and the Bureau of Land Management are overseeing reclamation at the mines. The Draft SEIS has been prepared to analyze additional reclamation alternatives developed by the agencies that may constitute a substantial change from those presented in the 1996 Final EIS.

The Draft SEIS presents 12 reclamation plans, six for reclamation of the Zortman Mine and six for reclamation of the Landusky Mine. The reclamation plans were developed based upon public scoping comments and through consultation with the Fort Belknap government and the Environmental Protection Agency. The SEIS discloses the environmental consequences of each alternative. Alternative Z6 is identified in the SEIS as the DEQ and BLM preferred reclamation alternative for the Zortman Mine, and Alternative L4 is identified as the preferred reclamation alternative for the Landusky Mine. The identification of the preferred alternatives does not constitute an agency decision but is intended to help focus public comment on the alternatives more likely to be selected.

You are invited to provide comments on the Draft SEIS. We are particularly interested in comments that address one or more of the following: (1) needs for clarification; (2) new information that would have a bearing on the analysis; (3) possible new alternatives; and (4) the identification of possible errors in the analysis. Comments that are specific will be most useful in development of the Final SEIS.

There is a 60-day public comment period on the Draft SEIS. Release of the Draft SEIS and public comment period will also provide public review and comment opportunities on the Draft MPDES permit contained in Appendix C of the Draft SEIS. Public meetings will be scheduled to receive written or oral comments. The public meeting locations and dates will be announced later. Written comments may also be submitted during the comment period. In order to be considered, your written comments need to be received by the close of business on July 9, 2001. Comments may also be sent electronically to: *ZLReclamation_EIS@blm.gov* Please include your name and complete mailing address on all written comments, including copies of any testimony you may submit to us at the public hearings.

Written comments should be sent to: Zortman/Landusky Mine Reclamation Plan SEIS, c/o Bureau of Land Management, Lewistown Field Office, P.O. Box 1160, Lewistown, MT 59457-1160.

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Draft Supplemental
Environmental Impact Statement

Reclamation of the Zortman and Landusky Mines
Phillips County, Montana

April 2001

Lead Agencies: United States Department of the Interior, Bureau of Land Management, Malta Field Office and State of Montana, Department of Environmental Quality, Environmental Management Bureau.

Cooperating Agencies: None.

Participating Agencies/Governments: United States Environmental Protection Agency and the Fort Belknap Indian Community Council.

Contacts for Further Information: Scott Haight, Bureau of Land Management, Lewistown Field Office, P.O. Box 1160, Lewistown, MT 59457 (406/538-1930) and Wayne Jepson, Montana Department of Environmental Quality, Environmental Management Bureau, P.O. Box 200901, Helena, MT 59620 (406/444-0529).

Abstract: This Draft Supplemental EIS is a supplement to the 1996 Final EIS on Reclamation Plan Modifications and Mine Life Extensions at the Zortman and Landusky Mines. Since 1996, the mines' operator has declared bankruptcy and the regulatory agencies (DEQ and BLM) are overseeing reclamation using the reclamation bonds. Reclamation issues include the amount of pit backfilling, the type of reclamation covers to place over acid generating materials, protection of water quality, disposal of heap effluent, and long-term water treatment. The Fort Belknap Indian Reservation is adjacent the mining area and reclamation plans include measures to protect trust resources. The Draft SEIS evaluates 12 reclamation alternatives, six for the Zortman Mine and six for the Landusky Mine. These include alternatives that could be implemented using the reclamation bond on hand and those that would require a considerable amount of additional funding. The alternatives were developed because they are either more cost effective, better address environmental concerns, or both, than those presented in the 1996 FEIS. The preferred reclamation alternatives in the Draft SEIS (Alternatives Z6 and L4) have an estimated cost of $51.6 million, which is approximately $22 million more than is available under the reclamation bonds.

Other Environmental Review: This Draft Supplemental EIS will also serve as the environmental review document for the Montana Pollutant Discharge Elimination System (MPDES) permit to be issued by the Montana DEQ. Draft MPDES permits are in Appendix C.

Comments: Comments should be received by close of business on July 9, 2001, and addressed to: Zortman/Landusky Mine Reclamation Plan SEIS, c/o Bureau of Land Management, Lewistown Field Office, P.O. Box 1160, Lewistown, MT 59457-1160. Comments may also be sent electronically to: *ZLReclamation_EIS@blm.gov*

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CHAPTER 1
INTRODUCTION: PURPOSE OF AND NEED FOR ACTION

1.1 INTRODUCTION

This EIS is a draft supplement to the March 1996 Final Environmental Impact Statement (FEIS), *Zortman and Landusky Mines Reclamation Plan Modifications and Mine Life Extensions.* This Draft Supplemental EIS (SEIS) incorporates by reference or summation much of the information presented in the 1996 FEIS. The SEIS has been written so the reader can follow the analysis without having to view both documents. However, some readers may wish to review the FEIS for additional detail or background information.

The SEIS has been prepared to analyze additional reclamation alternatives that may constitute a substantial change from those presented in the FEIS and from the reclamation plans initially approved in a June 1, 1998 Record of Decision issued by the Montana Department of Environmental Quality (DEQ) and the Bureau of Land Management (BLM). DEQ and BLM (also referred to in this document as "the agencies") are joint lead agencies responsible for preparation of the SEIS.

1.2 PROJECT LOCATION and HISTORY

From 1979 through 1998, Pegasus Gold Corporation and its wholly owned subsidiary operating company, Zortman Mining, Inc. (ZMI), operated the Zortman and Landusky Mines in the Little Rocky Mountains of northcentral Montana (Figure 1.2-1). While historic mining activity has occurred in the area since the mid-1860s, the advent of cyanide heap leach technology, combined with a sharp rise in gold prices, prompted the development of these large-scale, open pit mining operations beginning in the late 1970s. In 1979, a Draft EIS analyzing the mines was prepared by the Montana Department of State Lands[1] (DSL 1979a). The State's Final EIS documentation (responses to comments on the Draft EIS and adoption of the Draft as Final) was issued May 17, 1979 (DSL 1979b), and the Zortman and Landusky Mines were approved.

The Zortman Mine is located in Sections 7, 17, and 18, Township 25N, Range 25E, Montana Principal Meridian (MPM). The Landusky Mine is west of the Zortman Mine in Sections 14, 15, 22, and 23, Township 25N, Range 24E, MPM. Both mines are near the southern boundary of the Fort Belknap Indian Reservation in the southwest corner of Phillips County on a mixture of private land and public land managed by the BLM (Figure 1.2-2).

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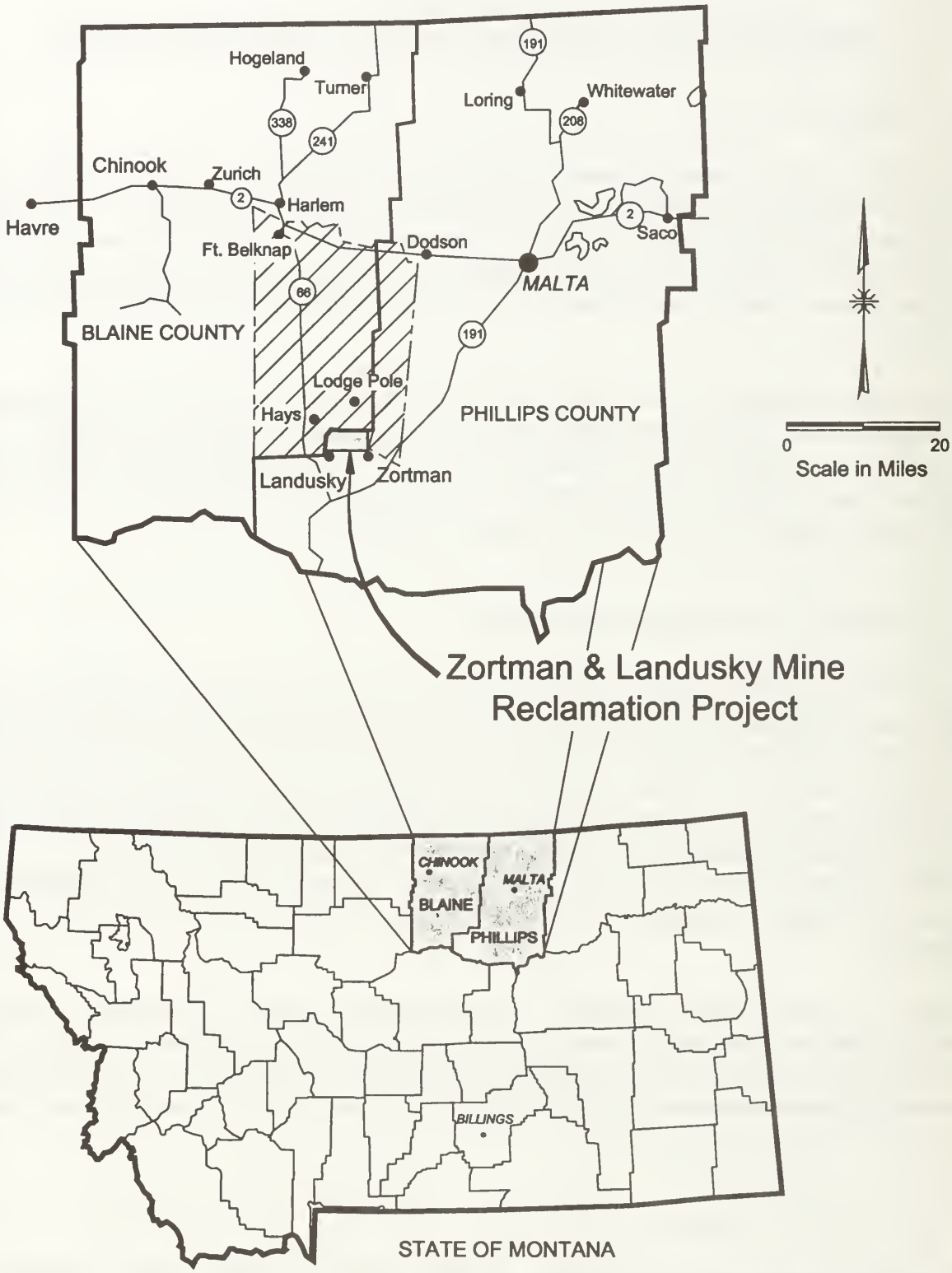
[1] In a 1995 reorganization the Montana DEQ was created from portions of the Montana Department of State Lands and the Montana Department of Health and Environmental Sciences.



GENERAL
LOCATION MAP

FIGURE 1.2-1

ZORTMAN-LANDUSKY MINE AREA

Figure 1.2-2
Detailed Location and Ownership Map

LEGEND

- BLM SURFACE
- PRIVATE SURFACE
- FT. BELKNAP RESERVATION
- AREA OF MINE DISTURBANCE*

* Mine disturbance includes mine pits, waste rock piles, leach pads, and processing plants. Not included are access roads, powerlines, land application areas and areas of exploration activity.

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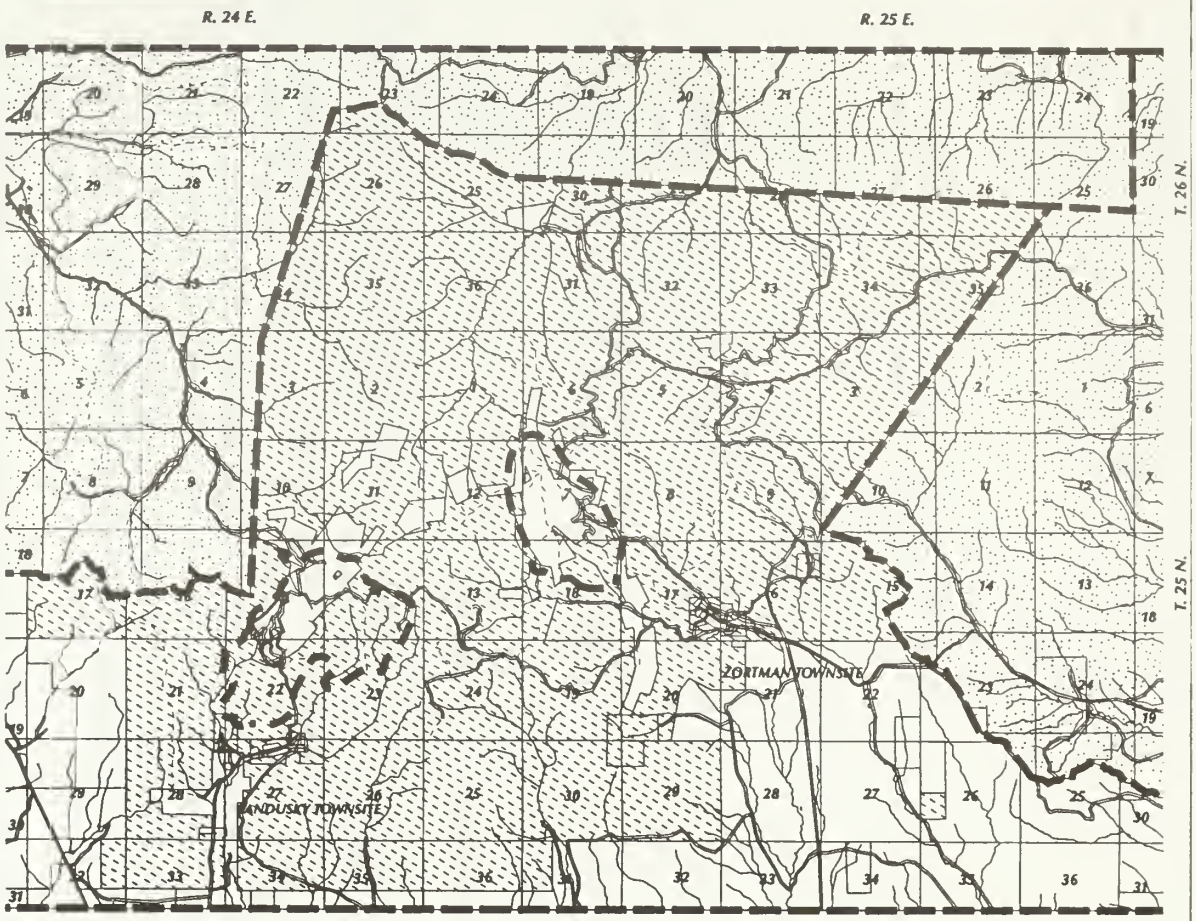
MILES



The towns of Hays and Lodgepole are located in the southern portion of the Reservation, on the northern edge of the Little Rocky Mountains. The town of Landusky is just southwest of the mountains, about one-half mile south of the Landusky Mine. The town of Zortman is about one mile south of the Zortman Mine, on the southeastern edge of the Little Rocky Mountains. Aerial photos of the Zortman and Landusky mining areas taken in 1977 show the amount of disturbance before the era of large-scale, modern mining which began in 1979 (FEIS Figures 1-2 and 1-3). FEIS Figure 1-4, taken in 1993, shows the mine disturbance as it generally looks today.

ZMI (or more precisely the bankruptcy trustee for ZMI) holds BLM Plan of Operations MTM-77778 and DEQ Operating Permit No. 00096 for conducting operations at the Zortman Mine. Eleven amendments to the operating plans were approved between 1979 and 1988, which allowed the disturbance area to increase from the original permitted 273 acres to the present 401 acres. A history of permit amendments for the Zortman Mine is shown in FEIS Table 1-1.

ZMI holds BLM Plan of Operations MTM-77779 and DEQ Operating Permit No. 00095 for conducting operations at the Landusky Mine. Ten amendments to the operating plans were approved between 1980 and 1991, which allowed the mine disturbance area to increase from the original permitted 256 acres to the present 814 acres. A history of permit amendments for the Landusky Mine is shown in FEIS Table 1-2.

1.2.1 Reclamation Plan Development History

Preparation of this SEIS on reclamation at the Zortman and Landusky Mines is the culmination of a review process that began over eight years ago. In 1992, ZMI submitted plans for a major expansion at the Zortman Mine (see FEIS, pages 2-104 to 2-170). Review of water resources monitoring information, concurrent with review of the mine expansion plans, showed that acid rock drainage (ARD) was a widespread occurrence at both the Zortman Mine and at the Landusky Mine. In late 1992, the agencies requested that ZMI propose corrective measures to their existing reclamation plans. In early 1993, the requests took the form of administrative orders issued under the authorities at §82-4-337(3), Montana Code Annotated (MCA) for DSL; and at 43 Code of Federal Regulations (CFR) §3809.1-7(c) for BLM (DSL 1993, BLM 1993).

ZMI responded with proposed modifications to the reclamation plans that were presented to the public in 1993. In response to public comment, and due to the technical complexity of the ARD issue when considered in combination with the mine expansion proposal, the agencies required that the reclamation plan modifications be analyzed in an EIS (DSL/BLM 1994). The EIS scoping period on the Zortman Mine expansion application was reopened and the scope of the EIS analysis was broadened to include both mine expansion and modified reclamation plans at both the Zortman and Landusky Mines.

Concurrent with the DSL and BLM efforts to have ZMI change its operating and reclamation plans, the Montana Department of Health and Environmental Sciences issued an enforcement order against ZMI for

the discharges coming from the mines into waters of the State. In August 1993, a suit was filed in District Court by the State of Montana against ZMI and Pegasus Gold, alleging violations of the Montana Water Quality Act. This was due in part to ARD at the mine sites. The Environmental Protection Agency (EPA) filed suit in Federal District Court in June 1995, alleging that discharges from the mine sites in seven drainages were in violation of the Federal Clean Water Act (Civil Action No. 95-95-BLG-JDS). The State of Montana then filed in Federal District Court and citizen suits were also filed in Federal District Court by Island Mountain Protectors and the Fort Belknap Indian Community Council (Fort Belknap) (Civil Action No. 95-96-BLG-JDS). Settlement discussions among the parties occurred during 1995 and early 1996 to resolve the complaints. A Consent Decree was lodged in Federal District Court on July 22, 1996. After a public comment period, the Consent Decree became effective on September 27, 1996.

The Consent Decree required ZMI 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. However, the Consent Decree did not address surface reclamation requirements for the mines, which are beyond the scope of the water quality acts.

After the completion of the FEIS and the signing of the water quality Consent Decree, the DEQ and BLM issued a Record of Decision (ROD) on October 25, 1996. This ROD decided two things: One, it approved additional mining operations at both mines; and two, it required implementation of specific reclamation measures to control acid drainage development, including incorporation into the reclamation plans of various water management requirements from the Consent Decree (FEIS Appendix A). The BLM approval of additional mining was appealed to the Interior Board of Land Appeals (IBLA) in late 1996 by Fort Belknap, Island Mountain Protectors, and the National Wildlife Federation. The DEQ approval of expanded mining was challenged in State District Court in January 1997 by Fort Belknap, the National Wildlife Federation and Montana Environmental Information Center.

In June 1997, the IBLA ordered the mine expansion approvals stayed while the appeal was under consideration. However, in January 1998, before a decision was issued on the merits of the appeal, Pegasus Gold Corporation and ZMI filed for bankruptcy protection. On March 10, 1998, the companies announced they were no longer going to proceed with the approved mine expansion plans and instead were going to reclaim and close the mines.

To recalculate the necessary reclamation bond in view of the pending bankruptcy proceedings and imminent mine closures, the agencies issued a second ROD on June 1, 1998. That decision rescinded the approved mine expansion and selected Alternative 3 from the FEIS for implementation. Alternative 3 did not provide for additional mining, but required reclamation of the existing disturbances using agency-developed mitigation. The agencies identified a shortfall of approximately $8.5 million in the reclamation bond available at that time to implement Alternative 3. ZMI appealed this decision, citing that reclamation under Alternative 3 would be too expensive and contained requirements that were unnecessary. At the same time as the agencies signed the June 1 ROD, the IBLA ruled on Fort Belknap's appeal of the mine expansion

approvals.[2] The IBLA ruled in favor of Fort Belknap and stated that the FEIS contained too much uncertainty about groundwater conditions and, therefore, BLM could not have adequately considered potential impacts to water resources and, specifically, to protection of Tribal water resources.

BLM requested reconsideration of the IBLA decision, stating that data requirements for reclamation of an existing mine need not be as detailed as those necessary to approve the mine expansion. On November 20, 1998, the IBLA issued an order that set aside the BLM ROD of June 1, 1998, and directed that prior to selecting a final reclamation alternative, "...BLM must separately analyze, and consult with the Tribes about, potential effects on Tribal water resources and report on its actions in its decision." At present there is no approved BLM plan for final reclamation of the mines. There is an agreement with the surety companies underwriting ZMI's reclamation bonds to fund reclamation up to the limits of the surety amounts.

BLM and DEQ have been consulting with the Fort Belknap government since March 1999, as directed by the IBLA Order (see also Chapter 5). This consultation effort has utilized a technical working group composed of specialists from BLM, DEQ, EPA, and Fort Belknap to consider various reclamation options for the mines. The technical working group has identified five additional reclamation alternatives for the Zortman Mine and five additional reclamation alternatives for the Landusky Mine that should be considered for possible implementation because they are either more cost effective, more protective of the environment, or both, when compared to the reclamation plan initially approved by the June 1998 ROD. BLM and DEQ have determined that selection of one of these additional reclamation alternatives may constitute a substantial change in the 1998 agency-proposed action. Since a substantial change in the proposed action is one of the regulatory triggers listed in 40 CFR 1502.9(c) that requires preparation of a supplemental EIS, the agencies decided in March 2000 to proceed with preparation of a supplemental EIS (BLM 2000).

1.3 PURPOSE OF and NEED FOR ACTION

The purpose of and need for action is to develop reclamation plans for the Zortman and Landusky Mines which address the acid-generating character of the mined material and pit areas, and which will successfully meet all applicable State and Federal requirements for mine reclamation necessary to protect human health and the environment with a reasonable assurance of long-term success. While past mining approvals simultaneously included plans for reclamation, the agencies determined in 1993 that those plans did not provide adequate consideration of the potential impacts from acid generating material and needed to be modified (DSL 1993, BLM 1993).

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[2] The agencies' June 1, 1998 ROD and the IBLA's decision of May 29, 1998 crossed in the mail. BLM had notified the IBLA of its intent to issue the ROD prior to June 1, but IBLA did not respond until after the ROD was signed.

The decisions to be made by DEQ and BLM are the manner and degree to which the ZMI trustee is required to modify the reclamation plans in the Operating Permits and Plans of Operations to achieve successful reclamation. It should be noted that while actual implementation of the reclamation would be carried out by the agencies using funds from the surety companies and, possibly, from other sources, the ZMI trustee legally holds the Operating Permits and Plans of Operations under which the reclamation is being conducted.

1.4 REGULATORY AUTHORITY, ROLES, and RESPONSIBILITIES

DEQ and BLM are joint lead agencies responsible for preparation of the SEIS and for issuing a decision regarding final mine reclamation. Technical expertise has been provided by independent third-party consultants selected by, and working under the direction of DEQ and BLM, and by a technical working group composed of specialists from BLM, DEQ, EPA and Fort Belknap.

DEQ and BLM will use the technical analysis in the Final SEIS to prepare a ROD that considers how the reclamation alternatives satisfy the legal requirements for reclamation. It should be noted that a determination as to how a particular reclamation alternative may or may not meet a performance requirement varies with the resource being considered and the guiding authority. For example, when dealing with numeric requirements such as a water quality standard, a fairly straightforward analysis can predict whether an exceedance of the water quality standard is likely under a particular alternative. In other instances, determining whether reclamation performance criteria such as "comparable stability and utility" or "prevention of unnecessary or undue degradation" have been met would be subject to some amount of interpretation. The ROD will consider these factors and select reclamation plans that modify the Operating Permits and Plans of Operations as needed to achieve successful reclamation.

Information on the lead and participating agencies' roles and responsibilities is presented below. A Memorandum of Understanding (MOU) between BLM, DEQ, EPA, and Fort Belknap was signed in November 2000. The MOU details the various agencies' roles and responsibilities for preparation of the SEIS. Other agencies may have future roles and responsibilities should site conditions change over time or response actions under other authorities be triggered.

1.4.1 Montana Department of Environmental Quality

Montana Metal Mine Reclamation Act

The purpose of the 1971 Montana Metal Mine Reclamation Act is to ensure that the usefulness, productivity and values of lands and waters disturbed by mining receive the greatest reasonable degree of protection and reclamation to a beneficial use (§82-4-302, MCA). This Act applies to all lands within the State of Montana, whether federal, state, or private. Under this Act, DEQ has the authority to (a) to issue an operating permit, (b) inspect facilities and operations for compliance with the permit and applicable laws,

and (c) check the company's self-monitoring. Mine pit reclamation is regulated by DEQ under §82-4-336 et seq., MCA, wherein DEQ is granted authority to require mine reclamation plans. Pit reclamation is considered in this SEIS in several places. Section 1.5.2 identifies pit reclamation as a significant mine reclamation issue. Partial backfill, complete backfill, and pit highwall reduction are considered in the various reclamation alternatives presented in Chapter 2.

Under §82-4-337(3), MCA, DEQ can require an operator to modify its operating permit when the previously adopted reclamation plan is impossible or impractical to implement, and when significant environmental problems are revealed by field inspection. This was the situation at the mines in 1992 that prompted the modification order issued by DEQ.

Montana Water Quality Act

DEQ is responsible for administration of Title 75, Chapters 5 and 6, MCA, better known as the Montana Water Quality Act and the Public Water Supply Act, respectively. The Montana Water Quality Act (§75-5-402, MCA) provides the authority for DEQ to issue permits in Montana.

DEQ also has delegated authority from EPA to implement the National Pollutant Discharge Elimination System (NPDES) program in Montana under the Federal Clean Water Act pursuant to 40 CFR 123, and to implement the water quality standards pursuant to 40 CFR 131. Facilities which discharge to State waters must obtain a state discharge permit and comply with both State and Federal regulatory requirements as administered by DEQ. The Montana equivalent to the NPDES program is the MPDES (Montana Pollutant Discharge Elimination System) program. Draft SEIS Appendix C contains the discharge permit requirements necessary for compliance with the Montana Water Quality Act.

1.4.2 Bureau of Land Management

Federal Land Policy and Management Act

The United States mining laws authorize the development of locatable mineral resources on public lands that are open to operation under the Mining Law (30 USC §22). Section 302(b) of the Federal Land Policy and Management Act of 1976 (FLPMA) directs the Secretary of the Interior to, "by regulation, or otherwise, take any action necessary to prevent unnecessary or undue degradation of the lands." (43 USC §1732(b)). In 1981 the BLM promulgated regulations under Title 43, Code of Federal Regulations, Part 3809, to implement the FLPMA requirements for mining activities on BLM-managed lands. These "3809" regulations detail the requirements for approving a Plan of Operations, or a significant modification to an already approved Plan of Operations, which is the action under consideration for the Zortman and Landusky Mines.

The prevention of *unnecessary or undue degradation* is the overall performance standard for mining and reclamation on BLM-managed lands. Unnecessary or undue degradation is not defined in FLPMA, but

is defined in the BLM regulations at 43 CFR 3809.0-5(k) and briefly means: (1) surface disturbance greater than what would normally result when activity is being accomplished by a prudent operator; (2) failure to take into consideration the effects of operations on other resources and land uses; (3) failure to initiate and complete reasonable mitigation measures, including reclamation; and (4) failure to comply with applicable environmental statutes and regulations. If it is determined that the action would not cause unnecessary or undue degradation, then BLM is required to approve a Plan of Operations for lands open to mineral entry. A determination as to the adequacy of a preferred reclamation plan in preventing unnecessary or undue degradation is made based upon the impacts identified during an environmental analysis.

In the existing situation, where the Zortman and Landusky Mines' operating companies are in bankruptcy, the BLM will issue to the bankruptcy trustee the approved modified reclamation plan that is needed to prevent unnecessary or undue degradation of the public lands (BLM cannot set reclamation requirements on private lands). BLM will oversee its implementation using the reclamation bonds and, if necessary, any other available funding.

On January 20, 2001, BLM promulgated new surface management regulations under 43 CFR subpart 3809. Under these new regulations, existing operations such as the Zortman and Landusky Mines are exempt from the new performance requirements and plan content requirements (§3809.400(a)). Other aspects of the new regulations do apply, but are generally not relevant since these mines have been through bankruptcy and are in the closure process.

National Environmental Policy Act

Approval of modified reclamation plans is a federal action which must be analyzed under the National Environmental Policy Act (NEPA). While approval of the reclamation plan modifications by BLM is only applicable to BLM lands, NEPA requires that the environmental analysis address impacts of the BLM approval on both private and public lands.

Environmental Justice

Executive Order 12898 on environmental justice requires that BLM, to the greatest extent practicable and permitted by law, identify and address disproportionately high adverse human health or environmental effects on minority and low income populations. Section 6-606 of the Order states that the Department of the Interior, including BLM, is responsible for coordinating government efforts to address environmental justice issues associated with Federally-recognized Indian Tribes.

Trust Responsibilities

The BLM, like other agencies of the Federal Government, has a trust responsibility to protect Tribal trust resources and assets. In the case of reclamation at the Zortman and Landusky Mines, residents of the

nearby Fort Belknap Indian Reservation have stated that the mines have impacted, and will continue to impact, Tribal trust resources. The affected resources often cited by Fort Belknap are the quality and quantity of the surface and ground water that originate in the mining areas and flow onto the Reservation. Fort Belknap and BLM are presently involved in consultation discussions over reclamation measures that are necessary to protect trust resources. Some of the reclamation plans considered as alternatives in the SEIS were developed by Fort Belknap's technical specialists, in consultation with the agencies, to address Fort Belknap's concern with impacts to trust resources.

1.4.3 Participating/Coordinating Agencies

Environmental Protection Agency

Clean Water Act

Montana DEQ will be issuing a MPDES permit under EPA-delegated authority pursuant to Section 402 of the Clean Water Act, which requires permits for point source discharges into navigable waters of the U.S. At the mine site, point sources include discharges from the current (or any new) treatment plants and all mine sources, i.e. toes of waste dumps, drains below leach pads, and surface discharge of groundwater discharge from the pits. EPA may review MPDES permits, comment, object and, if objections are not resolved, require their own permit. Two point sources discharge to streams above Tribal lands, including the Landusky pit groundwater discharge which surfaces into Swift Gulch, and the August #2 waste rock dump which discharges into King Creek. EPA's Indian policy recognizes a special government-to-government relationship with the Congressionally-recognized Fort Belknap government, and EPA is to assure that Tribal concerns and interests are considered whenever EPA actions are taken that may affect Indian Reservation environments.

EPA as a Party to the Consent Decree

EPA has a role under the Consent Decree entered in 1996 in U.S. and State of Montana v. Pegasus Gold Corporation and Zortman Mining, Inc., Civil Action No. 95-95-BLG-JDS, to comment on, approve or disapprove the proposed groundwater monitoring plan. It is expected that the groundwater monitoring plan would become the basis for establishing points of compliance under the MPDES permit for the mine discharges.

EPA NEPA Review

Under Section 309 of the Clean Air Act, EPA has the authority to comment on a lead agency's compliance with NEPA where EPA has jurisdiction by law or special expertise. EPA Region 8 was a cooperating agency with the joint lead agencies, BLM and Montana DEQ, for the previous EIS which considered modified reclamation plans and mine expansions. EPA is a participating agency for this SEIS. The Executive Order on environmental justice calls for Federal agencies to include social, economic and human

health effects when considering impacts to low-income and minority communities, and for EPA to consider this in its review and comments on Environmental Impact Statements.

Fort Belknap Indian Community Council

The Fort Belknap Indian Community Council (Fort Belknap) is the governing body of the Fort Belknap Indian Reservation, which is adjacent to the mines. While Fort Belknap does not have regulatory control over the mines, Fort Belknap is concerned with reclamation performance at the mine and the need to address impacts to Tribal trust resources. Fort Belknap has been participating in government-to-government consultation with the BLM, EPA and DEQ over development of reclamation plans for the mines. Fort Belknap has been assisted by hydrology and engineering consultants from the Center for Science in Public Participation. Some of the reclamation plans considered as alternatives in the SEIS were primarily developed by Fort Belknap and their consultants.

Bureau of Indian Affairs

The Bureau of Indian Affairs (BIA) is a commenting agency on the SEIS. A BIA office is located on the Fort Belknap Indian Reservation. Officials from BIA have occasionally participated in the technical working group meetings. Like BLM, the BIA has a trust responsibility to protect Tribal trust resources and assets.

1.5 ISSUES and CONCERNS

Sections 1.5.1 and 1.5.2 describe the scoping process conducted to date and the issues that have been identified for analysis in the SEIS. Section 1.5.3 describes the issues and concerns that are not addressed in the SEIS along with a brief rationale for their exclusion.

1.5.1 Scoping

In accordance with Council on Environmental Quality (CEQ) regulations, the procedures for preparation of a supplemental EIS are the same as those followed to prepare the initial EIS, exclusive of scoping (40 CFR 1502.9(c)(4)). The reason for non-mandatory scoping on a supplement is that an agency determination to prepare a supplement involves a scoping-type process to identify significant new information or substantial changes in the proposed action (two of the triggers for preparing a supplement). By conducting this review and identifying what is triggering the need to prepare the supplement, the agency defines the issues to be analyzed. Conducting further scoping may be redundant and unnecessary.

BLM and DEQ conducted a review in early March 2000 to determine if a supplemental EIS was required. The review was based upon the assumption that one of the reclamation alternatives developed by the technical working group would be implemented. The review concluded that the alternatives developed by

the technical working group (see Chapter 2) would likely constitute substantial changes from the reclamation proposed in the FEIS, and a supplemental EIS needed to be prepared. The review also identified eight issues which have been brought forward for consideration in the SEIS (BLM 2000).

In addition to the above evaluation, the agencies decided to conduct public scoping meetings to explain the reclamation alternatives developed by the technical working group, and to solicit additional suggestions on reclamation options or issues. Public scoping meetings were held in the communities of Lodgepole, Hays, and Landusky in mid-September 2000. Attendance numbered approximately 16, 19, and 16 people, respectively. Oral comments were taken and written comments were received through October.

As part of the scoping process, the agencies made a presentation to the Malta Chamber of Commerce on September 18 regarding the reclamation project, SEIS analysis, and the alternatives developed by the technical working group. Approximately 13 people attended this meeting.

1.5.2 Issues and Concerns Identified

In most environmental impact analyses, it is the projected effects of an activity that create "issues." In the case of reclaiming an existing disturbance, the issues already exist since the mining activity has already taken place. At the Zortman and Landusky Mines, the issues are created by the existing conditions and the projected effects of not reclaiming the sites or reclaiming them as initially proposed in 1998. Public and agency concerns with the existing conditions and potential impacts have defined the reclamation issues. The following issues have been identified for analysis in the SEIS:

Final Amounts of Mine Pit Backfill - There was a lot of discussion in the technical working group and during scoping about the appropriate amount of mine pit backfill. Both the benefits of mine pit backfill and the drawbacks have been raised as issues. Pit backfilling can be used to address surface drainage concerns, prevent exposure of acid generating highwalls, reduce visual impacts, and lessen the overall disturbance footprint. Fort Belknap and others commented that only complete pit backfilling to the original topography would reclaim the impacts to traditional and cultural resources and restore water flow patterns. Other comments were that pit backfilling primarily for aesthetic purposes would consume reclamation resources which may be better spent elsewhere on the mine sites and would create additional impacts during its implementation.

Relocation of Mine Waste Facilities - Connected with the pit backfill issue is the issue of impacts associated with the removal of mine waste facilities, such as waste rock dumps or spent ore from leach pads, and placing them as pit backfill. Removal of some of these waste facilities from problematic locations (such as near a drainage bottom) could eliminate a source of contamination. Relocation could be used to consolidate mine waste in a single location, thus reducing infrastructure costs for monitoring, capture, and treatment of impacted waters. Concern has also been identified about where relocated mine waste would be placed, and the increased environmental risk of moving mine waste from a watershed where capture

of contaminated seepage had been implemented to another drainage that does not have significant water quality contamination.

Drainage of the Mine Pits - Achieving free draining conditions of the mine pits was a priority reclamation objective in the 1996 EIS due to the potential adverse impacts associated with the infiltration of runoff through the mine pit floor or the creation of a pit lake. At the Landusky Mine, the EIS proposed to eliminate the potential for a pit lake by mining a notch at the south end of the pit complex to route surface drainage from the pit area to Montana Gulch. However, creating this drainage notch would expose additional sulfide minerals and increase the amount of highwall exposed at the site and would cost a significant portion of the reclamation bond. Creation of a pit lake at the Zortman Mine does not appear to be a significant issue due to the depth to groundwater. However, the present pit configuration collects runoff which infiltrates the pit floor to the underlying sulfide minerals and reports to Ruby Gulch in a degraded condition.

Reclamation Slope Regrading and Cover Design - Achieving a stable reclamation slope that will minimize infiltration and support revegetation is important to reclamation success. Impacts associated with performance of the reclamation covers are an issue. This includes impacts from infiltration of precipitation, slope erosion, failure of construction materials, and ability to support revegetation.

Non-acid Generating Criteria - The impact of mine waste units such as spent ore heaps, waste dumps, or highwalls, depends upon their acid generating character and where they are placed. Establishment of criteria for potentially acid generating versus non-acid generating material is needed to plan for water capture and treatment and to decide upon the appropriate reclamation cover. The criteria is also necessary to determine pretreatment requirements of the regraded surface prior to placement of topsoil and revegetation.

Revegetation Measures - Completion of reclamation with the establishment of an appropriate plant cover is an important reclamation issue. A self-sustaining stand of revegetation is necessary to stabilize the reclaimed surface, limit infiltration of precipitation that may generate undesirable leachate, provide for wildlife habitat, and mitigate visual impacts.

Water Management and Treatment - The sizing of water conveyance structures and pumpback facilities is important to protect water resources from the impacts of mine drainage. The location of the Zortman water treatment plant is an issue due to cost limitations under the existing water treatment bond. Relocation of the treatment plant may reduce costs and allow operations to be maintained within the existing bond amounts. Consideration of certain semi-passive water treatment systems may be appropriate in some drainages with low flow to further reduce costs and protect water quality.

Protection of Water Quality (Groundwater and Surface Water) - Existing and historic mining operations have impacted water quality and aquatic habitat. The mines are presently discharging under interim effluent guidelines that may not be protective of the environment (i.e. they may not meet Montana

water quality standards). Establishment of final effluent limits and points of compliance under an MPDES permit is an issue included in the analysis.

Protection-Restoration of Water Quantity (Groundwater and Surface Water) - The issue is the amount of change in surface and groundwater flow patterns that have been created by the mines, especially to streams that flow to the north and enter the Fort Belknap Indian Reservation. Estimation of the original, pre-mining hydrologic balance, the disruption due to historic mining, and the disruption due to the more recent ZMI mining activity are issues included in the analysis. Development of reclamation measures to restore the hydrologic balance is a standard reclamation objective and is included in the analysis. A determination of whether past or present changes in the hydrologic balance impacted individual or Tribal water rights is not included in the analysis (see Section 1.5.3).

Land Application Disposal (LAD) of Heap Solution - Process solutions are currently managed through treatment and disposal at a land application area on Goslin Flats. Impacts from nitrate and selenium in the applied water are presently the limiting factors for solution disposal. Development of the necessary pretreatment and application program for land applied solutions is an issue.

American Indian Traditional Use and Cultural Properties - Areas within the Little Rocky Mountains and specific sites near the Zortman and Landusky Mines are culturally and historically important to various North American Indian peoples. The existing mine disturbances have created impacts that affect the use of the mountains for traditional cultural practices. Development of reclamation measures that would make the mountains more conducive to traditional cultural practices has been identified as an issue.

Employment and Economic Development - The Zortman and Landusky Mines employed a large number of workers during the years 1979 through 1996. This employment represented a significant percentage of the total workforce in the surrounding region. A concern to many people is the negative socioeconomic impact that mine closure has had upon mine workers and the area's economic base. This has created interest in the economic opportunities that might arise both from reclamation and from possible future mining. Specifically, both the short-term employment opportunities associated with the reclamation earthwork and the longer-term employment opportunities for site care and maintenance as well as hiring preferences are issues. A second concern raised was that the reclamation not preclude the potential for future mining and its associated economic benefits.

1.5.3 Issues and Concerns Not Addressed

Certain issues or concerns will not be addressed in the SEIS as they are not within the scope of the purpose and need for decisions regarding mine reclamation.

Supplemental Funding Sources for Reclamation - It has been suggested that the SEIS should analyze potential sources of funding if the reclamation bond amounts are not adequate to implement the agencies' selected alternatives. While the relative cost and benefit of all the reclamation alternatives are disclosed in

the SEIS, developing alternatives for *where* funding beyond the bond amounts could come from is beyond the scope of the analysis and the reclamation decisions before the agencies. If a reclamation alternative selected for implementation cannot be funded with the available reclamation bond, there are numerous options for additional funding that have varying degrees of feasibility depending upon the amount of money requested, time period in which it is needed, and the funding entity (grant, appropriation, agency budget, etc.). At present, the source of funds (if any) beyond those in the present reclamation bonds cannot be predicted with enough certainty that a funding scenario could even be developed for analysis. Nor would it have any utility in the impact analysis. The SEIS analysis needs to assume full implementation in order to evaluate the environmental consequences of each reclamation alternative. The funding source would not be a discriminating factor in the outcome of such an analysis.

Effects of Mining on Water Rights - The question of the mines' impact on water rights has been raised by Fort Belknap and others. While changes in stream flows and water quantity are considered as part of mine reclamation, legal determinations as to the existence and validity of water rights and the effects of mining on such rights is beyond the scope of the environmental analysis. Since restoration of the hydrologic balance is one of the reclamation objectives, the analysis includes an evaluation of past changes in flow patterns. The results of this evaluation may be relevant to water rights proceedings at some time in the future. However, legal judgments regarding water rights are not part of the environmental analysis. Water rights determinations, impacts, and compensation should be settled under the applicable water rights laws and procedures.

Reclamation of the Clay Pits and Exploration Roads - Some commenters inquired about reclamation of the clay pits and exploration roads. These facilities are not included in the mine operating permits or plans of operations, but were authorized under open cut contracts and notices filed with the State and BLM, respectively. They are held under separate reclamation bonds and have separate reclamation plans which are not going to be substantially changed from that described in their initial authorization. Therefore, the reclamation of the clay pits and exploration roads have been excluded as issues.

Transfer of Lands to Fort Belknap - The Fort Belknap government is attempting to have some of the public lands in the Little Rocky Mountains transferred to the BIA to be held in trust for the benefit of Fort Belknap. The subject lands are generally referred to as the Grinnell lands, after the Grinnell Treaty which ceded these lands from the Reservation to the Federal Government in 1895. These lands lie mostly to the north of the mining disturbance. Any land transfer would require a separate action, affects a broader area, and has its own distinct set of potential resource impacts that are independent of mine reclamation. This issue is not addressed in the SEIS.

CHAPTER 2
ALTERNATIVES DEVELOPMENT AND DESCRIPTION

This chapter explains the process used to develop the reclamation alternatives, defines the alternatives eliminated from detailed analysis, and then describes each alternative considered. Sections describing reclamation actions common to all alternatives are included to reduce repetition in the later alternative descriptions. The individual reclamation alternative descriptions for each mine are presented to illustrate the differences among the alternatives. Additional detail on the individual alternatives are shown in Section 2.4, Figures 2.4-3 through 2.4-14.

Section 2.6 discusses the agencies' identification of a preferred alternative for reclamation at each mine and explains how the preferred alternative might be implemented. Toward the end of this chapter are two sections with summary tables and graphs to compare the alternatives and their predicted impacts. Tables 2.7-1 and 2.7-2 compare the different reclamation actions of each alternative. Tables 2.8-1 and 2.8-2 summarize the environmental impacts of each alternative based upon the analysis presented in Chapter 4. Figures 2.8-1 and 2.8-2 display the alternatives' estimated implementation costs versus overall environmental benefit in a manner that provides for a cost-benefit comparison of the different reclamation alternatives.

2.1 SIGNIFICANT ISSUES and ALTERNATIVES

The purpose of the alternatives is to provide decisionmakers with a means to consider and resolve the issues. The resolution of significant issues forms the framework of an alternative, with the resolution of lesser issues included around the alternative's central theme. This section describes how the significant issues drove the formulation of the alternatives.

The development of the alternatives centered on addressing six general reclamation issues: 1) final amounts of mine pit backfill; 2) relocation of mine waste facilities; 3) drainage of mine pits, especially at the Landusky Mine; 4) protection/restoration of water quality and quantity; 5) reclamation grading, cover design, and revegetation; and 6) restoration of area aesthetics and land use.

Mine Pit Backfill

The amount of mined waste rock and spent ore that must be backfilled into the open pits as part of mine reclamation is a significant issue for both economic and environmental reasons at the Zortman and Landusky Mines (FEIS, Section 2.2.5). Economic considerations include the high cost that can be associated with even a modest amount of backfilling. To place even the closest waste rock back into the pits could easily cost $1 per ton. This unit cost escalates quickly the farther the material has to be hauled. If the haul involves moving the material uphill, the unit cost increases even more rapidly. Costs of over $4 per ton could be incurred for backfilling some of the material at the mines. Considering that over 200

million tons of ore and waste rock have been mined, backfilling even a fraction of it would cost tens of millions of dollars.

On the environmental side of the issue, pit backfilling can be used to mitigate many of the impacts resulting from mining. Rock placed in the Zortman and Landusky Mine pits could be used to protect water quality by controlling surface drainage and covering pit highwalls that contain sulfide minerals in concentrations high enough to release acid and metals during weathering. Backfilling of mine pits could be used to reduce the visual and cultural impacts of the mine disturbance on American Indian traditional cultural activities and on recreationists visiting the public lands. Backfilling can also reduce or eliminate the safety hazard posed by pit highwalls.

Conversely, backfilling activities can create their own impacts through emission of earthmoving equipment exhaust, dust, and noise. In addition, the nature of the backfilled material and its placement can increase environmental risks to surface or groundwater and may adversely affect revegetation success.

It should be noted that there is an upper limit on the amount of backfilling that is possible. It is not technically feasible to backfill 100% of the mined material due to the increase in volume that occurs when rock is broken during mining. All the mined rock will not fit back in the pits. In addition, some of the original pre-mine slopes were steeper than 2H:1V. If these slopes were reconstructed using backfill to their original configuration, they would be more susceptible to erosion or failures than the adjacent slopes which had developed naturally.

Alternatives developed in response to this issue cover the full range of possible pit backfilling options. All Zortman Mine reclamation alternatives would require backfilling and grading of the mine pit floors to achieve a free draining condition. At the Landusky Mine, the alternatives include free draining pit backfill alternatives, a groundwater drawdown alternative, and a horizontal borehole alternative to prevent water from impounding in the mine pit. Other alternatives have been developed to include additional backfilling to cover the most sulfidic portions of the pit highwalls. And finally, alternatives have been developed that would restore the mine pit topography to near pre-mining conditions in order to address cultural and aesthetic concerns. Mitigation measures have been included in the alternatives to address the potential for increasing contaminates in groundwater from backfill sources that may be acid generating, and to protect revegetation from acid generating materials.

Relocation of Mine Waste Facilities

The removal and relocation of certain mine waste facilities such as waste rock dumps and spent ore heaps were considered during development of the alternatives. Relocation of mine waste can be used to remove the material from close proximity to surface water in streams and drainages, to improve the efficiency of seepage capture systems, and to provide for sources of mine pit backfill. Mine waste relocation was incorporated in the alternatives to represent the range of options required to support pit backfilling and where it would enhance the protection of water quality in the impacted drainages.

At the Zortman Mine, the Alder Gulch waste rock dump, Z85/86 leach pad/dike, and O.K. waste rock dump are the three mine waste facilities considered for relocation. The Z82 leach pad, the Z82 sulfide dump, the Ruby sulfide stockpile, and portions of the Z85/86 leach pad and the South Ruby dump are scheduled to be backfilled into the O.K. and Mint pits as part of interim reclamation conducted from November 2000 through 2001. Backfilling of this material is common to all alternatives.

Removal of the Alder Gulch waste rock dump at the Zortman Mine was required in the 1998 ROD to provide a source of pit backfill, eliminate a source of contamination to Alder Gulch, reduce water capture system requirements, and ease surface reclamation difficulties on the dump slope. This removal action has been carried forward under some of the reclamation alternatives. Other alternatives would either leave the dump in place or remove only a portion of the dump.

Similarly, removal of the Zortman Mine's Z85/86 leach pad and dike were considered in FEIS Alternative 3, but not adopted by the 1998 ROD due to concerns with placement of cyanidated material off the synthetic liner. The SEIS reconsiders the relocation issue of this mine waste facility with alternatives that range from reclaiming the majority of the spent ore in its present location, to total removal and placement of the spent ore as mine pit backfill.

Alternatives for addressing the O.K. waste rock dump range from complete removal, as in Alternative Z1, to taking no further actions. Regrading the dump in place and using some portion of the dump for backfill are considered under the alternatives.

At the Landusky Mine, materials from seven mine waste facilities are considered for relocation. These include a portion of the Montana Gulch waste rock dump, the L85/86 leach pad and dike, August #1 and #2 waste rock dumps, Gold Bug yellow waste rock dump, part of the L87 leach pad, and a portion of the L91 leach pad. Varying portions of the Montana Gulch waste rock dump would be removed and used as backfill under options that use a notch to provide for drainage from the Landusky Mine pit complex. Removal actions for the L85/86 leach pad vary by alternative; however, all alternatives would remove some material to aid in unblocking the western tributary of the drainage. Some alternatives would completely remove the leach pad and dike for use as pit backfill. A portion of the August #2 waste rock dump at the head of King Creek would be removed under all alternatives to eliminate a source of contamination and to provide pit backfill material. Removal of material from the very large L87 and L91 leach pads would be used to implement the restoration alternatives that require large volumes of backfill. None of the alternatives would totally remove the L87/91 leach pad complex, as all the spent ore would not fit back into the mine pits.

Drainage of the Mine Pits

As noted in Chapter 1, Section 1.5.2, drainage of the mine pits has an important relationship to the significant issues that are associated with pit lakes and with re-establishing the hydrologic balance. While

the pit drainage issue is of greatest concern at the Landusky Mine, drainage of the Zortman Mine pits are also an issue.

The existing pits at the Zortman Mine have not been excavated deep enough to intercept the groundwater table and therefore do not create permanent pit lakes. However, precipitation and runoff do infiltrate through the pit floors, resulting in a considerable volume of water with ARD contamination reporting to the Ruby Gulch capture system. Backfilling of the Zortman Mine pits to reduce infiltration, limit precipitation from contact with acid-forming minerals, and route runoff out of the pit areas does not require substantial amounts of material compared to the quantity needed at the Landusky Mine pits to achieve a similar result. Because interim reclamation work would establish free draining conditions at the Ross, Mint, O.K./Ruby, and South Alabama pits by a combination of backfill and grading, all of the alternatives start from this point. Alternatives considered for additional reclamation of the Zortman Mine pits range from limited backfilling to cover exposed sulfide zones to using a substantial amount of backfilling to re-create the approximate original contour of the mountain. These alternatives were all developed to protect water quality by establishing free draining conditions that would not impound water in the pit areas. The other criteria was to not route runoff from the mine pits northward to the Lodgepole Creek drainage. Since this stream does not appear to be impacted by mine drainage, the risk of creating impacts to an additional stream drainage is not warranted. Moreover, the volume of water that would normally flow in this direction is insignificant. Until the water quality from the pit area runoff can be assured it would not be routed to the north.

The 1998 ROD requirements for pit drainage at the Landusky Mine included cutting a large drainage notch at the south end of the pit complex that would discharge runoff into Montana Gulch. This is a high cost item that would expose additional sulfide minerals in the walls of the drainage notch. Other alternatives have been developed by the technical working group that also would achieve the desired free draining conditions. An artesian well located near the bottom of Montana Gulch has been found to have a direct influence on the water table in the floor of the pits (see Chapter 3, Section 3.3.3). When the well is plugged the water table rises and a shallow pit lake forms at the south end of the pit complex. When the well is open, the pit lake drains and the floor of the pit is dry. Alternatives have been developed to utilize this connection. One of these alternatives is to grade the pit floor to route runoff to the south end of the pit complex where it would infiltrate to groundwater and discharge through the wellhead. Other alternatives have been developed that would provide a directional borehole to further enhance this drainage pathway and serve as a backup in the event the artesian well collapsed or became plugged.

Several alternatives have been developed that involve partial backfilling of the pit to a level that a smaller drainage notch, which would not intersect sulfide minerals, could be constructed. In addition, there are alternatives involving large amounts of backfill, which could route runoff directly as surface flow without the need for a drainage notch or for reliance upon discharge of accumulated pit water via the groundwater system.

Protection/Restoration of Water Quality and Quantity

A major element of all reclamation alternatives is the need to protect area water quality and restore the area streamflows and hydrologic balance. As the contaminant loading analysis shows (see Section 4.3), the protection of water quality relies mostly upon the continued operation of the seepage capture systems and water treatment plants. Contaminant loads reporting to the capture systems would not be dramatically changed by the surface reclamation conducted on the mine waste units. Therefore, the best protection for water quality is realized by assuring the continued operation of the seepage capture and treatment systems. Continued operation and upgrade is provided for these systems under all reclamation alternatives at both mines.

Undoing the preferential groundwater flow paths established by the historic underground mining would be both technically unfeasible and outside the scope of reclaiming disturbance that occurred under the existing mine permits. However, several alternatives have been developed which would address hydrologic balance and the restoration of area water quantity by re-establishing the area topography to the extent that the natural distribution of surface runoff would be restored to pre-mine drainages. In addition, several Landusky Mine alternatives incorporate pumping and piping operations to return treated water to the drainage where it was captured to preserve streamflow volume. Most of the Zortman Mine pit reclamation alternatives have the option of being constructed so that the surface runoff could be routed to the north, at a later date, once the water quality was assured. This could compensate for the volume of water presently being diverted to the south by the mine disturbances. Calculations indicate it would require moving a relatively small volume of water to mitigate both the historic disruption in groundwater flow and the current disruption in surface runoff patterns caused by the mine pits (see Section 3.3.3).

Reclamation Grading, Cover Design, and Revegetation

The surface reclamation of mine waste facilities often has to meet multiple and sometimes conflicting objectives. Surface reclamation is desired to be stable and erosion resistant, prevent or limit the infiltration of precipitation which might generate leachate, contain enough soil and nutrients to support a self-sustaining stand of native vegetation, provide for wildlife habitat, and present an aesthetically pleasing environment. Reclamation cover designs, therefore, require consideration of the grading or degree of slope that the reshaped material must achieve, specification on the soil or other material placement and thickness, and plans for revegetation. Since these items are all interrelated, how one is accomplished can affect or dictate the options available for the remaining reclamation items. For example, a steep reclamation slope may be needed to match the pre-mine topography, but may not be stable if covered with a clay or geomembrane (plastic) cover. Or, a thick soil cover needed to hold moisture for revegetation may require new surface disturbance to obtain the soil material, creating its own set of impacts.

The surface reclamation measures considered range from those proposed in the 1998 ROD to those developed by the technical working group. The alternatives vary from the application of a single lift of cover soil to highly engineered barrier cover systems that use synthetic materials. Various reclamation

techniques such as the selective use of water barrier and water balance covers dependent upon slope; incorporation of available tailings in the cover soil; soil organic amendments and fertilizers; seed mix; weed control; visual impact mitigation through selective tree planting; and infiltration minimization have all been considered in developing the surface reclamation alternatives.

Restoration of Area Aesthetics and Land Use

The existing mine disturbance has had a significant impact on the aesthetics of the area and, in turn, on some of the land uses. Unreclaimed surfaces are not productive compared to the adjacent undisturbed environment. The visual impacts of the pit areas and other disturbances have had an adverse effect on American Indian traditional uses in the Little Rocky Mountains and on recreationists seeking hiking, hunting, or other outdoor activities.

The alternatives were developed to address these issues by reclaiming disturbed areas to productive conditions comparable to the undisturbed areas. The degree to which restoration of pre-mine conditions is attained would vary by alternative. Generally, the greater the amount of mine pit backfilling, the more restoration to pre-mining topographic conditions is achieved. Even in alternatives where restoration of the pre-mining topography is not achieved, other reclamation activities such as regrading to blend mine disturbance with adjacent landforms; replacement of the soil cover; revegetation techniques; capture and treatment of impacted waters; and re-establishment of wildlife habitat areas are used to address restoration of area aesthetics and land uses.

2.2 DEVELOPMENT of the ALTERNATIVES

In addition to the technical issues discussed above, there are several management issues important to the alternative development process. These include:

- Determining how to best use the available reclamation bonds and water management bonds to reclaim and manage the mine sites should funding be limited to these sources.

- Examining additional reclamation alternatives beyond those affordable under the reclamation bonds to be sure that the best practical reclamation alternative has been considered. This includes identifying and establishing a priority of additional reclamation measures to be implemented should funds become available.

- Continuing to identify reclamation measures common to all alternatives that could be implemented as interim reclamation. Performance of interim reclamation is desirable because it maximizes effective use of the bonds' present value and reduces existing environmental impacts, yet preserves final reclamation options.

Development of the specific reclamation alternatives began with an evaluation of the reclamation plans in the June 1998 ROD. Those 1998 reclamation plans are used in this SEIS as the base case, or "no action" reclamation alternatives (designated Alternative Z1 for the Zortman Mine and Alternative L1 for the Landusky Mine). While there has been no BLM decision to approve the 1998 reclamation plans due to action by the IBLA, the DEQ's 1998 decision is still in effect. In this particular circumstance the BLM would have to issue a new decision before the existing state-approved reclamation plan could be implemented on BLM-managed lands.

After reviewing the 1998 ROD reclamation plans and considering the issues discussed previously, other alternatives for reclaiming the mines were developed by a technical working group composed of representatives from BLM, DEQ, EPA, and Fort Belknap. The technical working group developed the alternatives using a "Multiple Accounts Analysis" (MAA) process under the direction of Robertson GeoConsultants and Spectrum Engineering. The MAA is an iterative process of considering possible reclamation measures under a central theme, evaluating the effectiveness of the reclamation alternatives, and then revising the alternatives to optimize their effectiveness (see also Appendix A).

The technical working group developed reclamation alternatives to address the issues at each mine under several phase 1 and phase 2 scenarios to meet the purpose and need (see Chapter 1). All alternatives were developed by the technical working group to meet legal and regulatory requirements and be technically feasible, yet represent a logical reclamation approach in addressing the issues under their respective funding levels. Phase 1 alternative development assumed reclamation expenditures would be limited to that available under the reclamation bonds. Phase 2 reclamation plan alternatives were not constrained by the reclamation bond amounts. While not limited by cost, the development of phase 2 reclamation alternatives did not ignore the need for the reclamation to be financially responsible.

Phase 1 alternative development for the Zortman Mine reclamation considered how to best utilize the existing bond monies under several approaches. One alternative was to reduce the long-term operating and maintenance costs of the water treatment plant by using reclamation bond monies to relocate the treatment plant to Goslin Flats, where captured water could be routed for treatment without pumping (Alternative Z2). The second approach is an alternative that would continue operation of the water treatment plant in its present location and use the available reclamation monies only to conduct regrading and reclamation cover placement, with an emphasis on controlling infiltration that might create leachate requiring water treatment (Alternative Z3).

Reclamation alternatives for the Zortman Mine, developed under phase 2 of the MAA, combined the reclamation strategies minimizing water treatment costs in Alternatives Z2 and source control under Alternative Z3 with plans for additional amounts of pit backfilling as a way to further enhance source control and restore the area topography. This led to the development of Alternative Z4, which includes additional pit backfilling for waste dump removal and application of engineered barrier reclamation covers intended to minimize the need for water treatment. Alternative Z5 was developed to address the issue of restoring the original topography to the extent technically feasible. It incorporates surface reclamation covers similar

to the natural soil profile. Alternatives Z4 and Z5 were derived, in part, from the alternative reclamation plan proposal submitted by Fort Belknap at the beginning of the consultation process (Fort Belknap 1999). Alternative Z6 was developed by the technical working group after an initial evaluation of Alternatives Z1 through Z5. Alternative Z6 combines the most environmentally beneficial aspects of Alternative Z4 with Alternative Z3 in order to optimize reclamation performance. This alternative considers using engineered barrier covers in selected areas while providing two feet of growth medium over the majority of the reclaimed area. It provides extensive surface regrading with limited waste dump removal.

The phase 1 alternative development for the Landusky Mine reclamation considered how to best utilize the existing bond monies. Alternative L2, developed under phase 1, optimizes the amount of reclamation earthwork throughout the mine by regrading the ore heaps and waste rock dumps; replacing cover soil and establishing vegetation; providing for pit drainage; and capturing, treating and releasing water impacted by acid drainage. Only a single phase 1 alternative was developed for the Landusky Mine. Relocating the water treatment plant at the Landusky Mine was considered to provide only marginal benefit and did not warrant development of a separate alternative.

Reclamation alternatives for the Landusky Mine, developed under phase 2 of the MAA, were created to incrementally consider the advantages and disadvantages of various amounts of additional mine pit backfill. Within these alternatives are provisions for management of runoff or drainage from the pit area, removal of mine facilities from drainages to improve water management, and an increase in the areas where revegetation can be established. Alternative L3 addresses the issue of reliable drainage from the Landusky Mine pit complex by including the drilling of a directional borehole to provide a backup mechanism for drainage. Alternative L3 also addresses some of the visual impacts by including blasting of the upper bench along a portion of the pit highwall. Alternative L4 increases the amount of pit backfill and unblocks the Montana Gulch drainage to address concerns with water management around the L85/86 leach pad. Alternative L4 also addresses the visual impacts by highwall reduction through blasting and covers about 85% of the exposed sulfide minerals in the highwall that might affect water quality. Alternative L5 addresses the same issues as Alternative L4, but increases the amount of backfill so pit drainage can be achieved without relying on subsurface means and so virtually all exposed sulfides in the mine pit highwalls that might generate acidity and impact water quality can be covered. Alternative L6 would restore the mining area topography to near its pre-mining configuration. It is designed to address the issue of impacts to traditional cultural use of the area, maximize area aesthetics, and restore the surface water drainage configuration. Alternatives L5 and L6 were derived, in part, from the alternative reclamation plan proposal submitted by Fort Belknap at the beginning of the consultation process (Fort Belknap 1999).

2.3 ALTERNATIVES ELIMINATED FROM DETAILED ANALYSIS

An alternative to move the Landusky Mine water treatment plant to a lower elevation (similar to Alternative Z2 for the Zortman Mine) was considered and eliminated from detailed analysis. The present location of the Landusky Mine water treatment plant is optimal as it allows most flows from the seepage capture

systems to be gravity fed to the plant with minimum pumping. Moving the treatment plant further downhill does not offer any significant environmental or cost benefits. It could actually increase costs if future water capture in the northern drainages is to be returned to those drainages after treatment.

Alternatives which applied reclamation measures only to a single mine facility, to the exclusion of other disturbance areas, were not considered in detail. For example, reclamation plans which only worked on water resource protection or only addressed pit backfilling were not considered in detail as they would not meet minimum regulatory requirements for reclamation of the remaining disturbance areas.

Several modifications to Alternative L5 were considered and eliminated from detailed analysis. One possible alternative was to use "clean" fill from offsite as pit backfill instead of spent ore from the L87/91 leach pad. This was considered as a way to eliminate potential impacts to water resources from backfilling the pit with the leach pad material, which is likely to be acid generating. Preliminary calculations show that to haul in clean fill from within 10 miles would require 378,000 haul truck trips through the community of Hays, on the Fort Belknap Reservation, and would take an estimated 63 years to complete (Spectrum 2001). It would also increase the estimated cost for Alternative L5 by over 2.5 times, from $67.9 million to $170.8 million. Due to the extreme timeframe required for reclamation completion and the potential for severe offsite impacts from haul truck traffic, this alternative was eliminated from detailed analysis and further consideration.

The second modification considered for Alternative L5 was to amend the backfill from the L87/91 leach pad with agricultural lime in order to neutralize any acidity that develops in the backfill. Estimates indicate it would require approximately 431,500 tons of agricultural lime to amend the backfill as it is placed (Spectrum 2001). This option would cost more than double the estimated amount for Alternative L5, increasing it from $67.9 million to $135.9 million. Moreover, the neutralization of the backfill would probably fail to adequately protect water quality. Water infiltrating the backfill could still pick up elevated levels of sulfate and total dissolved solids. Although this leachate would not contain significant amounts of metals such as copper, lead and zinc that are mobile at a low pH, it could very well contain other metals such as arsenic and selenium that are mobile under the alkaline conditions which would exist in the backfill amended with lime. Due to the low feasibility for lime amended backfill to substantially increase the protection of water quality, this alternative was eliminated from detailed analysis and further consideration.

2.4 DESCRIPTION of the ALTERNATIVES

The following Sections 2.4.1 through 2.4.3 describe the reclamation alternatives. Section 2.4.1 presents general reclamation measures such as water management, material testing, and cover design considerations that are common to reclamation at both mines. Section 2.4.2 discusses reclamation that is common to all Zortman Mine reclamation alternatives, followed by a description of each Zortman Mine alternative from Z1 through Z6. Section 2.4.3 discusses reclamation that is common to all Landusky Mine reclamation alternatives, followed by a description of each Landusky Mine alternative from L1 through L6.

The alternatives description and subsequent impact analysis in Chapter 4 are presented for each mine independently of alternatives at the other mine. This is a change from the presentation in the FEIS, where a single alternative described reclamation actions for both mines. The alternative descriptions have been kept separate because the mines are under two separate operating permits, with two separate bond amounts that are non-transferable. Furthermore, agency decisions regarding reclamation plans for each mine are not necessarily linked and may have to be made separately.

2.4.1 Reclamation Common to All Alternatives

There are many common elements for reclamation actions that would occur at both mines under all alternatives. These include:

- Water management, consisting of surface water runoff control, water capture, water treatment, leach pad water land application disposal, and water resources monitoring;
- Reclamation testing and cover determinations for liming soil covers, water balance covers, and water barrier covers;
- Reclamation material sources, consisting of identified non-acid generating materials (NAG), tailings, limestone/dolomite, cover soil, and liners;
- Reclamation of support facilities, including soil stockpiles, access and haul roads, land application areas, and borrow areas;
- Revegetation procedures, including seed mix, planting locations, and soil treatments such as fertilizers or mulch; and,
- Interim reclamation, including reclamation measures done to date that would not be significantly altered under any alternative.

Reclamation measures in these categories are similar across the various alternatives. Any differences are highlighted under the individual alternative descriptions in Sections 2.4.2 and 2.4.3.

Water Management

Under all alternatives, the water management objectives at both mines are to protect beneficial use and to achieve and maintain compliance with the water quality standards. The approach to water management is to use a combination of source control and water treatment to protect water quality. Various reclamation covers would be used in each alternative to limit infiltration of precipitation into mine waste, thereby restricting water contact with potentially acid generating materials. Each of these reclamation covers is discussed in detail under its respective alternative. Source control emphasizes the removal and isolation of acid generating materials from areas proximal to surface and groundwater. The management of mine water would continue to keep mine drainage, stormwater and process waters segregated so that each would be handled using the technology most appropriate to its character. Diversion of runon water that might enter the mine waste would be used to prevent stored acidity from being transported into adjacent surface or groundwaters.

Water Treatment

Capture and treatment of degraded waters would be the primary measures used to prevent residual water quality impacts. Treatment of acid drainage would continue to utilize the existing lime precipitation plants. Biological treatment circuits for removal of selenium and nitrate are under development and may be added to the existing water treatment plants. Passive, semi-passive or semi-active water treatment systems would be constructed in drainage locations where seepage size, rate, composition and drainage geometry show they would have practical application.

Seepage Capture Systems

All seepage capture systems would be upgraded, as needed, in order to improve seepage capture efficiency so that downstream water quality would meet the regulatory requirements at the designated points of compliance in the MPDES permits. Actions associated with improvement of the capture systems could include installation of recovery/monitoring wells, construction of capture ponds, installation of groundwater interception trenches or cutoff walls, and replacement of existing equipment with higher capacity components.

Surface Water Runoff Control

Drainage ditches would be maintained throughout the mining area to route stormwater and runoff around the pit complex, leach pads and waste dumps. All new runon and runoff drainage ditches would be constructed to convey runoff from at least a 6.33-inch, 24-hour storm event. This is the calculated 100-year storm event. Drains carrying stormwater would be routed to dispersion points consisting of coarse rock filters or sediment control ponds that overflow into natural drainages. Maintenance would consist of removal of sediment buildup and repositioning of riprap when necessary.

Berms would be constructed along the upper perimeter of the mine pit highwalls. The berms would divert runoff from the pit areas and provide for a safety barrier.

Leach Pad Water Land Application Disposal

Because the leach pads capture and hold all water falling within their lined perimeters, the accumulation of precipitation stored within these facilities must be managed. Although this leach pad water is not suitable for direct release into streams, it can be applied to the land in a controlled manner which minimizes adverse environmental impacts. 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. At the facility, it is directed through smaller pipes to various application areas where it is 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 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).

Current conditions require yearly leach pad water draindown at the rate of 125 to 150 million gallons from both mines. The cyanide content in most pad waters has been reduced through natural degradation to the point that specific treatment for cyanide is usually not needed. Leach pad waters would continue to be pumped from the various pads to the Z82 pond for treatment with hydrogen peroxide to detoxify any residual cyanide prior to re-entering the pipeline to Goslin Flats for land application. All solutions would be at or below 0.22 mg/l WAD cyanide concentration prior to land application. Leach pad water would be run through the water treatment plant, if necessary, to reduce the acidity prior to land application.

Testing, which included a pilot scale treatment demonstration, has been completed on a biological process to remove nitrates, cyanide, and selenium from the leach pad water. The results indicate the nitrate, cyanide and selenium levels can be economically treated to the drinking water standard using naturally occurring microbes. Plans to construct a full-scale biological treatment facility are under development. Depending on full-scale treatment results, the treated water could be released, routed through a water treatment plant, or sent to the land application area for final treatment and disposal.

The leach pad liners would not be perforated until the leachate in the liners meets water quality standards without treatment. Until that time, maintenance of the pumping systems and treatment of the pad waters would continue using the water treatment plants and land application system.

Water Resources Monitoring

An Interim Groundwater Monitoring Plan was prepared by ZMI in February 1997. In May 1998, a draft Groundwater Monitoring Plan was prepared by the operator in accordance with the requirements specified in Section VII (Paragraph 15) and Appendix C of the Consent Decree; however, ZMI's bankruptcy prevented its completion. The following interim monitoring plan has been conducted since that time.

At the Zortman Mine, routine monitoring under the Consent Decree has included the following number of surface water and groundwater monitoring locations:

Drainage	Surface Water	Groundwater
Ruby Gulch	1	8
Alder Gulch	3	5
Lodgepole Creek	2	6
Goslin Gulch/LAD	10	14

At the Landusky Mine, routine monitoring under the Consent Decree has included the following number of surface water and groundwater monitoring locations:

Drainage	Surface Water	Groundwater
Sullivan Gulch	1	2
Mill Gulch/Rock Creek	1	10
Montana Gulch	2	6
King Creek	1	5
Swift Gulch	3	5

In addition to these monitoring sites, 14 mine drainage monitoring sites and 22 stormwater locations are monitored.

Routine water analysis consists of 6 general parameters, including pH, specific conductance, total dissolved solids (TDS), alkalinity, bicarbonate, and total hardness; 11 anions and cations, including total cyanide; and 11 metals and trace elements. These parameters are specified in Table 3.3.2 of the Interim Monitoring Plan. Other analyses are performed for special purposes as needed.

The interim monitoring plan would continue to be implemented until replaced by a revised monitoring plan that would incorporate requirements from the mine permits, Consent Decree, and MPDES permits. The revised monitoring plan is being prepared by the agencies and would be implemented in 2001.

Reclamation Testing and Cover Development

Prior to placement of the surface reclamation covers, all regraded surfaces would be tested to determine acidification potential and to evaluate the need for lime treatment. Lime application rates would be determined by sampling the regraded surface on 100-foot centers or closer, if variations in rock type suggest the need for closer infill sampling. Field pH and TDS measurements of the material fines would be recorded at each sampling point. In addition, samples would be collected for lab analyses of acid potential (AP) and neutralization potential (NP). The net acid potential (Net AP) at each sample point would be calculated from the lab results (Net AP=AP-NP). The amount of lime required to provide long-term neutralization of the mine rock at each sample point on the regraded surface would then be determined. Neutralization values for the areas between sample points would be derived by linear interpolation from the known points. Agricultural lime would be delivered to the site in belly dump trailers. After being dumped in the application area, the lime would be spread by motor grader before being incorporated into the top two feet by a bulldozer equipped with rippers. More details on the liming program are available in Robertson GeoConsultants Report 075001/4 (Robertson 2000a).

A variety of reclamation cover types were considered for use on the regraded surfaces. These range from simple soil covers, to water balance covers designed to maximize evapotranspiration, to the more engineered water barrier covers designed to restrict water infiltration below the barrier layer. Figure 2.4-1 displays the reclamation covers that would be used in the various alternatives for reclamation at the Zortman Mine. Figure 2.4-2 shows the reclamation covers that would be used at the Landusky Mine.

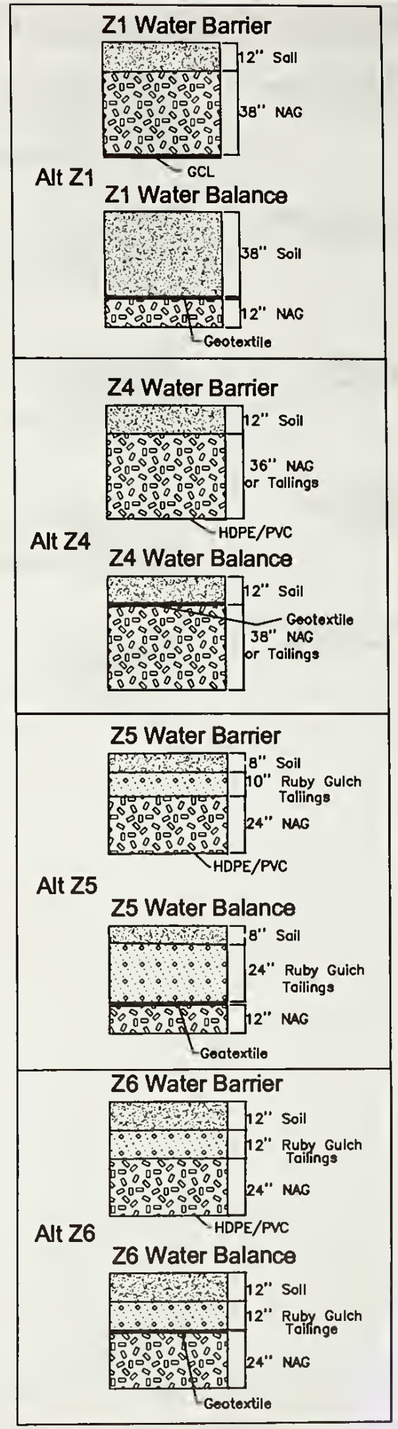
Soil Covers

Soil covers are designed with two primary functions in mind. The first is to provide a suitable substrate for vegetative growth. The second is to minimize infiltration through the cover. The depth of the soil cover would vary somewhat between the alternatives, and between the mine facilities in any one alternative. From 8 to 36 inches of soil would be place over NAG material. The NAG would either be imported from another area of the mine and placed at depths ranging from 0 to 36 inches, or in-situ material would be tested and lime amended as described above. At the Zortman site, tailings could also be used as a source of NAG or as a separate soil layer.

Water Balance Covers

Water balance covers are designed to limit the amount of moisture reaching the waste zone by maximizing evapotranspiration. The cover consisting of soil (12 to 36 inches) and NAG (12 to 24 inches) would provide water storage capacity and would serve as a substrate for vegetative rooting. Water is mostly taken up by vegetation or is lost directly to the atmosphere. A filter fabric would be placed on top of the capillary break (coarse rock drain layer) to limit downward migration of fine-grained particles which could clog the capillary break drainage capacity. A geosynthetic liner would not be used in this reclamation cover

Feature	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	Alternative Z6
Mine Pits						
O.K./Ruby Pit	Z1 Water Barrier - 5.96 ac Z1 Water Balance - 26.48 ac	12" Soil 24" NAG 8" Clay	11" Soil 7" Ruby Gulch Tailings 24" NAG 8" Clay	Z4 Water Barrier - 20.33 ac Z4 Water Balance - 1.10 ac	Z5 Water Barrier - 10.07 ac Z5 Water Balance - 24.65 ac	Z6 Water Barrier - 20.92 ac Z5 Water Balance - 1.10 ac
Mint Pit	Z1 Water Barrier - 7.67ac	12" Soil 24" NAG	11" Soil 7" Ruby Gulch Tailings 24" NAG	Z4 Water Barrier - 5.65 ac Z4 Water Balance - 4.71 ac	8" Soil 10" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG
North Alabama Pit	Z1 Water Barrier - all	12" Soil Native Materials	12" Soil Native Materials	Z4 Water Barrier - 3.10 ac Z4 Water Balance - 5.38 ac	8" Soil 10" Ruby Gulch Tailings	Z6 Water Barrier - 5.41 ac
South Alabama Pit	Z1 Water Barrier - all	12" Soil 24" NAG	11" Soil 7" Ruby Gulch Tailings 24" NAG	Z4 Water Balance - 17.68 ac	8" Soil 10" Ruby Gulch Tailings	18" Soil 6" Ruby Gulch Tailings 24" NAG
Ross Pit	12" Soil 12" NAG	12" Soil 12" NAG	12" Soil 12" NAG	Z4 Water Barrier - 4.30 ac Z4 Water Balance - 14.61 ac	8" Soil 10" Ruby Gulch Tailings	18" Soil 6" Ruby Gulch Tailings 12"–24" NAG
Leach Pads						
Z 62 Leach Pad Footprint (Pad placed in OK/Ruby Pit)	12" Soil 12" NAG Native Materials	12" Soil 12" NAG Native Materials	12" Soil 12" NAG Native Materials	12" Soil 12" NAG Native Materials	8" Soil 12" NAG Native Materials	18" Soil 6" Ruby Gulch Tailings Native Materials Limed
Z 85/86 Leach Pad	Z1 Water Barrier - 17.77 ac Z1 Water Balance - 15.22 ac	12" Soil 24" NAG	11" Soil 7" Ruby Gulch Tailings 24" NAG	Z4 Water Barrier - 10.36 ac Z4 Water Balance - 22.99 ac	8" Soil 10" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG
Z 85/86 Drainage Notch	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG
Z 79-81 Leach Pad	Z1 Water Barrier - 4.26 ac Z1 Water Balance - 10.89 ac	More Revegetation	More Revegetation	Z4 Water Barrier - 4.26 ac Z4 Water Balance - 10.89 ac	More Revegetation	More Revegetation
Z 83, 84, 89 Leach Pads	Z1 Water Barrier - 16.68 ac Z1 Water Balance - 24.38 ac	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG
Pad Dikes						
Z 83, 84, 89 Pad Dikes	More Revegetation	More Revegetation	More Revegetation	More Revegetation	More Revegetation	More Revegetation

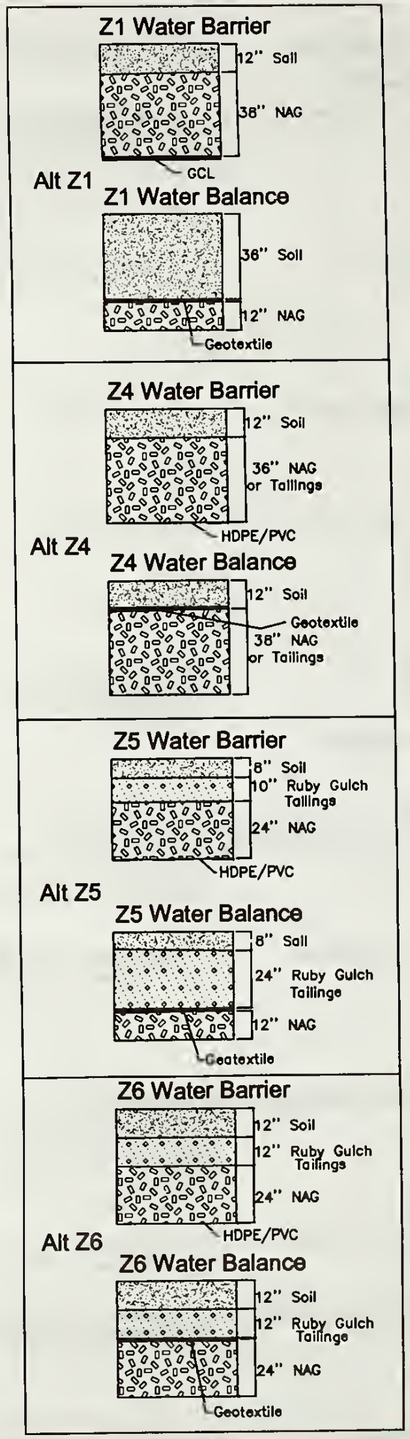


SOURCE: Spectrum Engineering 2001

ZORTMAN MINE RECLAMATION COVERS ALTERNATIVES Z1-Z6

FIGURE 2.4-1a

Feature	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	Alternative Z6
Dumps						
Alder Gulch Waste Rock Dump	12" Soil 12" NAG Native Materials	Already Reclaimed No Action	Already Reclaimed No Action	12" Soil 12" NAG Native Materials	8" Soil 10" Ruby Gulch Tailings Native Materials	Z6 Water Barrier 12.33 ac
South Ruby Waste Rock Dump	12" Soil 12" NAG Native Materials	12" Soil 24" NAG	11" Soil 7" Ruby Gulch Tailings 24" NAG	Z4 Water Barrier - 2.49 ac Z4 Water Balance - 5.17 ac 12" Soil over 4.93 oc Native Materials	8" Soil 10" Ruby Gulch Tailings 24" NAG	18" Soil 6" Ruby Gulch Tailings 24" NAG
O.K. Waste Rock Dump	12" Soil Native Materials	Already Reclaimed No Action	Already Reclaimed No Action	Z4 Water Balance - 10.32 ac	8" Soil 10" Ruby Gulch Tailings	18" Soil 6" Ruby Gulch Tailings 24" NAG
Facilities						
Haul Roads/ Facilities	12" Soil Native Materials	12" Soil Native Materials	12" Soil Native Materials	12" Soil Native Materials	8" Soil Native Materials	18" Soil 6" Ruby Gulch Tailings Native Materials Limed
New Disturbances						
Limestone Quarry	12" Soil Native Materials	Not Required	Not Required	12" Soil Native Materials	Not Required	Not Required

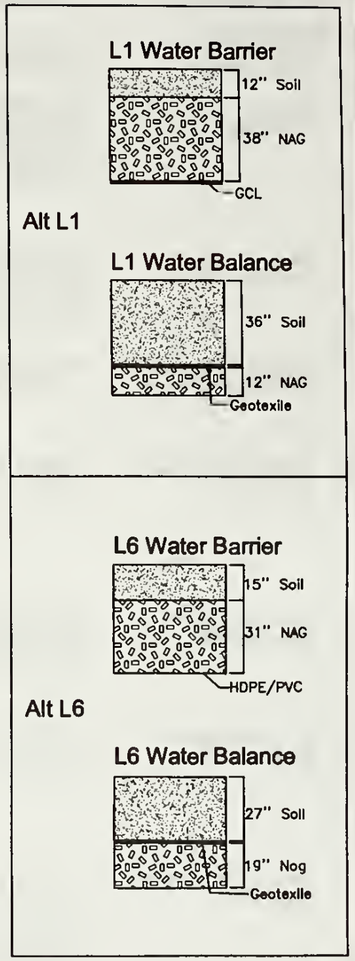


SOURCE: Spectrum Engineering 2001

ZORTMAN MINE RECLAMATION COVERS ALTERNATIVES Z1-Z6

FIGURE 2.4-1b

Feature	Alternative L1	Alternative L2	Alternative L3	Alternative L4	Alternative L5	Alternative L6
Pits						
August-Little Ben Suprise Pit Complex	L1 Water Barrier - 40.98 ac 12" Soil 12" Soil 12" NAG	18" Soil 6" NAG	18" Soil 6" NAG 12" Soil	24" Soil 24" NAG	25" Soil 21" NAG	L6 Water Barrier - 14.24 ac L6 Water Balance - 151.11 ac
Queen Rose Pit	L1 Water Barrier - 16.84 ac L1 Water Balance - 3.45 ac	18" Soil 6" NAG	18" Soil 6" NAG	24" Soil 24" NAG	25" Soil 21" NAG	(Part of August-Little Ben/Suprise Pit Complex)
Gold Bug Pit Complex	L1 Water Barrier - 17.72 ac L1 Water Balance - 3.81 ac	24" Soil 24" NAG	24" Soil 24" NAG	24" Soil 24" NAG	25" Soil 21" NAG	L6 Water Barrier - 11.11 ac L6 Water Balance - 82.45 ac
Gold Bug Highwall Reduction	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	(Part of Gold Bug Pit Complex)
Leach Pads						
L 79 Pad	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation
L 80-82, 83, 84 Pads	L1 Water Barrier - 31.73 ac L1 Water Balance - 38.47 ac	18" Soil 6" King Cr. Tailings 24" NAG	18" Soil 6" King Cr. Tailings 24" NAG	18" Soil 6" King Cr. Tailings 24" NAG	18" Soil 6" King Cr. Tailings 24" NAG	18" Soil 6" King Cr. Tailings 24" NAG
L 85/86 Pad	L1 Water Barrier - 4.84 ac L1 Water Balance - 22.10 ac	24" Soil 24" NAG	24" Soil 24" NAG	24" Soil Native Material Limed	12" Soil Native Material	12" Soil Native Material
L 87-91 Pad Complex	L1 Water Barrier - 65.10 ac L1 Water Balance - 138.54 ac	24" Soil 15" NAG	24" Soil 15" NAG	24" Soil 24" NAG	25" Soil 21" NAG	L6 Water Barrier - 144.64 ac L6 Water Balance - 59.42 ac
Pad Dikes						
L 85-86 Dike	L1 Water Balance - 3.04 ac	24" Soil 24" NAG	24" Soil 24" NAG	(See 85/86 Leach Pad - Total Removal)	(See 85/86 Leach Pad - Total Removal)	(See 85/86 Leach Pad - Total Removal)
L 83 Dike	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation
L 91 Dike	L1 Water Barrier - 1.62 ac L1 Water Balance - 17.50 ac	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation
Dumps						
Montana Gulch Waste Rock Dump	L1 Water Barrier - 13.43 ac	24" Soil 15" NAG	24" Soil 15" NAG	24" Soil 24" NAG	25" Soil 21" NAG	L6 Water Barrier - 7.04 ac

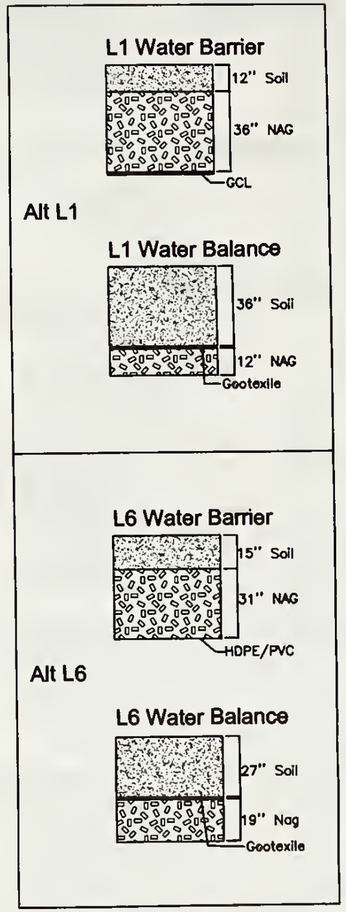


SOURCE: Spectrum Engineering 2001

LANDUSKY MINE RECLAMATION COVERS ALTERNATIVES L1-L6

FIGURE 2.4-2a

Feature	Alternative L1	Alternative L2	Alternative L3	Alternative L4	Alternative L5	Alternative L6
Dumps Cont.						
Montana Gulch Topsoil Stockpile	12" Soil	12" Soil	12" Soil	12" Soil	12" Soil	12" Soil
August #1 Waste Rock Dump	12" Soil 24" NAG Limed	24" Soil 24" NAG Limed	24" Soil 24" NAG Limed	24" Soil 24" NAG Limed	24" Soil 24" NAG Limed	(See August-Little Ben/Suprise Pit Complex)
August #2 Waste Rock Dump (East Lobe)	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material
August #2 Waste Rock Dump (West Lobe)	Already Reclaimed No Action	Already Reclaimed No Action	Already Reclaimed No Action	Already Reclaimed No Action	Already Reclaimed No Action	12" Soil Native Material
Gold Bug Yellow Waste Rock Repository	L1 Water Barrier - 9.38 ac L1 Water Balance - 3.73 ac	24" Soil 24" NAG	24" Soil 24" NAG	24" Soil 24" NAG	25" Soil 21" NAG	(Part of Gold Bug Pit Complex)
Upper Gold Bug Blue Waste Stockpile	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	(Part of Gold Bug Pit Complex)
Lower Gold Bug Blue Waste Stockpile	Native Material	24" Soil Native Material	24" Soil Native Material	24" Soil Native Material	24" Soil Native Material	24" Soil Native Material
South Gold Bug Limestone Stockpile/Pit	L1 Water Barrier - 5.24 ac L1 Water Balance - 2.28 ac 12" Soil 12" NAG	24" Soil 24" NAG	24" Soil 24" NAG	24" Soil 24" NAG	25" Soil 21" NAG	(Part of Gold Bug Pit Complex)
Gold Bug Topsoil Stockpile	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material
Mill Gulch Waste Rock Dump	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation
Facilities/Other						
Haul Roads/Facilities	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material	12" Soil Native Material
Big Horn Ramp	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation	Additional Revegetation
New Disturbances						
Limestone Quarries	12" Soil Native Material	Not Required	Not Required	Not Required	Not Required	Not Required
West Montana Gulch Drain (Around 85/86 Pad)	12" Soil Native Material	Not Required - Partial Notch Only	Rock Cliff - Too Steep to Reclaim	Not Required (85/86 Leach Pad and Dike have been Removed)	Not Required (85/86 Leach Pad and Dike have been Removed)	Not Required (85/86 Leach Pad and Dike have been Removed)



SOURCE: Spectrum Engineering 2001

LANDUSKY MINE RECLAMATION COVERS ALTERNATIVES L1-L6

FIGURE 2.4-2b

because of the decreased potential for surface water infiltration, due in part to the increased water holding capacity and evapotranspiration provided by reclaimed surfaces.

Water Barrier Covers

Water barrier covers limit the downward migration of water into the waste zone by using low permeability materials such as compacted clay, PVC, HDPE or GCL to restrict downward water movement. Water barrier covers would be installed on flat or gently sloping (less than 25%) areas that are determined to be acid generating. Facilities such as backfilled pit surfaces, waste rock facility surfaces, ore processing areas, and some haul roads would be expected to need a water barrier cover. Unlike the water balance cover, the barrier cover would incorporate a geosynthetic liner to provide additional assurance that surface water would not seep into the potentially acid generating material underneath. Infiltration of water is more likely to occur on the gently sloping surfaces where surface water could pond and be less likely to run off.

For this cover, 12 to15 inches of soil, or a composite layer of 8 to 12 inches of soil plus 10 to 12 inches of tailings, would be placed over 24 to 36 inches of NAG. The NAG layer serves as a drain layer should infiltration water accumulate above the geosynthetic liner. It also provides the amount of cover needed to achieve a 3.5- to 4-foot thickness over potentially acid generating areas. Only 12 inches of coarse material is needed to function as a drain layer, and the upper 12 to 24 inches could be constructed with subsoil.

Reclamation Materials

Cover Soil

Soil salvaged during mining and stored in the stockpiles would be used to construct the reclamation covers. Another source of soil is the material salvaged during re-reclamation activities on facilities that have already been soiled and revegetated. Other materials used in reclamation include unconsolidated rock, scree and soil above and below roadway cuts, which are incorporated into the regrading of haul and access roads.

Geosynthetic Liners

Several types of geosynthetic liners may be used in construction of the reclamation covers. A geosynthetic clay liner (GCL) is a combination of a thin bentonite clay layer sandwiched between two geotextile layers. The bentonite provides a seal between the geotextiles. When the bentonite is exposed to moisture it swells, providing added protection against leaks or cracks. HDPE stands for high density polyethylene. This is basically a plastic sheeting that is laid in large strips and seamed together. Other similar synthetic materials, such as PVC or hypalon, may be substituted if determined more desirable or cost effective.

Support Facilities Reclamation

Final reclamation of the mine includes the removal of structures and equipment used in the mining and processing of ore.

Access and Haul Road Reclamation

Haul roads would be ripped to reduce compaction, reshaped to approximate original contour, tested to determine their acid generating potential, limed where necessary, covered with soil, and revegetated. Roadway berms and loose, unconsolidated material above and below the roadway cut would be pulled or dozed into the roadway using a dozer or backhoe. Some haul roads may also be left to function as post-reclamation access roads, though with a reduction in the width of the running surface.

All alternatives would leave a post-reclamation access road between the Zortman and Landusky Mines over Antoine Butte. The communication sites on Antoine Butte would continue to be accessible by vehicle from the towns of either Zortman or Landusky. Roads would also be left to provide access to each mine's water treatment plants and the seepage capture systems. The access road from the Landusky Mine to the community of Hays would remain in place.

While the post-reclamation access roads described above would all remain in place, their use may be restricted to authorized personnel only, in order to protect the reclaimed areas, water treatment plants, and communication facilities from theft, damage or vandalism.

Land Application Area Reclamation

Reclamation of the Goslin Flats land application area would include removal of irrigation equipment and pipelines, regrading of roadways, any necessary amendment of the area soils, and revegetation of disturbed surfaces.

Revegetation Procedures

Areas disturbed by mine-related operations would be revegetated to stabilize soil and slopes, re-establish plant communities ecologically comparable to pre-mine conditions, maximize water use, and restore watershed, wildlife, recreational, and aesthetic values that meet post-operation land use objectives. Trees would be used in revegetation on a limited basis for visual impact mitigation and to enhance water use. Grasses, forbs, and shrubs would be used to enhance wildlife habitat. Shrubs would also enhance water use. Plant species selected for revegetation would be based on species occurrence within the project area, land use objectives, presence of the species on pre-mine disturbances, establishment potential, growth characteristics, soil adaptation and stabilizing qualities, wildlife palatability, water consumption and availability (See also Section 4.5, Vegetation and Revegetation). Revegetation procedures would also include the amendment and cultivation of substrates to support healthy plant communities. After planting

and seeding, supplementary fertilization would be used until self-sustaining vegetation is established. These considerations are components of the revegetation plan entitled Revegetation Investigation and Revegetation Prescriptions for Zortman-Landusky Mine Sites (Bighorn Environmental Sciences 2000).

Interim Reclamation

Interim reclamation work has been ongoing since 1999. This is reclamation work that the agencies and interested parties agreed would not prejudice the selection of a final reclamation alternative and should proceed in order to begin remediation of existing mine impacts. This reclamation work is presently scheduled to continue through 2001.

2.4.2 Zortman Mine Reclamation Alternatives

Section 2.4.2 presents a description of the six reclamation alternatives developed for the Zortman Mine. Although the alternatives vary in emphasizing certain aspects of reclamation, all alternatives were formulated by the agencies' engineering consultants, under the direction of the technical working group, to meet the applicable regulatory requirements and standards for mine reclamation. The major difference between the Zortman Mine reclamation alternatives is the amount of pit backfill placed in the North and South Alabama, Ross, O.K./Ruby and Mint pits. The amount of backfilling dictates how much dump and leach pad material would be picked up and placed back into the pits, as well as the extent of tailings removal in Ruby Gulch.

Alternative Z1 is basically the same as that initially selected in the agencies' June 1998 Record of Decision, and is based on Alternative 3 from the FEIS. It has been modified slightly to account for the interim reclamation that has been completed to date.

Alternative Z2 is designed to be affordable within the current reclamation bond amount and to optimize the long-term economics of the water treatment plant operation. The funding would first be used to relocate the water treatment plant to Goslin Flats. The remainder would be used to regrade, topsoil, and revegetate the mine disturbance.

Alternative Z3 is also designed to be affordable within the current reclamation bond amounts. The water treatment plant would be left where it is currently located. The reclamation funds would be used to place a greater thickness of growth medium over all regraded surfaces to further limit water contact with acid generating materials. The additional growth medium would be obtained from the tailings stockpiles.

Alternative Z4 is not restricted by the reclamation bond amounts. The earthwork portion of the alternative includes removal of the Alder Gulch waste rock dump and backfilling the upper pits to cover the majority of sulfide minerals exposed in the pit highwalls. Additional regrading of the leach pads would be conducted and all potentially acid generating materials would be covered with water barrier or water balance reclamation covers.

Alternative Z5 is also not restricted by the reclamation bond amounts. The mine pits would be backfilled using material from the waste rock dumps and portions of the leach pads in order to restore the approximate pre-mine topography. Only the O.K./Ruby pit backfill would be covered with water barrier or water balance reclamation covers.

Alternative Z6 is the "Preferred Alternative." It is not restricted by the reclamation bond amount. The water treatment plant would be left where it is currently located. The earthwork portion of the alternative would provide for partial relocation of the Alder Gulch waste rock dump to the North Alabama pit, covering exposed sulfides in the Ross pit, and additional regrading. The use of geosynthetic liners would be limited to the O.K./Ruby pit backfill, Alder Gulch waste rock dump, and North Alabama pit backfill. A 24-inch thick soil/tailings cover would be placed over the majority of the reclaimed area.

Reclamation Common Among Zortman Mine Alternatives

Water Management

This section presents an overview of water management plans for the Zortman Mine that would be used under all alternatives to mitigate water quality impacts from mine facility discharges. It includes a description of measures that would continue to be implemented for management of process waters, stormwaters and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment, land application disposal, and monitoring.

Surface Water Runoff Control

All Zortman Mine pits would be backfilled and graded to prevent impoundment of runoff in pit areas. Currently, water which infiltrates through the mine pit floor enters the groundwater system and resurfaces in Ruby Gulch considerably degraded. This water management approach would restrict precipitation from infiltrating the pit floor and instead route the runoff into Ruby Gulch as surface water.

Water Capture

The water capture structures in Ruby Gulch, Alder Spur and Carter Gulch would remain in place as long as needed to capture seepage that would impact water quality. When no longer needed, the water capture structures would be dismantled and removed, and the disturbance area would be regraded and revegetated.

Water Treatment

ZMI constructed a water treatment plant at the Zortman Mine in May 1994 to treat acidic seepage captured at the base of the leach pad dikes and Alder Gulch waste rock dump. The plant operates at a rate of 200 to 800 gallons per minute approximately 8 days per month, depending on factors such as precipitation amounts and seasonal operating conditions. Interim effluent discharge standards from the plant are required to meet the Consent Decree standards. Establishment of final effluent limits and outfall points would occur as part of MPDES permit development (Appendix C). The Zortman Mine water treatment plant would continue to operate indefinitely, although it would be relocated to Goslin Flats under Alternatives Z2, Z4 and Z5.

Leach Pad Water Land Application Treatment

All leach pad draindown water at the Zortman Mine would be treated when necessary to remove residual cyanide, reduce acidity, and remove metals and nitrates prior to being piped to Goslin Flats for final treatment and disposal via land application.

Water Resources Monitoring

The interim monitoring program for groundwater and surface water would continue until replaced by the MPDES permit (Appendix C). A monitoring program containing the combined requirements from the Consent Decree, MPDES permit and the mine operating permits is under development.

Reclamation Materials

A variety of materials would be used in the construction and installation of the reclamation covers and drainage ditches. The primary reclamation materials to be used are cover soil, stockpiled non-acid generating waste rock, non-acid generating spent ore or materials amended with lime to neutralize acidity, limestone quarried on site, and the Ruby Gulch tailings. In addition, certain synthetic materials such as a geosynthetic clay liner or a geomembrane liner would be used in the construction of the water barrier component of the reclamation covers.

Cover Soil

There are presently 185,400 cubic yards of soil stockpiled at the Zortman Mine. Excess cover soil stockpiled at the Landusky Mine could be used to supplement the limited supply at Zortman.

Support Facilities Reclamation

Final reclamation of the mine would include the removal of structures and equipment used in the mining and processing of ore. Surface facilities at the Zortman Mine include the Zortman guard shack and gate, Degerstrom shop, refinery, and the Merrill Crowe plant. Facilities associated with water management include the water treatment plant, Z82 pond, barren pond, Ruby capture pond and Ruby Gulch pumpback, sludge pit, Zortman emergency generator, Carter Gulch seepage capture system, and Alder Spur seepage capture system.

Under all alternatives the surface facilities would be removed. All water management structures would be left intact in alternatives where the water treatment plant stays at the mine site. In alternatives where the water treatment plant is moved to Goslin Flats, the footprint of the removed facilities would be covered with soil and revegetated.

Zortman Mine Interim Reclamation

Interim reclamation work at the Zortman Mine includes regrading, placement of cover soil and planting the Z83, Z84, and Z89 leach pads; partial backfill of the Ross pit; backfilling the O.K./Ruby and Mint pits; regrading the north half of the Z85/86 leach pad; highwall reduction along the west side of the South Alabama pit; capping the barren pond; and various reclamation actions on the Z82 leach pad, Z82 sulfide

stockpile, Ruby sulfide stockpile, South Ruby waste rock dump, South Ruby Saddle soil stockpile, Z82 soil stockpile, and Ruby Gulch West tailings stockpile.

The Z82 sulfide stockpile and Ruby sulfide stockpile have been placed in the bottom of the O.K. pit, capped with 8 inches of clay, and then covered with 60 to 70 feet of backfill. The Z82 leach pad, South Ruby waste rock dump, and a portion of the Z85/86 leach pad are presently being backfilled into the O.K./Ruby pit complex and the Mint pit. Work is anticipated to be completed by June 2001 and will leave three pits (O.K./Ruby and Mint) backfilled to a free draining condition. Three of the worst acid-generating sources (Z82 sulfide stockpile, Ruby sulfide stockpile, and Z82 leach pad test pile) at the Zortman Mine will be buried in their original source areas and capped to limit infiltration of surface water.

The pit backfill project includes regrading the north half of the Z85/86 leach pad to convey runoff around the north edge of the site and into an undisturbed draw on the east side. In order to make this runoff discharge into Ruby Gulch, a 42,000 cubic-yard notch would be cut through the saddle at the head of the draw.

Regrading the Z83, Z84, and Z89 leach pads to 3H:1V slopes was completed in 2000. All surfaces have been tested for acid generation on a 100-foot grid spacing. Any areas not meeting the NAG criteria have been lime treated to ensure that 24 inches of NAG covers the entire leach pad surface. Once limed, Ruby Gulch tailings from the West tailings stockpile were placed on the graded leach pads to a depth of 6 inches. Soil from the South Ruby Saddle soil stockpile and the Z82 soil stockpile was then placed to a depth of 18 inches. The entire surface area of these three leach pads has 24 inches of NAG, 6 inches of tailings, and 18 inches of soil, for a total depth of 48 inches of suitable plant growth medium. All areas were then reseeded with the general grass-forb seed mix listed in Section 4.5.1. The only area of the regraded leach pads left unreclaimed at this time is the sludge pit on the Z89 leach pad, which is needed for disposal of sludge from operation of the water treatment plant.

During 2001, the highwall along the west side of the South Alabama pit would be reduced by up to 70 feet. Because this highwall extends up to the top of the ridge, highwall reduction would restore the original ridge line at a somewhat lower elevation. Most of the work would be accomplished by drill and blasting the rock along the top of the highwall and then using bulldozers to push the shot material into the pit. Additional material would be borrowed from an area to the north of the pit to complete backfilling on the pit floor and to cover a sulfide zone in the pit wall on the east side of the pit.

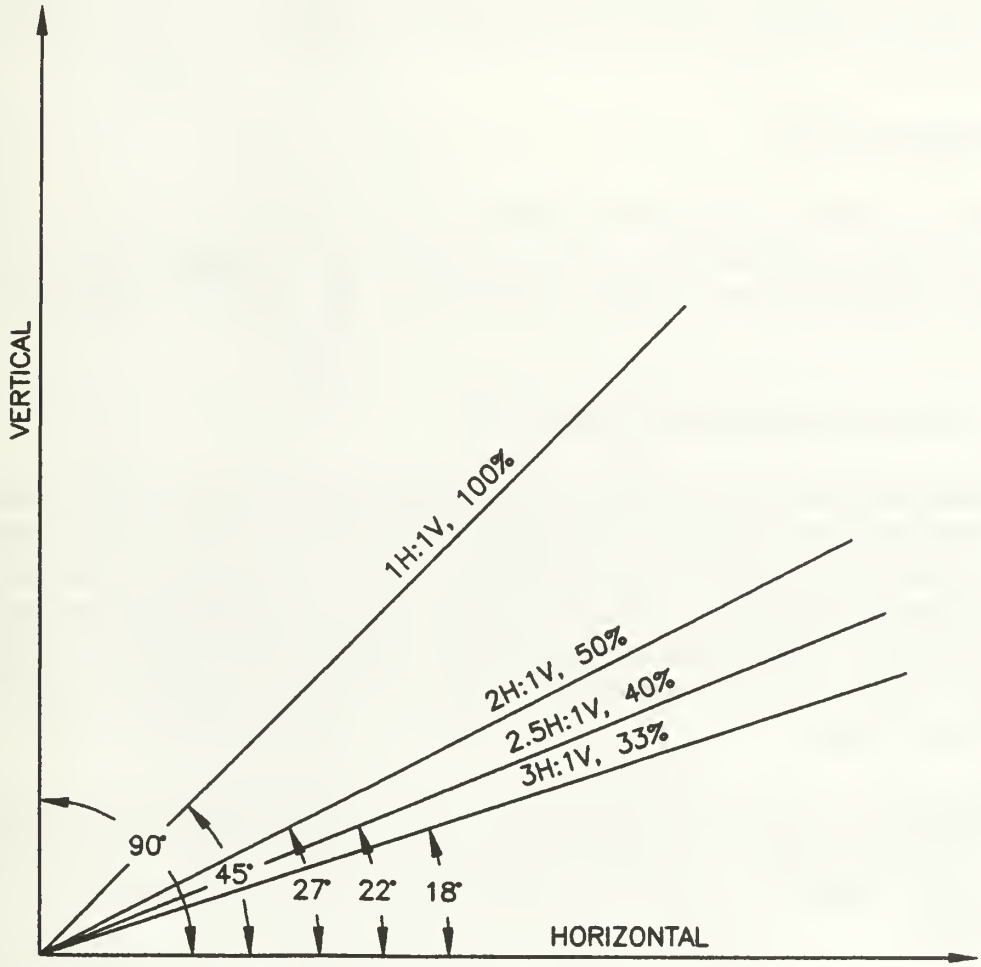
The barren pond would be reclaimed in 2001. The sludge which has accumulated in this pond would first be mixed with spent ore from the Z85/86 leach pad. Then the pond and the bench on which it is located would be backfilled with additional material borrowed from the Z85/86 leach pad.

In 1999, the floor and accessible benches in the Ross pit were graded. A channel was cut to direct runoff toward the Ruby Gulch drainage. The flat pit bench was amended with lime to prevent acid generation. Additional interim work in 2001-2002 would cover a portion of the sulfide-bearing highwall and a lower

sulfide bench with 133,000 cubic-yards of non-acid generating material borrowed from the disturbed area between the North and South Alabama pits. This backfill would be left as a steep rubble slope extending from the pit floor up to a benched area about halfway up the highwall.

Cleanup and removal of old mining equipment and debris took place during 2000. The timing for removal of support facilities such as maintenance sheds, roads, powerlines, etc. would vary by alternative. Removal of the ruins of the old Whitcomb Mill at the head of Ruby Gulch would occur in 2001 after consultation with the State Historic Preservation Office.

The following diagram shows the relationship between reclamation slopes, grades, and the angle from the horizontal. This diagram is useful when reading the alternative descriptions. Reclamation slopes are commonly described as a ratio of the horizontal measurement to the vertical measurement, expressed as H:V. For example, a slope described as 2H:1V, would change by 1 foot in elevation every 2 feet of horizontal distance.



Alternative Z1, 1998 ROD Reclamation

Alternative Z1 would implement the reclamation described under Alternative 3 of the FEIS, as modified by the June 1998 ROD. This alternative has been re-costed with revised unit costs and with bond money set aside for leach pad water management. The reclamation costs for this alternative would exceed the existing reclamation bond amount. The three major cost items include placement of geosynthetic liner and geotextile as part of the respective water barrier or water balance reclamation covers, removal of the Alder Gulch waste rock dump, and leach pad water management. See Section 4.12 for a description of the reclamation costs. The reclamation action for each mine feature is shown in Figure 2.4-3. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action."

Mine Pit Reclamation

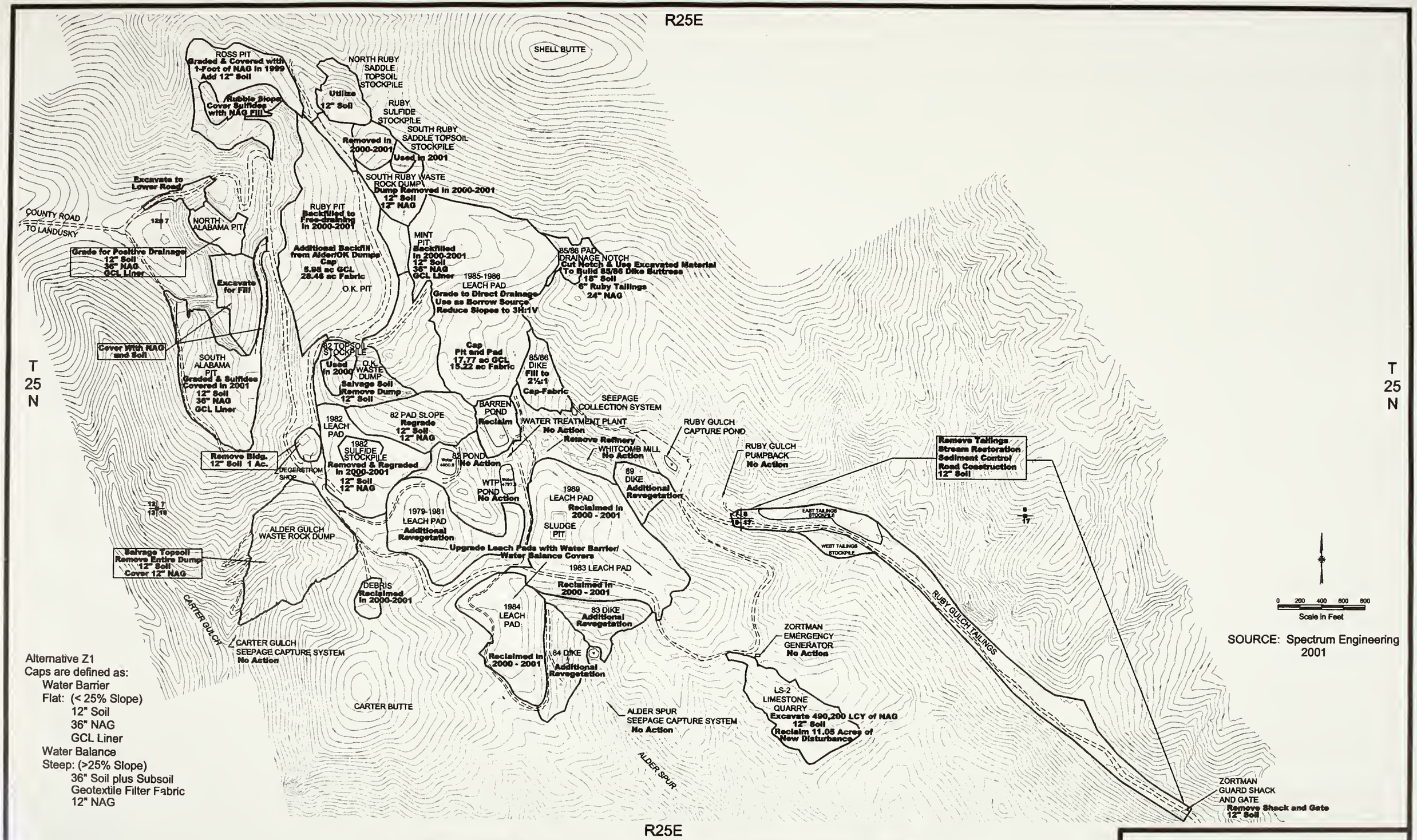
In the initial phase of operations at the Zortman Mine there were six distinct pits. These were the North Alabama, South Alabama, Ross, O.K., Ruby, and Mint pits. By late 1985, continued mining activity had combined the O.K. and Ruby pits into a single pit complex (see also, aerial photos in 1995 Draft EIS, Appendix D).

North Alabama and South Alabama Pits

The North and South Alabama pits are located at the head of the Ruby Gulch drainage. The pit complex stretches for 2200 feet along the ridge between the Ruby Gulch and Carter Gulch drainages. The North Alabama pit was mined down to an elevation of 5370 feet above mean sea level (amsl), while the South Alabama pit was mined to 5230 feet amsl. A long, wide bench with a floor elevation of 5440 feet amsl was mined between the two pits. Along the entire west side of the complex, the pit highwalls extend up to the crest of the ridge. On the east side, there are either low walls or the benches break out along the east-facing slope of Ruby Gulch.

The north wall of the North Alabama pit was mined up to a saddle on the divide between the Ruby Gulch and Lodgepole Creek drainages. The pit highwalls reach to elevations of 5485 feet and 5610 feet, respectively, on the northeast and northwest sides of the saddle. There are no exposed sulfides in the North Alabama pit.

The central bench between the North and South Alabama pits has a 90-foot highwall on its west side and daylights into Ruby Gulch along its east side. Because the topography rapidly increases to the north, the walls at the south end of the South Alabama pit are minimal, yet the pit wall at the north end of the pit reaches nearly 350 feet high. Near the center, the pit highwall is 200 feet high along the ridge on the west side and is less than 80 feet high along the low wall on the east side. Sulfide minerals are exposed in some areas near the bottom of the South Alabama pit.



ALTERNATIVE Z1: RECLAMATION PERFORMED IN ACCORDANCE WITH THE 1996 FINAL EIS, ALTERNATIVE 3 AND 1998 RECORD OF DECISION.

ZORTMAN MINE ALTERNATIVE Z1

FIGURE 2.4-3

Reclamation at the South Alabama pit would include highwall reduction and pit backfilling to cover the exposed sulfide zones and to make the pit floor free draining. This work would cover most of the pit area with NAG-quality material leaving only a few sections of highwall at the north end on the pit exposed. Some additional backfilling and grading would be required to moderate the slopes for installation of water balance and water barrier reclamation covers. Water barrier covers would incorporate a GCL liner and 36 inches of NAG.

Earthwork on the North Alabama pit would consist of lowering the north rim of the pit and grading the pit floor. The central bench area and haul road would be covered with 12 inches of NAG and 12 inches of soil. The pit floor at the North Alabama would be covered with a GCL liner, 36 inches of NAG, and revegetated. Upon completion of reclamation, all of the highwalls associated with the North Alabama pit (about 220 vertical feet) would still be exposed. These highwalls stand at approximately 45 degrees (1H:1V).

Ross Pit

The Ross pit is situated on a small ridge between two draws on the south side of the Lodgepole Creek drainage. Its uppermost benches extend up to the top of the divide between the Ruby Gulch and the Lodgepole Creek drainages. The Ross pit faces to the north with its highwall extending up to the road on the north edge of the North Alabama pit. The Ross pit was not mined as a pit but was developed by mining along the contour. In this way, the nose of the ridge was pushed back between 600 and 800 feet, leaving a 450-by-600-foot bottom bench at an elevation of 5110 feet amsl. A highwall with multiple benches extends up to an elevation of 5450 feet amsl. These highwalls stand at approximately 45 degrees (1H:1V).

The Ross pit area was partially regraded in 1999 and the flat pit bench was amended with lime to prevent acid generation. Additional interim work would cover a portion of the sulfide-bearing highwall and a lower sulfide bench with non-acid generating material. The backfill placed over the highwall would be left as steep rubble slope. The regraded areas would be covered with12 inches of soil and revegetated. Upon completion of reclamation about 200 vertical feet of highwall would be exposed.

O.K./Ruby and Mint Pits

The O.K./Ruby and Mint pits are both located on an east-facing slope near the head of Ruby Gulch. They are situated below and to the east of the North Alabama pit. The northern end of the O.K./Ruby pit walls extend to the Ross pit. The haul road from the Ross pit travels along the edge of the O.K./Ruby pit. The Mint pit is located to the east of and below the haul road.

The Mint pit is a small pit developed near the head of the drainage. Before being backfilled as part of the Zortman Pit Backfill Project in 2000-2001, it was less than 250 feet wide and around 700 feet long. The pit floor was at an elevation of 4860 feet amsl. The northern portion of the Z85/86 leach pad is located

east of the Mint pit. The toe of the South Ruby waste rock dump had encroached into the northwest corner of the Mint pit.

The O.K./Ruby pit was mined along the contour of the hillside for a length of 2300 feet before the open pit was developed. The open pit is 1500 feet long from north to south and has a maximum width of 700 feet. It was mined to a bottom elevation of 4850 feet amsl in two separate sections of the pit. Because the topography rises from south to north, the highwall running along the west side extends up to an elevation of 5200 feet amsl at the south end and to 5350 feet amsl at the north end. The low wall on the east side of the pit sat at about 4975 feet amsl at the south corner, then climbed up to 5070 feet at the north end. Sulfides were exposed at the bottom of the pit and extend part of the way up the west highwall. Remnants of the old drifts and stopes from the underground workings are still visible in the highwalls. The bottom of the pit was blasted as part of interim reclamation to fill other underground openings which were evident in the bottom of the pit.

The O.K./Ruby and Mint pits were backfilled to a free draining condition under interim reclamation. Material from the worst acid generating sources, including the Z82 leach pad, Z82 sulfide stockpile, Ruby sulfide stockpile, and the South Ruby waste rock dump were used as backfill. The two sulfide stockpiles were placed into the O.K. pit, compacted, and covered with a 6-inch layer of clay obtained from the test heap on top of the Z82 leach pad. The Z82 leach pad and Ruby waste rock dump were then placed in the bottom of the O.K./Ruby and Mint pits, thereby adding another 60 to 70 feet of fill over the sulfides. Another 22,000 cubic yards of clay salvaged from the Z82 leach pad was used to cap the entire O.K./Ruby backfill area with 8 inches of clay. The clay was then covered with 24 inches of NAG. Completion of the Zortman Pit Backfill Interim Reclamation Project in 2001 would leave the three pits (O.K./Ruby and Mint) backfilled to a free draining condition. Three of the worst sources of acid generating materials (Z82 sulfide stockpile, Ruby sulfide stockpile, and Z82 leach pad) at the Zortman Mine were reburied in their original excavation area and the backfilled areas were capped to limit water contact with these materials.

Additional reclamation of the O.K./Ruby and Mint pits would include backfilling the pits with material from the Alder Gulch waste rock dump and the O.K. waste rock dump. The additional fill would create an overall 3H:1V slope which would cover most of the pit highwalls.

All backfilled pit surfaces would be covered with a water barrier or water balance reclamation cover. In order to obtain the amount of NAG material needed, an 11-acre limestone borrow area would be developed at the LS-2 site above the town of Zortman (Figure 2.4-3).

Leach Pad Reclamation

There are six leach pads at the Zortman Mine. These include the Z79-81, Z82, Z83, Z84, Z85/86 and Z89 leach pads. The Z79-81 and Z82 pads are free draining into ponds. The other pads have buttresses

or dikes associated with them to impound the leaching solutions. Five of these leach pads have already been graded as part of interim reclamation.

Z79-81 Leach Pad

The Z79 and Z80-81 leach pads were constructed adjacent one another in one pad complex. This leach pad complex covers an area of 15.18 acres on the north side of the Zortman-to-Landusky main access road. It is located almost due south of the water treatment plant and due west of the Z83 and Z89 leach pads. A total of 1,170,900 cubic yards of spent ore is contained on these leach pads.

The Z79 leach pad has been regraded and covered with 8 to 12 inches of soil. Grass was planted in 1989 and trees were planted in 1990. The Z80-81 leach pad was covered with 8 to 12 inches of soil with grass planted in 1991. Trees were planted in 1992. Further reclamation would be conducted on this leach pad complex to install the water barrier or water balance reclamation covers described in the 1998 ROD.

Z82 Leach Pad

The Z82 leach pad covered an area of 10.68 acres and contained approximately 1,154,400 cubic yards of spent ore. The pad was located due south of the O.K. waste rock dump and northwest of the Z79-81 leach pad complex. This leach pad was placed as backfill into the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. The leach pad footprint would be graded for positive drainage.

Originally, under Alternative 3 of the FEIS the Z82 leach pad would not have been moved but would have been regraded in place with maximum 3H:1V slopes. The surface would have been reclaimed with a water barrier cap or water balance reclamation cover, and revegetated. Since the material has already been backfilled, Alternative Z1 would leave it in the pit and reclaim the leach pad footprint and the slope extending down from its north side with 12 inches of NAG and 12 inches of soil.

Z83, Z84, and Z89 Leach Pads

The Z83, Z84, and Z89 leach pads are the three southernmost pads. The main access road between the Zortman and Landusky Mines goes through the middle of these leach pads. The Z83 leach pad covers an area of 12.89 acres and contains 1,227,100 cubic yards of spent ore. The Z84 leach pad covers 14.2 acres and has 1,489,900 cubic yards of spent ore. The Z89 leach pad covers 14.21 acres and contains 2,174,300 cubic yards of spent ore. The three pads are immediately adjacent one another.

The retaining dikes associated with these leach pads have already been graded, covered with soil and seeded. The 6.02-acre Z83 dike was covered with 8 to 12 inches of soil and revegetated in 1992. The Z84 dike, occupying 6.73 acres, was covered with 8 to 12 inches of soil and revegetated in 1992. The Z89 dike, covering 3.87 acres, was covered with 8 to 12 inches of soil and revegetated with grass and

trees between 1989 and 1990. Additional planting and fertilization would be conducted to enhance the existing vegetation on these dikes.

Interim reclamation during 1999 and 2000 included regrading the Z83, Z84 and Z89 leach pads to 3H:1V slopes. The regraded surface was sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of Ruby Gulch tailings were placed as cover material, followed by 18 inches of soil. All surfaces were seeded in December 2000.

Under this alternative, additional work would be required on the Z83, Z84 and Z89 leach pads to upgrade the reclamation covers to the water barrier or water balance reclamation covers as shown in Figure 2.4-1.

Z85/86 Leach Pad

The Z85/86 leach pad is located at the head of Ruby Gulch. It covers an area of 32.5 acres and contains 4,881,600 cubic yards of spent ore. This pad is due east of the Mint pit and immediately south of Shell Butte. A portion (386,000 cubic yards) of this pad was used for backfill in the O.K./Ruby and Mint pits as part of the Zortman Pit Backfill Interim Reclamation Project. Another 70,000 cubic yards was removed to reclaim the barren pond.

Under the FEIS, the Z85/86 leach pad and dike were to be removed and used as backfill in the O.K./Ruby and Mint pits along with the Alder Gulch waste rock dump. This was changed in the 1998 ROD which specified that the Z85/86 leach pad would be regraded in place to 3H:1V slopes and capped with a water barrier (11.65 acres) or water balance (21.70 acres) cover appropriate to the slope conditions.

The Z85/86 dike occupies 3.61 acres and contains 229,200 cubic yards of sulfide material. The dike would be regraded or buttressed to achieve a 2.5H:1V slope. This flattened slope would be reclaimed with a water balance cover.

Waste Rock Dump Reclamation

There are five waste rock repositories at the Zortman Mine: the Alder Gulch waste rock dump, O.K. waste rock dump, South Ruby waste rock dump, Z82 sulfide stockpile and Ruby sulfide stockpile.

Alder Gulch Waste Rock Dump

The Alder Gulch waste rock dump occupies a draw on the northeast side of Carter Gulch. The top bench on the dump juts out from the ridge separating the Alder Gulch, Carter Gulch and Ruby Gulch drainages. The main access road cuts between the top of the rock dump and the Z82 leach pad. The top of the dump sits at an elevation of 5005 feet amsl. Its toe extends down to an elevation of 4625 feet amsl. The Alder Gulch waste rock dump contains an estimated 2,236,000 cubic yards of acid generating waste rock. A

seepage capture system has been constructed below the toe of the dump. The dump has a 17.94-acre footprint which was reclaimed by ZMI in 1991 and 1992 by placing 8 to 12 inches of soil as cover material and reseeding. Lined surface runoff drains have been constructed across the dump face. Surface reclamation on this dump face failed several times prior to placement of the runoff drains across its surface.

The Alder Gulch waste rock dump would be removed and used as backfill in the O.K./Ruby pit. The footprint from the dump would be tested on 100-foot centers for acid generating potential. Those areas with total sulfur content greater than 0.5% sulfur would either be limed or capped to provide at least 12 inches of NAG beneath a 12-inch layer of soil. The entire area would be revegetated.

O.K. Waste Rock Dump

The O.K. waste rock dump occupies a draw on the west side of Ruby Gulch. The dump is situated between the south end of the O.K./Ruby pit and the north end of the Z82 leach pad. The top of the dump sits at an elevation of 5035 feet amsl. Its toe extends down to an elevation of 4770 feet amsl. Below the toe, the drainage is blocked by the Z85/86 leach pad. The O.K. waste rock dump contains an estimated 746,000 cubic yards of waste rock. Its footprint covers 8.69 acres. The face of the dump was reclaimed in 1993 with a cover of 8 to 12 inches of soil and was seeded. The Z82 soil stockpile, which covered a portion of this dump's top bench, was removed and used to cover the Z83 and Z89 leach pads.

The O.K. waste rock dump would be removed and used as backfill in the O.K./Ruby and Mint pits. The dump footprint would be tested on 100-foot centers for acid generating potential. Those areas with total sulfur content greater than 0.5% sulfur would either be limed or capped with a layer of NAG. After placing 12 inches of soil on the surface, the area would be revegetated.

South Ruby Waste Rock Dump

The South Ruby waste rock dump is located at the head of Ruby Gulch. It is situated across the road and just to the east of the O.K./Ruby pit. Before this dump was partially removed and regraded in 2000-2001, it contained an estimated 550,000 cubic yards of waste rock and covered over 15 acres of land straddling the drainage at the head of the gulch. The top of the dump was at an elevation of 5050 feet amsl. The dump toe had extended down into the Mint pit at an elevation of 4875 feet amsl.

A total of 281,000 cubic yards would be cut off the top of the dump and backfilled into the O.K./Ruby pit. Approximately 158,000 cubic yards would be pushed into the Mint pit backfill area. The remainder of the pile, about 111,000 cubic yards, would be regraded in place. Final reclamation of the dump footprint would include application of 12 inches of NAG, 12 inches of soil, and revegetation.

Z82 Sulfide Stockpile

The Z82 sulfide stockpile contained 30,000 cubic yards of sulfide rock and was located on top of the Z82 leach pad. The Z82 sulfide stockpile was placed into the bottom of the O.K. pit as part of interim reclamation. The Ruby sulfide stockpile was also placed in the bottom of the O.K. pit. Both were capped with 6 inches of clay prior to backfilling all of the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. No further reclamation action would be conducted on this stockpile.

Ruby Sulfide Stockpile

The Ruby sulfide stockpile contained 135,000 cubic yards of sulfide rock and was located on top of the South Ruby waste rock dump. This material was placed in the bottom of the O.K. pit along with the Z82 sulfide stockpile. The sulfide disposal area was capped with 6 inches of clay prior to backfilling all of the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. No further reclamation action would be conducted on this stockpile.

Ruby Gulch Tailings

The Ruby Gulch tailings were generated by mining operations in Ruby Gulch dating back to the early 1900s. The tailings are located in Ruby Gulch, downstream of the Ruby Gulch pumpback system, at the toe of the Ruby Gulch Pond embankment. They extend all the way downstream through the town of Zortman and end shortly before reaching Goslin Flats. ZMI excavated some of the tailings from the drainage in order to construct the seepage capture pond. The excavated tailings were stockpiled adjacent the mine access road. There are four main portions or deposits of tailings:

1. The West tailings stockpile, which is located above the access road going up Ruby Gulch, contains approximately 102,700 cubic yards and covers an area of 2.11 acres.

2. The East tailings stockpile contains about 91,700 cubic yards and covers an area of 3.38 acres.

3. The tailings in the drainage bottom between the pumpback and the Zortman guard shack cover an area of 19.4 acres and include approximately 191,200 cubic yards.

4. The amount of tailings going through the town of Zortman is uncertain. Cleanup of this portion of the tailings is not considered as part of the reclamation effort, but may be conducted in conjunction with mine reclamation to increase removal efficiency.

The Ruby Gulch drainage bottom, from the Ruby Gulch pumpback station to the Zortman guard shack on the upstream edge of town, would be restored by removal of tailings in the two stockpiles and in the stream bottom. The streambed would be reconstructed and sediment controls would be put into place. The county road would be moved to the east side of the drainage onto the old roadbed and widened. Tailings

removed from the stockpiles and streambed would be hauled up to the mine area where they would be spread as NAG or cover material. The tailings have been sampled and found to be non-acid generating. The entire drainage area would be covered with 12 inches of soil and revegetated. The soil would be excavated from Goslin Flats and hauled to the Ruby Gulch area.

Reclamation Covers

In developing a reclamation cover system for the Zortman Mine, the FEIS assumed that most of the waste rock and spent ore heap facilities contained potentially acid generating materials. As a result, one of the requirements of the FEIS Alternative 3 was to develop reclamation covers that would support revegetation and limit the surface water infiltration that could lead to the formation of acidic leachate. The cover systems included water barrier (for slopes less than 25%) and water balance (for slopes greater than 25%) covers on both mines. The water barrier cover would consist of a GCL layer placed over NAG waste and overlain by 36 inches of NAG and 12 inches of soil. The water balance cover would consist of a filter fabric (or geotextile) placed on top of 12 inches of NAG waste and overlain by 24 inches of subsoil and 12 inches of soil. Most other areas would be covered with 12 inches of NAG and 12 inches of soil. Additional detail on the reclamation covers is shown in Figure 2.4-1 and in Appendix B.

Support Facilities Reclamation

All of the support facilities (shops, refinery, processing plant, etc.) would be removed and their footprints covered with 12 inches of soil and revegetated. The water treatment plant, drainage capture systems, ponds, and associated structures would stay in operation in their current locations.

Limestone Quarry

This alternative would use an additional 490,200 loose cubic yards of NAG in the reclamation effort. The material would be quarried from limestone quarry LS-2. The soil would be stripped from the quarry area and stockpiled for use in reclamation. After the limestone is mined, the area would be regraded, covered with soil, and revegetated.

Alternative Z2, Optimize Water Treatment

Alternative Z2 is designed to be affordable within the current reclamation bond funding. The goal of this alternative is to optimize the economics of the water treatment plant operations. This alternative would first use the reclamation funds to relocate the Zortman Mine water treatment plant to Goslin Flats, so that long-term cost savings could be realized by using gravity flow to minimize pumping and lime delivery expenses. The remainder of the funds would then be applied to reclamation measures such as grading, backfilling, topsoiling and revegetation. The reclamation action for each mine feature is shown in Figure 2.4-4. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

North Alabama and South Alabama Pits

The South Alabama pit grading would be complete after the interim highwall reduction and backfilling work in 2001. The interim backfill would leave a small section of highwall at the north end of the pit. Below this highwall at the upper end of the pit, some of the backfill would be left as steep rubble slopes. The remainder of the backfilled pit, the associated borrow areas, and the pit access road would be covered with 12 inches of soil and revegetated. Only non-acid generating material would be used as backfill. The final configuration would provide a free draining backfill surface which would cover all sulfide areas in the pit.

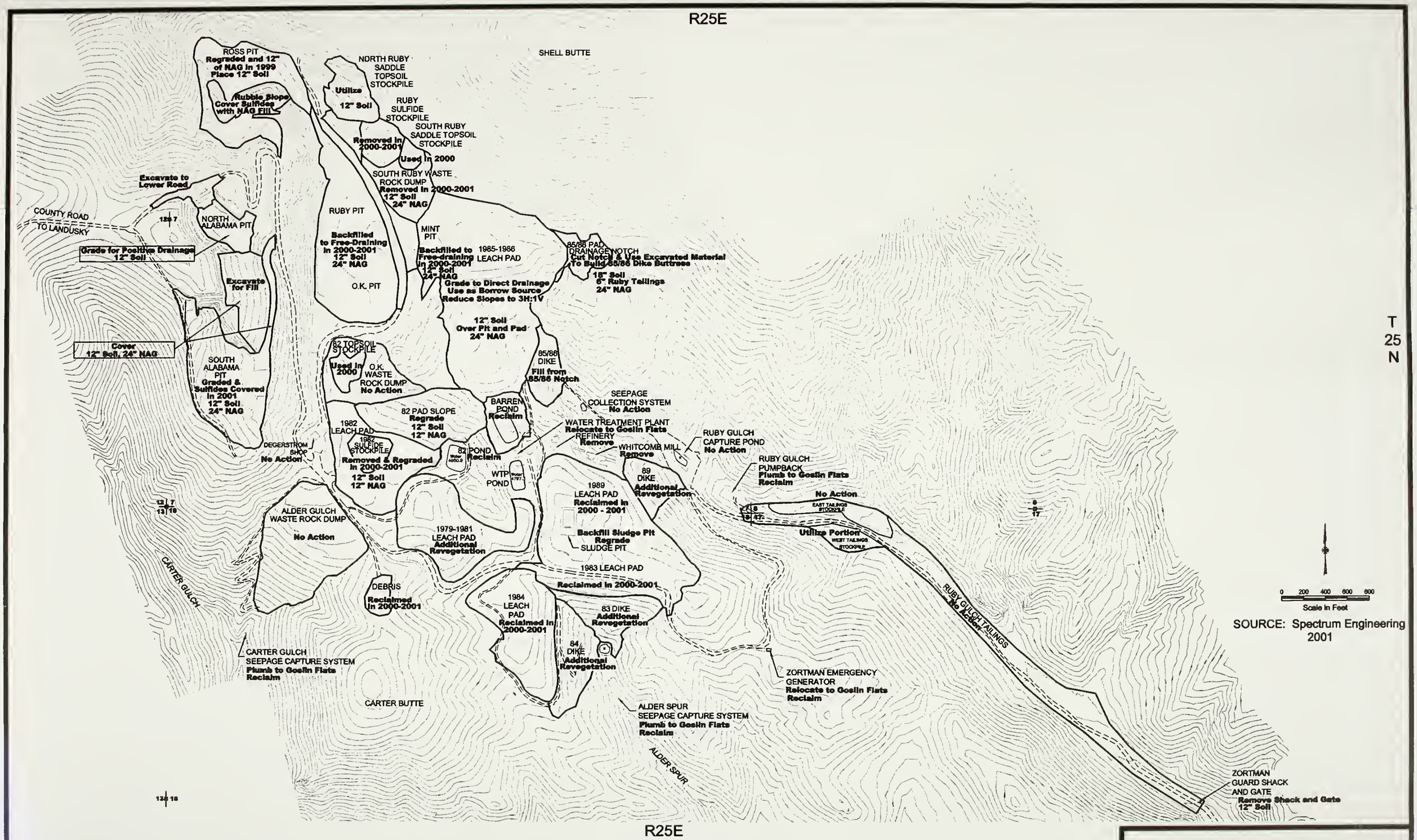
The North Alabama pit would be made free draining with very minimal earthwork and no need for backfill from external sources. The pit floor would be covered with 12 inches of soil and revegetated. Upon completion, all of the highwalls associated with the North Alabama pit (about 220 vertical feet) would be exposed.

Ross Pit

The Ross pit area was partially regraded in 1999, and the flat pit bench was amended with lime to prevent acid generation. Additional interim work in 2001-2002 would cover a portion of the sulfide-bearing highwall and a lower sulfide bench with non-acid generating material. The backfill placed over the highwall would be left as steep rubble slope. The regraded areas would be covered with12 inches of soil and revegetated. Upon completion of reclamation on the Ross pit about 200 vertical feet of highwall would be exposed; however, most of the sulfides would be covered.

O.K./Ruby and Mint Pits

These pits would be backfilled and graded to drain freely. The entire regraded surface would be covered with 24 inches of NAG, 12 inches of soil, and revegetated. Upon completion, the highwall of the O.K./



ALTERNATIVE Z2: RECLAMATION GOAL IS TO OPTIMIZE WATER TREATMENT PLANT (WTP) OPERATION BY MOVING WTP TO GOSLIN FLATS AND TO STAY WITHIN THE BOND AMOUNT.

ZORTMAN MINE ALTERNATIVE Z2

FIGURE 2.4-4

Ruby pit above 5,030 feet (the upper 220 to 300 feet) would be exposed. About 5% of the sulfide-bearing zones in the highwalls would be exposed.

Leach Pad Reclamation

There are six leach pads at the Zortman Mine. These include the Z79-81, Z82 , Z83, Z84, Z85/86 and Z89 leach pads. The Z79-81 and Z82 leach pads are free draining into ponds. The other pads have buttresses or dikes associated with them. Five of these leach pads would be considered reclaimed.

Z79-81 Leach Pad

The Z79 leach pad has been covered with 8 to 12 inches of soil. Grass was planted in 1989 and trees were planted in 1990. The Z80-81 leach pad was covered with 8 to 12 inches of soil with grass planted in 1991. Trees were planted in 1992. Additional planting and fertilization would be employed to enhance the existing vegetation.

Z82 Leach Pad

The Z82 leach pad was backfilled into the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. The leach pad footprint would be graded for positive drainage. The steep fill slope directly below the pad would be regraded at 2.5H:1V. The area below the Z82 pond would be graded at 2H:1V. After grading, the entire pad footprint and these regraded slopes would be covered with 12 inches of NAG, 12 inches of soil, and revegetated.

Z83, Z84, and Z89 Leach Pads

The reclamation done to date on the leach pad retaining dikes would be considered complete. The 6.02-acre Z83 dike was covered with 8 to 12 inches of soil and revegetated in 1992. The Z84 dike, occupying 6.73 acres, was covered with 8 to 12 inches of soil and revegetated in 1992. The Z89 dike, covering 3.87 acres, was covered with 8 to 12 inches of soil and revegetated with grass and trees between 1989 and 1990. Additional planting and fertilization would be conducted to enhance the existing vegetation on these dikes.

Interim reclamation during 1999 and 2000 included regrading the Z83, Z84 and Z89 leach pads to 3H:1V slopes. The regraded surface was sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of Ruby Gulch tailings were placed as cover material, followed by 18 inches of soil. All surfaces were seeded in December 2000. This reclamation work would be considered final. After relocating the water treatment plant to Goslin Flats, the sludge pit on the Z89 leach pad would be backfilled, covered with soil, and revegetated.

Z85/86 Leach Pad

The north half of the Z85/86 leach pad would be used as a backfill source for reclamation of the O.K./Ruby and Mint pits. This area would be regraded to convey runoff around the north edge of the site and into an undisturbed drainage to the east. A portion of the pad would also be excavated to provide about 70,000 cubic yards of material for reclamation of the barren pond.

The remainder of the Z85/86 leach pad would be regraded to 3H:1V slopes. The top 2 feet of the entire pad area would be amended with lime to ensure that it would be non-acid generating. The area would then be covered with 12 inches of soil and revegetated. The Z85/86 dike face would be covered with 42,000 cubic yards of NAG generated while constructing the channel around the north edge of the pad. The NAG fill would be covered with 12 inches of soil and revegetated.

Waste Rock Dump Reclamation

Alder Gulch Waste Rock Dump

The Alder Gulch waste rock dump would not be removed. The existing reclamation on the dump surface would be the final reclamation.

O.K. Waste Rock Dump

The O.K. waste rock dump would not be removed. The existing reclamation on the dump surface would be the final reclamation.

South Ruby Waste Rock Dump

The upper portion of this dump would be used for O.K./Ruby and Mit pit backfill. The remaining 111,000 cubic yards of the South Ruby waste rock dump that was not used as pit backfill would be regraded in place as part of interim reclamation. The regraded dump surface would be covered with 12 inches of NAG, 12 inches of soil, and revegetated.

Z82 Sulfide Stockpile

The Z82 sulfide stockpile was placed into the bottom of the O.K. pit, capped with clay and then buried below 100 feet of backfill as part of interim reclamation.

Ruby Sulfide Stockpile

The Ruby sulfide stockpile was placed into the bottom of the O.K. pit along with the Z82 sulfide stockpile as part of interim reclamation, capped with clay and then buried below 100 feet of backfill. The footprint would be reclaimed as part of the South Ruby waste rock dump.

Ruby Gulch Tailings

No reclamation of the Ruby Gulch tailings would take place as part of mine reclamation. A portion of the West tailings stockpile was removed as part of interim reclamation and used for cover soil on the Z83, Z84, and Z89 leach pads.

Support Facilities Reclamation

All of the support facilities such as shops, the refinery, processing plants, etc. would be removed and their footprints covered with 12 inches of soil and revegetated. The water treatment plant, ponds, and associated structures would be relocated to Goslin Flats. Pipelines would be constructed to route captured seepage to the Goslin Flats water treatment plant. When no longer needed, the Goslin Flats water treatment plant would be dismantled and the disturbance footprint reclaimed with 12 inches of soil and revegetated.

Alternative Z3, Optimize Source Control

Alternative Z3 is similar to Alternative Z2 in that it is designed to be implemented within the current reclamation bond funding. In this alternative, the water treatment plant would be left where it is currently located. The reclamation funds would be used to buttress the Z85/86 dike and to create a 24-inch thick NAG zone over acid generating surfaces by lime amendment. In most areas a growth medium of 7 inches of tailings and 11 inches of soil would be placed before revegetation. The reclamation action for each mine feature is shown in Figure 2.4-5. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

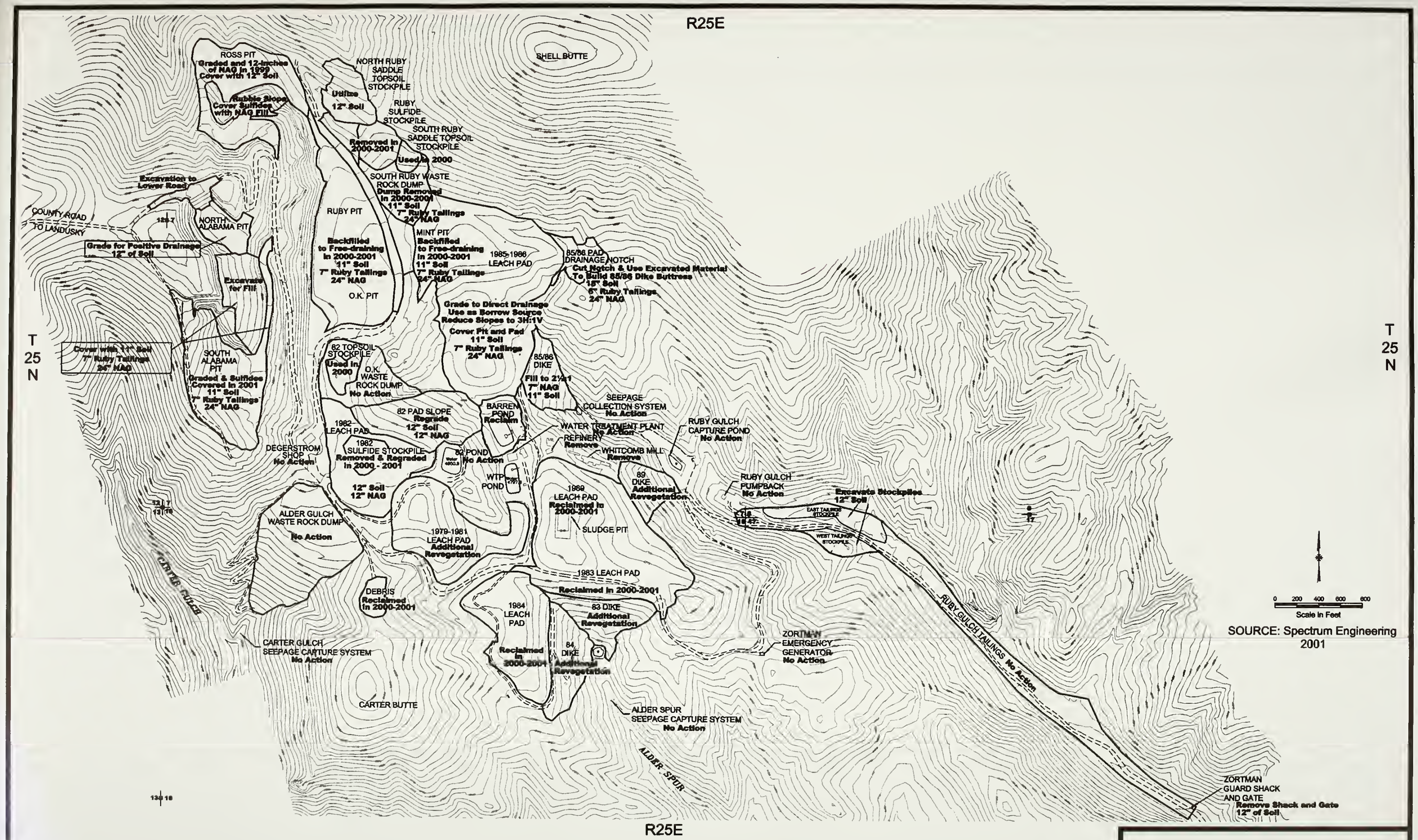
North Alabama and South Alabama Pits

The South Alabama pit grading would be complete after the interim highwall reduction and backfilling work in 2001. The interim backfill would leave a small section of highwall at the north end of the pit. Below this highwall at the upper end of the pit, some of the backfill would be left as steep rubble slopes. The remainder of the backfilled pit, the associated borrow areas, and the pit access road would be covered with 7 inches of Ruby Gulch tailings, 11 inches of soil, and revegetated. Only non-acid generating material would be used as backfill. The final configuration would provide a free draining backfill surface which would cover all sulfide areas in the pit.

The North Alabama pit would be made free draining with minimal earthwork and no need for backfill from external sources. The upper bench between the north and south pits would be covered with 7 inches of Ruby Gulch tailings, 11 inches of soil, and revegetated. The North Alabama pit floor would be covered with 12 inches of soil and revegetated. Upon completion, the highwalls associated with the North Alabama pit (about 220 vertical feet) would be exposed.

Ross Pit

The Ross pit area was partially regraded in 1999, and the flat pit bench was amended with lime to prevent acid generation. Additional interim work in 2001-2002 would cover a portion of the sulfide-bearing highwall and a lower sulfide bench with non-acid generating material. The backfill placed over the highwall would be left as steep rubble slope. The regraded areas would be covered with12 inches of soil and revegetated. Upon completion of reclamation on the Ross pit about 200 vertical feet of highwall would be exposed; however, most of the sulfides would be covered.



ALTERNATIVE Z3: RECLAMATION GOAL IS TO OPTIMIZE SOURCE CONTROL WITHIN THE BOND AMOUNT.

ZORTMAN MINE ALTERNATIVE Z3

FIGURE 2.4-5

O.K./Ruby and Mint Pits

The O.K./Ruby and Mint pits would be backfilled to relatively flat, free-draining surfaces. The top 24 inches of material placed in the backfill would be NAG. The NAG fill would be covered with 7 inches of Ruby Gulch tailings, 11 inches of soil, and revegetated. Upon completion, the highwall of the O.K./Ruby pit above 5,030 feet (the upper 220-300 feet) would be exposed. About 5% of the sulfide zones in the highwalls would be exposed.

Leach Pad Reclamation

There are six leach pads at the Zortman Mine. These include the Z79-81, Z82 , Z83, Z84, Z85/86 and Z89 leach pads. The Z79-81 and Z82 leach pads are free draining into ponds. The other pads have buttresses or dikes associated with them. The existing reclamation on five of these leach pads would be considered final.

Z79-81 Leach Pad

The Z79 leach pad has been covered with 8 to 12 inches of soil. Grass was planted in 1989 and trees were planted in 1990. The Z80-81 leach pad was covered with 8 to 12 inches of soil with grass planted in 1991. Trees were planted in 1992. Additional planting and fertilization would be conducted to enhance the existing vegetation.

Z82 Leach Pad

The Z82 leach pad was backfilled into the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. The leach pad footprint would be graded for positive drainage. The steep fill slope directly below the pad would be regraded at 2.5H:1V. The area below the Z82 pond would be graded at 2H:1V. After grading, the entire pad footprint and these regraded slopes would be covered with 12 inches of NAG, 12 inches of soil, and revegetated.

Z83, Z84, and Z89 Leach Pads

The reclamation done to date on the leach pad retaining dikes would be considered complete. The 6.02-acre Z83 dike was covered with 8 to 12 inches of soil and revegetated in 1992. The Z84 dike, occupying 6.73 acres, was covered with 8 to 12 inches of soil and revegetated in 1992. The Z89 dike, covering 3.87 acres, was covered with 8 to 12 inches of soil and revegetated with grass and trees between 1989 and 1990. Additional planting and fertilization would be conducted to enhance the existing vegetation on these dikes.

Interim reclamation during 1999 through 2001 included regrading the Z83, Z84 and Z89 leach pads to 3H:1V slopes. The regraded surface was sampled for acid generating potential to a depth of 2 feet on a

grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of Ruby Gulch tailings were placed as cover material, followed by 18 inches of soil. All surfaces were seeded in late 2000. This interim reclamation work would be considered final on the Z83, Z84 and Z89 leach pads.

The water treatment plant sludge pit on the Z89 leach pad is expected to be used for many years, as long as the water treatment plant is in operation. When no longer needed the sludge pit would be regraded, covered with soil, and revegetated.

Z85/86 Leach Pad

The north half of the Z85/86 leach pad would be used as a backfill source for reclamation of the O.K./Ruby and Mint pits. This area would be regraded to convey runoff around the north edge of the site and into an undisturbed drainage to the east. A portion of the pad would be excavated to provide about 70,000 cubic yards of material for reclamation of the barren pond.

The remainder of the Z85/86 leach pad would be regraded to 3H:1V slopes. The top 2 feet would be lime amended to ensure 24 inches of NAG. Seven inches of Ruby Gulch tailings and 11 inches of soil would then be placed as cover and the surface would be revegetated. The Z85/86 dike face would be buttressed with 133,000 cubic yards of NAG-quality material to achieve a 2.5H:1V slope. About 42,000 cubic yards of this material would be placed over the dike face during construction of the Z85/86 pad drainage notch. This flattened slope would be covered with 7 inches of NAG, 11 inches of soil, and revegetated.

Waste Rock Dump Reclamation

Alder Gulch Waste Rock Dump

The Alder Gulch waste rock dump would not be removed. The existing reclamation on the dump surface would be the final reclamation.

O.K. Waste Rock Dump

The O.K. waste rock dump would not be removed. The existing reclamation on the dump surface would be left as the final reclamation.

South Ruby Waste Rock Dump

The upper portion of this dump would be used for O.K./Ruby and Mint pit backfill. The remaining 111,000 cubic yards of the South Ruby waste rock dump that was not used as pit backfill would be regraded in place. The top 24 inches of the dump footprint would be amended with lime to produce a

NAG base. The regraded surface would be covered with 7 inches of tailings, 11 inches of soil, and revegetated.

Z82 Sulfide Stockpile

The Z82 sulfide stockpile was placed into the bottom of the O.K. pit, capped with clay and then buried below 100 feet of backfill as part of interim reclamation.

Ruby Sulfide Stockpile

The Ruby sulfide stockpile was placed into the bottom of the O.K. pit along with the Z82 sulfide stockpile, capped with clay and then buried below 100 feet of backfill as part of interim reclamation. The footprint would be reclaimed as part of the South Ruby waste rock dump.

Ruby Gulch Tailings

A portion of the West tailings stockpile was removed to use as soil cover on the Z83, Z84 and Z89 leach pads. The remainder of the West tailings stockpile and the East tailings stockpile would be used as NAG and to supplement the cover soil for the South Alabama, O.K./Ruby, and Mint pits and on the Z85/86 leach pad.

Support Facilities Reclamation

All of the support facilities such as shops, refinery, processing plants, etc. would be removed and their footprints covered with 12 inches of soil and revegetated. The water treatment plant, drainage capture systems, ponds, and associated structures would stay in operation in their current locations. When no longer needed, the water treatment facilities would be removed and their footprint area reclaimed. This alternative does not require additional NAG beyond what would be obtained from the Ruby Gulch tailings stockpiles for the reclamation effort. No new disturbance would be required.

Alternative Z4, Additional Backfilling

Alternative Z4 would not be limited by funding available under the reclamation bonds. The earthwork portion of this alternative is similar to Alternative Z1 with additional backfilling of the mine pits. All acid generating source areas would be covered with a water barrier or water balance reclamation cover, depending upon the steepness of the regraded slope. The reclamation action for each mine feature is shown in Figure 2.4-6. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

North Alabama and South Alabama Pits

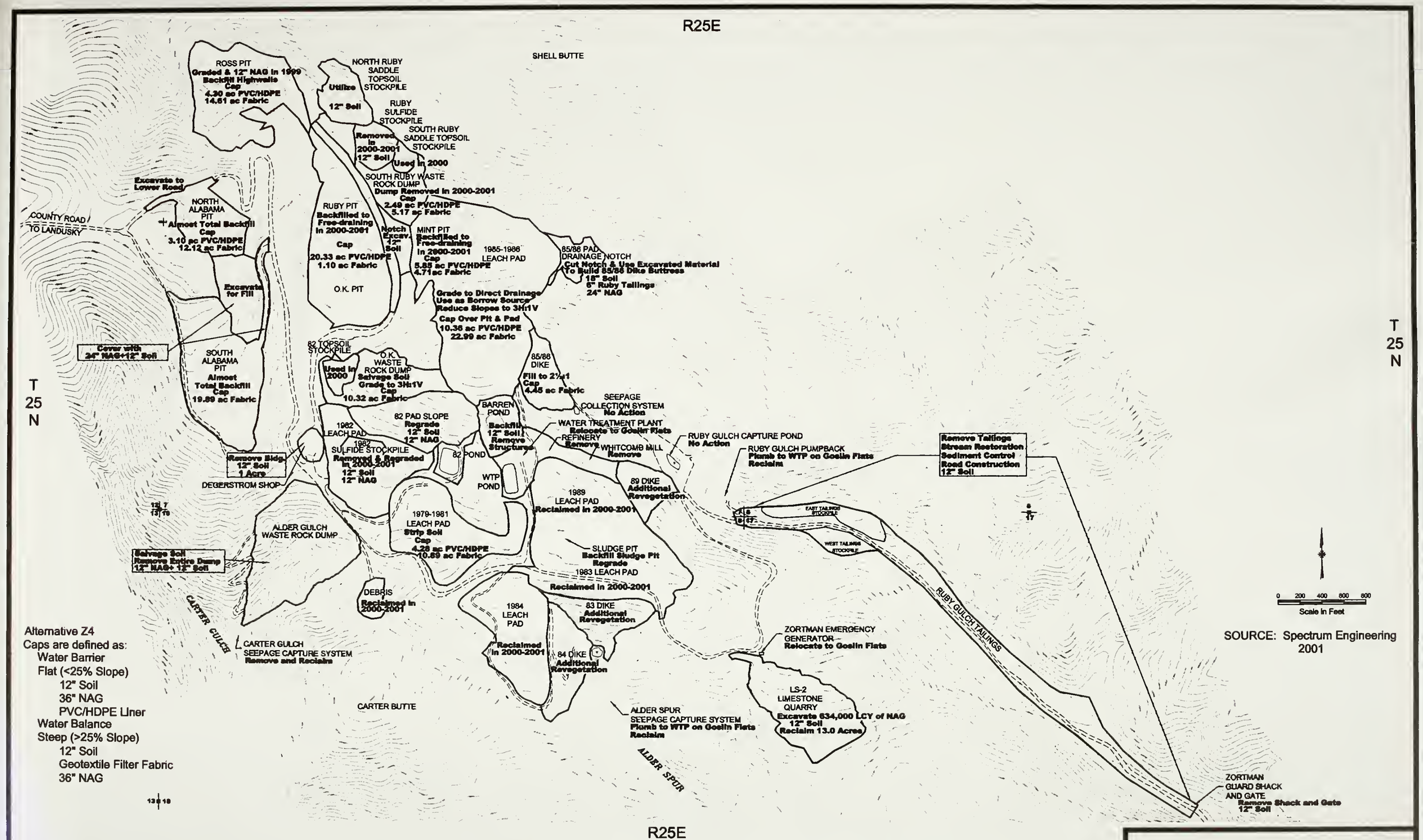
The North Alabama pit would be almost completely backfilled with material from the Alder Gulch waste rock dump. The west highwall of the South Alabama pit would first be reduced by blasting then the remainder of the pit would be almost completely backfilled with material from the Alder Gulch waste rock dump. The regraded areas would be covered with 4-foot thick water barrier or water balance reclamation covers and revegetated. Upon completion, a maximum of 90 vertical feet of the North Alabama pit highwall would be exposed and 50 vertical feet of the South Alabama pit highwall on the north end of the pit would be exposed.

Ross Pit

In addition to interim grading and backfilling, all of the sulfide zones in the highwalls within the Ross pit would be covered with material from the Alder Gulch waste rock dump. The Ross pit would be backfilled to an overall slope of 2.7H:1V. A flat spot 300 feet deep into the hillside and 600 feet along the hillside would not be backfilled. A small section at the top of the highwall would also be left uncovered by backfill. The slopes would be covered with a geotextile filter fabric and the flat bench would be covered with a geosynthetic liner. The reclamation covers would consist of 36 inches of NAG, 12 inches of soil, and revegetation. Upon completion, only a small upper area of the highwall would be left exposed.

O.K./Ruby and Mint Pits

The O.K./Ruby and Mint pits would be backfilled to free draining surfaces. The graded backfill surface on the O.K./Ruby would be lined with clay before being covered with 20.33 acres of water barrier cover and 1.10 acres of water balance cover. The Mint would be covered with 5.85 acres of water barrier cover and 4.71 acres of water balance cover. The water barrier covers would consist of a geosynthetic liner covered by 36 inches of NAG and 12 inches of soil. The water barrier covers would be constructed with geotextile filter fabric sandwiched between 36 inches of NAG and 12 inches of soil. Upon completion, most of the O.K./Ruby pit highwall above 5,030 feet (the upper 200-280 feet) would be left exposed.



ALTERNATIVE Z4: RECLAMATION GOAL IS TO BACKFILL ALL PITS AND PARTIALLY BACKFILL THE HIGHWALLS. PITS ARE COVERED WITH GEOSYNTHETIC LINERS IN ASSOCIATION WITH THREE FEET OF NAG AND/OR TAILINGS AND ONE FOOT OF SOIL.

ZORTMAN MINE ALTERNATIVE Z4

FIGURE 2.4-6

Leach Pad Reclamation

There are six leach pads at the Zortman Mine. These include the Z79-81, Z82 , Z83, Z84, Z85/86 and Z89 leach pads. The Z79-81 and Z82 leach pads are free draining into ponds. The other leach pads have buttresses or dikes associated with them.

Z79-81 Leach Pad

The Z79 leach pad has been covered with 8 to 12 inches of soil. Grass was planted in 1989 and trees were planted in 1990. The Z80-81 leach pads were covered with 8 to 12 inches of soil with grass planted in 1991. Trees were planted in 1992. Due to the sparseness of the existing revegetation, the existing vegetation and soil would be stripped from the Z79 and Z80-81 leach pads. The surface would be covered with water barrier or water balance covers, depending on slope steepness, and revegetated.

Z82 Leach Pad

The Z82 leach pad was backfilled into the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. The leach pad footprint would be graded for positive drainage. The steep fill slope directly below the pad would be regraded at 2.5H:1V. The area below the Z82 pond would be graded at 2H:1V. After grading, the entire pad footprint and these regraded slopes would be covered with 12 inches of NAG, 12 inches of soil, and revegetated.

Z83, Z84, and Z89 Leach Pads

Reclamation work was conducted on these leach pad dikes about ten years ago. The 6.02-acre Z83 dike was covered with 8 to 12 inches of soil and revegetated in 1992. The Z84 dike, occupying 6.73 acres, was covered with 8 to 12 inches of soil and revegetated in 1992. The Z89 dike, covering 3.87 acres, was covered with 8 to 12 inches of soil and revegetated with grass and trees between 1989 and 1990. Additional planting and fertilization would be conducted to enhance the existing vegetation on these dikes.

Interim reclamation during 1999 through 2001 included regrading the Z83, Z84 and Z89 leach pads to 3H:1V slopes. The regraded surface was sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of Ruby Gulch tailings were placed as cover material, followed by 18 inches of soil. All surfaces were seeded in later 2000. The interim reclamation on these leach pads would be considered final.

After relocating the water treatment plant to Goslin Flats, the sludge pit on the Z89 leach pad would be backfilled, covered with soil, and revegetated.

Z85/86 Leach Pad

The north half of the Z85/86 leach pad would be used as a backfill source for reclamation of the O.K./Ruby and Mint pits. This area would be regraded to convey runoff around the north edge of the site and into an undisturbed drainage to the east. A portion of the pad would be excavated to provide about 70,000 cubic yards of material for reclamation of the barren pond.

The remainder of the Z85/86 leach pad would be regraded to 3H:1V slopes. The entire pad would be covered with 10.36 acres of water barrier cover and 22.99 acres of water balance cover, depending on slope steepness. The leach pad would then be revegetated. The Z85/86 dike face would be buttressed with 133,000 cubic yards of NAG-quality material to achieve a 2.5H:1V slope. About 42,000 cubic yards of this material would be placed over the dike face during construction of the Z85/86 pad drainage notch. This flattened slope would be covered with a water balance cover consisting of 36 inches of NAG, a geotextile filter fabric, 12 inches of soil, and revegetated.

Waste Rock Dump Reclamation

Alder Gulch Waste Rock Dump

The entire Alder Gulch waste rock dump would be removed and used to backfill the North Alabama, South Alabama, and Ross pits. The regraded footprint would be sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential would be neutralized with lime. After liming, 12 inches of NAG would be placed as cover, followed by 12 inches of soil, and the area would be revegetated.

O.K. Waste Rock Dump

The O.K. waste rock dump would be re-reclaimed. The soil would be stripped and the dump regraded to 3H:1V slopes. The regraded surface would be tested and lime would be applied to neutralize areas with a net acid generating potential. The surface would then be covered with 36 inches of NAG, a geotextile filter fabric, 12 inches of soil, and revegetated.

South Ruby Waste Rock Dump

The upper portion of this dump would be used for O.K./Ruby and Mit pit backfill. The remainder of the South Ruby waste rock dump that was not placed as pit backfill (about 111,000 cubic yards) would be regraded in place. The regraded dump surface would be covered with 2.49 acres of water barrier and 5.17 acres of water balance cover, depending on slope steepness. In those areas of the footprint where native ground would be exposed, the reclamation cover would be 12 inches of soil.

Z82 Sulfide Stockpile

The Z82 sulfide stockpile was placed into the bottom of the O.K. pit, capped with clay and then buried below 100 feet of backfill as part of interim reclamation.

Ruby Sulfide Stockpile

The Ruby sulfide stockpile was placed into the bottom of the O.K. pit along with the Z82 sulfide stockpile, capped with clay and then buried below 100 feet of backfill. The footprint would be reclaimed as part of the South Ruby waste rock dump.

Ruby Gulch Tailings

The Ruby Gulch drainage bottom from the Ruby Gulch pumpback to the Zortman guard shack would be restored by removal of the tailings in the two stockpiles and in the stream bottom. The streambed would be reconstructed and sediment controls would be put into place. The county road would be moved from the drainage bottom to the old roadbed on the north side of the drainage. Tailings removed from the stockpiles and streambed would be hauled up to the mine area where they would be spread as part of the reclamation cover material. The entire drainage area would be covered with 12 inches of soil over the native ground surface and revegetated. The soil used for reclamation would be stripped from the water treatment plant construction area on Goslin Flats.

Support Facilities Reclamation

All of the support facilities would be removed and their footprints covered with 12 inches of soil and revegetated. The water treatment plant, ponds, and associated structures would be relocated to Goslin Flats. Pipelines would be constructed to route captured seepage to the Goslin Flats water treatment plant. When no longer needed, the Goslin Flats water treatment plant would be dismantled and the disturbance footprint reclaimed with 12 inches of soil and revegetated.

Limestone Quarry

Approximately 634,000 loose cubic yards of NAG would be mined for use in reclamation. This material would be quarried from the 13-acre limestone quarry LS-2. The soil would be stripped from the quarry area and stockpiled for use in reclamation. After the limestone is mined, the area would be regraded, covered with soil, and revegetated.

Alternative Z5, Extensive Backfilling

This alternative includes complete backfilling of all mine pits to approximate pre-mine topography using the Alder Gulch waste rock dump and the Z85/86 leach pad as sources of fill. A water barrier cover would be used only over the O.K./Ruby pit. Other reclaimed surfaces would be covered with 8 inches of soil and 10 to 34 inches of tailings or NAG. Where feasible, lime amendment in the top 24 inches of the regraded surface would be utilized in place of hauling in NAG. The reclamation action for each mine feature is shown in Figure 2.4-7. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

North Alabama and South Alabama Pits

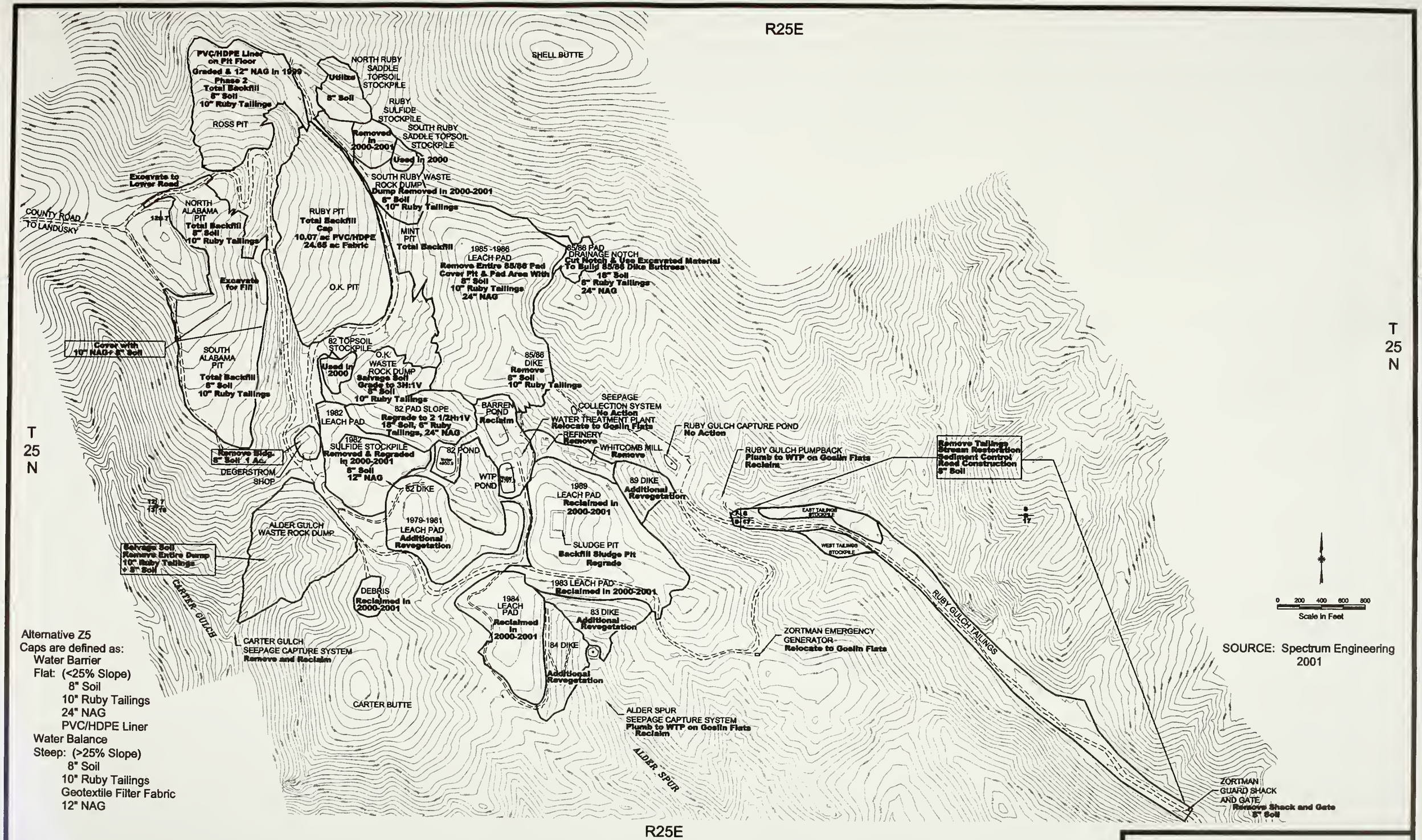
The North and South Alabama pits would be backfilled with material from the Alder Gulch waste rock dump and the Z85/86 leach pad. The North Alabama would receive an additional 92,000 cubic yards more backfill under Alternative Z5 than under Alternative Z4. Reclamation of the South Alabama would also involve reduction of its west highwall. The regraded surfaces would be covered with 10 inches of tailings, 8 inches of soil, and revegetated. Upon completion, only small portions of the highwall in both pits would be exposed.

Ross Pit

A geosynthetic liner would be installed on the floor of the Ross pit. All of the sulfide highwalls within the Ross pit would be covered by backfill. The Ross pit backfill would be graded to a 3H:1V slope to approximate the pre-mine topography. An estimated 307,000 cubic yards from the Alder Gulch waste rock dump and 632,000 cubic yards from the Z85/86 leach pad would be used as backfill sources. The regraded slopes would be covered with 10 inches of tailings, 8 inches of soil, and revegetated. Upon completion, none of the Ross pit highwall would be exposed.

O.K./Ruby and Mint Pits

An additional 3,909,000 cubic yards of material would be backfilled over the interim reclamation backfill. On the flat slopes (10.07 acres) the O.K./Ruby pit would be capped with a water barrier cover. The steep slopes (24.65 acres) would be covered with a water balance cover. The Mint pit would be covered with 24 inches of NAG, 10 inches of Ruby Gulch tailings, and 8 inches of soil. All surfaces would be revegetated. Upon completion of backfilling and grading, all of the O.K./Ruby and Mint pit highwalls would be covered. No sulfide-bearing highwalls would be exposed.



ALTERNATIVE Z5: RECLAMATION GOAL IS TOTAL BACKFILL OF PITS AND HIGHWALLS.

ZORTMAN MINE ALTERNATIVE Z5

FIGURE 2.4-7

Leach Pad Reclamation

There are six leach pads at the Zortman Mine. These include the Z79-81, Z82 , Z83, Z84, Z85/86 and Z89 leach pads. The Z79-81 and Z82 leach pads are free draining into ponds. The other leach pads have buttresses or dikes associated with them.

Z79-81 Leach Pad

The Z79 leach pad has been covered with 8 to 12 inches of soil. Grass was planted in 1989 and trees were planted in 1990. The Z80-81 leach pad was covered with 8 to 12 inches of soil with grass planted in 1991. Trees were planted in 1992. Additional planting and fertilization would be conducted to enhance the existing vegetation

Z82 Leach Pad

The Z82 leach pad was backfilled into the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. The leach pad footprint would be graded for positive drainage. The steep fill slope directly below the pad would be regraded at 2.5H:1V. The area below the Z82 pond would be graded at 2H:1V. After grading, the entire pad footprint and these regraded slopes would be covered with 12 inches of NAG, 8 inches of soil, and revegetated.

Z83, Z84, and Z89 Leach Pads

The reclamation done to date on the leach pad retaining dikes would be considered complete. The 6.02-acre Z83 dike was covered with 8 to 12 inches of soil and revegetated in 1992. The Z84 dike, occupying 6.73 acres, was covered with 8 to 12 inches of soil and revegetated in 1992. The Z89 dike, covering 3.87 acres, was covered with 8 to 12 inches of soil and revegetated with grass and trees between 1989 and 1990. Additional planting and fertilization would be conducted to enhance the existing vegetation on these dikes.

Interim reclamation during 1999 through early 2001 included regrading the Z83, Z84 and Z89 leach pads to 3H:1V slopes. The regraded surface was sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of Ruby Gulch tailings were placed as cover material, followed by 18 inches of soil. All surfaces were seeded in late 2000. This interim reclamation work would be accepted as the final reclamation. After relocating the existing water treatment plant to Goslin Flats, the sludge pit on top of the Z89 leach pad would be backfilled, covered with soil, and revegetated.

Z85/86 Leach Pad

The entire Z85/86 leach pad would be removed from the upper Ruby Gulch drainage and used to backfill the mine pits and the barren pond. The entire leach pad footprint area would be covered with 24 inches of NAG, 10 inches of Ruby Gulch tailings, 8 inches of soil, and revegetated. The entire Z85/86 dike would be removed, restoring the area to its original topography. The footprint area would be covered with 10 inches of Ruby Gulch tailings, 8 inches of soil, and revegetated. The drainage notch used during interim reclamation would be covered with soil and revegetated.

Waste Rock Dump Reclamation

Alder Gulch Waste Rock Dump

The Alder Gulch waste rock dump would be removed and used as backfill in the North Alabama, South Alabama, and Ross pits. The regraded footprint would be sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential would be neutralized with lime. After liming, 10 inches of Ruby Gulch tailings would be placed over the footprint, followed by 8 inches of soil, and the area would be revegetated.

O.K. Waste Rock Dump

The O.K. waste rock dump would be re-reclaimed. Soil would be stripped and the dump would be regraded to 3H:1V slopes. After being sampled for acid generating potential, the surface would be covered with 10 inches of Ruby Gulch tailings, 8 inches of soil, and revegetated.

South Ruby Waste Rock Dump

Most of the South Ruby waste rock dump would be used for O.K./Ruby and Mint pit backfill. About 111,000 cubic yards not used as pit backfill would be regraded in place. The entire regraded surface would be covered with 24 inches of NAG, 10 inches of Ruby Gulch tailings, 8 inches of soil, and revegetated.

Z82 Sulfide Stockpile

The Z82 sulfide stockpile was placed into the bottom of the O.K. pit, capped with clay and then buried below 100 feet of backfill as part of interim reclamation.

Ruby Sulfide Stockpile

The Ruby sulfide stockpile was placed into the bottom of the O.K. pit along with the Z82 sulfide stockpile, capped with clay and then buried below 100 feet of backfill. The footprint would be reclaimed as part of the South Ruby waste rock dump.

Ruby Gulch Tailings

The Ruby Gulch drainage bottom from the Ruby Gulch pumpback to the Zortman guard shack would be restored by removal of the tailings in the two stockpiles and in the stream bottom. The streambed would be reconstructed and sediment controls would be put into place. The county road would be moved from the drainage bottom to the old roadbed on the north slope of the drainage. Tailings removed from the stockpiles and streambed would be hauled up to the mine area where they would be spread as part of the reclamation cover material. The entire drainage area would be covered with 8 inches of soil over the native ground surface and revegetated. The soil used for reclamation would be stripped from the water treatment plant construction area on Goslin Flats.

Support Facilities Reclamation

All of the support facilities would be removed and their footprints covered with 12 inches of soil and revegetated. The water treatment plant, ponds, and associated structures would be relocated to Goslin Flats. Pipelines would be constructed in Ruby Gulch and Alder Gulch to route captured seepage to the Goslin Flats water treatment plant. When no longer needed, the Goslin Flats water treatment plant and the seepage transport pipelines would be dismantled and the disturbance footprint reclaimed with 12 inches of soil and revegetated.

Alternative Z6, Optimize Grading for Source Control (Preferred Alternative)

Alternative Z6 would not be limited by the funding available under the reclamation bonds. The earthwork portion of this alternative combines aspects of Alternatives Z3 and Z4. It limits removal of the Alder Gulch waste rock dump to the top lifts. Material excavated from the Alder Gulch waste rock dump would be placed into the North Alabama pit. Additional backfilling in the Ross pit with NAG from the area between the North and South Alabama pits would be used to cover exposed sulfides. Water barrier reclamation covers would be placed over the excavation area on the Alder Gulch waste rock dump, over the backfilled area in the North Alabama pit, and over the backfill in the O.K./Ruby pit. All other areas would be covered with 6 inches of tailings and 18 inches of soil. Because only about half of the necessary soil would be available on the site, soil would be transferred from the Landusky Mine. The water treatment plant would be left in its present location. The reclamation action for each mine feature is shown in Figure 2.4-8. Those mine features considered reclaimed and not receiving additional reclamation work under this alternative are marked "No Action" or "Reclaimed in 2000-2001."

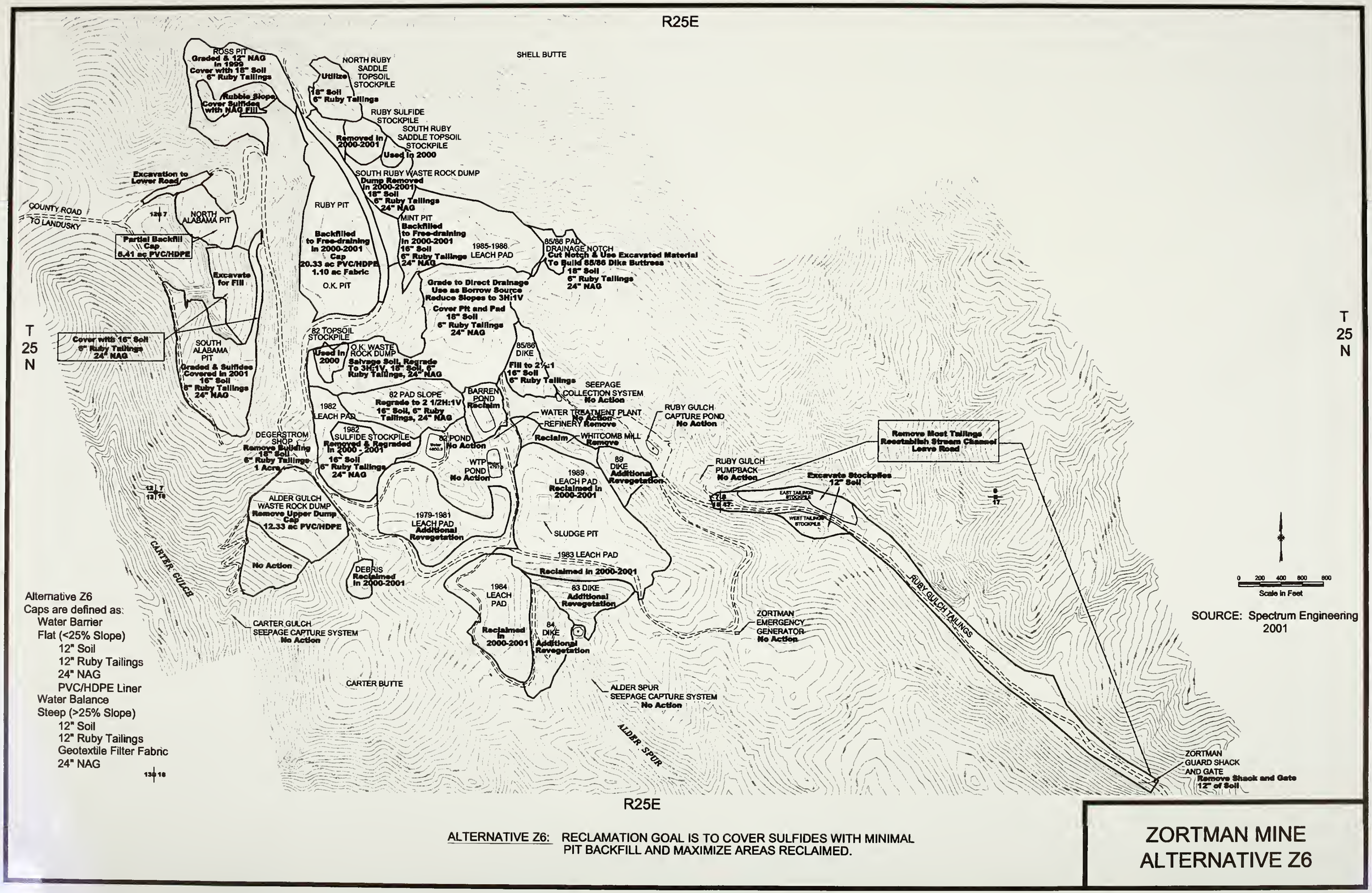
Mine Pit Reclamation

South Alabama Pit

The South Alabama pit grading would be complete after the interim highwall reduction and backfilling work in 2001. The interim backfill would leave a small section of highwall at the north end of the pit. Below this highwall at the upper end of the pit, some of the backfill would be left as steep rubble slopes. The remainder of the backfilled pit, the associated borrow areas, and the pit access road would be covered with 6 inches of tailings, 18 inches of soil, and revegetated. Only non-acid generating material would be used as backfill. The final configuration would provide a free draining backfill surface which would cover all sulfide areas in the pit.

North Alabama Pit

The North Alabama pit would be backfilled with 432,000 cubic yards of material from the Alder Gulch waste rock dump. The backfill would be graded at a 4.5H:1V slope, which would raise the backfill up to the level of the county road on the north wall of the pit. About 100 vertical feet of highwall would remain below the peak on the west side of the pit. A 20-30 foot ledge would also be left exposed on the east side of the pit. The remainder of the pit would be backfilled and completely covered with a synthetic liner. A cover consisting of 24 inches of NAG, 12 inches of tailings, and 12 inches of soil would be placed over the liner and revegetated.



ALTERNATIVE Z6: RECLAMATION GOAL IS TO COVER SULFIDES WITH MINIMAL PIT BACKFILL AND MAXIMIZE AREAS RECLAIMED.

ZORTMAN MINE ALTERNATIVE Z6

FIGURE 2.4-8

Ross Pit

The Ross pit was partially regraded as part of interim reclamation and the flat pit bench was limed to prevent acid generation. A portion of the sulfide-bearing highwall and a lower sulfide bench would be covered with 133,000 cubic yards of non-acid generating material borrowed from the disturbed area between the North and South Alabama pits. About 200 vertical feet of highwall that is partially broken by benches would be left above the backfilled area. The top of the backfill would be configured as a bench extending out from the highwall. Below the graded upper bench, the fill would extend down to the floor of the pit as a steep, rubble slope. The pit floor and all regraded areas except the rubble slope would be covered with 6 inches of tailings, 18 inches of soil, and revegetated.

O.K./Ruby Pit

The O.K./Ruby pit would be backfilled to a free draining configuration. Approximately 20 acres of this backfill surface would be covered with 24 inches of NAG, a geosynthetic liner, 12 inches of tailings and 12 inches of soil. The remaining 1.10 acres would be covered with a 4-foot thick water balance cover. The entire regraded area except for the pit rim road would be revegetated. Upon completion, most of the O.K./Ruby pit highwall above 5,030 feet (the upper 200-280 feet) would be exposed. However, the backfill would still cover most of the sulfide areas.

Mint Pit

The Mint pit was backfilled under interim reclamation. The backfill surface would be tested for acid generating potential, limed if necessary, and then covered with 6 inches of tailings, 18 inches of soil, and revegetated.

Leach Pad Reclamation

There are six leach pads at the Zortman Mine. These include the Z79-81, Z82, Z83, Z84, Z85/86 and Z89 leach pads. The Z79-81 and Z82 leach pads are free draining into ponds. The other leach pads have buttresses or dikes associated with them.

Z79-81 Leach Pad

The Z79 leach pad has been covered with 8 to 12 inches of soil. Grass was planted in 1989 and trees were planted in 1990. The Z80-81 leach pad was covered with 8 to 12 inches of soil with grass planted in 1991. Trees were planted in 1992. Additional planting and fertilization would be conducted to enhance the existing vegetation.

Z82 Leach Pad

The Z82 leach pad was backfilled into the O.K./Ruby pit as part of the Zortman Pit Backfill Interim Reclamation Project. The leach pad footprint would be graded for positive drainage. The steep fill slope directly below the pad would be regraded to a 2.5H:1V slope. Regrading would also be conducted on the area below the Z82 pond, which would be graded at a 2H:1V slope. After grading, the entire pad footprint and these regraded slopes would be covered with 6 inches of tailings, 18 inches of soil, and revegetated.

Z83, Z84, and Z89 Leach Pads

The reclamation done to date on the leach pad retaining dikes would be considered complete. The 6.02-acre Z83 dike was covered with 8 to 12 inches of soil and revegetated in 1992. The Z84 dike, occupying 6.73 acres, was covered with 8 to 12 inches of soil and revegetated in 1992. The Z89 dike, covering 3.87 acres, was covered with 8 to 12 inches of soil and revegetated with grass and trees between 1989 and 1990. Additional planting and fertilization would be conducted to enhance the existing vegetation.

Interim reclamation during 1999 through 2001 included regrading the Z83, Z84 and Z89 leach pads to 3H:1V slopes. The regraded surfaces were sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of Ruby Gulch tailings were placed as cover material, followed by 18 inches of soil. All surfaces were seeded in late 2000. The interim reclamation on these leach pads would be considered the final reclamation.

The water treatment plant sludge pit on the Z89 leach pad is expected to be used for as long as the water treatment plant is in operation. When no longer needed the sludge pit would be regraded, covered with soil, and revegetated.

Z85/86 Leach Pad

The north half of the Z85/86 leach pad was used as a backfill source for reclamation of the O.K./Ruby and Mint pits. This area would be regraded to convey runoff around the north edge of the site and into an undisturbed draw on the east edge of the site. A portion of the pad would also be excavated to provide about 70,000 cubic yards of material for reclamation of the barren pond and the bench on which it is located.

Approximately 300,000 cubic yards of additional grading would be conducted to regrade the south half of this pad to a free draining surface with maximum 3H:1V slopes. The surface configuration would tie into the O.K. waste rock dump regrade and would include moving part of this material off the lined area to contour adjacent areas. Following grading, the entire pad along with its associated fill and borrow areas would be sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids

with a net acid potential would be neutralized with lime. After liming, 6 inches of Ruby Gulch tailings and 18 inches of soil would be used to cover the regraded area, and the entire area would then be revegetated.

The Z85/86 dike face would be buttressed with 133,000 cubic yards of NAG-quality material to achieve a 2.5H:1V slope. About 42,000 cubic yards of this material would be placed over the dike face during construction of the Z85/86 leach pad drainage notch. The remainder of the fill would be obtained by selectively excavating material from the O.K. waste rock dump and the Z85/86 leach pad. After grading the fill, 6 inches of Ruby Gulch tailings and 18 inches of topsoil would be used to cover the buttressed area. The entire area would then be revegetated.

Waste Rock Dump Reclamation

Alder Gulch Waste Rock Dump

The upper 432,000 cubic yards in the Alder Gulch waste rock dump would be removed and used to backfill the North Alabama pit. Prior to excavation, the existing reclamation soil would be stripped and stockpiled for re-use. The top section of the dump would then be excavated to a maximum 20% grade so that the entire top of the remaining portion of the dump could be covered with a water barrier cover. The cover would consist of 24 inches of NAG, a geosynthetic liner, 12 inches of tailings, and 12 inches of soil. The redisturbed area would be revegetated.

O.K. Waste Rock Dump

The O.K. waste rock dump would be re-reclaimed. After soil has been salvaged from the dump face, the dump would be regraded to 3H:1V slopes. In conjunction with this work, subsidence areas on the north side of the dump would be backfilled and the sump below the dump would be eliminated. After grading, the regraded surface would be sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential would be neutralized with lime. After liming, 6 inches of tailings would be placed, followed by 18 inches of soil. The regraded area would then be revegetated.

South Ruby Waste Rock Dump

The upper portion of this dump would be used to backfill the O.K./Ruby and Mint pits. The remaining 111,000 cubic yards of the South Ruby waste rock dump that was not used as backfill would be regraded. The regraded surface would be sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential would be neutralized with lime. After liming, 6 inches of tailings would be placed, followed by 18 inches of soil. The reclaimed surface would then be revegetated.

Z82 Sulfide Stockpile

The Z82 sulfide stockpile was placed into the bottom of the O.K. pit, capped with clay and then buried below 100 feet of backfill as part of interim reclamation.

Ruby Sulfide Stockpile

The Ruby sulfide stockpile was placed in the bottom of the O.K. pit along with the Z82 sulfide stockpile as part of interim reclamation. A clay layer was placed over the top of these sulfides and an additional 100 feet of backfill would be placed over this material.

Ruby Gulch Tailings

Nearly all of the tailings in the Ruby Gulch drainage bottom from the Ruby Gulch pumpback to the Zortman guard shack would be used as reclamation materials at the Zortman Mine. After removal of the tailings, the streambed would be reconstructed with sediment controls. The county road would be rebuilt where necessary.

Support Facilities Reclamation

All support facilities such as shops, refinery, processing plants, ponds, etc. would be removed and their footprints covered with 6 inches of tailings, 18 inches of soil, and revegetated. The water treatment plant, drainage capture systems, ponds, and associated structures would stay in operation in their current locations. Once no longer needed, the water treatment plants would be removed and their footprint area reclaimed with soil and revegetated. This alternative does not require additional NAG to support the reclamation effort beyond what can be obtained from the tailings in Ruby Gulch and from previously disturbed mine areas. There would be no new disturbance to obtain reclamation materials.

2.4.3 Landusky Mine Reclamation Alternatives

Section 2.4.3 presents a description of the six reclamation alternatives developed for the Landusky Mine. Although the alternatives vary in emphasizing certain aspects of reclamation, all alternatives were formulated by the agencies' engineering consultants, under the direction of the technical working group, to meet the applicable regulatory requirements and standards for mine reclamation. The major difference between alternatives is the amount of pit backfill placed in the mine pits. The amount of backfilling required under each alternative determines whether additional mine dumps or spent ore heaps are picked up and placed back into the pits. Another difference in the alternatives is the method of ensuring free draining conditions from the pit complex, with some alternatives using surface drainage and some groundwater discharge.

Alternative L1 is the same as that initially selected in the agencies' June 1998 Record of Decision, and is based on Alternative 3 of the FEIS.

Alternative L2 is designed to be affordable within the existing reclamation bond amount. Leach pad slopes would be regraded, covered with soil, and revegetated. The pit complex would be drained via the existing artesian well. A partial drainage notch would be cut around the west side of the L85/86 leach pad in order to restore drainage to a tributary to Montana Gulch.

Alternative L3 includes all provisions of Alternative L2, plus a few more reclamation features that are beyond the existing reclamation bond amount. The pit complex would be drained via an 8-inch diameter directional drill hole into Montana Gulch. Sulfides exposed in the highwall and upper bench of the Suprise pit would be covered. A full drainage notch would be constructed on the west side of the L85/86 leach pad to eliminate standing water.

Alternative L4 is not restricted by the reclamation bond amounts. The entire L85/86 leach pad and dike would be completely removed from the Montana Gulch drainage. This material would be used to cover highwalls and to partially backfill the August/ Little Ben pit. Sulfides exposed in the highwall and upper bench of the Suprise pit would also be covered using material from the August #2 waste rock dump. The pit complex would be drained via groundwater discharge through the existing artesian well. An 8-inch diameter directional drill hole into Montana Gulch could also be provided as a backup drainage measure. In the Gold Bug pit, highwall reduction would be used to cover pit walls. The L87/91 leach pad would be reclaimed in place with the spent ore regraded to an overall slope of 2.5H:1V.

Alternative L5 includes additional backfill in the pit to cover most of the sulfide highwalls. The L85/86 leach pad and dike, and much of the L87 leach pad spent ore would be removed and used as backfill in the mine pits. A synthetic liner would be installed over the entire floor of the pit complex prior to backfilling. A small notch would be cut through the highwall at the south end of the pit complex to provide drainage from the pit area.

Alternative L6 includes backfilling of the mine pits to restore the pit areas to their approximate pre-mining topography and drainage pattern. The north-south drainage divide would be re-established. All regraded surfaces in the pit area and on the L87/91 leach pad would be covered with low-infiltration water barrier or water balance reclamation covers, depending on slope steepness. Prior to backfill, impermeable liners would be installed over the pit floors in the August/Little Ben/Suprise/Queen Rose pit complex.

Reclamation Common Among Landusky Mine Alternatives

Water Management

This section presents an overview of water management plans at the Landusky Mine which would occur under all alternatives to mitigate water quality impacts from mine facility discharges. It includes a description of measures that have been implemented for management of process waters, stormwaters and mine drainage. This section is divided into discussions on surface water runoff control, water capture, water treatment and land application disposal.

Surface Water Runoff Control

The Gold Bug, Queen Rose and Suprise pits would be free draining. The pit floors would be sloped to prevent impoundment of runoff in the pit. Currently, water which infiltrates through the August/Little Ben pit area enters the groundwater system and reports to the artesian well designated WS3. This flow is then routed to the Landusky Mine water treatment plant where it is treated and discharged to Montana Gulch. Options for routing runoff through the August/Little Ben pit area are developed in the alternatives.

In King Creek, the historic mine tailings downstream from the Landusky Mine have been removed and the channel has been rehabilitated. The tailings have been placed as reclamation cover material on the L80-82, L83, and L84 leach pads. This action took place during the summer of 2000 as part of an EPA removal action.

Water Capture

The water capture structures in upper Montana Gulch, lower Montana Gulch, Mill Gulch, and Sullivan Gulch would remain in place as long as needed to capture seepage that would impact water quality. These capture systems would be upgraded as necessary under all reclamation alternatives so that downstream water quality at the points of compliance meets the requirements in the MPDES permit. Seepage capture systems and semi-passive treatment systems may be placed in King Creek and Swift Gulch, depending upon future monitoring results and feasibility studies.

Water Treatment

ZMI constructed a water treatment plant at the Landusky Mine in 1997 to treat water discharging from the old underground mine workings and the seepage capture systems. The plant treats around 22 million gallons per month on a 24-hour per day, 7-day per week basis. Interim effluent discharge standards for the water treatment plant were established under the 1996 Consent Decree. Establishment of final effluent limits and outfall points would occur as part of MPDES permit development (Appendix C). The water treatment plant would continue to operate indefinitely, as long as there is water being captured that requires treatment.

Leach Pad Water Land Application Disposal

Water drained from the leach pads at the Landusky Mine would continue to be pumped to the Z82 pond at the Zortman Mine for treatment with hydrogen peroxide to detoxify residual cyanide. It then enters the pipeline for transport to Goslin Flats where the pad water is land applied. All solutions must be at or below 0.22 mg/l WAD cyanide prior to land application. Operation of the Goslin Flats land application area is described in Section 2.4.1, Leach Pad Water Land Application Disposal, as part of the reclamation actions common to both mines.

Water Resources Monitoring

The monitoring program for groundwater and surface water would continue as currently required under the Consent Decree until replaced by the MPDES permit. A monitoring program containing the combined requirements of the Consent Decree, MPDES permit (Appendix C), and mine operating plans would be established.

Reclamation Materials

Reclamation materials would be required for construction and installation of the reclamation covers, and for construction of runoff drains and diversions. The primary reclamation materials to be used are cover soil, existing non-acid generating rock, rock amended with lime, limestone quarried on site, and the King Creek tailings. In addition, the water barrier covers would incorporate the use of a geosynthetic clay liner or synthetic liner. Water balance covers would use a geotextile filter fabric.

Tailings

The King Creek tailings, excavated as part of a removal action by EPA, are suitable as reclamation cover material. Approximately 75,000 cubic yards of tailings have been placed on the lower leach pads (L80-82, L83 and L84). This provided a 6-inch thick layer of tailings over the regraded leach pad surface.

Limestone/Dolomite

Limestone from existing stockpiles would be used to line drainages where durable material was required. Under some of the alternatives, such as L1, limestone would be quarried from adjacent areas for use in reclamation.

Soil

Soil salvaged during mine construction and operation would be applied over the regraded mine disturbances as the final 12- to 24-inch lift on the reclamation covers. Soil for reclamation at the Landusky Mine would be obtained from one of four stockpiles: the Montana Gulch soil stockpile, Gold Bug soil

stockpile, August/Little Ben soil stockpile, or Mill Gulch soil stockpile. The approximate total volume of soil available in these stockpiles is 1,780,000 cubic yards.

Based on the estimated amounts in the soil stockpiles, there appears to be more than adequate soil stockpiled at the Landusky Mine to construct the various alternative reclamation covers. Excess soil from the Landusky Mine stockpiles would then be used to supplement the limited supply of soil available at the Zortman Mine.

Support Facilities Reclamation

All cement structure footings and pads would be removed and used to help backfill depressions or openings such as ponds, or would be disposed of as solid waste. The footprint of mine facilities that have been removed would be covered with 12 inches of soil and revegetated.

Access and Haul Road Reclamation/Relocation

All alternatives would leave post-reclamation access roads between the Zortman and Landusky Mines over Antoine Butte. The access roads from the Landusky Mine to the communities of Hays and Landusky would remain in place, although their use may be restricted. Roads would also be left to provide access to the water treatment plants and the seepage capture systems.

Gold Bug Waste Repository

The Gold Bug waste repository was designed to hold acid generating waste. Construction began in 1993 with plans to ultimately contain 21.7 million tons of waste. However, only the first stage of construction (11 million tons) and a small portion of the second phase were completed before the mine ceased operation in 1996. The repository is estimated to contain a total of 13.4 million tons of waste. This quantity includes the lower Gold Bug blue waste stockpile, which was constructed in the southeast corner of the facility over the lower repository fill, and the upper Gold Bug blue waste stockpile.

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, the more sulfidic "green" waste materials were selectively placed toward the interior of the facility. The margins were filled with "yellow" wastes having an average net neutralization potential of near zero. At the 4740 level, a 6-inch barrier was installed to separate the upper repository from the lower repository. This layer was inclined with a 2% grade that was contoured to direct leachate to the southwest. A collection trough was constructed to convey these fluids to the repository toe at the southern end of the repository, where they can be collected.

Slopes on the completed portion of the repository were reclaimed by placing a 6-inch layer of compacted clay over the graded yellow 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.

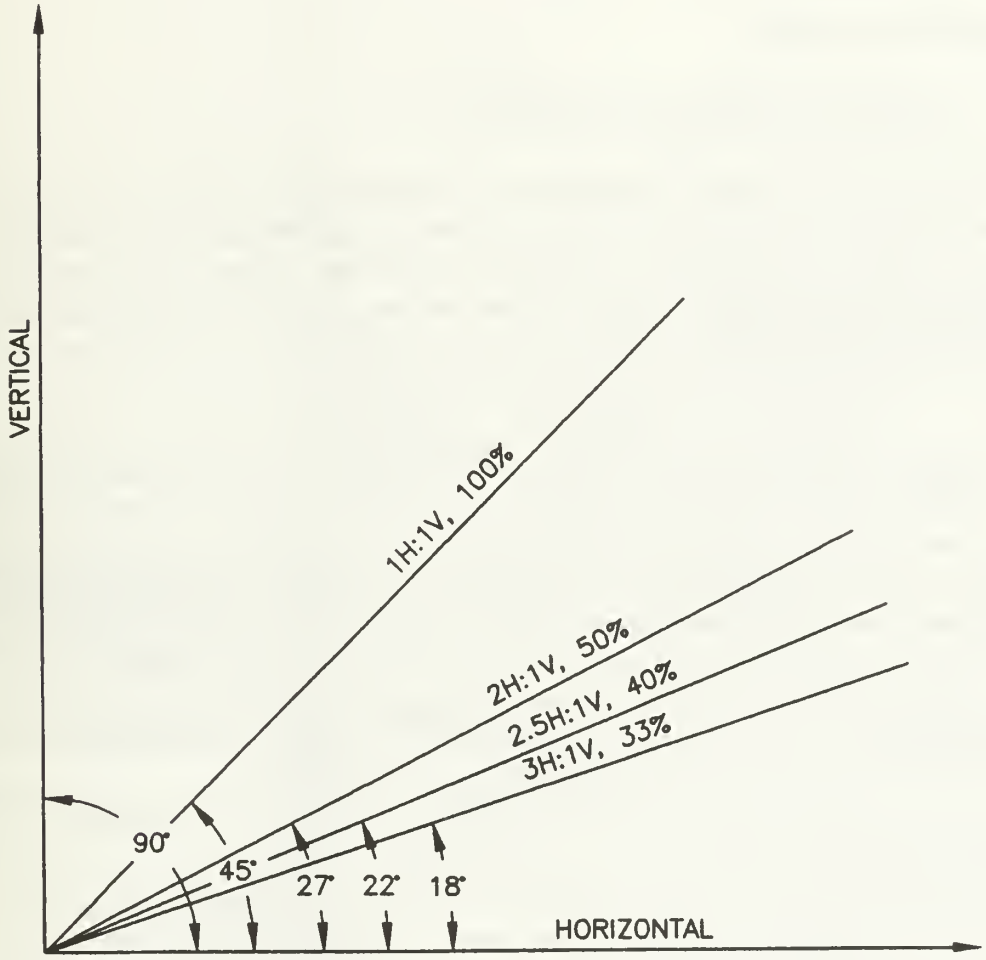
Drainage off the main repository face was controlled by constructing benches every 100 vertical feet (200 horizontal feet). The benches were from 15 to 30 feet wide and sloped back into the repository at grades of 5 to 10%. The benches were also capped with clay. A drainage ditch, with an impermeable synthetic liner held in place by 6 inches of blue waste material, was constructed along the toe of the facility.

Landusky Mine Interim Reclamation

Interim reclamation work at the Landusky Mine includes: regrading, placement of soil and planting on the L80-82, L83 and L84 leach pads; cutting a drainage notch around the L85/86 leach pad; regrading the Gold Bug pit complex; extending the liner on the east side of the L91 leach pad and regrading that side of the heap; building out the L84 dike and contouring the slope southeast of the L84 dike; reducing the highwall at the north end of the Gold Bug pit by blasting; backfilling the Suprise and Queen Rose pits to establish positive drainage; installing HDPE liner over the backfill on the Suprise pit floor; and regrading the August #1 waste rock dump to cover adjacent pit benches. Some of this work is scheduled to begin late in the year 2001 and could extend into the next year.

In addition, other reclamation work completed in 2000 includes integrating the EPA removal of the tailings from King Creek with the interim mine reclamation work. The tailings excavated from King Creek were placed on the L80-82, L83 and L84 leach pads as part of the reclamation cover, instead of being transported to an off-site waste repository for disposal. This action saved money for both the King Creek removal action and the Landusky Mine reclamation, while providing needed reclamation resources for construction of the leach pad reclamation covers. Other interim reclamation work conducted in 2000 included cleanup and removal of old mining equipment and supplies.

The following diagram shows the relationship between reclamation slopes, grades, and the angle from the horizontal. This diagram is useful when reading the alternative descriptions. Reclamation slopes are commonly described as a ratio of the horizontal measurement to the vertical measurement, expressed as H:V. For example, a slope described as 2H:1V, would change by 1 foot in elevation every 2 feet of horizontal distance.



Alternative L1, 1998 ROD Reclamation

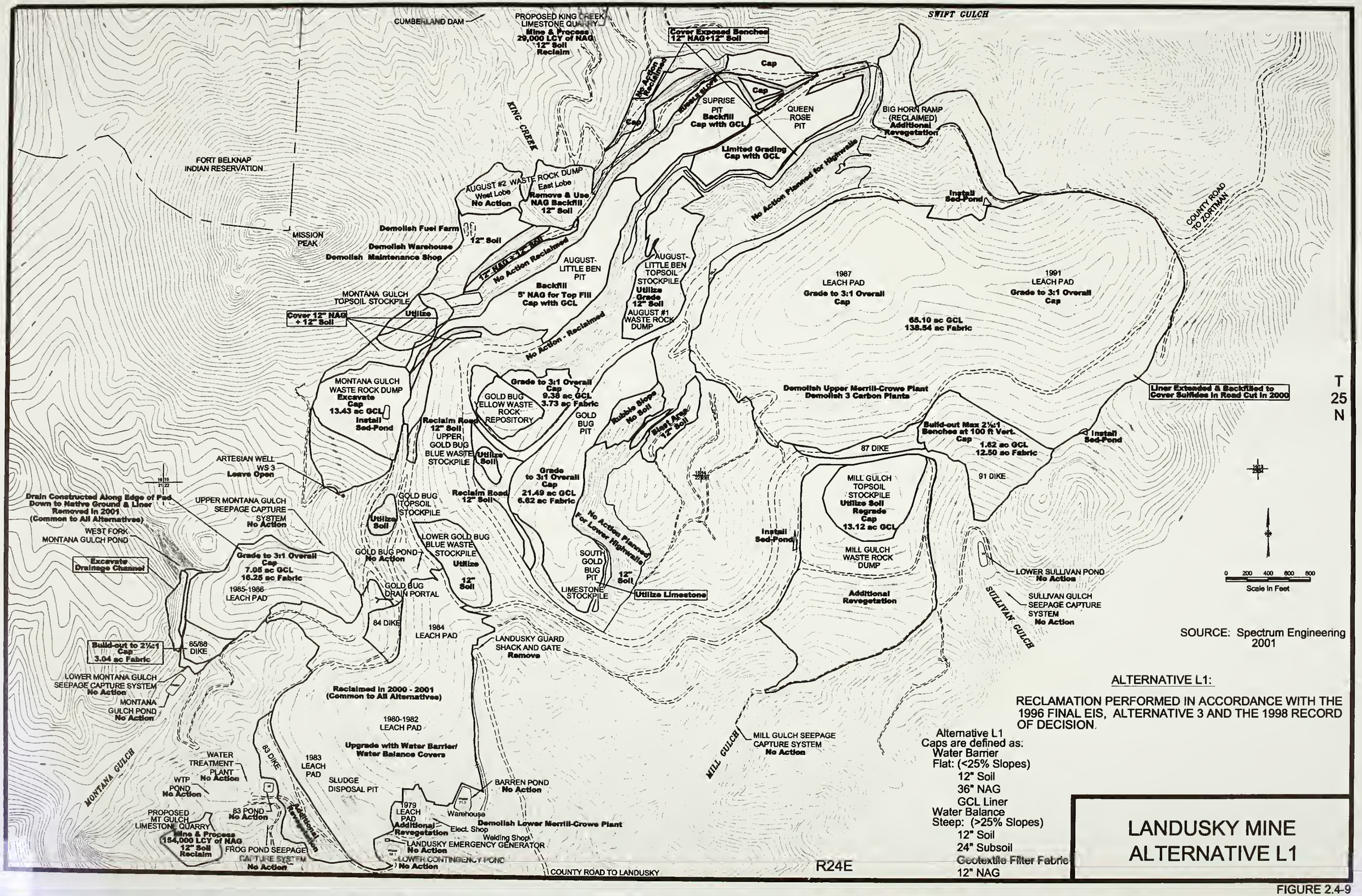
Alternative L1 would implement the reclamation described under Alternative 3 of the FEIS, as modified by the June 1998 ROD. The reclamation cost for this alternative would exceed the existing reclamation bond amount. The major cost items include placement of geosynthetic liner or geotextile fabric as part of the respective water barrier or water balance covers, construction of the pit drainage notch, and leach pad water management. See Section 4.12 for reclamation cost details and a description of this alternative's impact on reclamation costs. The reclamation action for each mine feature is shown in Figure 2.4-9. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action."

Mine Pit Reclamation

August/Little Ben-Suprise Pit Complex

The August/Little Ben pit is located on the ridge dividing the Montana Gulch and King Creek drainages. The northeast end of this pit extends into the Suprise pit, which straddles the divide between King Creek and Swift Gulch. Sulfide minerals are exposed in the lower portions of most of the pit walls. The pit highwalls are broken by randomly spaced benches of various configurations. Some of these benches have been covered with reclamation covers and reclaimed. Some of the smaller benches are no longer accessible (see also, aerial photos in Appendix D, 1995 Draft EIS).

The August/Little Ben pit was excavated to a depth of 4645 feet amsl. The floor of the Suprise pit is at an elevation of 4740 feet amsl. These elevations are at least 100 feet below the lowest rim of the pit. Consequently, precipitation around the pit complex tends to collect on the pit floor. Interim reclamation work in 2001 provided backfill, grading, and a HDPE liner in the Suprise pit to prevent water from collecting at the north end of the pit complex. All precipitation runs down the pit floor to the August/Little Ben pit. From there, the runoff either evaporates or infiltrates into the underground mine workings below the pit floor. Water collecting in these underground workings used to drain out through a drain tunnel located in Montana Gulch. However, the tunnel is now blocked and its portal is buried beneath the Montana Gulch waste rock dump. Although the drain tunnel is blocked, there is still a connection between the underground workings and artesian well WS3. Water levels in the pit can be controlled by opening and closing this well. Discharge from the well is captured by the upper Montana Gulch capture system and treated in the water treatment plant. The pit can be kept drained by leaving the well unplugged. In order to prevent impoundment of runoff within the pit and to reduce the potential for acid drainage, a drainage notch would be excavated through the pit wall on the southwest end of the August/Little Ben pit to Montana Gulch.



SOURCE: Spectrum Engineering 2001

ALTERNATIVE L1:

RECLAMATION PERFORMED IN ACCORDANCE WITH THE 1996 FINAL EIS, ALTERNATIVE 3 AND THE 1998 RECORD OF DECISION.

Alternative L1
Caps are defined as:
Water Barrier
Flat: (<25% Slopes)
12" Soil
36" NAG
GCL Liner
Water Balance
Steep: (>25% Slopes)
12" Soil
24" Subsoil
Geotextile Filter Fabric
12" NAG

LANDUSKY MINE
ALTERNATIVE L1

FIGURE 2.4-9

The excavation would cut through the bedrock wall of the pit and continue through the upper lift of the Montana Gulch waste rock dump. Because the size of the notch is controlled by its bottom elevation, all materials removed during construction of the notch would be backfilled into the pit to raise the drainage elevation. Therefore, notch construction would balance excavation and backfill quantities.

The pit complex would be backfilled to a minimum elevation of 4740 feet amsl, as measured at the southwest end of the August pit, to create a surface that would drain freely through the notch and into Montana Gulch. Backfill within the pit complex would be sloped at approximately 2% all the way back to the end of the Suprise pit. The 2% gradient would also be maintained through the notch and along the channel cut across the Montana Gulch waste rock dump. The backfill design within the August/Little Ben pit would insure that only non-acid generating material would be placed in the top 5 feet of the fill.

An estimated 2,933,000 cubic yards of excavation and backfill would be used to construct the drainage notch and regrade the bottom of the pit. Because 1,486,000 cubic yards of this total would be excavated from the Montana Gulch waste rock dump, the width of the notch would have to be wide enough to accommodate a haul road. In those areas where the excavation would cut through bedrock, the walls of the notch would be left as steep as the walls in the rest of the pit. Benching would provide stability. In unconsolidated areas of the notch, the side slopes would be graded to 3H:1V.

The channel constructed through the pit floor and out the drainage notch would be sized to accommodate the runoff from a 6.33-inch, 24-hour storm event. After passing though the notch and traveling through a channel cut along the east side of the Montana Gulch waste rock dump, runoff from the pit would follow a lined channel which has been built along an old haul road on the east slope of the Montana Gulch drainage. The channel follows the road around the L85/86 leach pad. During reclamation of the L85/86 leach pad, several sections of this channel would be reconstructed. The channel would also be extended to provide for discharge into a drainage downstream of the L85/86 dike. A sediment pond would be constructed on the Montana Gulch waste rock dump to remove sediment from the runoff before it enters the lined channel.

In order to limit infiltration of precipitation through the backfill material placed in the pit, a water barrier reclamation cover would be placed over the graded surface of the backfill. The relatively flat area would be covered with a 4-foot thick cover consisting of a geosynthetic liner, 36 inches of NAG, and 12 inches of soil. Because there are exposed sulfides on the benches on the north and west sides of the Suprise pit, the narrow benches and pit wall below the elevation of 4875 feet amsl would also be covered with NAG backfill. Water barrier covers would be used to cover the benches above this elevation. A bench cover consisting of 12 inches of NAG and 12 inches of soil would be placed over 16.8 acres of pit benches around the August/Little Ben pit. Approximately 61.5 acres would be covered and revegetated.

Queen Rose Pit

The Queen Rose pit is an upper bench extension of the August/Little Ben-Suprise pit complex. It is situated on the southeast side of the Suprise pit, with its floor at an elevation of 4825 feet amsl. A haul road ramps up the 75-foot highwall between the two pits. On the opposite side of the pit, the pit wall extends up nearly 400 feet vertically to the road running along the base of the L87 leach pad.

The pit floor would be backfilled and graded to drain freely into the partially backfilled Suprise pit. This relatively flat 16.8-acre bench would be covered with a 4-foot thick water barrier cover consisting of a geosynthetic liner, 36 inches of NAG, and 12 inches of soil. A bench cover consisting of 12 inches of NAG and 12 inches of soil would be placed over 3.5 acres of narrow pit benches that are still accessible around this pit. Approximately 20.3 acres would be covered and revegetated.

Gold Bug and South Gold Bug Pits

The Gold Bug pit was excavated at the head of the King Creek drainage. It is situated 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 amsl. However, between 1993 and 1996, much of the pit was turned into a repository for potentially acid generating waste rock. Construction of this facility is presented under Reclamation Common Among Landusky Mine Alternatives. Approximately 13.4 million tons of waste rock was placed into the facility before the mine ceased operation. As the fill in the repository was raised up to its current mean elevation of 5055 feet amsl, a large area on the face of the dump was graded, sealed with a layer of compacted clay, and covered with NAG and soil. Along the east side of the repository, the original pit walls extend up to the crest of the ridge, which is at 5400 feet amsl. A zone containing sulfide rock reaches about halfway up the exposed portion of the pit wall.

During 2001 interim reclamation, the fill in the unreclaimed portion of the pit was graded to slopes of 3H:1V or flatter. All depressions and 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 would be blasted to lower the top of the wall by about 50 feet. The blast material would be pushed into the pit, producing a rubble slope that extends up the face of the highwall.

The South Gold Bug pit is a southerly extension of the Gold Bug pit that wraps around the ridge into the Montana Gulch drainage. The South Gold Bug section of the pit complex contains some lower benches that bring the floor down to an elevation of 4925 feet amsl. During the later stages of the mining operation this area of the pit was used to stockpile limestone. After the limestone stockpile has been removed and utilized either as NAG cover or NAG fill, the lower benches on the west side of the pits would be reduced to 3H:1V slopes, producing a free draining surface.

In order to limit infiltration of precipitation through the backfill in the regraded area of the pit complex, an area containing approximately 28.1 acres would be covered with a combination of a 21.5-acre water

barrier and a 6.6-acre water balance cover, and revegetated. These reclamation covers are each four feet thick. An additional one-half acre of accessible bench on the east side of the South Gold Bug pit would be covered with 12 inches of NAG, 12 inches of soil, and revegetated. The highwall reduction source area, which covers about 3.6 acres, would be covered with 12 inches of soil and revegetated.

Leach Pad Reclamation

All spent ore heaps would be recontoured to provide a topography that blends into the surrounding landscape. The leach pads would be reclaimed in place, with some redistribution of the spent ore onto the associated dikes and areas adjacent the leach pads. Surfaces would be graded to reduce pad slopes to an overall 3H:1V slope to stabilize cover soil, enhance the potential for successful revegetation and limit surface water infiltration. Benches would be constructed every 100 vertical feet. Slope reduction would be performed in part by bulldozers pushing ore heap material from the top of the heap down over the lift slopes. Where the desired grades could not be obtained by dozing alone, trucks and loaders would offload the spent ore and redistribute it to fill areas. Leach pad surfaces would be covered with either the water balance or water barrier covers, except for on the L79 leach pad, where the existing reclamation cover would be considered final. Heap retaining dikes requiring reclamation would be reduced to a nominal slope of 2.5H:1V, covered with the water balance covers, and revegetated.

Leach pad drawdown water would continue to be treated and disposed of at Goslin Flats. After 10 years, the leach pad liners would be perforated if it is determined that water quality management objectives would be met. No dewatering of the pads would occur unless the rate of accumulation dictated that dewatering was necessary before the 10-year monitoring period was reached. The liners would be perforated by drilling 3 to 4 drain holes 6 inches in diameter into the underlying drainage system to provide an exit for solution within the heap. Each perforated drain hole would be backfilled with drain rock to an elevation of at least 5 feet above the liner surface to ensure continued drainage. The drain holes would be positioned at the lowest elevation in the pad collection basin to provide for adequate drainage and to prevent the formation of undesirable hydraulic conditions within the heap.

L79 Leach Pad

The L79 Pad is part of the complex of leach pads located near the lower Merrill-Crowe plant at the southwest corner of the mine. This leach pad was reclaimed with 8 to 12 inches of soil and revegetated in September 1991. Additional planting and fertilization would be conducted to enhance the existing vegetation.

L80-82, L83, and L84 Leach Pads

The L80-82, L83, and L84 leach pads make up the remainder of the complex of leach pads located near the lower Merrill-Crowe plant at the southwest corner of the mine. They are all on their own individual

liners, although some share common containment dikes and collection facilities. This complex of spent ore heaps contains about 5,526,000 cubic yards of material.

These leach pads were regraded as part of the 2000 interim reclamation. Approximately 1.1 million cubic yards of grading and excavation were conducted to recontour these heaps to overall grades of less than 3H:1V. Because the pads were reduced to a height of just over 100 feet, benching was not needed. The regrading included some offloading of the spent ore onto unlined and partially lined areas adjacent to the pads and included filling several large depressions between the L80-82 and L83 leach pads and extending the backfill over the upper contingency pond and the process water pond.

Interim reclamation also included building out the L84 dike to a 3H:1V slope using material from the L85/86 leach pad. In conjunction with this effort, the over-steepened slope to the south of the dike was also rebuilt using material offloaded from the L80/82 leach pad and the L85/86 leach pad.

The regraded leach pads were covered with an interim reclamation cover consisting of 6 inches of King Creek tailings and 18 inches of soil over 24 inches of NAG. They were revegetated in 2001. The interim reclamation would be removed and the water barrier and water balance reclamation covers would be placed on the regraded surface. The L84 dike and adjacent slope reclamation would be covered with 24 inches of soil and seeded. Existing reclamation on the L83 dike would be improved with additional fertilization, seeding and planting.

L85/86 Leach Pad

The L85/86 leach pad, containing 3,264,000 cubic yards of spent ore, was constructed in the bottom of Montana Gulch. Consequently, it blocks normal drainage along the main channel and from several tributaries near the head of the gulch. The lower Montana Gulch seepage capture system and pond are just downstream of the containment dike. The upper Montana Gulch seepage capture system is directly upstream of the leach pad and downstream of the Montana Gulch waste rock dump. Underdrains are used to convey runoff beneath this leach pad.

Interim reclamation work would offload approximately 443,000 cubic yards of the spent ore to the L84 dike and slope buildout areas. A drainage channel would be constructed along the west margin of the L85/86 leach pad to unblock surface water drainage and eliminate the West Fork Montana Gulch pond. An estimated 113,800 bank cubic yards of excavation along the adjacent hillside would be required to re-establish a free draining channel. This channel would connect into an existing lined channel which bypasses the capture system. The material generated by this excavation would be used as NAG fill and NAG cover on the L85/86 and L91 dikes, and in the Gold Bug pit.

The reclamation grading would pull back the north edge of the leach pad to partially re-establish drainage from the upper end of the gulch. The entire leach pad would be regraded to 3H:1V overall, with benches constructed at 100-foot intervals. Because the pad was constructed in a constrained area, the amount of

slope reduction that can be achieved by dozing is limited to about 80,000 cubic yards. The remaining material would be moved by hauling the material off the pad in trucks. This material would be moved to the northeast end of the pad where it would be placed in the gap between the upper edge of the leach pad and the hillside. A large portion of the material would be placed off the liner, but runoff passing over or through the fill would still drain toward the lined area.

The entire 27 acres associated with the leach pad regrade would be capped with water barrier (4.84 acres) and water balance (22.1 acres) covers appropriate to slope conditions, and revegetated. Because most of the west side channel would be cut through rock, most of this disturbance would not be revegetated.

The slope on the front of the L85/86 dike would be built out to a 2.5H:1V slope using about 35,000 cubic yards of the material from the channel excavation. After reconstructing the face of this dike, it would be covered with the water balance cover and revegetated.

L87/91 Leach Pad

The L87 leach pad is situated at the head of Mill Gulch. The L91 leach pad is located at the head of Sullivan Gulch. Individual seepage capture systems are located in both drainages downstream of the leach pads. These two heaps are joined together at the top of the ridge that originally separated the two drainages. They form a huge, flat-topped structure that is several hundred feet high. The structure is benched at about 50-foot intervals, creating overall 2H:1V slopes. Not including the associated containment dikes, the L87/91 pad complex covers over 200 acres and contains nearly 64 million cubic yards of spent ore. The upper Merrill-Crowe plant, three carbon plants, and a large pond are located on the L87 pad. Pump facilities are located on the L91 pad. The main access road from the Zortman Mine crosses the leach pad.

The entire pad complex would be regraded to overall 3H:1V slopes with benches spaced every 100 vertical feet. The liner would be extended on the east and west sides of the leach pad to maximize the quantity of spent ore that can be moved downhill to achieve the 3H:1V slope configuration. Reclamation would include the following excavation and haulage:

- 1,816,000 cubic yards of bulldozer grading;
- 1,164,000 cubic yards of truck/loader redistribution; and
- 1,098,000 cubic yards hauled to the L91 dike for buildout.

The regraded surfaces on the leach pads and the L91 dike would be covered with the water barrier and water balance reclamation covers, depending on the slope conditions. The entire L87/91 Pad and L91 dike area, totaling 223 acres, would be revegetated. All of the facilities on the leach pads, except the pumping facilities, would be removed before regrading. The large pond on the top of the L87 Pad would be backfilled during the grading operation.

The L87 dike would be considered to be reclaimed as it is covered by the Mill Gulch waste rock dump. The L91 dike, which is 350 feet high, would be resloped with maximum 2.5H:1V slopes with a bench every 100 vertical feet. All of the resloping would be accomplished by adding fill to the front face of the dike. Most of this material would be obtained by offloading spent ore from the L87 and L91 leach pads. The last 123,000 cubic yards of fill placed on the surface of the dike would be NAG material hauled in from the L85/86 leach pad drainage cut.

Waste Rock Dump Reclamation

Mill Gulch Waste Rock Dump

The Mill Gulch waste rock dump is located in Mill Gulch directly downstream of the L87 leach pad. It contains over 10 million cubic yards of waste rock. The exposed face of the dump was reclaimed between 1993 and 1995 with a water barrier cover (FEIS Figure 2.5-5). The only portion not presently reclaimed is occupied by the Mill Gulch soil stockpile. After all of the soil stored in this facility has been removed from the top of the waste rock dump, the disturbed area would be regraded and the water barrier cover would be extended across the entire top of the bench. The existing vegetation on the face of the dump would be improved with additional fertilization, seeding and planting.

Montana Gulch Waste Rock Dump

The Montana Gulch waste rock dump is located at the head of Montana Gulch. It contains approximately 5,174,000 cubic yards of waste rock. The front face of the rock dump was reclaimed between September 1989 and April 1990. A truck ready-line still covers a large area on top of this dump, while the back edge is covered by the Montana Gulch soil stockpile.

The soil stockpile and truck ready-line would be removed from the top of the rock dump before construction of the August/Little Ben drainage notch. In order for the pit complex to drain into a lined channel, approximately 1,486,000 cubic yards of material would be excavated from the waste rock dump. This rock would be hauled to the August/Little Ben and Suprise pits and used for backfill. Due to the large backfill requirement, nearly the entire upper lift of the dump would be removed exposing the original ground surface in some areas. Where sections of the top lift are left in place, the surfaces would be regraded with very gentle slopes. A channel connecting the drainage notch to an existing lined channel would be constructed along the east edge of the dump and sized to contain the runoff from a 6.33-inch, 24-hour storm event.

After the top lift of the dump has been excavated and regraded, the remaining portion at the top of the dump (about 13.5 acres) would be covered with the water barrier cover. Twelve inches of NAG and 12 inches of soil would be placed in those areas where removal of the dump lift had exposed the original ground surface.

August #1 Waste Rock Dump

The August #1 waste rock dump is spread across several of the topmost benches on the south side of the August/Little Ben pit. Because the August/Little Ben soil stockpile was dumped over the top of the waste rock dump, the two piles are mixed together to some degree. They contain a combined total of about 579,000 cubic yards of material.

Material from the two piles would be segregated and used in reclamation of various areas around the Landusky Mine. Enough of the waste dump would be left in place to grade the dump and stockpile areas plus an additional 5 acres of adjacent pit benches to 3H:1V slopes. The bench cover would use about 124,000 cubic yards of stockpile material and 6,000 cubic yards of bench reduction. The pit benches that would be covered are situated on the north side of the stockpile and below it. All 14.8 acres of the stockpile footprint and regraded bench area would be covered with 12 inches of soil and revegetated.

August #2 Waste Rock Dump

The August #2 waste rock dump is located at the head of the King Creek drainage. It is divided into two lobes, with each lobe occupying a fork in the upper reaches of the drainage. The west lobe abuts into the fill where the maintenance shop, warehouse and fuel farm are located. The west lobe has been graded to blend into the natural terrain and has been covered with 8 to 12 inches of soil. Trees were planted on this lobe in April 1990 and again in April 1991. Reclamation on the west lobe would be considered to be final.

The east lobe, containing about 599,000 cubic yards of material, sits on the north wall of the August/Little Ben pit. This lobe was covered with 8 to 12 inches of soil and revegetated in May 1992. The material in this dump is non-acid generating in character. It would be completely removed and utilized for NAG fill and cover. After this dump has been removed, the exposed slopes would be covered with 12 inches of soil and revegetated.

Gold Bug Yellow Waste Rock Repository

The Gold Bug yellow waste rock repository is located on a bench between the Gold Bug pit and the August/Little Ben pit. It is on the east side of Montana Gulch, directly uphill from the Montana Gulch waste rock dump, and contains about 283,000 cubic yards of waste rock. The Gold Bug yellow waste rock repository is a potential acid producer.

The waste rock would be left in its current location and regraded to slopes of 3H:1V or flatter. The water barrier reclamation cover would be placed over 9.38 acres of the regraded surface. The remaining 3.73 acres of the graded waste rock would have steeper slopes and would be covered with the water balance reclamation cover.

Lower Gold Bug Blue Waste Rock Stockpile

The lower Gold Bug blue waste rock stockpile covers an area of about 6.5 acres and contains 202,000 cubic yards of material. It is located on the east side of Montana Gulch in an area below the South Gold Bug pit. The material in this dump is non-acid generating and would be used in construction of the reclamation covers for other mine facilities. The remaining footprint would be covered with 12 inches of soil and revegetated.

Upper Gold Bug Blue Waste Rock Stockpile

The upper Gold Bug blue waste rock stockpile covers an area of about 2.1 acres and contains 27,000 cubic yards of non-acid generating material. It is located on the east side of Montana Gulch on the same bench as the Gold Bug yellow waste rock repository. The material in this dump is non-acid generating and would be used in construction of reclamation covers for other mine facilities. The remaining footprint would be covered with 12 inches of soil and revegetated.

Reclamation Covers

In developing a reclamation cover system for the Landusky Mine, the FEIS assumed that most of the waste rock and spent ore heap facilities contained potentially acid-generating materials. As a result, one of the requirements of the FEIS Alternative 3 was to develop reclamation covers that would support revegetation and limit the surface water infiltration that could lead to the formation of acidic leachate. The cover systems included water barrier (for slopes less than 25%) and water balance (for slopes greater than 25%) covers on both mines. The water barrier cover would consist of a geosynthetic clay liner placed over non-acid generating waste (NAG) and overlain by 36 inches of NAG and 12 inches of soil. The water balance cover would consist of a filter fabric (or geotextile) placed on top of 12 inches of NAG waste and overlain by 24 inches of subsoil and 12 inches of soil. Pit benches would be covered with 12 inches of NAG and 12 inches of soil. Additional detail on the reclamation covers is shown in Figure 2.4-2. Information on the predicted performance of the reclamation covers can be found in Appendix B.

Support Facilities Reclamation

All of the mining-related facilities not associated with water treatment would be removed and their footprints covered with 12 inches of soil and revegetated. These facilities include the fuel farm, upper warehouse, maintenance shop, lower Merrill-Crowe plant, three carbon plants, and the Landusky guard shack and gate. The upper Merrill-Crowe plant and two carbon plants are located on the L87 leach pad, so their footprints would be reclaimed as part of the leach pad reclamation.

The water treatment plant, drainage capture systems, ponds, and associated structures would be left intact and continue functioning where presently located until no longer needed. Once removed, their footprints would be regraded, covered with soil, and revegetated.

Limestone Quarry

This alternative requires more non-acid generating material for reclamation covers and NAG fill than is available in the mine stockpiles. Additional NAG material would be obtained by developing two limestone quarries in the mine area. One quarry with the capacity to supply 154,000 cubic yards of limestone would be developed on a hilltop located southwest of the water treatment plant. The other quarry would be developed in the Damon Hill area in the King Creek watershed.

The two quarries would increase disturbance by about 5 acres. After supplying the necessary quantity of limestone, the disturbed areas would be regraded to 3H:1V slopes. The soil salvaged during the quarry development would be replaced and the area revegetated.

Alternative L2, Optimized Earthwork

Alternative L2 was designed to optimize the amount of earthwork that would be performed within the available bond amount. Waste rock and heap slopes would be regraded, the August/Little Ben pit would be drained via the existing artesian well, and the upper Gold Bug pit highwall would be blasted and used to cover the upper mine benches and sulfides near the pit bottom. A partial drainage notch would be cut around the L85/86 leach pad to restore free drainage around the west side of the leach pad. The reclamation action for each mine feature is shown in Figure 2.4-10. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

August/Little Ben-Suprise Pit Complex

The water level in the pit would be controlled through artesian well WS3. This method of controlling pit drainage has been practiced successfully since October 1999. By using artesian well WS3 to drain the pit, impoundment of water on the pit floor would be eliminated. NAG backfilling, grading, and installation of a HDPE liner in the Suprise pit would be done to prevent water from collecting at the north end of the pit complex. NAG backfill would be placed around the north and west sides of the pit to cover exposed sulfides in the pit walls below the elevation of 4875 feet amsl.

A 6-inch thick layer of NAG would be spread over the remainder of the pit floor and over the lined area in the Suprise pit. The NAG fill would be covered with 18 inches of soil and revegetated. Because there are exposed sulfides on the pit benches on the north and west sides of the Suprise pit, these areas would receive the same reclamation cover. About 28.4 acres of pit floor and bench would be revegetated.

Queen Rose Pit

The pit floor would be backfilled and graded to drain freely into the Suprise pit. Reclamation would consist of placing a 6-inch thick layer of NAG on the regraded pit floor, covering it with 18 inches of soil, and revegetating. Approximately 15 acres would be covered and revegetated.

Gold Bug and South Gold Bug Pits

In the later stages of the mining operation this pit was partially backfilled and lower sections of the backfilled area were reclaimed. During 2000-2001 interim reclamation, the remainder of the backfilled area would be graded to maximum 3H:1V slopes. All depressions and benches would be eliminated to produce a free draining surface.

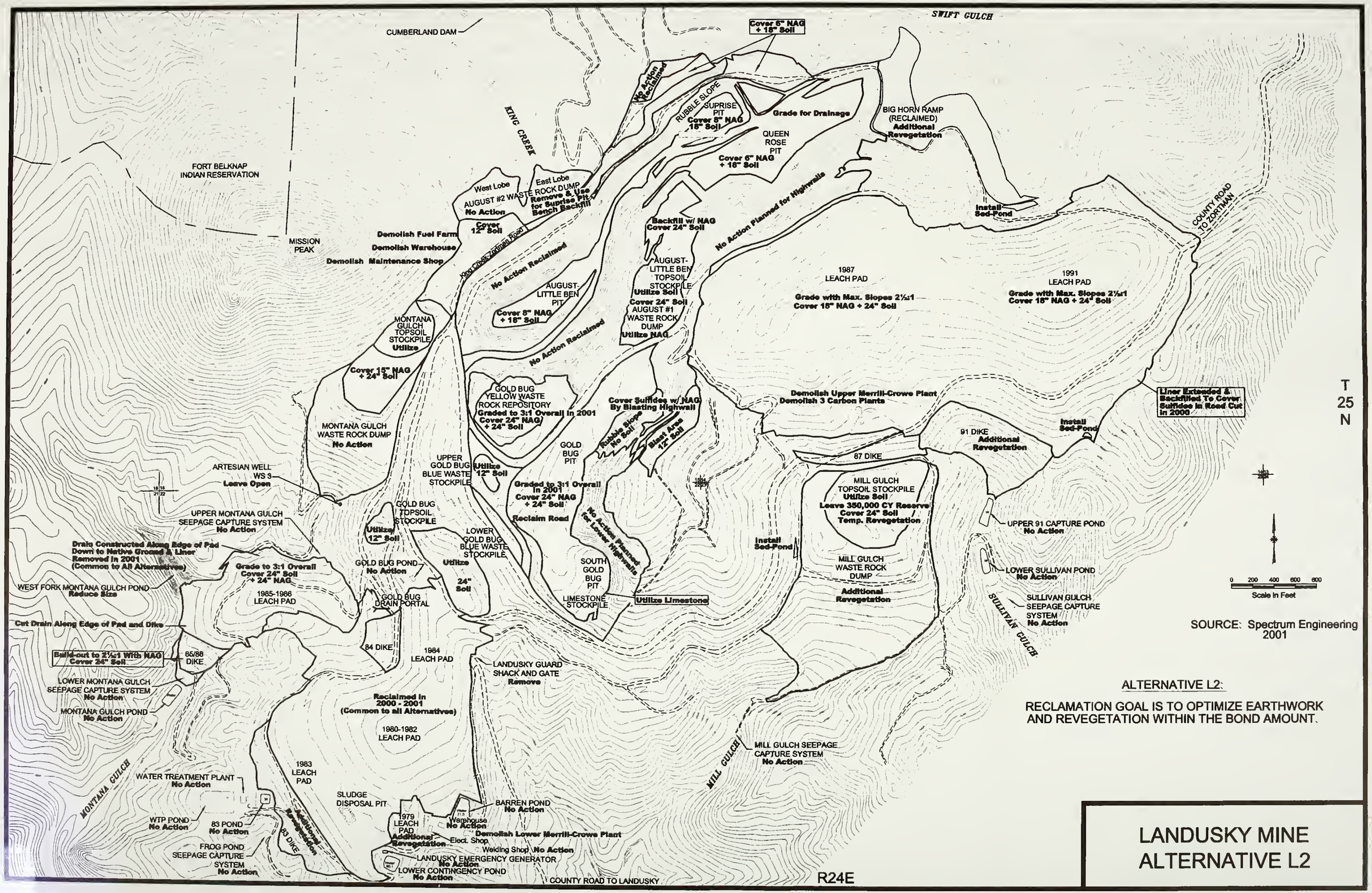

SWIFT GULCH
CUMBERLAND DAM
Cover 5" NAG + 15" Soil
No Action Reclaimed
RUBBLE SLOPE
SUPRISE PIT
Cover 5" NAG 15" Soil
Grade for Drainage
BIG HORN RAMP (RECLAIMED)
Additional Revegetation
QUEEN ROSE PIT
Cover 5" NAG + 15" Soil
KING CREEK
FORT BELKNAP INDIAN RESERVATION
West Lobe
East Lobe
AUGUST #2 WASTE ROCK DUMP
Remove & Use for Suprise Pit Bench Backfill
No Action
Cover 12" Soil
Install Sed-Pond
COUNTY ROAD TO ZORTMAN
Backfill w/ NAG Cover 24" Soil
No Action Planned for Highwalls
MISSION PEAK
Demolish Fuel Farm
Demolish Warehouse
Demolish Maintenance Shop
King Creek-Zortman Road
No Action Reclaimed
AUGUST-LITTLE BEN TOPSOIL STOCKPILE
Utilize Soil
Cover 24" Soil
AUGUST #1 WASTE ROCK DUMP
Utilize NAG
AUGUST-LITTLE BEN PIT
Cover 5" NAG + 15" Soil
1987 LEACH PAD
Grade with Max. Slopes 2½:1
Cover 15" NAG + 24" Soil
1991 LEACH PAD
Grade with Max. Slopes 2½:1
Cover 15" NAG + 24" Soil
MONTANA GULCH TOPSOIL STOCKPILE
Utilize
Cover 15" NAG + 24" Soil
No Action Reclaimed
GOLD BUG YELLOW WASTE ROCK REPOSITORY
Graded to 3:1 Overall in 2001
Cover 24" NAG + 24" Soil
Cover Sulfides w/ NAG By Blasting Highwall
Demolish Upper Merrill-Crowe Plant
Demolish 3 Carbon Plants
Liner Extended & Backfilled To Cover Sulfides in Road Cut in 2000
T 25 N
MONTANA GULCH WASTE ROCK DUMP
No Action
Rubble Slope No Soil
Blast Area 12" Soil
GOLD BUG PIT
91 DIKE
Additional Revegetation
Install Sed-Pond
87 DIKE
ARTESIAN WELL WS 3
Leave Open
UPPER GOLD BUG BLUE WASTE STOCKPILE
Utilize 12" Soil
Graded to 3:1 Overall in 2001
Cover 24" NAG + 24" Soil
Reclaim Road
MILL GULCH TOPSOIL STOCKPILE
Utilize Soil
Leave 350,000 CY Reserve
Cover 24" Soil / Temp. Revegetation
UPPER MONTANA GULCH SEEPAGE CAPTURE SYSTEM
No Action
GOLD BUG TOPSOIL STOCKPILE
Utilize 12" Soil
LOWER GOLD BUG BLUE WASTE STOCKPILE
Utilize 24" Soil
No Action Planned for Lower Highwalls
SOUTH GOLD BUG PIT
Install Sed-Pond
UPPER 91 CAPTURE POND
No Action
Drain Constructed Along Edge of Pad Down to Native Ground & Liner Removed in 2001 (Common to All Alternatives)
Grade to 3:1 Overall Cover 24" Soil + 24" NAG
GOLD BUG POND
No Action
MILL GULCH WASTE ROCK DUMP
Additional Revegetation
LOWER SULLIVAN POND
No Action
WEST FORK MONTANA GULCH POND
Reduce Size
1985-1986 LEACH PAD
GOLD BUG DRAIN PORTAL
LIMESTONE STOCKPILE
Utilize Limestone
SULLIVAN GULCH SEEPAGE CAPTURE SYSTEM
No Action
SULLIVAN GULCH
Cut Drain Along Edge of Pad and Dike
84 DIKE
1984 LEACH PAD
Build-out to 2½:1 With NAG Cover 24" Soil
86/88 DIKE
LANDUSKY GUARD SHACK AND GATE
Remove
LOWER MONTANA GULCH SEEPAGE CAPTURE SYSTEM
No Action
MONTANA GULCH POND
No Action
Reclaimed in 2000 - 2001 (Common to all Alternatives)
1980-1982 LEACH PAD
MILL GULCH
MILL GULCH SEEPAGE CAPTURE SYSTEM
No Action
MONTANA GULCH
WATER TREATMENT PLANT
No Action
1983 LEACH PAD
SLUDGE DISPOSAL PIT
BARREN POND
No Action
WTP POND
No Action
83 POND
No Action
1979 LEACH PAD
Additional Revegetation
Warehouse
No Action
Elect. Shop
Demolish Lower Merrill-Crowe Plant
Welding Shop No Action
83 DIKE
Additional Revegetation
FROG POND SEEPAGE CAPTURE SYSTEM
No Action
LANDUSKY EMERGENCY GENERATOR
No Action
LOWER CONTINGENCY POND
No Action
COUNTY ROAD TO LANDUSKY
R24E
0 200 400 600 800
Scale in Feet
SOURCE: Spectrum Engineering 2001
ALTERNATIVE L2:
RECLAMATION GOAL IS TO OPTIMIZE EARTHWORK AND REVEGETATION WITHIN THE BOND AMOUNT.
LANDUSKY MINE
ALTERNATIVE L2

FIGURE 2.4-10

In addition, a 700-foot long section of highwall at the north end of the Gold Bug pit would be blasted to lower the top of the wall by about 50 feet. The blast material would be pushed into the pit, producing a rubble slope that extends up the face of the highwall. This work would involve improving an existing exploration road up to the top of the ridge, stripping soil from 3.58 acres along the ridge top, and then blasting 93,000 bank cubic yards of NAG material in the stripped area. The rubble slope would be left at its angle of repose. The highwall reduction source area at the top of the ridge would be regraded, covered with 12 inches of soil, and revegetated.

After the limestone stockpile in the South Gold Bug pit has been removed and utilized either as NAG cover or NAG fill, the benches on the west side of the pit would be reduced to 3H:1V slopes to produce a free draining surface. The regraded area of the pit complex (approximately 29 acres) would be covered with 24 inches of NAG, 24 inches of soil, and revegetated.

Leach Pad Reclamation

All spent ore heaps would be recontoured to provide a topography that blends into the surrounding landscape. The leach pads would be reclaimed in place with some redistribution of the spent ore onto associated dikes and to areas adjacent the leach pads. All of the pads in the southwest corner of the mine area would be graded to reduce pad slopes to an overall 3H:1V grade. In most cases, there would be no need to incorporate benches into the regrading designs for these relatively low heaps. The L87 and L91 leach pads would be regraded with maximum 2.5H:1V slopes and 25-foot wide benches constructed on 100-foot vertical spacing. Slope reduction would be performed, in part, by bulldozers pushing ore heap material from the top of the facility down over the lift slopes. Where the desired grades could not be obtained by dozing alone, trucks and loaders would be used to offload the material and redistribute it into the fill areas. Depending on the acid generating potential of the material in the heap, leach pad surfaces would be covered with a combination of NAG material and soil. The total cover thickness would vary by pad, between 24 and 48 inches. The reclamation cover would then be revegetated.

Additional reclamation work would be performed on two of the heap retaining dikes, the L85/86 dike and the L84 dike. The L85/86 dike slopes would be built out to a nominal slope of 2.5H:1V. The L84 dike would be built out to a nominal slope of 3H:1V. Since NAG fill would be used in the buildout, the reclamation cover would be limited to 24 inches of soil and the dike faces would be revegetated.

L79 Leach Pad

The L79 Pad is part of the complex of leach pads located near the lower Merrill-Crowe plant at the southwest corner of the mine. This pad has already been reclaimed with 8 to 12 inches of soil and revegetated in September 1991. The existing reclamation would be enhanced with additional fertilization, seeding, and planting.

L80-82, L83, and L84 Leach Pads

Regrading of these leach pads was undertaken as part of the 2000 interim reclamation project. Approximately 1.1 million cubic yards of grading and excavation were conducted to recontour these heaps to final overall grades of less than 3H:1V. Because the pads were reduced to a height of just over 100 feet, benching was not incorporated into the grading plan. The regrading plan required some offloading of the spent ore onto unlined and partially lined areas adjacent to the pads and included filling several large depressions between the L80-82 and L83 leach pads and extending the backfill over the upper contingency pond and the process water pond.

Before applying the interim reclamation cover, the regraded surface was sampled for acid generating potential to a depth of 24 inches on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of King Creek tailings were placed as cover material, followed by 18 inches of soil. The 74-acre surface was seeded in 2001. This interim reclamation would be considered final.

Reclamation on the L83 dike would also be limited to improving the existing vegetation with additional fertilization, seeding, and planting. The L84 dike at the north end of the pad complex has been built out to a 3H:1V slope with about 61,000 cubic yards of material borrowed from the L85/86 leach pad. In conjunction with this effort, the over-steepened slope to the south of the dike would be rebuilt using material offloaded from the L80/82 and L85/86 leach pads. All of the material used in the dike and slope buildout would be NAG. The regraded dike would be covered with 24 inches of soil and revegetated.

L85/86 Leach Pad

The north and west sides of the pad would be reduced to 3H:1V slopes and channels would be constructed around the outside edges to re-establish drainage around the pad. On the north side of the pad, the toe of the heap would be pulled back away from the hillside about 60 feet to allow construction of a channel between the upper Montana Gulch seepage capture system and the West Fork Montana Gulch pond, which is in a tributary drainage plugged by the L85/86 pad. A second channel would be excavated along the west side of the pad and would cut through the northwest corner of the L85/86 dike to convey overflow from the pond into an existing lined channel used to bypass the capture system. Although the west side channel would establish an outlet for the West Fork Montana Gulch pond, it would not eliminate the pond as in Alternative L1, but would reduce the pond's storage elevation by approximately ten feet. Nearly all of the material excavated by slope reduction and channel construction would be used to build out the L84 dike and recontour the disturbed hillside south and west of the dike with 3H:1V slopes.

Alternative L2 incorporates all of the work accomplished by interim reclamation. In addition to this work, contouring on the south and east sides of the pad would be conducted. Relocation of the access roads to the capture system would also be conducted. Final grading of the leach pad would achieve overall 3H:1V

slopes in all areas. The relocated road would function as a bench breaking most of the slopes, and no other benches would be constructed.

The amount of slope reduction that could be achieved by dozing is limited to about 77,000 cubic yards. In addition to the material moved during interim reclamation, another 274,000 cubic yards of material would be moved by trucks to the northeast end of the pad, where it would be placed in the gap between the upper edge of the pad and the hillside. A large portion of the material, most of which is non-acid generating, would be placed off the liner but water passing over and through the fill would still drain toward the lined area.

The slope on the front of the L85/86 dike would be built out to a 2.5H:1V slope using about 27,000 cubic yards of the material borrowed from the pad excavation. After reconstructing the face of this dike, it would be covered with 24 inches of soil and revegetated. Approximately 3 acres would be associated with reclamation of the dike.

The pad regrade area would be tested for acid generating potential. Areas requiring neutralization would be amended with lime to insure that 24 inches of NAG would cover the entire area. The entire surface would then be covered with 24 inches of soil and revegetated.

L87/91 Leach Pad

The entire L87/91 leach pad would be regraded with maximum 2.5H:1V slopes with 25-foot wide benches spaced every 100 vertical feet. A 45-foot wide access road would be substituted for one of the benches on the south side of the L91 dike. The liner would be extended on the southeast side of the leach pad to maximize the quantity of spent ore that could be moved downhill to achieve an overall slope configuration of between 2.6H:1V and 3H:1V. The extension of the liner on the southeast side of the L91 leach pad has already been incorporated into the 2000-2001 interim grading plan.

The grading plan would include the following excavation and haulage amounts: 1,884,000 cubic yards of bulldozer grading; and 102,000 cubic yards of truck/loader redistribution. The regraded surface on both leach pads would be covered with 15 inches of NAG and 24 inches of soil. The entire area, totaling 201 acres, would be revegetated. All of the facilities on the leach pads, with the exception of the pumping facilities, would be removed before grading was completed. The large pond on the top of the L87 Pad would be completely backfilled during the grading operation.

The L87 dike is considered to be reclaimed as it is covered by the Mill Gulch waste rock dump. No additional grading would occur on the 350-foot high L91 dike. Buttressing of the dike is not necessary since it is stable in its current configuration (see Section 3.2.2, Geotechnical Conditions). However, the existing vegetation would be improved with additional fertilization, seeding, and planting.

Waste Rock Dump Reclamation

Mill Gulch Waste Rock Dump

The exposed face of the Mill Gulch waste rock dump was reclaimed between 1993 and 1995 (see FEIS Figure 2.5-5). This reclamation would be improved with additional fertilization, seeding, and planting. A reserve soil stockpile of 350,000 cubic yards would be retained on the top of the dump. Additional reclamation would include regrading and seeding the stockpile area.

Montana Gulch Waste Rock Dump

The soil stockpile and truck ready-line would be removed from the top of the Montana Gulch waste rock dump. The top of the dump would then be covered with 15 inches of NAG material and 24 inches of soil. In those areas where removal of the soil stockpile exposed native ground, 12 inches of soil would be placed. About 6.6 acres on the waste rock dump and 6.8 acres of soil stockpile footprint would be revegetated. In other areas of the dump, the existing reclamation would be considered final.

August #1 Waste Rock Dump

The August #1 waste rock dump is spread across several of the topmost benches on the south side of the August/Little Ben pit. Because the August/Little Ben soil stockpile was dumped over the top of the waste rock dump, the two piles are mixed together to some degree.

Material from the two piles would be segregated and used in the reclamation of various areas around the Landusky Mine. Enough of the waste rock dump would be left in place to grade the dump and stockpile areas plus an additional 5 acres of adjacent pit benches to 3H:1V slopes. The bench cover would use about 124,000 cubic yards of stockpile material and 6,000 cubic yards of bench reduction. The pit benches selected for reclamation are situated on the north side of the stockpile and below it. The 14.8 acres within the stockpile footprint and in the regraded bench area would be covered with 24 inches of soil and revegetated.

August #2 Waste Rock Dump

The west lobe of the August #2 waste rock dump has been graded to blend into the natural terrain and covered with 8 to 12 inches of soil. Trees were planted on this lobe in April 1990 and again in April 1991. This reclamation on the west lobe would be considered final.

The east lobe, containing about 599,000 cubic yards of material, sits on the north wall of the August/Little Ben pit. This lobe was covered with 8 to 12 inches of soil and revegetated in May 1992. This lobe would be redisturbed for use as a NAG source for reclamation in the Suprise pit. The disturbed portion of the dump would be regraded, covered with 12 inches of soil, and revegetated.

Gold Bug Yellow Waste Rock Repository

The material in the Gold Bug yellow waste rock repository would be regraded with maximum 3H:1V slopes. The 13.1-acre regraded area would be covered with 24 inches of NAG material, 24 inches of soil, and revegetated.

Lower Gold Bug Blue Waste Rock Stockpile

The material in the lower Gold Bug blue waste rock stockpile is non-acid generating and would be used in construction of the reclamation covers. The remaining footprint would be covered with 24 inches of soil and revegetated.

Upper Gold Bug Blue Waste Rock Stockpile

The material in the upper Gold Bug blue waste rock stockpile has been characterized as non-acid generating and would be used in construction of the reclamation covers. The remaining footprint would be covered with 12 inches of soil and revegetated.

Support Facilities Reclamation

All of the mining-related facilities not associated with water treatment would be removed, their footprints covered with 12 inches of soil, and revegetated. These include the fuel farm, upper warehouse, maintenance shop, lower Merrill-Crowe plant, three carbon plants, and the Landusky guard shack and gate. The upper Merrill-Crowe plant and two carbon plants are located on the L87 leach pad so their footprints would be reclaimed as part of the leach pad reclamation.

The water treatment plant, drainage capture systems, ponds, and associated structures would be left intact and continue functioning at their present location until no longer needed. Once removed, their footprints would be regraded, covered with soil, and revegetated.

Alternative L3, Improved Pit Drainage

Alternative L3 was designed to include all of the Alternative L2 reclamation measures plus the following additional actions to improve reclamation performance. This alternative slightly exceeds the funding available from the reclamation bond. The August/Little Ben pit would be drained via an 8-inch diameter directional drill hole, in addition to artesian well WS3. The entire east lobe of the August #2 waste rock dump would be removed and used to cover sulfide highwalls in the Suprise pit. A full drainage notch would be constructed on the west side of the L85/86 leach pad to eliminate any impoundment of water behind the leach pad. The reclamation action for each mine feature is shown in Figure 2.4-11. Those mine features that would be considered reclaimed, and not receiving additional reclamation work under this alternative, are marked "No Action" or "Reclaimed in 2000-2001."

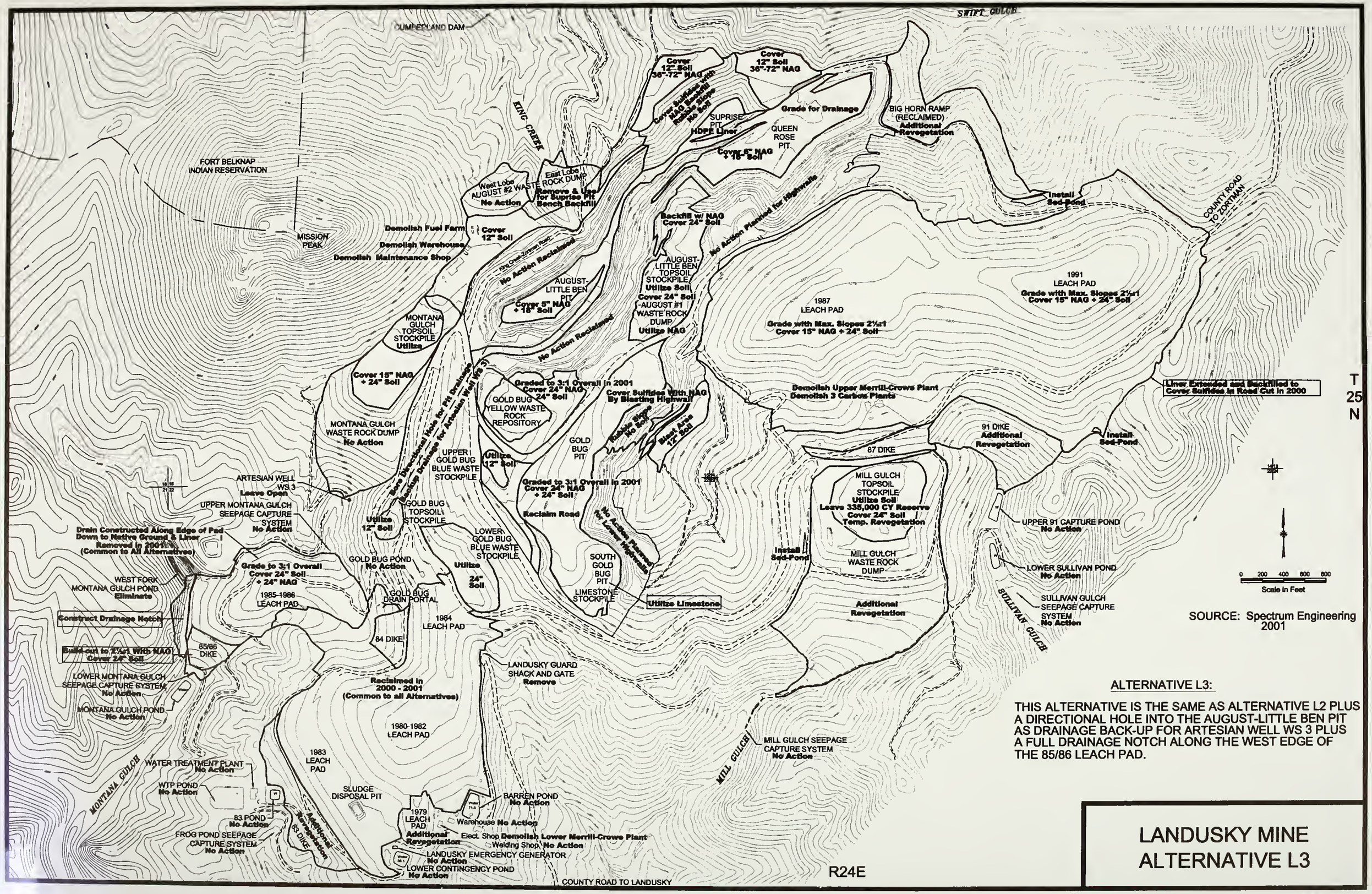
Mine Pit Reclamation

August/Little Ben-Suprise Pit Complex

The water level in the August/Little Ben pit would be controlled through artesian well WS3. This method of controlling pit drainage has been practiced successfully since October 1999. By using artesian well WS3 to drain the pit, impoundment of water on the pit floor has been eliminated. In order to reduce the resultant risk if artesian well WS3 eventually plugs, silts in, or otherwise ceases to function, a backup drain would be installed. A directional, angled drill hole 2500 feet long would be drilled to run from the bottom of the August/Little Ben pit into Montana Gulch. This hole would be cased with an 8-inch HDPE SDR11 pipe. Around the inlet, a catchment basin would be constructed to collect ponded water. A spillway would be constructed on the outlet end of the pipe. This pipe would only function or flow if the water level rose to the elevation of the bottom of the pit. artesian well WS3 would continue to function as the primary drainage control.

In order to direct runoff out of the Suprise pit, backfill would be placed on the pit floor to establish a 2% grade. The graded fill would be covered with HDPE liner to minimize water infiltration through the fill. Exposed sulfides in the northern pit highwalls and pit benches of the Suprise pit would be covered with NAG from the east lobe of the August #2 waste rock dump (about 599,000 cubic yards). This material would be end-dumped over the highwall, creating a rubble slope at the angle of repose (approximately 1.3 to 1.4H:1V). The pit benches would be covered with 36 to 72 inches of NAG as part of the backfill operation, followed by 12 inches of soil, and revegetated.

Reclamation inside the pit would consist of placing a 6-inch thick layer of NAG over the liner in the Suprise pit and directly over the pit floor in the August/Little Ben pit, followed by 18 inches of soil. About 28 acres of pit floor and bench would be revegetated.



SOURCE: Spectrum Engineering 2001

ALTERNATIVE L3:

THIS ALTERNATIVE IS THE SAME AS ALTERNATIVE L2 PLUS A DIRECTIONAL HOLE INTO THE AUGUST-LITTLE BEN PIT AS DRAINAGE BACK-UP FOR ARTESIAN WELL WS 3 PLUS A FULL DRAINAGE NOTCH ALONG THE WEST EDGE OF THE 85/86 LEACH PAD.

LANDUSKY MINE
ALTERNATIVE L3

FIGURE 2.4-11

Queen Rose Pit

The Queen Rose pit floor would be backfilled and graded to drain freely toward the partially backfilled Suprise pit. The regraded pit floor (approximately 15 acres) would be covered with a 6-inch thick layer of NAG, 18 inches of soil, and revegetated.

Gold Bug and South Gold Bug Pits

In the later stages of the mining operation the Gold Bug pit was partially backfilled and lower sections of the backfilled area were reclaimed. The remainder of the backfilled area would be graded with maximum 3H:1V slopes. All depressions and benches would be eliminated, producing a free draining surface.

Limited highwall reduction would be used to cover the exposed sulfide zone with non-acid generating rubble. This work would entail improving an existing exploration road up to the top of the ridge, stripping soil from 3.58 acres along the ridge top, and then blasting 93,000 bank cubic yards of NAG material in the stripped area. Bulldozers would push the blasted material over the edge of the highwall. The blasted NAG would be allowed to pile up along the face of the highwall, forming a wedge-shaped cover over the lower section of the pit wall. The rubble slope would be left at its angle of repose and would not be graded or covered. The highwall reduction source area at the top of the ridge would be regraded, covered with 12 inches of soil, and revegetated.

After the limestone stockpile in the South Gold Bug pit has been removed and utilized either as NAG cover or fill, the benches on the west side of the pits would be reduced to 3H:1V slopes to produce a free draining surface. The regraded area of the Gold Bug pit complex (approximately 29 acres), would be covered with 24 inches of NAG, 24 inches of soil, and revegetated.

Leach Pad Reclamation

All spent ore heaps would be recontoured to provide a topography that blends into the surrounding landscape. The leach pads would be reclaimed in place with some redistribution of the spent ore onto associated dikes and to areas adjacent the leach pads. All of the pads in the southwest corner of the mine area would be graded to reduce pad slopes to an overall 3H:1V grade. In most cases, there would be no need to incorporate benches into the regrading designs for these relatively low heaps. The L87 and L91 leach pads would be regraded with maximum 2.5H:1V slopes and 25-foot wide benches constructed on 100-foot vertical spacing. Slope reduction would be performed, in part, by bulldozers pushing ore heap material from the top of the facility down over the lift slopes. Where the desired grades could not be obtained by dozing alone, trucks and loaders would be used to offload and redistribute the material into fill areas. Depending on the acid generating potential of the material in the heap, leach pad surfaces would be covered with a combination of NAG material and soil. The total cover thickness would vary by pad from 24 to 39 inches. The reclamation cover would then be revegetated.

Additional reclamation work would be performed on the L84 and L85/86 dikes. The L84 dike would be built out to a nominal 3H:1V slope. The L85/86 dike would be built out to a nominal 2.5H:1V slope. Because NAG fill would be used in the buildout, the reclamation cover would be limited to 24 inches of soil and the dike faces would be revegetated.

L79 Leach Pad

The L79 leach pad is part of the complex of leach pads located near the lower Merrill-Crowe plant at the southwest corner of the mine. This pad has already been reclaimed with 8 to 12 inches of soil and revegetated in September 1991. The existing reclamation would be enhanced with additional fertilization, seeding, and planting.

L80-82, L83, and L84 Leach Pads

Regrading of the L80-82, L83, and L84 leach pads was undertaken as part of the 2000 interim reclamation project. Approximately 1.1 million cubic yards of grading and excavation were conducted to recontour these heaps to final overall grades of less than 3H:1V. Because the pads were reduced to a height of just over 100 feet, benching was not incorporated into the grading plan. The regrading plan required some offloading of the spent ore onto unlined and partially lined areas adjacent to the pads and included filling several large depressions between the L80-82 and L83 leach pads and extending the backfill over the upper contingency pond and the process water pond.

Before applying the interim reclamation cover, the regraded surface was sampled for acid generating potential to a depth of 24 inches on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of King Creek tailings were placed as cover material, followed by 18 inches of soil. The 74-acre surface was seeded in 2001. This interim reclamation cover would be considered final.

Reclamation on the L83 dike would be enhanced with additional fertilization, seeding, and planting to improve the existing vegetation. The L84 dike at the north end of the pad complex would be built out to a 3H:1V slope with about 61,000 cubic yards of material borrowed from the L85/86 leach pad. In conjunction with this effort, the over-steepened slope to the south of the dike would be rebuilt using material offloaded from the L80/82 and L85/86 leach pads. All of the material used in the dike and slope buildout would be NAG. The regraded dike would be covered with 24 inches of soil and revegetated.

L85/86 Leach Pad

The north and west sides of the pad would be excavated to re-establish drainage around the pad. On the north side of the pad, the base of the heap would be pulled back away from the hillside about 60 feet, permitting construction of a channel between the upper Montana Gulch seepage capture system and the West Fork Montana Gulch pond, which is contained in a blocked tributary behind the L85/86 pad. Nearly all of the excavated material would be used to build out the L84 dike and recontour the disturbed hillside south and west of the dike with 3H:1V slopes.

A second drainage channel would be constructed along the west margin of the L85/86 leach pad to completely unblock surface water drainage and eliminate the West Fork pond. This channel is the same design as used in Alternative L1. An estimated 113,800 bank cubic yards of excavation along the abutting hillside would occur to re-establish a free draining channel. The channel would connect into an existing lined channel that by-passes the capture system. The material generated by this excavation would be used as NAG fill and NAG cover on the L85/86 dike and in the Gold Bug pit.

The L3 Alternative incorporates all of the work accomplished by interim reclamation. In addition, contouring on the south and east sides of the pad would continue. Relocation of the access roads to the capture system and final grading of the leach pad surface to overall 3H:1V slopes would also occur. The relocated road would function as a bench breaking some of the slopes. No other benches would be constructed.

The amount of slope reduction that can be achieved by dozing is limited to about 77,000 cubic yards. In addition to the material moved during interim reclamation, another 274,000 cubic yards of material would be moved to the northeast end of the pad by trucks, where it would be placed in the gap between the upper edge of the pad and the hillside. A large portion of the material would be placed off the liner; however, seepage into the fill would still drain toward the lined area.

The slope on the front of the L85/86 dike would be built out to a 2.5H:1V slope using about 27,000 cubic yards of material from the drainage excavation. After reconstructing the face of this dike, it would be covered with 24 inches of soil and revegetated. Approximately 3 acres of surface would be revegetated.

The pad regrade area would be tested for acid generating potential. Areas requiring neutralization would be amended with lime to insure that 24 inches of NAG would cover the entire area. Then the surface would be covered with 24 inches of soil and revegetated.

L87/91 Leach Pad

The entire L87/91 leach pad would be regraded with maximum 2.5H:1V slopes with 25-foot wide benches spaced every 100 vertical feet. A 45-foot wide access road would be substituted for one of the benches on the south side of the L91 dike. The leach pad liner would be extended on the southeast side of the leach

pad to maximize the quantity of spent ore that could be moved downhill to achieve an overall slope configuration between 2.6H:1V and 3H:1V and still keep the spent ore on a lined surface. The extension of the leach pad liner on the southeast side of the L91 leach pad has already been incorporated into the 2000-2001 interim grading plan.

The grading plan would include the following excavation and haulage: 1,884,000 cubic yards of bulldozer grading; and 102,000 cubic yards of truck/loader redistribution. The regraded surface on both pads would be covered with 15 inches of NAG and 24 inches of soil. The entire 201 acres would be revegetated. All of the facilities on the leach pads, with the exception of the pumping facilities, would be removed before the grading occurred. The large pond on the top of the L87 leach pad would be backfilled during the grading operation.

The L87 dike is considered to be reclaimed as it is covered by the Mill Gulch waste rock dump. No additional grading would occur on the 350-foot high L91 dike. Buttressing of the dike is not necessary as it is stable in its current configuration (see Section 3.2.2, Geotechnical Conditions). However, the existing vegetation would be improved with additional fertilization, seeding, and planting.

Waste Rock Dump Reclamation

Mill Gulch Waste Rock Dump

The only portion of the waste rock dump presently unreclaimed is occupied by the Mill Gulch soil stockpile on the top of the dump. A reserve of 335,000 cubic yards of soil would be retained in this stockpile. Reclamation would consist of regrading and seeding the top of the stockpile area after it is removed. The existing reclamation on the face of the dump would be enhanced with additional fertilization, seeding, and planting.

Montana Gulch Waste Rock Dump

The soil stockpile and the truck ready-line would be removed from the Montana Gulch waste rock dump. The top of the dump would then be covered with 15 inches of NAG material and 24 inches of soil. In those areas where removal of the soil stockpile exposed native ground, 12 inches of soil would be placed. About 6.6 acres on the waste dump and 6.8 acres of soil stockpile footprint would be revegetated. In other areas of the dump such as the front and side slopes, the existing reclamation would be considered final.

August #1 Waste Rock Dump

The August #1 waste rock dump is spread across several of the topmost benches on the south side of the August/Little Ben pit. Because the August/Little Ben soil stockpile was dumped over the top of the waste rock dump, the two piles are mixed together to some degree.

Material from the two piles would be segregated and used in the reclamation of various areas around the Landusky Mine. Enough of the waste rock dump would be left in place to grade the dump and stockpile areas plus an additional 5 acres of adjacent pit benches to 3H:1V slopes. The bench cover would use about 124,000 cubic yards of stockpile material and 6,000 cubic yards of bench reduction. The pit benches that would be reclaimed are on the north side of the stockpile and below it. All 14.8 acres of the stockpile footprint and the regraded area would be covered with 24 inches of soil and revegetated.

August #2 Waste Rock Dump

The west lobe of the August #2 waste rock dump has been graded to blend into the natural terrain and covered with 8 to 12 inches of soil. Trees were planted on this lobe in April 1990 and again in April 1991. This reclamation would be considered final.

The east lobe, containing about 599,000 cubic yards of material, sits on the north wall of the August/Little Ben pit. This lobe was covered with 8 to 12 inches of soil and revegetated in May 1992. The existing soil and vegetation would be stripped and the entire east lobe would be excavated. The material would be used as a NAG source for covering the southeast-facing slopes and pit benches within the Suprise pit. The 8.56-acre footprint of the east lobe would be covered with 12 inches of soil and revegetated.

Gold Bug Yellow Waste Rock Repository

This dump would be regraded to 3H:1V slopes or flatter. The 13.1-acre regraded area would be covered with 24 inches of NAG material, 24 inches of soil, and revegetated.

Lower Gold Bug Blue Waste Rock Stockpile

The material in the lower Gold Bug blue waste rock stockpile has been characterized as non-acid generating and would be used in construction of the reclamation covers. The remaining footprint would be covered with 24 inches of soil and revegetated.

Upper Gold Bug Blue Waste Rock Stockpile

The material in the upper Gold Bug blue waste rock stockpile has been characterized as non-acid generating and would be used in construction of the reclamation covers. The remaining footprint would be covered with 12 inches of soil and revegetated.

Support Facilities Reclamation

All of the mining-related facilities not associated with water treatment would be removed, their footprints covered with 12 inches of soil, and revegetated. This includes the fuel farm, upper warehouse, maintenance shop, lower Merrill-Crowe plant, three carbon plants, and the Landusky guard shack and gate. The upper

Merrill-Crowe plant and two carbon plants are located on the L87 leach pad so their footprints would be reclaimed as part of the leach pad reclamation.

The water treatment plant, drainage capture systems, ponds, and associated structures would be left intact and continue functioning where presently located until no longer needed. Once removed, their footprints would be regraded, covered with soil, and revegetated.

Alternative L4, Removal and Backfill of L85/86 Leach Pad (Preferred Alternative)

Alternative L4 would cost approximately twice the available reclamation bond amount. It would include removing the L85/86 leach pad and dike from the Montana Gulch drainage and hauling them to the August/Little Ben pit as pit backfill. Additional highwall reduction and backfill would be used to cover various sections of the pit wall throughout the pit complex. The reclamation for each mine feature is shown in Figure 2.4-12. Those mine features that would be considered already reclaimed and not receiving additional reclamation work under this alternative are labeled "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

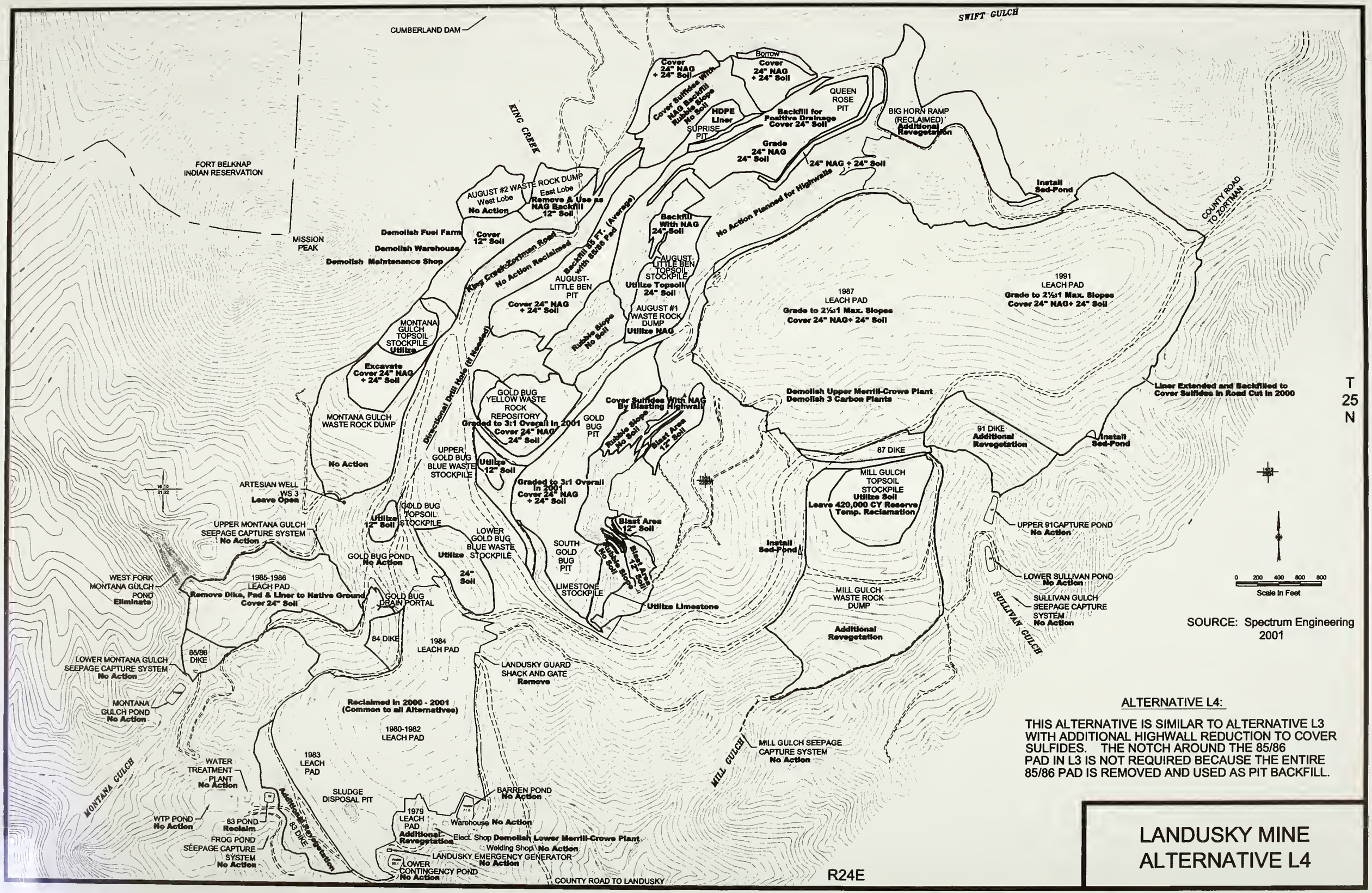
August/Little Ben-Suprise Pit Complex

Backfill would be placed in the Suprise pit to establish a 2% grade. A HDPE liner would be placed over the graded fill to maximize water infiltration through the pit floor. The sulfides in the north and west pit walls and benches of the Suprise pit would be covered with NAG fill from the east lobe of the August #2 waste rock dump and the L85/86 leach pad. This material would be end-dumped over the highwall, creating a rubble slope at the angle of repose (approximately 1.3 to 1.4H:1V). The pit benches would also be covered with fill to a depth of 36 to 72 inches, and several feet of fill would be placed over the liner on the pit floor.

The 2,325,000 cubic yards of material removed from the L85/86 leach pad would be placed in the August/Little Ben pit. Part of this material would be dumped over the highwall between the August #1 waste rock dump and the Gold Bug yellow waste rock repository. This material would be left as a steep rubble slope extending from the pit floor up to the top of the highwall. The remainder of the material would be placed in the bottom of the pit, raising the floor an average of 85 feet. The fill would be graded to drain to the south end of the pit where the elevation of the pit floor would be approximately 4715 feet amsl.

Pit drainage would be via infiltration through the fill into the groundwater system that is controlled by the existing artesian well in Montana Gulch. Drainage would be supplemented (if needed) by the addition of a directional, angled drill hole from the August/Little Ben pit into Montana Gulch as described in Alternative L3.

Reclamation covers consisting of 24 inches of NAG and 24 inches of soil would be placed over the fill on the pit floors and over the benches on the north and west sides of the Suprise pit. Because most of the fill material would be non-acid generating, the NAG layer would be produced by adding agricultural lime into the top 24 inches of the graded backfill. Approximately 33 acres would be revegetated.



SOURCE: Spectrum Engineering 2001

ALTERNATIVE L4:

THIS ALTERNATIVE IS SIMILAR TO ALTERNATIVE L3 WITH ADDITIONAL HIGHWALL REDUCTION TO COVER SULFIDES. THE NOTCH AROUND THE 85/86 PAD IN L3 IS NOT REQUIRED BECAUSE THE ENTIRE 85/86 PAD IS REMOVED AND USED AS PIT BACKFILL.

LANDUSKY MINE ALTERNATIVE L4

FIGURE 2.4-12

Queen Rose Pit

The floor of the Queen Rose pit would be backfilled and graded to produce a surface that directs runoff toward the Suprise pit. The entire pit floor and about 3.5 acres of accessible pit bench would be covered with 24 inches of NAG and 24 inches of soil. In the pit backfill areas, the NAG layer would be produced by treating the top 24 inches of fill with agricultural lime. Approximately 20 acres would be revegetated.

Gold Bug and South Gold Bug Pits

In the later stages of the mining operation, the Gold Bug pit was partially backfilled and lower sections of the backfilled area were reclaimed. Under this alternative, the remainder of the backfilled area would be graded to 3H:1V slopes or less. All depressions and benches would be eliminated to produce a free draining surface.

Limited highwall reduction would be conducted at the north end of the Gold Bug pit to cover the exposed sulfide zone with non-acid generating rubble. This work would entail improving an existing exploration road up to the top of the ridge, stripping soil from 3.58 acres along the ridge top, and then blasting 93,000 bank cubic yards of NAG material in the stripped area. Bulldozers would push the blasted material over the edge of the highwall. The blasted NAG would be allowed to pile up along the face of the highwall, forming a wedge-shaped cover over the lower section of the pit wall. The rubble slope would be left at its angle of repose. The highwall reduction source area at the top of the ridge would be regraded, covered with 12 inches of soil, and revegetated.

The limestone stockpile in the South Gold Bug pit would be removed and used as NAG cover. The benches on the west side of the pits would be reduced to 3H:1V slopes, producing a free draining surface. Then the pit walls on the north and west sides would be reduced by blasting about 4.8 acres along the top of the highwall. The blasted material would be pushed into the pits, creating a steep rubble slope covering most of the pit walls. The reduction area above the rubble slope would be regraded with maximum 3H:1V slopes before being covered with 12 inches of soil, while the rubble slope would be left in a rough, uncovered condition. A reclamation cover consisting of 24 inches of soil over 24 inches of NAG would be placed over the remaining 27.5 acres in the Gold Bug pit complex.

Leach Pad Reclamation

The L85/86 leach pad and dike would be removed from Montana Gulch. The L87/91 leach pad would be reshaped to reduce the slopes to a maximum grade of 2.5H:1V incorporating 25-foot wide benches every 100 vertical feet. The reclamation on the L80/82-L83-L84 leach pad complex would be considered final. The L84 dike would be built out to a slope of 3H:1V. Reclamation of the L79 leach pad, the L91 dike, and the L83 dike would be considered complete except for additional revegetation.

The leach pads and dikes would be covered with at least 24 inches of NAG, followed by 24 inches of soil. The NAG layer could be imported from the mine stockpiles or could be created by treating the in-place materials with lime.

L79 Leach Pad

The L79 leach pad has already been regraded, reclaimed with 8 to 12 inches of soil, and revegetated in September 1991. The existing reclamation would be enhanced with additional fertilization, seeding, and planting.

L80-82, L83, and L84 Leach Pads

Regrading of these leach pads was undertaken as part of the 2000 interim reclamation project. Approximately 1.1 million cubic yards of grading and excavation were conducted to recontour these heaps to a final grade of less than 3H:1V. Because the pads were reduced to a height of just over 100 feet, benching was not incorporated into the regrading. The regrading plan required some offloading of the spent ore onto unlined and partially lined areas adjacent to the pads, and included filling several large depressions between the L80-82 and L83 Pads and extending the backfill over the upper contingency pond and the process water pond.

Before applying the interim reclamation cover, the regraded surface was sampled for acid generating potential to a depth of 24 inches on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of King Creek tailings were placed as cover material, followed by 18 inches of soil. The 74 acres of surface were seeded in 2001. This interim reclamation would be considered final. However, the existing reclamation on the L83 dike would be improved with additional fertilization, seeding, and planting.

The L84 dike at the north end of the pad complex would be built out to a 3H:1V slope with about 61,000 cubic yards of material borrowed from the L85/86 pad. In conjunction with this effort, the over-steepened slope to the south of the dike would be rebuilt using material offloaded from the L80/82 and L85/86 leach pads. All of the material used in the dike and slope buildout is expected to be NAG. However, the regraded surfaces would be tested for acid generating potential before applying 24 inches of soil and seeding the 11.2 acres of reclamation.

L85/86 Leach Pad

The entire L85/86 leach pad and dike would be removed from the bottom of Montana Gulch. Leach pad removal work would include removing the exposed leach pad liner and reconstructing the drainage bottom, which would remove the spent ore blocking free drainage through this section of the gulch. In most areas, removal would extend down to the pre-mining surface. Most of the material (2,577,000 cubic yards) would be hauled to the August/Little Ben-Suprise pit complex as backfill. The remainder of the heap

(413,000 cubic yards) would be used for interim reclamation to build out the L84 dike and the adjacent over-steepened slope to the south.

Due to the steep pre-mining surface below the L84 dike buildout areas, portions of the heap would be left in place to stabilize the base of this dike. Access roads through this area would also be relocated. The entire 27.6 acres associated with the pad and dike removal would be covered with 24 inches of soil and revegetated.

L87/91 Leach Pad

The entire L87/91 leach pad would be regraded with maximum 2.5H:1V slopes with 25-foot wide constructed benches spaced every 100 vertical feet. A 45-foot wide access road would be substituted for one of the benches on the south side of the L91 dike. The leach pad liner would be extended on the southeast side of the leach pad to maximize the quantity of spent ore that could be moved downhill to achieve an overall slope configuration between 2.6H:1V and 3H:1V. The extension of the liner on the southeast side of the L91 pad was conducted as part of the 2000-2001 interim reclamation.

The grading plan would include 1,884,000 cubic yards of bulldozer grading and 102,000 cubic yards of truck/loader redistribution. The regraded surface on both pads would be covered with 24 inches of NAG and 24 inches of soil. The entire 203-acre area would be revegetated. All of the facilities on the pads, with the exception of the pumping facilities, would be removed. The large pond on the top of the L87 pad would be backfilled during the grading operation.

The L87 dike is considered to be reclaimed as it is covered by the Mill Gulch waste rock dump. No additional grading would occur on the 350-foot high L91 dike. Buttressing of the dike is not necessary as it is stable in its current configuration (see Section 3.2.2, Geotechnical Conditions). However, the existing vegetation would be improved with additional fertilization, seeding, and planting.

Waste Rock Dump Reclamation

Mill Gulch Waste Rock Dump

The only portion of the Mill Gulch waste rock dump presently unreclaimed is occupied by the Mill Gulch soil stockpile on the top of the dump. Approximately 202,000 cubic yards of Landusky Mine soil would be transferred to the Zortman Mine site and a reserve of 218,000 cubic yards would be retained in this soil stockpile. Reclamation would consist of regrading and seeding the stockpile area after it is removed. The existing reclamation on the face of the dump would be enhanced with additional fertilization, seeding, and planting.

Montana Gulch Waste Rock Dump

The soil stockpile and truck ready-line would be removed from the top of the dump. The dump would then be graded. The regraded surface would be sampled for acid generating potential to a depth of 2 feet on a grid spacing of 100 feet. Grids with a net acid potential would be neutralized with lime. This procedure would provide at least 24 inches of NAG at the top of the regraded surface. After liming, 24 inches of soil would be spread over the top of the dump. In those areas where removal of the soil stockpile exposed native ground, 12 inches of soil would be placed. About 6.6 acres on the waste dump and 6.8 acres of the soil stockpile footprint would be revegetated. In other areas of the dump such as the front and side slopes, the existing reclamation would be considered final.

August #1 Waste Rock Dump

The August #1 waste rock dump is spread across several of the topmost benches on the south side of the August/Little Ben pit. Because the August/Little Ben soil stockpile was dumped over the top of the waste dump, the two piles are mixed together to some degree.

Material from the two piles would be segregated and used in the reclamation of various areas around the Landusky Mine. Enough of the waste rock dump would be left in place to grade the dump and stockpile areas plus an additional 5 acres of adjacent pit benches to 3H:1V slopes. The bench cover would use about 124,000 cubic yards of stockpile material and 6,000 cubic yards of bench reduction. The pit benches that would be reclaimed are north of, and below, the soil stockpile. Some 15 acres within the stockpile footprint and in the regraded bench area would be covered with 24 inches of soil and revegetated.

August #2 Waste Rock Dump

The west lobe of the August #2 waste rock dump has been graded to blend into the natural terrain and covered with 8 to 12 inches of soil. Trees were planted in April 1990 and again in April 1991. The existing reclamation on the west lobe of the waste rock dump would be considered final.

The east lobe, containing about 599,000 cubic yards of material, sits on the north wall of the August/Little Ben pit. This lobe was covered with 8 to 12 inches of soil and revegetated in May 1992. The material in this dump is non-acid generating. The existing soil and vegetation would be stripped off and the east lobe would be completely removed and used for NAG fill and cover. After removal, the exposed slopes would be covered with 12 inches of soil and revegetated. The King Creek-to-Zortman access road would be relocated through the dump footprint.

Gold Bug Yellow Waste Rock Repository

The Gold Bug yellow waste rock repository would be regraded to 3H:1V slopes or less. The 13-acre regraded surface would be covered with 24 inches of NAG, 24 inches of soil, and revegetated.

Lower Gold Bug Blue Waste Rock Stockpile

The material in the lower Gold Bug blue waste rock stockpile is non-acid generating. The stockpile would be removed and used in construction of the reclamation covers. The remaining footprint would be covered with 24 inches of soil and revegetated.

Upper Gold Bug Blue Waste Rock Stockpile

The material in the upper Gold Bug blue waste rock stockpile is non-acid generating. The stockpile would be removed and used in construction of the reclamation covers. The remaining footprint would be covered with 12 inches of soil and revegetated.

Support Facilities Reclamation

All of the mining-related facilities not associated with water treatment would be removed, their footprints covered with 12 inches of soil, and revegetated. These facilities include the fuel farm, upper warehouse, maintenance shop, lower Merrill-Crowe plant, three carbon plants, and the Landusky guard shack and gate. The upper Merrill-Crowe plant and two carbon plants are located on the L87 leach pad so their footprints would be reclaimed as part of the leach pad reclamation.

The water treatment plant, drainage capture systems, ponds, and associated structures would be left intact and continue functioning where presently located until no longer needed. Once removed, their footprints would be regraded, covered with soil, and revegetated.

Alternative L5, Backfill to Cover Sulfide Highwalls

Alternative L5 would cost approximately four times the available reclamation bond amount. It would include substantial backfilling of the mine pit complex. All the pit highwalls in the sulfide zone would be covered with backfill and graded to a 2H:1V slope or less. The L85/86 leach pad and dike, and much of the spent ore from the L87 leach pad would be removed and used as backfill. The reclamation action for each mine feature is shown in Figure 2.4-13. Those mine features that would be considered reclaimed and not receiving additional reclamation work under this alternative are labeled "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

August/Little Ben-Suprise Pit Complex

Under this alternative, the pit complex would be extensively backfilled to establish a free draining surface and to cover nearly all of the exposed sulfide zones in the pit walls. Prior to backfilling, grading fill would be placed over the pit floor to produce a 2% grade sloping to the south end of the pit. A geosynthetic liner would be installed over this subgrade surface to prevent water from infiltrating into the pit floor.

A drainage notch to Montana Gulch would be excavated through the pit wall on the southwest end of the August/Little Ben pit. The pit complex would be backfilled with 10,342,000 cubic yards of material. Because the bottom of the notch would be positioned at an elevation of 4822 feet amsl at the southwest end of the August pit, only 95,000 bank cubic yards of excavation through the bedrock wall of the pit would be required to break into Montana Gulch at a point where a connection could be made into the previously constructed surface water control system. Backfill within the pit complex would be sloped at approximately 1.3% all the way to the north end of the Suprise pit. A 2.4% gradient would be maintained along the roughly 500 feet of channel required to make the connection into the existing drainage facility.

Much of the backfill surface would be shaped by dumping material off the highwalls surrounding the pit and then dozing the material down on approximately 3H:1V slopes. Near the bottom of the slope the grade would gradually flatten out until a narrow, relatively flat bottom was created. Hence, the backfilled surface would have the appearance of a V-shaped trough extending from the end of the Suprise pit to the notch. Due to variations in the pit width and in the heights of the pit walls, the contours and grades would vary along both sides of the pit. In the wider areas of the pit, even the upper slopes would be more gentle than 3H:1V. The backfill would cover nearly all of the pit benches, including the upper benches at the north end of the Suprise pit.

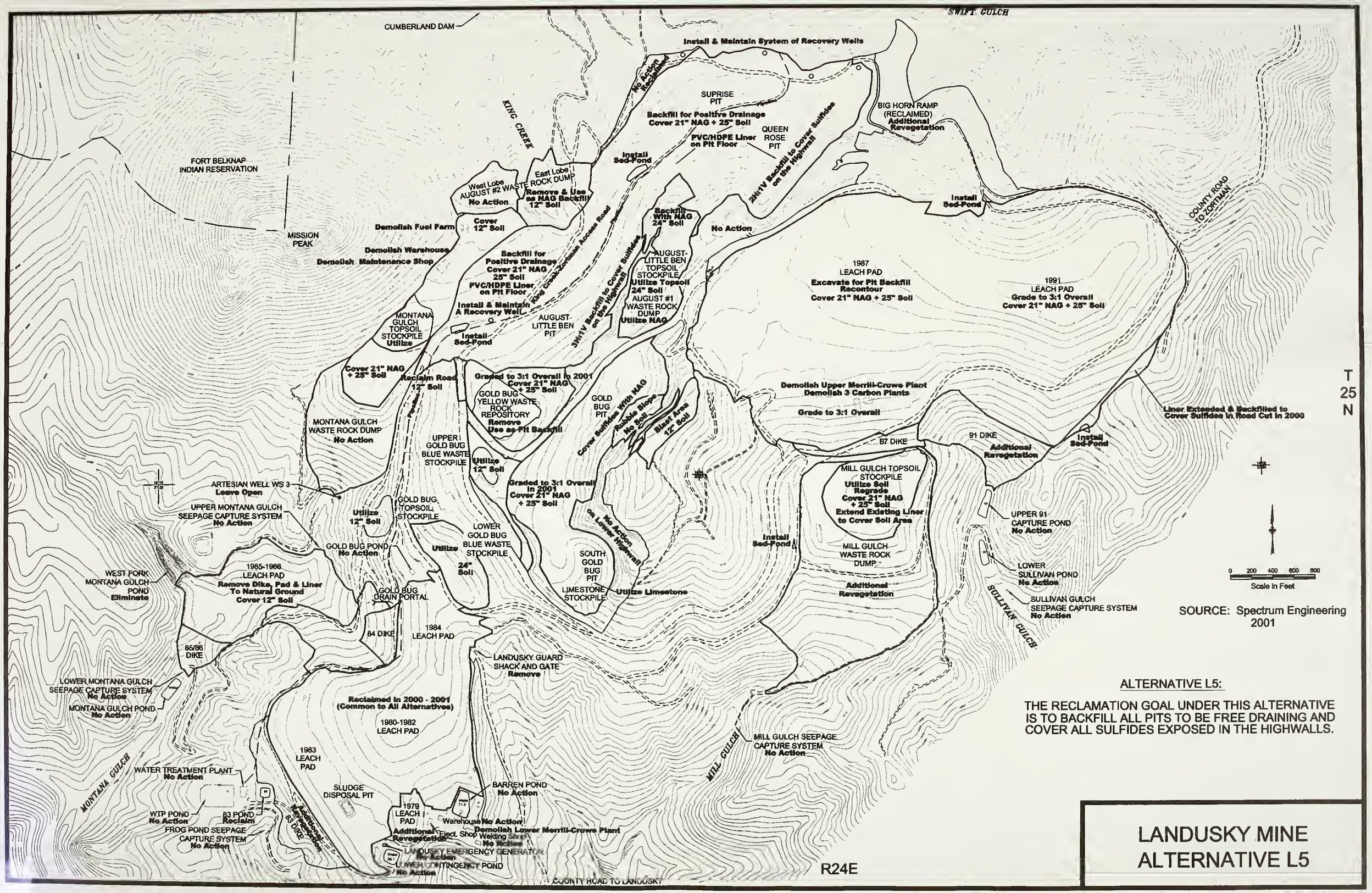

SWIFT GULCH
CUMBERLAND DAM
Install & Maintain System of Recovery Wells
No Action Reclaimed
SUPRISE PIT
Backfill for Positive Drainage
Cover 21" NAG + 25" Soil
PVC/HDPE Liner on Pit Floor
QUEEN ROSE PIT
2H:1V Backfill to Cover Sulfides on the Highwall
BIG HORN RAMP (RECLAIMED)
Additional Revegetation
KING CREEK
FORT BELKNAP INDIAN RESERVATION
Install Sed-Pond
West Lobe AUGUST #2 WASTE
No Action
East Lobe ROCK DUMP
Remove & Use as NAG Backfill
12" Soil
Cover 12" Soil
Demolish Fuel Farm
MISSION PEAK
Demolish Warehouse
Demolish Maintenance Shop
Backfill for Positive Drainage
Cover 21" NAG
25" Soil
PVC/HDPE Liner on Pit Floor
Install & Maintain A Recovery Well
King Creek-Zortman Access Road
3H:1V Backfill to Cover Sulfides on the Highwall
Backfill With NAG
24" Soil
AUGUST-LITTLE BEN TOPSOIL STOCKPILE
Utilize Topsoil
24" Soil
AUGUST #1 WASTE ROCK DUMP
Utilize NAG
AUGUST-LITTLE BEN PIT
No Action
Install Sed-Pond
1987 LEACH PAD
Excavate for Pit Backfill
Recontour
Cover 21" NAG + 25" Soil
1991 LEACH PAD
Grade to 3:1 Overall
Cover 21" NAG + 25" Soil
COUNTY ROAD TO ZORTMAN
MONTANA GULCH TOPSOIL STOCKPILE
Utilize
Install Sed-Pond
Cover 21" NAG + 25" Soil
Reclaim Road
12" Soil
Graded to 3:1 Overall in 2001
Cover 21" NAG + 25" Soil
GOLD BUG YELLOW WASTE ROCK REPOSITORY
Remove
Use as Pit Backfill
GOLD BUG PIT
Cover Sulfides With NAG
Rubble Slope
No Soil
Blast Area
12" Soil
Demolish Upper Merrill-Crowe Plant
Demolish 3 Carbon Plants
Grade to 3:1 Overall
Liner Extended & Backfilled to Cover Sulfides in Road Cut in 2000
MONTANA GULCH WASTE ROCK DUMP
No Action
UPPER GOLD BUG BLUE WASTE STOCKPILE
Utilize
12" Soil
B7 DIKE
91 DIKE
Additional Revegetation
Install Sed-Pond
MILL GULCH TOPSOIL STOCKPILE
Utilize Soil
Regrade
Cover 21" NAG + 25" Soil
Extend Existing Liner to Cover Soil Area
ARTESIAN WELL WS 3
Leave Open
UPPER MONTANA GULCH SEEPAGE CAPTURE SYSTEM
No Action
Graded to 3:1 Overall in 2001
Cover 21" NAG + 25" Soil
GOLD BUG TOPSOIL STOCKPILE
Utilize
12" Soil
LOWER GOLD BUG BLUE WASTE STOCKPILE
Utilize
24" Soil
No Action on Lower Highwall
SOUTH GOLD BUG PIT
LIMESTONE STOCKPILE
Utilize Limestone
Install Sed-Pond
MILL GULCH WASTE ROCK DUMP
Additional Revegetation
UPPER 91 CAPTURE POND
No Action
LOWER SULLIVAN POND
No Action
SULLIVAN GULCH SEEPAGE CAPTURE SYSTEM
No Action
SULLIVAN GULCH
GOLD BUG POND
No Action
WEST FORK MONTANA GULCH POND
Eliminate
1985-1986 LEACH PAD
Remove Dike, Pad & Liner
To Natural Ground
Cover 12" Soil
GOLD BUG DRAIN PORTAL
84 DIKE
1984 LEACH PAD
85/86 DIKE
LANDUSKY GUARD SHACK AND GATE
Remove
LOWER MONTANA GULCH SEEPAGE CAPTURE SYSTEM
No Action
MONTANA GULCH POND
No Action
Reclaimed in 2000 - 2001
(Common to All Alternatives)
1980-1982 LEACH PAD
MILL GULCH SEEPAGE CAPTURE SYSTEM
No Action
MILL GULCH
1983 LEACH PAD
MONTANA GULCH
WATER TREATMENT PLANT
No Action
SLUDGE DISPOSAL PIT
BARREN POND
No Action
WTP POND
No Action
83 POND
Reclaim
FROG POND SEEPAGE CAPTURE SYSTEM
No Action
Additional Revegetation
83 DIKE
1979 LEACH PAD
Warehouse No Action
Additional Revegetation
Elect. Shop
Welding Shop
No Action
Demolish Lower Merrill-Crowe Plant
LANDUSKY EMERGENCY GENERATOR
No Action
LOWER CONTINGENCY POND
No Action
COUNTY ROAD TO LANDUSKY
R24E
T 25 N
0 200 400 600 800
Scale In Feet
SOURCE: Spectrum Engineering 2001
ALTERNATIVE L5:
THE RECLAMATION GOAL UNDER THIS ALTERNATIVE IS TO BACKFILL ALL PITS TO BE FREE DRAINING AND COVER ALL SULFIDES EXPOSED IN THE HIGHWALLS.
LANDUSKY MINE
ALTERNATIVE L5

FIGURE 2.4-13

Backfill material for the pit complex would come from the following sources:

L85/86 leach pad and dike	2,059,000 cubic yards
Gold Bug yellow waste rep.	278,000 cubic yards
L87/91 pad spent ore	7,732,000 cubic yards (mostly the L87 pad)
Facilities area	137,000 cubic yards
Notch construction	95,000 bank cubic yards
Slope reduction	13,000 cubic yards

The drainage channel would be constructed to pass runoff from a 6.33-inch, 24-hour storm event. After going though the notch and traveling through a channel cut along the east side of the Montana Gulch waste rock dump, runoff from the pit would drain into a lined channel that has already been constructed along an old haul road on the east slope of Montana Gulch. At the L85/86 leach pad excavation area, a riprapped, lined channel would be used to convey the pit runoff down to the reconstructed drainage bottom in Montana Gulch. Two sediment ponds would be constructed on the pit backfill to remove sediment from the runoff before it enters the lined channel.

The 85-acre graded surface of the pit backfill would be covered with a minimum 21 inches of NAG, 25 inches of soil, and revegetated.

Four wells would be drilled along the north edge of the mine pit complex to monitor and intercept degraded water that might infiltrate into the Swift Gulch groundwater system. A fifth well would be drilled near the southwest end of the August pit for the same purposes. A pipeline would be constructed to transfer any recovered water from the wells back to the Landusky water treatment plant for processing. A parallel pipeline would be constructed to pump an equal amount of treated water back to the Swift Gulch drainage.

Queen Rose Pit

The floor of the Queen Rose pit would be graded to establish a free draining surface that would slope to the southwest toward the August/Little Ben pit. The regraded floor would be covered with a geosynthetic liner and then backfilled with 3,107,000 cubic yards of material to cover the sulfide zone in the highwall. Due to the height of the sulfide zone in the Queen Rose pit, 2H:1V slopes would be used along much of its highwall. These slopes would extend down and gradually blend into the contours of the backfilled surface in the August/Little Ben-Suprise pit. The backfill surface would be constructed by building a narrow fill bench near the top of the highwall then dozing the material downhill on a 2H:1V grade. This would cover about half of the highwall and benches in the Queen Rose pit. Material for backfilling this pit would be imported from the L87 pad (2,873,000 cubic yards) and from the L85/86 pad (234,000 cubic yards). Approximately 30 acres of graded backfill would be covered with 21 inches of NAG, 25 inches of soil, and revegetated.

Gold Bug and South Gold Bug Pits

In the later stages of the mining operation the pit was used as a waste repository and partially backfilled. The embankment slopes along the west face of the repository were graded, sealed with a layer of compacted clay, and reclaimed as successive layers of backfill were added. Under this alternative, the unreclaimed upper sections of the repository and pit would be graded to produce a free draining surface from the pit highwall to the road. All of the bottom benches would be regraded to create a smooth recontoured surface with maximum 3H:1V slopes. Approximately 100,000 cubic yards of balanced cut/fill grading would be conducted.

Limited highwall reduction would be conducted at the north end of the Gold Bug pit to cover the exposed sulfide zone with non-acid generating rubble. This work would entail stripping soil from 3.58 acres along the ridge top and then blasting 93,000 bank cubic yards of NAG material in the stripped area. Bulldozers would push the blasted material over the edge of the highwall, allowing it to pile up along the face of the highwall. The rubble slope would be left at its angle of repose. The highwall reduction source area at the top of the ridge would be regraded, covered with 12 inches of soil, and revegetated. An additional 324,000 cubic yards of NAG backfill obtained from the L85/86 pad would be used to cover other sulfide zones around the pit.

After 116,000 cubic yards of the 209,000 cubic yards of limestone in the stockpile has been removed and utilized either as NAG cover or fill, approximately 69,000 cubic yards of NAG would be hauled in from the L85/86 leach pad to cover the sulfides exposed in the pit highwall. The backfill cover would be constructed by building a narrow fill bench near the top of the zone and then dozing the material downhill on a 2H:1V grade. This wedge of NAG backfill would sit on top of the limestone left in the pit. Some minor grading would be done to reduce the exposed benches on the west side of the pit to 3H:1V slopes and to blend the contours.

All backfilled and regraded areas in the Gold Bug and South Gold Bug pits (27 acres) would be covered with 21 inches of NAG, 25 inches of soil, and revegetated.

Leach Pad Reclamation

The L85/86 leach pad, liner, and dike would be removed from Montana Gulch. The remaining pads in the southwest corner on the mine area have been graded to reduce pad slopes to an overall 3H:1V grade. This reclamation would be considered final. The upper lifts on the west half of the L87 pad would be excavated for pit backfill, leaving a substantial surface area that could be regraded with less than 10% slopes.

Additional reclamation would be conducted on four of the heap retaining dikes. The L85/86 dike would be completely removed. The L84 dike would be built out to a 3H:1V slope using NAG material. Additional revegetation work would be conducted on the L83 and L91 dikes as preventative maintenance.

L79 Leach Pad

The L79 leach pad was reclaimed with 8 to 12 inches of soil and revegetated in September 1991. The existing reclamation would be enhanced with additional fertilization, seeding, and planting.

L80-82, L83, and L84 Leach Pads

Regrading these leach pads was undertaken as part of the 2000 interim reclamation project. Approximately 1.1 million cubic yards of grading and excavation were conducted to recontour these heaps to a final grade of less than 3H:1V. Because the pads were reduced to a height of just over 100 feet, benching was not incorporated into the grading plan. The regrading plan required some offloading of the spent ore onto unlined and partially lined areas adjacent to the pads, and included filling several large depressions between the L80-82 and L83 leach pads and extending the backfill over the upper contingency pond and the process water pond.

Before applying the reclamation cover, the regraded surface was sampled for acid generating potential to a depth of 24 inches on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of King Creek tailings were placed as cover material, followed by 18 inches of soil. The area was seeded in 2001. This interim reclamation would be considered final. However, the existing reclamation on the L83 dike would be improved with additional fertilization, seeding, and planting.

Additional revegetation would be done on the L83 dike. The L84 dike at the north end of the pad complex would be built out to a 3H:1V slope with about 61,000 cubic yards of material borrowed from the L85/86 leach pad. In conjunction with this effort, the over-steepened slope to the south of the dike would be rebuilt using material offloaded from the L80/82 leach pad and the L85/86 leach pad. All of the material used in the dike and slope buildout would be NAG. However, the regraded surfaces would be tested for acid generating potential before applying 24 inches of soil and seeding the reclamation. This interim reclamation would be considered final.

L85/86 Leach Pad

In 2001, the north and west sides of the pad would be excavated to improve drainage around the pad. This material would be used to build out the L84 dike and to recontour the disturbed hillside south and west of the dike with gentle 3H:1V slopes.

The leach pad and dike would be removed from the bottom of Montana Gulch to completely unblock drainage through this section of the gulch. Relocation of the access roads through this area would also be required. Pad removal work would include removing all exposed leach pad liner and reconstructing the drainage bottom. In most areas, removal would extend down to the pre-mining surface. The material (2,676,000 cubic yards) would be hauled to a variety of areas around the mine. Due to the steep pre-mining surface below the L84 dike interim reclamation buildout areas, portions of the heap would be left

in place to buttress the dike fill. The entire 27.6 acres associated with the pad and dike removal would be covered with 12 inches of soil and revegetated.

L87/91 Leach Pad

Approximately 10,605,000 cubic yards of spent ore would be offloaded from the L87/91 leach pad (primarily from the L87 leach pad) and used to backfill the August/Little Ben, Suprise, and Queen Rose pits. The remainder of the material on the two heaps would be regraded to overall 3H:1V slopes with 40-foot wide benches spaced every 100 vertical feet. The leach pad liner would be extended on the east and west sides so that spent ore could be offloaded into these areas. This would greatly increase the quantity of material that can be dozed downhill to achieve the 3H:1V configuration. The extension of the liner on the southeast side of the L91 leach pad was incorporated into 2000-2001 interim reclamation grading. Excluding the export of spent ore to pit backfill areas, recontouring the pads to 3H:1V slopes would include 1,464,000 cubic yards of bulldozer grading and 102,000 cubic yards of truck/loader redistribution. All of the facilities on the pads, with the exception of the pumping facilities, would be removed before grading. The large pond on the top of the L87 Pad would be removed as the top of the pad is excavated for pit backfill.

Before placement of the reclamation cover, the regraded surface would be tested for acid generating potential. Lime would be used in the top 24 inches where neutralization is determined to be required. After the surface is prepared, it would be covered with 21 inches of NAG and 25 inches of soil, and the entire L87/91 leach pad area, totaling 202 acres, would be revegetated.

The L87 dike is considered to be reclaimed as it is covered by the Mill Gulch waste rock dump. The 350-foot high L91 dike would be planted with supplementary revegetation to improve erosion resistance and reduce infiltration. Buttressing of the dike is not required as it is stable in its current configuration (see Section 3.2.2, Geotechnical Conditions).

Waste Rock Dump Reclamation

Mill Gulch Waste Rock Dump

The only portion of the Mill Gulch waste rock dump presently unreclaimed is occupied by the Mill Gulch soil stockpile. After all of the soil stored in this facility has been removed from the top of the waste dump, the disturbed area would be regraded and a reclamation cover consisting of 21 inches of NAG and 25 inches of soil would be extended across the newly regraded area on top of the bench. The existing synthetic liner would be extended to cover this area. The previously reclaimed face of the dump would be treated with additional fertilization, seeding, and planting to improve the existing vegetation.

Montana Gulch Waste Rock Dump

A minor amount of excavation for the August/Little Ben Notch would occur along the dump margin but would not extend into the rock dump. The soil stockpile and truck ready-line would be removed. The top of the dump would be covered with 21 inches of NAG material and 25 inches of soil. In those areas where removal of the soil stockpile exposed native ground, 12 inches of soil would be placed. About 6.6 acres on the waste dump and 5.4 acres of the soil stockpile footprint would be revegetated. In the undisturbed areas of the waste rock dump, the existing reclamation would be considered final.

August #1 Waste Rock Dump

The August #1 waste rock dump is spread across several of the topmost benches on the south side of the August/Little Ben pit. Because the August/Little Ben soil stockpile was dumped over the top of the waste rock dump, the two piles are mixed together to some degree.

Material from the two piles would be segregated and used in the reclamation of various areas around the Landusky Mine. Enough of the dump would be left in place to grade the dump and stockpile areas plus an additional 5 acres of adjacent pit benches to 3H:1V slopes. The bench cover would use about 124,000 cubic yards of stockpile material and 6,000 cubic yards of bench reduction. The pit benches to be reclaimed are to the north and below the stockpile. All 15 acres within the stockpile footprint and in the regraded bench area would be covered with 24 inches of soil and revegetated.

August #2 Waste Rock Dump

The west lobe of the August #2 waste rock dump has been graded to blend into the natural terrain and covered with 8 to 12 inches of soil. Trees were planted on this lobe in April 1990 and again in April 1991. This existing reclamation on the west lobe of the dump would be considered final.

The east lobe, containing about 599,000 cubic yards of material, sits on the north wall of the August/Little Ben pit. This lobe was covered with 8 to 12 inches of soil and revegetated in May 1992. The material in this dump is non-acid generating. The existing soil and vegetation would be stripped and the east lobe of the dump would be completely removed and used for NAG fill and cover. After this dump has been removed, the exposed slopes would be covered with 12 inches of soil and revegetated. The King Creek-to-Zortman access road would be relocated through the dump footprint.

Gold Bug Yellow Waste Rock Repository

The entire Gold Bug yellow waste rock repository would be removed. About 255,000 cubic yards of the stockpiled material would be buried deep in the August/Little Ben backfill. The remaining 27,000 cubic yards would be used to cover exposed sulfides on the upper mining bench in the northeast corner of the stockpile area. After removing the stockpile, an intermediate bench covered by the stockpile would be

blasted and reduced to 3H:1V slopes. About 22,500 cubic yards of the bench material would be graded over the August/Little Ben highwall. The remainder would be contoured to form a free draining surface. The 13.3-acre regraded area would be covered with 21 inches of NAG material, 25 inches of soil, and revegetated.

Lower Gold Bug Blue Waste Rock Stockpile

The material in the lower Gold Bug blue waste rock stockpile is non-acid generating and would be removed for use in construction of the reclamation covers. The remaining footprint would be covered with 24 inches of soil and revegetated.

Upper Gold Bug Blue Waste Rock Stockpile

The material in the upper Gold Bug blue waste rock stockpile is non-acid generating and would be removed for use in construction of the reclamation covers. The remaining footprint would be covered with 12 inches of soil and revegetated.

Support Facilities Reclamation

All of the mining-related facilities not associated with water treatment would be removed, their footprints covered with 12 inches of soil, and revegetated. These facilities include the fuel farm, upper warehouse, maintenance shop, lower Merrill-Crowe plant, three carbon plants, and the Landusky guard shack and gate. The upper Merrill-Crowe plant and two carbon plants are located on the L87 leach pad so their footprints would be reclaimed as part of leach pad reclamation.

The water treatment plant, drainage capture systems, ponds, and associated structures would be left intact and continue functioning where presently located until no longer needed. Once removed, their footprints would be regraded, covered with soil, and revegetated.

Alternative L6, Total Backfill and Topography Restoration

Alternative L6 would cost more than eight times the available reclamation bond amount. It would backfill the pit areas to restore the approximate pre-mining topography and re-establish the north-south drainage divide. Reclaimed surfaces would be covered with a low permeability water barrier cover or low infiltration water balance cover. The reclamation for each mine feature is shown in Figure 2.4-14. Those mine features that would be considered already reclaimed and not receiving additional reclamation work under this alternative are labeled "No Action" or "Reclaimed in 2000-2001."

Mine Pit Reclamation

August/Little Ben, Suprise, and Queen Rose Pit Complex

The August/Little Ben, Suprise, and Queen Rose pits would be completely backfilled with nearly 42 million cubic yards of material. The estimated earthwork quantities that would go into these pits are as follows:

L85/86 leach pad and dike	1,533,000 cubic yards
L87/91 leach pad	38,414,000 cubic yards
Montana Gulch waste rock dump	1,015,000 cubic yards
Facilities area	277,000 cubic yards
Highwall reduction	873,000 cubic yards

Prior to backfilling, the pit floor would be graded and covered with a geosynthetic liner to direct infiltrating water to the south. The backfilled surface would be graded to a configuration that restores the original drainage divides, allowing all surfaces to drain freely in the same direction as they did prior to 1979. However, the surface configuration would not restore the changes to the groundwater flow made by the old underground workings. The original contour of the pit area had slopes averaging 2H:1V to 2.8H:1V. These would be replaced with slopes of 3H:1V with 25-foot wide benches at 100 foot vertical intervals in order to maintain stability.

The regraded slopes would be covered with 46-inch thick water barrier (14.24 acres) and water balance (151.11 acres) reclamation covers which incorporate geosynthetic liner or geotextile filter fabric, depending on the slope grade. Within the August/Little Ben-Suprise-Queen Rose pit complex, 165.3 acres would be revegetated.

Four wells would be drilled along the north edge of the Suprise pit to monitor and intercept degraded water that might infiltrate the Swift Gulch groundwater system. A fifth well would be drilled in the bottom of King Creek to recover any pit water infiltrating into the King Creek drainage. A pipeline would be constructed to transfer any recovered water back to the Landusky water treatment plant for processing. A parallel pipeline would be constructed to pump an equal amount of treated water back to the Swift Gulch or King Creek drainages.

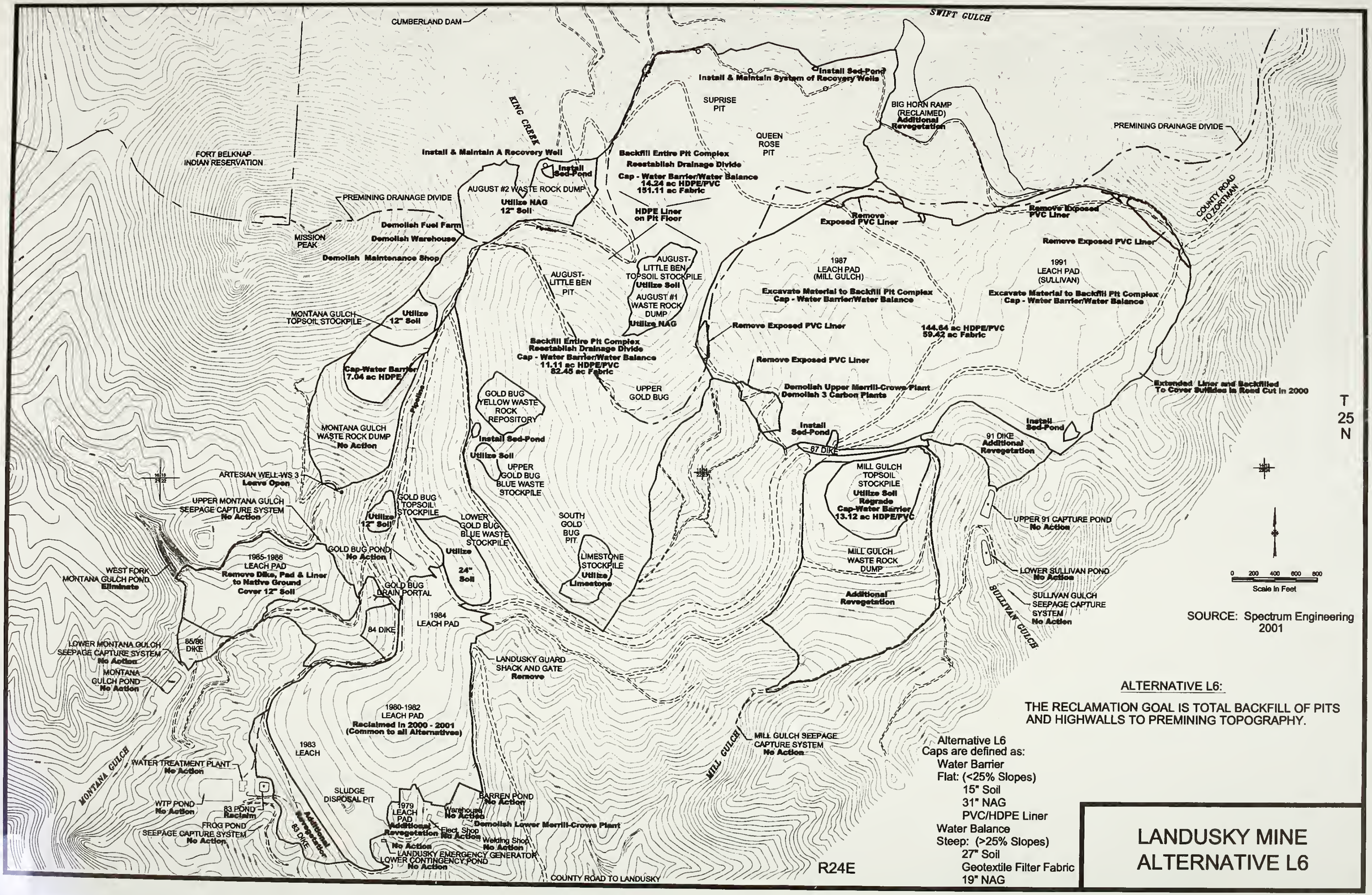

CUMBERLAND DAM
SWIFT GULCH
KING CREEK
Install Sed-Pond
Install & Maintain System of Recovery Wells
SUPRISE PIT
QUEEN ROSE PIT
BIG HORN RAMP (RECLAIMED) Additional Revegetation
PREMINING DRAINAGE DIVIDE
FORT BELKNAP INDIAN RESERVATION
Install & Maintain A Recovery Well
Backfill Entire Pit Complex
Reestablish Drainage Divide
Cap - Water Barrier/Water Balance
14.24 ac HDPE/PVC
151.11 ac Fabric
AUGUST #2 WASTE ROCK DUMP
Utilize NAG
12" Soil
HDPE Liner on Pit Floor
Remove Exposed PVC Liner
COUNTY ROAD TO FORTMAN
Demolish Fuel Farm
Demolish Warehouse
Demolish Maintenance Shop
MISSION PEAK
AUGUST-LITTLE BEN TOPSOIL STOCKPILE
Utilize Soil
AUGUST-LITTLE BEN PIT
AUGUST #1 WASTE ROCK DUMP
Utilize NAG
1987 LEACH PAD (MILL GULCH)
1991 LEACH PAD (SULLIVAN)
Excavate Material to Backfill Pit Complex
Cap - Water Barrier/Water Balance
144.64 ac HDPE/PVC
59.42 ac Fabric
MONTANA GULCH TOPSOIL STOCKPILE
Utilize 12" Soil
Backfill Entire Pit Complex
Reestablish Drainage Divide
Cap - Water Barrier/Water Balance
11.11 ac HDPE/PVC
82.45 ac Fabric
Cap-Water Barrier 7.04 ac HDPE
UPPER GOLD BUG
Demolish Upper Merrill-Crowe Plant
Demolish 3 Carbon Plants
Extended Liner and Backfilled To Cover Sulfides in Road Cut in 2000
GOLD BUG YELLOW WASTE ROCK REPOSITORY
MONTANA GULCH WASTE ROCK DUMP
No Action
Utilize Soil
UPPER GOLD BUG BLUE WASTE STOCKPILE
87 DIKE
91 DIKE
Additional Revegetation
ARTESIAN WELL-WS 3
Leave Open
UPPER MONTANA GULCH SEEPAGE CAPTURE SYSTEM
No Action
GOLD BUG TOPSOIL STOCKPILE
MILL GULCH TOPSOIL STOCKPILE
Regrade
Cap-Water Barrier
13.12 ac HDPE/PVC
UPPER 91 CAPTURE POND
LOWER GOLD BUG BLUE WASTE STOCKPILE
SOUTH GOLD BUG PIT
GOLD BUG POND
1985-1986 LEACH PAD
Remove Dike, Pad & Liner to Native Ground
Cover 12" Soil
WEST FORK MONTANA GULCH POND
Eliminate
LIMESTONE STOCKPILE
Utilize Limestone
24" Soil
GOLD BUG DRAIN PORTAL
MILL GULCH WASTE ROCK DUMP
LOWER SULLIVAN POND
SULLIVAN GULCH SEEPAGE CAPTURE SYSTEM
SULLIVAN GULCH
84 DIKE
1984 LEACH PAD
LOWER MONTANA GULCH SEEPAGE CAPTURE SYSTEM
85/86 DIKE
MONTANA GULCH POND
LANDUSKY GUARD SHACK AND GATE
Remove
1980-1982 LEACH PAD
Reclaimed in 2000 - 2001
(Common to all Alternatives)
1983 LEACH
MILL GULCH SEEPAGE CAPTURE SYSTEM
MONTANA GULCH
WATER TREATMENT PLANT
SLUDGE DISPOSAL PIT
BARREN POND
WTP POND
83 POND
Reclaim
FROG POND SEEPAGE CAPTURE SYSTEM
83 DIKE
1979 LEACH PAD
Warehouse
Elect. Shop
Welding Shop
Demolish Lower Merrill-Crowe Plant
LANDUSKY EMERGENCY GENERATOR
LOWER CONTINGENCY POND
COUNTY ROAD TO LANDUSKY
R24E
T 25 N
0 200 400 600 800
Scale in Feet
SOURCE: Spectrum Engineering 2001
ALTERNATIVE L6:
THE RECLAMATION GOAL IS TOTAL BACKFILL OF PITS AND HIGHWALLS TO PREMINING TOPOGRAPHY.
Alternative L6
Caps are defined as:
Water Barrier
Flat: (<25% Slopes)
15" Soil
31" NAG
PVC/HDPE Liner
Water Balance
Steep: (>25% Slopes)
27" Soil
Geotextile Filter Fabric
19" NAG
LANDUSKY MINE
ALTERNATIVE L6

FIGURE 2.4-14

Gold Bug and South Gold Bug Pits

During the later stages of the mining operation, the South Gold Bug pit was used to stockpile limestone. This stockpile would be used for NAG fill and cover, after which both pits would be completely backfilled as part of the full restoration of the entire pit complex. The Gold Bug pit area backfill would be obtained partially from highwall reduction (1,022,000 cubic yards) and partially by importing 8,740,000 cubic yards from the L85/86 and L87/91 leach pads. The backfill would be graded to a configuration that restores the original surface drainage pattern. The original contour of the pit area had slopes averaging 2.2H:1V to 2.6H:1V. These would be replaced with slopes of 3H:1V with 25-foot wide benches at 100 foot vertical intervals in order to maintain stability.

The regraded slopes would be covered with 46-inch thick water barrier (11.11 acres) and water balance (82.45 acres) reclamation covers which incorporate geosynthetic liner or geotextile fabric, depending on the slope. Revegetation within the Gold Bug pit would take place on 93.6 acres. The previously reclaimed areas along the west side of the pit would not be affected by this alternative.

Leach Pad Reclamation

The L85/86 leach pad, dike and liner would be removed from Montana Gulch. The native ground would be covered with 12 inches of soil and revegetated. The interim reclamation on the L80-82, L83 and L84 leach pads would be considered final. A large amount of spent ore from the L87/91 leach pad would be used for pit backfill. The remaining spent ore would be regraded and covered with either a water barrier or water balance reclamation cover.

The L85/86 dike would be removed. The L84 dike would be built out to 3H:1V slopes. Additional revegetation would occur on the L83 and L91 dikes as a preventative maintenance measure.

L79 Leach Pad

The L79 leach pad was reclaimed with 8 to 12 inches of soil and revegetated in September 1991. The existing reclamation would be enhanced with additional fertilization, seeding, and planting.

L80-82, L83, and L84 Leach Pads

Regrading these leach pads was undertaken as part of the 2000 interim reclamation project. Approximately 1.1 million cubic yards of grading and excavation were conducted to recontour these heaps to overall slopes of 3H:1V or flatter. Because the pads were reduced to a height of just over 100 feet, benching was not incorporated into the regrading.

The regrading included some offloading of the spent ore onto unlined and partially lined areas adjacent to the pads, and included filling several large depressions between the L80-82 and L83 leach pads and extending the backfill over the upper contingency pond and the process water pond.

Before applying the reclamation cover, the regraded surface was sampled for acid generating potential to a depth of 24 inches on a grid spacing of 100 feet. Grids with a net acid potential were neutralized with lime. After liming, 6 inches of King Creek tailings were placed as cover material, followed by 18 inches of soil. The area was seeded in 2001. This interim reclamation would be considered final.

Additional revegetation work would be conducted on the L83 dike. The L84 dike at the north end of the leach pad complex would be built out to a 3H:1V slope with about 61,000 cubic yards of NAG material from the L85/86 leach pad. The regraded dike would be covered with 24 inches of soil and revegetated.

L85/86 Leach Pad

In 2001, the north and west sides of the pad would be excavated to improve interim drainage around the pad. This material would be used to build out the L84 dike and recontour the disturbed hillside south and west of the dike to a gentle 3H:1V slope.

The spent ore blocking this section of Montana Gulch would be removed. In most areas, removal would extend down to the pre-mining surface. Pad removal work would include removing all exposed leach pad liner and reconstructing the drainage bottom. Most of the material (2,569,000 cubic yards) would be hauled to pit backfill areas or would be used as NAG cover (107,000 cubic yards). Due to the steep pre-mining surface below the interim reclamation buildout areas, portions of the heap would be left in place to buttress these fills. The access road through this area would be relocated.

The area associated with the pad and dike removal would be covered with 12 inches of soil and revegetated. The slope buildout area would be covered with 24 inches of soil and revegetated.

L87/91 Leach Pad

An estimated 22,732,000 cubic yards of spent ore from the L87 leach pad and 23,386,000 cubic yards of spent ore from the L91 leach pad would be offloaded and used for pit backfill. The remainder of the material on the two heaps would be regraded to 3H:1V slopes. The excavation and grading would approximate the shape of the pre-mining drainages, although not at the original elevations. Complex slopes and small draws would be incorporated into the regraded surface instead of using benches.

The leach pad liner would be extended on the east and west sides so that pad material could be offloaded into these areas. The extension of the liner on the southeast side of the L91 leach pad was incorporated into the 2000-2001 interim reclamation grading. Excluding the export of spent ore to pit backfill areas, recontouring the pads would require 174,000 cubic yards of bulldozer grading.

After regrading, the surface would be tested for acid generating potential. Lime would be incorporated in the top 24 inches where neutralization is determined necessary. The regraded surface on both pads would be covered with 46-inch thick water barrier (144.64 acres) and water balance (59.42 acres) reclamation covers that incorporate a geosynthetic liner or geotextile filter fabric, depending on the slope steepness. Within the L87/91 leach pad area, 204.1 acres would be revegetated. All of the processing facilities on the leach pads would be removed except for the pumping facilities. The large pond on the top of the L87 leach pad would be removed as the top of the pad was excavated for pit backfill.

The L87 dike would be considered to be reclaimed as it is covered by the Mill Gulch waste rock dump. The 350-foot high L91 dike would be planted with supplementary revegetation to improve surface stability.

Waste Rock Dump Reclamation

Mill Gulch Waste Rock Dump

The only portion of the Mill Gulch waste rock dump presently unreclaimed is occupied by the Mill Gulch soil stockpile. After all of the soil stored in the stockpile has been removed from the top of the dump, the disturbed area would be regraded and the water barrier cover installed on the dump top would be extended across the stockpile footprint. The previously reclaimed face of the dump would be treated with additional fertilization, seeding, and planting to improve the existing vegetation.

Montana Gulch Waste Rock Dump

The soil stockpile and truck ready-line would be removed from the top of the dump. The disturbed area would be regraded and a water barrier cover consisting of a geosynthetic liner, 31 inches of NAG, and 15 inches of soil would be installed over the 7-acre dump top. In those areas where removal of the soil stockpile exposed native ground (5.6 acres), 12 inches of soil would be placed. In the undisturbed areas of the waste rock dump, the existing reclamation would be considered final.

August #1 Waste Rock Dump

The August #1 waste rock dump is spread across several of the topmost benches on the south side of the August/Little Ben pit. Because the August/Little Ben soil stockpile was dumped over the top of the waste dump, the two piles are mixed together to some degree. The material from the two piles would be segregated and used in the reclamation of various areas around the Landusky Mine. This dump area would be covered by the mine pit backfill.

August #2 Waste Rock Dump

The west lobe of the August #2 waste rock dump has been graded to blend into the natural terrain and covered with 8 to 12 inches of soil. Trees were planted on this lobe in April 1990 and again in April 1991.

The east lobe, containing about 599,000 cubic yards of material, sits on the north wall of the August/Little Ben pit. This lobe was covered with 8 to 12 inches of soil and revegetated in May 1992.

The material in both lobes of the dump is non-acid generating. The soil would be salvaged off both lobes and the waste rock utilized for NAG cover in various areas. After the entire dump has been removed, the exposed slopes would be covered with 12 inches of soil and revegetated. The King Creek-to-Zortman access road would be relocated through the dump footprint.

Gold Bug Yellow Waste Rock Repository

The Gold Bug yellow waste rock repository is situated on a mine bench between the Gold Bug pit and the August/Little Ben pit and has been characterized as a potential acid producer. The waste rock would be left in place and covered by mine pit backfill.

Lower Gold Bug Blue Waste Rock Stockpile

The material in the lower Gold Bug blue waste rock stockpile is non-acid generating and would be used in construction of the reclamation covers. The remaining footprint would be covered with 24 inches of soil and revegetated.

Upper Gold Bug Blue Waste Rock Stockpile

The material in the upper Gold Bug blue waste rock stockpile is non-acid generating and would be removed and used in construction of the reclamation covers. The remaining footprint would be buried under the mine pit backfill.

Support Facilities Reclamation

All of the mining-related facilities not associated with water treatment would be removed, their footprints covered with 12 inches of soil, and revegetated. These facilities include the fuel farm, upper warehouse, maintenance shop, lower Merrill-Crowe plant, three carbon plants, and the Landusky guard shack and gate. The upper Merrill-Crowe plant and two carbon plants are located on the L87 leach pad so their footprints would be reclaimed as part of the leach pad reclamation.

The water treatment plant, drainage capture systems, ponds, and associated structures would be left intact and continue functioning where presently located until no longer needed. Once removed, their footprint would be regraded, covered with soil, and seeded. The pumping facilities on the L91 pad would be disrupted by the excavation. After excavation, these facilities would be rebuilt at a substantially lower elevation on the regraded surface.

2.5 CUMULATIVE ACTIONS

Other actions in the area of the Little Rocky Mountains include the reclamation of exploration roads and clay pits, the tailings removal action in King Creek by EPA, and possible removal of the historic mine tailings in the Ruby Gulch drainage. These actions could occur independent of mine reclamation.

2.6 PREFERRED ALTERNATIVE IDENTIFICATION

As part of the environmental analysis process, the agencies are required to identify, when one exists, the preferred alternative in the draft and final EIS. The identification of a preferred alternative does not constitute a decision to select that alternative for implementation. The purpose of identifying a preferred alternative is to let the public know which way the agencies are leaning, at this point in the analysis, so the public can focus comments on the alternative(s) which are likely to be selected.

The preferred alternative may change between the draft SEIS and the final SEIS, based upon public comments and further agency analysis. Once the final SEIS has been completed, a Record of Decision (ROD) will be prepared that actually selects the reclamation alternatives to be implemented and provides a detailed rationale for that selection (see also FEIS Section 1.5). The alternatives selected in the ROD, and their manner of implementation, may be a change from that identified as the preferred alternative in the final SEIS. Such changes could be the result of additional mitigation considerations, policy direction, or budget constraints (FEIS Section 2.4).

2.6.1 Preferred Alternatives

At this time the agencies have identified, as the preferred alternatives, Alternative Z6 for reclamation of the Zortman Mine and Alternative L4 for reclamation of the Landusky Mine. These are the alternatives the agencies believe would best address the purpose and need to reclaim the mines with a reasonable assurance for long-term success in meeting the State and Federal requirements for mine reclamation, while protecting human health, the environment, and trust resources.

At the Zortman Mine, reclamation under Alternative Z6 would revegetate disturbed areas, isolate or control toxic or deleterious materials, and cover virtually all of the sulfide portions of the mine pit highwalls with backfill. Alternative Z6 avoids the potentially negative impacts of additional backfill placement in drainages which flow toward the north, thus protecting Tribal water resources.

Reclamation of the Landusky Mine using Alternative L4 would also revegetate disturbed areas, isolate or control toxic or deleterious materials, and cover the majority of the sulfide portions of the mine pit highwalls with backfill or rubble slopes. Alternative L4 would take all the readily available, relatively non-acid generating material and use it as backfill in the mine pits. Alternative L4 would avoid the potential negative impacts on the drainages to the north of the mine that would occur with the use of spent ore from the

L87/91 leach pad as backfill. In addition, Alternative L4 would remove the L85/86 leach pad, which is obstructing the Montana Gulch drainage, and through highwall reduction would reduce the visual impact of the mine pit highwalls that would remain after partial backfilling.

2.6.2 Implementation and Additional Preferred Alternatives

Selection and implementation of Alternatives Z6 and L4 are dependent upon adequate funding. At this time it is estimated that Alternative Z6 would cost approximately $5 million more than is available under the existing reclamation bond, and Alternative L4 would cost approximately $17 million more than is available under the existing reclamation bond. Should the additional funding needed to implement these alternatives not be forthcoming in the next several years, the agencies have identified other preferred alternatives that would be implemented within the existing reclamation bond amounts. These additional preferred alternatives are Alternative Z3, for reclamation of the Zortman Mine; and Alternative L3, for reclamation of the Landusky Mine.

Alternatives Z3 and L3 would also meet the basic purpose and need to reclaim the mines with a reasonable assurance for long-term success in meeting the State and Federal requirements for mine reclamation, while protecting human health, the environment, and trust resources. However, these alternatives would require considerably more long-term active management in order to maintain resource protection, and would not address the aesthetic and environmental considerations associated with the pit highwalls as well as Alternatives Z6 and L4. Should it be necessary to select Alternatives Z3 and L3, their implementation would not preclude the addition of the preferred reclamation features contained in Alternatives Z6 and L4 at a later date if funding became available.

2.7 ALTERNATIVE COMPARISON TABLES

The following tables compare the major provisions of the alternatives considered in detail. Table 2.7-1 shows the components of the six alternatives for reclamation of the Zortman Mine. Table 2.7-2 shows the components of the six alternatives for reclamation of the Landusky Mine.

Table 2.7-1. Zortman Mine Reclamation Alternatives Comparison

Mine Feature ***Interim Reclamation Action***	***Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)**	***Alternative Z2*, Optimized Water Treatment within Bond Amounts**	***Alternative Z3*, Optimize Source Control within Bond Amounts**	***Alternative Z4*, Added Backfilling with Barrier Reclamation Covers**	***Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers**	***Alternative Z6* Optimize Grading for Source Control (Preferred Alt.)**
General Reclamation Cover Description (see also Figure 2.4-1):						
Water Barrier Cover	Use on slopes flatter than 4H:1V over 24" neutral waste. Place a GCL, 36" NAG/ subsoil, 12" soil, and revegetate.	Not used.	Not used.	Same as Z1 cover, but use geosynthetic membrane such as HDPE or PVC instead of GCL in cover construction.	Use on slopes flatter than 4H:1V. Place geosynthetic liner, 24"NAG, 10" Ruby tailings, 8" soil, and revegetate.	Use on slopes flatter than 4H:1V. Place geosynthetic liner, 24"NAG, 12" Ruby tailings, 12" soil, and revegetate.
Water Balance Cover	Use on slopes steeper than 4H:1V. Place 12" NAG, geotextile filter fabric, 36" soil, and revegetate.	Not used.	Not used.	Use on slopes steeper than 4H:1V. Place 36" NAG, geotextile filter fabric, 12" soil, and revegetate.	Use on slopes steeper than 4H:1V. Place 12" NAG, geotextile filter fabric, 24" Ruby tailings, 8" soil, and revegetate.	Use on slopes steeper than 4H:1V. Place 12" NAG, geotextile filter fabric, 12" Ruby tailings, 12" soil, and revegetate.
Soil Cover *24" NAG by lime amendment, 6" tailings, and 18" soil*	12" NAG and 12" soil over acid generating footprints or native ground. 12" soil over non-acid generating surfaces. Revegetate entire cover.	12"-24" NAG and 12" soil over acid generating materials or native ground. 12" soil over non-acid generating areas. Revegetate entire cover.	12"-24" NAG, 0"-7" Ruby tailings, and 12" soil over acid generating materials or native ground. 12" soil over non-acid generating areas. Revegetate entire cover.	Same as Alt. Z1.	12"-24" NAG, 10" Ruby tailings, and 8" soil over acid generating footprints or native ground. 8"soil or 10" Ruby tailings and 8" soil over non-acid generating areas. Revegetate entire cover.	6" Ruby tailings, and 18" soil over regraded surfaces. Test all areas for acid generating potential to depth of 24" and lime as required. Revegetate entire cover.

Mine Feature *Interim Reclamation Action*	*Alternative Z1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)	*Alternative Z2,* Optimized Water Treatment within Bond Amounts	*Alternative Z3,* Optimize Source Control within Bond Amounts	*Alternative Z4,* Added Backfilling with Barrier Reclamation Covers	*Alternative Z5,* Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6* Optimize Grading for Source Control (Preferred Alt.)
Mine Pits:						
O.K./Ruby Pit *Cut notch in east highwall and backfill with Z82 and Z85/86 leach pads to be free draining.*	Backfill with Alder Gulch waste rock dump to make pit free draining; Cover backfill with water barrier and water balance reclamation covers.	Backfilled by interim reclamation. Cover backfill with 8" clay, 24" NAG, 12" soil, and revegetate.	Same as Alt. Z2. Cover backfill with 8" clay, 24" NAG, 7" Ruby tailings, 11" soil, and revegetate.	Same as Alt. Z2. Cover with water barrier and water balance reclamation covers.	Completely backfill pit to approximate original contour. Cover with water barrier and water balance reclamation covers.	Same as Alt. Z2. Cover with water barrier and water balance reclamation covers.
Mint Pit *Backfill to be free draining*	Backfilled by interim reclamation. Cover with water barrier reclamation cover.	Backfilled by interim reclamation. Cover with 24" NAG, 12" soil, and revegetate.	Backfilled by interim reclamation. Cover with 24" NAG, 7" Ruby tailings, 11" soil, and revegetate.	Backfilled by interim reclamation. Cover with water barrier and water balance reclamation covers.	Completely backfill pit to approximate original contour. Cover with 24" NAG, 10" Ruby tailings, 8" soil, and revegetate.	Backfilled by interim reclamation. Lime amend top 24" of fill to NAG. Cover with 6" Ruby tailings, 18" soil, and revegetate.
North Alabama Pit	Minor grading to be free draining. Cover pit floor with water barrier reclamation cover.	Minor grading to be free draining. Cover with 12" soil only and revegetate.	Same as Alt. Z2.	Almost totally backfilled. Cover with water barrier and water balance reclamation covers.	Completely backfill pit to approximate original contour. Cover with 10" Ruby tailings, 8" soil and revegetate.	Fill to top of north pit wall with material from Alder Gulch waste rock dump. Cover backfill surface with water barrier reclamation cover.

Mine Feature *Interim Reclamation Action*	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6* Optimize Grading for Source Control (Preferred Alt.)
South Alabama Pit *Blast to reduce and cover west wall of pit; backfill along lower east benches; grade to be free draining.*	Grade to recontour steep rubble backfill slopes. Cover pit floor with water barrier reclamation cover.	Cover with 24" NAG, 12" soil, and revegetate.	Same as Alt. Z2. Cover with 24" NAG, 7" Ruby tailings, 11" soil, and revegetate.	Almost totally backfilled. Cover with water balance reclamation cover.	Completely backfill the pit to approximate original contour. Cover with 10" Ruby tailings, 8" soil, and revegetate.	Lime amend top 24 " of fill as NAG. Cover graded areas with 6" Ruby tailings, 18" soil, and revegetate.
Ross Pit *Grade for free drainage; cover sulfide benches and walls with NAG fill.*	Cover pit floor with 12" NAG, 12" soil, and revegetate.	Same as Alt. Z1.	Same as Alt. Z1.	Backfill and grade half- way up pit wall. Cover with water barrier and water balance reclamation covers.	Completely backfill the pit to approximate original contour. Cover with 10" Ruby tailings, 8" soil, and revegetate.	Same as Alt. Z1. Cover graded areas with 12"-24" NAG, 6" Ruby tailings, 18" soil, and revegetate.
Leach Pads:						
Z79-81 Pad	Re-reclaim with water barrier or water balance reclamation cover if needed to prevent cover soil acidification.	Existing 8-12" soil reclamation cover left as final reclamation. Enhance existing vegetation.	Same as Alt. Z2.	Remove existing reclamation. Replace with water barrier and water balance reclamation covers.	Same as Alt. Z2.	Same as Alt. Z2.

Mine Feature ***Interim Reclamation Action***	***Alternative Z1,*** **Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)**	***Alternative Z2,*** **Optimized Water Treatment within Bond Amounts**	***Alternative Z3,*** **Optimize Source Control within Bond Amounts**	***Alternative Z4,*** **Added Backfilling with Barrier Reclamation Covers**	***Alternative Z5,*** **Extensive Backfilling with Soil Reclamation Covers**	***Alternative Z6*** **Optimize Grading for Source Control (Preferred Alt.)**
Z82 Pad *Removed.*	Regrade slope on north side. Cover footprint with 12" NAG, 12" soil, and revegetate.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1. Cover footprint with 12" NAG, 8" soil, and revegetate.	Regrade slope on north side. Lime amend top 24" of subgrade as NAG. Cover footprint and slope with 6" Ruby tailings, 18" soil, and revegetate.
Z83 Pad *Regraded to 3H:1V and covered with 24" NAG, 6" tailings, and 18" soil.*	Remove interim reclamation and replace with water barrier and water balance reclamation covers.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.
Z84 Pad *Regraded to 3H:1V and covered with 24" NAG, 6" tailings, and 18" soil.*	Remove interim reclamation and replace with water barrier and water balance reclamation covers.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.

Mine Feature *Interim Reclamation Action*	*Alternative Z1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)	*Alternative Z2,* Optimized Water Treatment within Bond Amounts	*Alternative Z3,* Optimize Source Control within Bond Amounts	*Alternative Z4,* Added Backfilling with Barrier Reclamation Covers	*Alternative Z5,* Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6* Optimize Grading for Source Control (Preferred Alt.)
Z85/86 Pad and Z85/86 Dike *Excavated portion for pit backfill; Regrade north area to 3H:1V slope; make free draining around the north edge.* *Put fill from drainage notch over Z85/86 Dike.*	Grade to 3H:1V slope with grading confined to lined area. Add fill to Z85/86 dike to make 2.5H:1V. Cover with water barrier and water balance reclamation covers.	Same as Z1. Cover with 24" NAG, 12" soil, and revegetate.	Same as Z1. Cover with 24" NAG, 7" tailings, 11" soil, and revegetate.	Same as Z1. Cover with water barrier and water balance reclamation covers.	Completely remove Z85/86 leach pad and dike for use as backfill. Cover footprint with 24" NAG, 10" tailings, 8" soil, and revegetate.	Excavate portion for pit backfill; Regrade remainder to 3H:1V make free draining around the north edge. Add fill to Z85/86 dike to achieve 2.5H:1V slope. Lime amend top 24" of subgrade as NAG. Cover regrade with 6" Ruby tailings, 18" soil, and revegetate.
Z89 Pad *Regraded to 3H:1V slope and covered with 24" NAG, 6" tailings, and 18" soil.*	Remove interim reclamation and replace with water barrier and water balance reclamation covers.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.	Interim reclamation cover left as final. Enhance existing vegetation on dike.

Mine Feature *Interim Reclamation Action*	*Alternative Z1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)	*Alternative Z2,* Optimized Water Treatment within Bond Amounts	*Alternative Z3,* Optimize Source Control within Bond Amounts	*Alternative Z4,* Added Backfilling with Barrier Reclamation Covers	*Alternative Z5,* Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6* Optimize Grading for Source Control (Preferred Alt.)
Waste Rock Dumps:						
Ruby Sulfide Stockpile *Backfilled in bottom of O.K. pit.*	Cover footprint with 12" NAG, 12" soil, and revegetate.	Cover footprint with 24" NAG, 12" soil, and revegetate.	Cover footprint with 24" NAG, 7" tailings, 11" soil, and revegetate.	Cover with 12" soil and revegetate.	Cover footprint with 24" NAG, 10" tailings, 8" soil, and revegetate.	Lime amend top 24" of footprint as NAG. Cover footprint with 6" Ruby tailings, 18" soil, and revegetate.
Z82 Sulfide Stockpile *Placed in bottom of O.K. pit.*	Would be covered by pit reclamation.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.
South Ruby Waste Rock Dump *Top removed and placed in pit. Bottom regraded to 3:1 in place.*	Cover footprint with 12" NAG, 12" soil, and revegetate.	Cover footprint with 24" NAG, 12" soil, and revegetate.	Cover footprint with 24" NAG, 7" tailings, 11" soil, and revegetate.	Cover footprint with water barrier and water balance reclamation covers.	Lime amend top 24 " of footprint as NAG. Cover with 10" tailings, 8" soil, and revegetate.	Lime amend top 24" of footprint as NAG. Cover with 6" Ruby tailings, 18" soil, and revegetate.
O.K. Waste Rock Dump	Salvage soil. Remove and use as pit backfill. Lime footprint, cover with 12" soil, and revegetate.	Leave existing reclamation as final.	Same as Alt. Z2.	Salvage soil, regrade to 3H:1V, and cover with water balance reclamation cover.	Salvage soil, regrade to 3H:1V, cover with 10" tailings, 8" soil, and revegetate.	Salvage soil, regrade to 3H:1V. Lime amend top 24" of footprint as NAG then cover with 6" Ruby tailings, 18" soil, and revegetate.

Mine Feature ***Interim Reclamation Action***	***Alternative Z1,*** **Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)**	***Alternative Z2,*** **Optimized Water Treatment within Bond Amounts**	***Alternative Z3,*** **Optimize Source Control within Bond Amounts**	***Alternative Z4,*** **Added Backfilling with Barrier Reclamation Covers**	***Alternative Z5,*** **Extensive Backfilling with Soil Reclamation Covers**	***Alternative Z6*** **Optimize Grading for Source Control (Preferred Alt.)**
Alder Gulch Waste Rock Dump	Salvage soil. Remove and use as pit backfill. Lime footprint and cover with 12" NAG, 12" soil, and revegetate.	Leave existing reclamation as final.	Same as Alt. Z2.	Same as Alt. Z1.	Salvage soil. Remove and use as pit backfill. Lime footprint and cover with 10" Ruby tailings, 8" soil, and revegetate.	Salvage soil. Remove 432,000 CY from top and use as pit backfill. Install water barrier cover over regraded excavation area.
Ruby Gulch Tailings:						
West Stockpile *Partially removed.*	Use as subsoil. Cover with 12" soil and revegetate.	Partial use as subsoil.	Same as Alt. Z1.	Same as Alt. Z1.	Use as subsoil. Cover with 8" soil and revegetate.	Same as Alt. Z1.
East Stockpile	Use as subsoil. Cover with 12" soil and revegetate.	Leave as is.	Same as Alt. Z1.	Same as Alt. Z1.	Use as subsoil. Cover with 8" soil and revegetate.	Same as Alt. Z1.
Tailings to Gate	Use as subsoil. Cover with 12" soil and revegetate.	Leave as is.	Same as Alt. Z2.	Same as Alt. Z1.	Use as subsoil. Cover with 8" soil and revegetate.	Partial removal for use as subsoil.
New Disturbance:						
Limestone Quarry LS-2	Develop 11-acre quarry to supply NAG material at LS-2 site.	No new disturbance. Limestone quarry would not be needed.	Same as Alt. Z2.	Develop 13-acre quarry to supply NAG material.	Same as Alt. Z2.	Same as Alt. Z2.
Goslin Flats	8-acre soil borrow area.	8-acre disturbance for water treatment plant.	None.	Same as Alt. Z2.	Same as Alt. Z2.	None.

Mine Feature *Interim Reclamation Action*	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6* Optimize Grading for Source Control (Preferred Alt.)
Drainage Notch around Z85/86 Leach Pad	3.6 acres	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.
Seepage Capture and Water Treatment:						
Water Treatment Plant and Ponds	Continue to use at current location.	Move to Goslin Flats.	Same as Alt. Z1.	Same as Alt. Z2.	Same as Alt. Z2.	Same as Alt. Z1.
Capture Systems	Upgrade as indicated by monitoring to meet MPDES discharge requirements.	Same as Alt. Z1. Pipe captured water to Goslin Flats for treatment.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.
Leach Pad Process Water	Upgrade treatment system to treat for nitrates and selenium. Pump treated pad water to Goslin Flats LAD.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.
Reclamation Schedule and Labor:						
Reclamation Timeframe	1999-2003	1999-2001	1999-2001	1999-2004	1999-2006	1999-2002
Direct Reclamation Employment	11-21 people	17-23 people	17-23 people	17-23 people	17-23 people	26 people

Table 2.7-2. Landusky Mine Reclamation Alternatives Comparison

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2,* Optimize Earthwork within Bond Amount	*Alternative L3,* Improved Pit Drainage Drill Hole	*Alternative L4,* Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5,* Pit Backfill to Cover Sulfide Highwalls	*Alternative L6,* Pit Backfill to Restore Pre-Mine Contours
General Reclamation Cover Description (see also Figure 2.4-2):						
Water Barrier Cover	Use on slopes flatter than 4H:1V over 24" neutral waste. Place a GCL, 36" NAG, 12" soil, and revegetate.	Not used.	Not used.	Not used.	Not used.	Use on slopes flatter than 4H:1V) over 24" neutral waste. Place a geosynthetic liner, 31" NAG, 15" soil, and revegetate.
Water Balance Cover	Use on slopes steeper than 4H:1V. Place 12" NAG, geotextile filter fabric, 36" soil, and revegetate.	Not used.	Not used.	Not used.	Not used.	Use on slopes steeper than 4H:1V. Place 19" NAG, geotextile filter fabric, 27" soil, and revegetate.
Soil Cover *Top 24" lime amended and covered with 6" tailings and 18" soil.*	12" NAG and 12" soil over acid generating footprints. 12" soil over non-acid generating surfaces. Revegetate entire cover.	6" NAG and 18" soil in pit complex. 24" NAG and 24" soil or 15" NAG and 24" soil over acid generating footprints. 12" or 24" soil over non-acid generating surfaces. Revegetate entire cover.	Same as Alt. L2.	24" NAG and 24" soil on most areas. NAG can be produced by lime amendment. 12" to 24" soil over non-acid generating native ground. Revegetate entire cover.	21" NAG and 25" soil or 24" NAG and 24" soil over acid generating footprints. 12" soil over non-acid generating surfaces. Revegetate entire cover.	12" or 24" soil over non-acid generating surfaces.

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* **Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)**	*Alternative L2,* **Optimize Earthwork within Bond Amount**	*Alternative L3,* **Improved Pit Drainage Drill Hole**	*Alternative L4,* **Remove & Backfill L85/86 Leach Pad (Preferred Alt.)**	*Alternative L5,* **Pit Backfill to Cover Sulfide Highwalls**	*Alternative L6,* **Pit Backfill to Restore Pre-Mine Contours**
Mine Pits						
August/Little Ben Pit	Cut drainage notch in SW end of pit and backfill to make free draining into Montana Gulch. Place 5' NAG on backfill. Cover fill with water barrier reclamation cover; Cover benches and notch with 0"-12" NAG, 12" soil, and revegetate.	Drain pit through artesian well WS3. Cover pit floor with 6" NAG, 18" soil, and revegetate.	Same as Alt. L2, but add a directional bore hole to ensure free draining. Cover pit floor with 6" NAG, 18" soil, and revegetate.	Drain pit through artesian well WS3 or directional bore hole. Backfill average 85 feet with L85/86 pad; Cover 900 linear feet of sulfide highwall with NAG fill. Lime amend subgrade to produce 24" NAG. Cover with 24" soil and revegetate.	Backfill the pit to be free draining. Cover sulfide highwalls with 3H:1V slopes. Place geosynthetic liner on pit floor. Cover with 21" NAG, 25" soil, and revegetate.	Backfill to pre-mine drainage with 3H:1V slopes. Place geosynthetic liner on pit floor. Cover with water barrier and water balance reclamation covers.
Suprise Pit *Partial backfill to make free draining and cover pit floor with HDPE liner.*	Backfill to make free draining. Cover benches and backfill with water barrier cover.	Cover benches and pit floor with 6" NAG, 18" soil, and revegetate.	Cover benches with 12" soil. Cover pit floor with 6" NAG, 18" soil, and revegetate. Backfill to cover sulfides with rubble slope.	Backfill with material from L85/86 pad and dike. Lime amend subgrade to produce 24 " NAG. Cover with 24" soil and revegetate. Backfill to cover sulfides with rubble slope.	Backfill to cover sulfide highwalls at 3H:1V slopes. Install groundwater recovery wells. Cover fill with 21" NAG, 25" soil, and revegetate.	Backfill to pre-mine drainage with 3H:1V slopes. Install groundwater recovery wells. Cover fill with water barrier and water balance reclamation covers.

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2,* Optimize Earthwork within Bond Amount	*Alternative L3,* Improved Pit Drainage Drill Hole	*Alternative L4,* Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5,* Pit Backfill to Cover Sulfide Highwalls	*Alternative L6,* Pit Backfill to Restore Pre-Mine Contours
Queen Rose Pit *Backfill and grade to make free draining.*	Cover benches with 12"NAG, 12" soil, and revegetate. Cover pit floor with water barrier reclamation cover.	Cover pit floor backfill with 6" NAG, 18" soil, and revegetate. No bench covers.	Same as Alt. L2.	Lime amend bench to produce 24 " NAG; Cover with 24" soil. Cover pit floor with 24 " NAG and 24" soil. Revegetate.	Place geosynthetic liner on pit floor. Backfill to be free draining plus cover sulfide highwalls at 2H:1V slope. Cover fill with 21" NAG, 25" soil, and revegetate.	Place geosynthetic liner on pit floor. Backfill to pre-mine drainage with 3H:1V slopes. Cover fill with water barrier and water balance reclamation covers.
Gold Bug Pit *Regrade existing backfill to 3H:1V slopes. Blast highwall to cover sulfides.*	No cover on highwall rubble slope. Cover floor area with water barrier and water balance reclamation covers.	Cover floor with 24" NAG, 24" soil, and revegetate.	Same as Alt. L2.	Same as Alt. L2.	Import NAG fill to cover additional highwalls at 2H:1V slope. Cover fill with 21" NAG, 25" soil, and revegetate.	Backfill to the pre-mine drainage with 3H:1V slopes. Cover fill with water barrier and water balance reclamation covers.

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2,* Optimize Earthwork within Bond Amount	*Alternative L3,* Improved Pit Drainage Drill Hole	*Alternative L4,* Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5,* Pit Backfill to Cover Sulfide Highwalls	*Alternative L6,* Pit Backfill to Restore Pre-Mine Contours
South Gold Bug Pit	Regrade backfill to 3H:1V slopes. Cover with water barrier and water balance reclamation covers	Regrade backfill to 3H:1V slopes. Cover with 24" NAG, 24" soil, and revegetate.	Same as Alt. L2.	Reduce east pit wall by blasting and cover with rubble fill. Grade cut area, west benches and fill at 3H:1V slopes. Cover blast source area with 12" soil. Cover floor with 24" NAG, 24" soil, and revegetate.	Import NAG fill to cover sulfide highwalls at 2H:1V slopes. Cover with 21" NAG, 25" soil, and revegetate.	Backfill to the pre-mine drainage with 3H:1V slopes. Cover with water barrier and water balance reclamation covers.
Leach Pads:						
L79 Pad	Additional Revegetation.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.
L80-82, L83, and L84 Pads plus L83 & L84 Dikes *Pads regraded at 3H:1V slopes. Top 24" lime amended & covered with 6" tailings & 18" soil. L84 Dike built out to 3H:1V slope.*	Remove interim reclamation and replace with water balance and water barrier reclamation covers. Additional revegetation on L83 dike.	Interim reclamation would be final. Additional revegetation on L83 dike.	Interim reclamation would be final. Additional revegetation on L83 dike.	Interim reclamation would be final. Additional revegetation on L83 dike.	Interim reclamation would be final. Additional revegetation on L83 dike.	Interim reclamation would be final. Additional revegetation on L83 dike.

Mine Feature ***Interim Reclamation Actions***	***Alternative L1,*** **Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)**	***Alternative L2,*** **Optimize Earthwork within Bond Amount**	***Alternative L3,*** **Improved Pit Drainage Drill Hole**	***Alternative L4,*** **Remove & Backfill L85/86 Leach Pad (Preferred Alt.)**	***Alternative L5,*** **Pit Backfill to Cover Sulfide Highwalls**	***Alternative L6,*** **Pit Backfill to Restore Pre-Mine Contours**
L85/86 Pad and L85/86 Dike *Partial removal to build out L84 Dike and adjacent slope to the south.*	Regrade to 3H:1V slopes. Excavate a drainage channel along western edge to make free draining. Build out dike to a 2.5H:1V slope. Cover with water balance and water barrier reclamation covers.	3H:1V slope regrade of heap with limited drainage restoration. Build out dike to 2.5H:1V slope. Cover with 24" NAG, 24" soil, and revegetate.	Same as Alt. L1.	Complete removal of leach pad and dike for use as pit backfill: Test and lime amend native surface as required. Cover native ground with 24" soil and revegetate.	Complete removal of leach pad and dike for use as pit backfill: Test and lime amend native surface as required. Cover native ground with 12" soil and revegetate.	Same as Alt. L5.
L87 Pad	Regrade to overall 3H:1V slopes. Cap with water barrier and water balance reclamation covers.	Regrade to 2.5:1V slopes. Cover with 15" NAG, 24" soil, and revegetate.	Same as Alt. L2.	Regrade to 2.5:1V slopes. Cover with 24" NAG, 24" soil, and revegetate.	Use part for backfill of pit complex. Regrade remainder to max. 3H:1V slopes. Cover with 21"NAG, 25" soil, and revegetate.	Remove large portion for fill in pit complex. Regrade remainder to max. 3H:1V slopes. Cover with water barrier and water balance reclamation covers.

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2,* Optimize Earthwork within Bond Amount	*Alternative L3,* Improved Pit Drainage Drill Hole	*Alternative L4,* Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5,* Pit Backfill to Cover Sulfide Highwalls	*Alternative L6,* Pit Backfill to Restore Pre-Mine Contours
L91 Pad and Dike *Extended liner into road cut to the east; Grade east side of leach pad and relocate county road.*	Regrade to overall 3H:1V slopes and cap. Build out L91 dike to 2.5H:1V slope using pad. Cover with water balance and water barrier reclamation covers.	Regrade to overall 2.5H:1V slopes on the leach pad. L91 dike left in current configuration. Additional revegetation of L91 dike. Cover with 15" NAG, 24" soil, and revegetate.	Same as Alt. L2.	Regrade to overall 2.5H:1V slopes on the leach pad. L91 dike left in current configuration. Additional revegetation of L91 dike. Cover with 24" NAG, 24" soil, and revegetate.	Remove part for backfill of pit complex. Regrade remainder to 3H:1V slopes. L91 dike left in current configuration. Additional revegetation of L91 dike. Cover with 21" NAG, 25" soil, and revegetate.	Remove large portion for backfill of pit complex. Regrade remainder to overall 3H:1V slope. L91 dike left in current configuration. Additional revegetation of L91 dike. Cover with water balance and water barrier reclamation covers.
Waste Rock Dumps:						
Mill Gulch Waste Rock Dump	Use soil stockpile on top. Extend existing water barrier reclamation cover over stockpile footprint. Additional revegetation on dump slope.	Leave soil reserve on top. Additional revegetation on dump slope.	Same as Alt. L2.	Same as Alt. L2.	Use soil stockpile on top. Extend existing liner to cover soil stockpile area. Cover with 21" NAG, 25" soil. Additional revegetation on dump slope.	Use soil stockpile on top. Cover with water balance and water barrier reclamation covers. Additional revegetation on dump slope.

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2,* Optimize Earthwork within Bond Amount	*Alternative L3,* Improved Pit Drainage Drill Hole	*Alternative L4,* Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5,* Pit Backfill to Cover Sulfide Highwalls	*Alternative L6,* Pit Backfill to Restore Pre-Mine Contours
Montana Gulch Waste Rock Dump	Excavate top bench as drainage notch cut into August/Little Ben pit. Use excavation as backfill in August/ Little Ben pit. Cover top with water barrier reclamation cover.	Cover dump top with 15" NAG, 24" soil, and revegetate. Existing reclamation on dump slope would be left as final.	Same as Alt. L2.	Cover dump top with 24" NAG, 24" soil, and revegetate. Existing reclamation on dump slope would be left as final.	Cover dump top with 21" NAG, 25" soil, and revegetate. Existing reclamation on dump slope would be left as final.	Cover dump top with water barrier reclamation cover. Existing reclamation on dump slope would be left as final.
August #1 Waste Rock Dump *Use as NAG cover and to backfill adjacent benches. Regrade footprint to 2.7H:1V slopes.*	Cover with 12" soil and revegetate over NAG fill.	Cover with 24" soil and revegetate over NAG fill.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.	Entire area is part of pit backfill. Cap with water balance and water barrier reclamation covers.
August #2 Waste Rock Dump	Excavate east lobe as NAG cover and fill source. Cover with 12" soil and revegetate. Reclamation on west lobe would be final.	Partially excavate east lobe for use as NAG. Cover with 12" soil and revegetate. Reclamation on west lobe would be final.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Remove east and west lobes for use as NAG. Cover with 12" soil and revegetate.

Mine Feature *Interim Reclamation Actions*	*Alternative L1,* Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2,* Optimize Earthwork within Bond Amount	*Alternative L3,* Improved Pit Drainage Drill Hole	*Alternative L4,* Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5,* Pit Backfill to Cover Sulfide Highwalls	*Alternative L6,* Pit Backfill to Restore Pre-Mine Contours
Gold Bug Yellow Waste Rock Dump *Regraded to 3H:1V slope*	Cover with water balance and water barrier reclamation covers and cap.	Cover with 24" NAG, 24" soil, and revegetate.	Same as Alt. L2.	Same as Alt. L2.	Remove for Backfill. Grade exposed bench at 3H:1V slope. Cover footprint with 21" NAG, 25" soil, and revegetate.	Buried by pit area backfill. Cap as part of pit with water barrier and water balance reclamation covers.
Lower Gold Bug Blue Waste Rock Stockpile	Excavate for use as NAG cover source. Cover with 12" soil and revegetate.	Excavate for use as NAG cover source. Cover with 24" soil and revegetate.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.
Upper Gold Bug Blue Waste Rock Stockpile	Excavate for use as NAG cover source. Cover with 12" soil and revegetate.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Excavate for use as NAG cover. Cap as part of pit backfill with water barrier and water balance reclamation covers.
New Disturbance:						
Limestone Quarry	Develop two quarries to supply NAG material.	No new disturbance - quarry is not required.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.
Gold Bug Highwall	3.6 acres	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.

Mine Feature ***Interim Reclamation Actions***	***Alternative L1,*** **Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)**	***Alternative L2,*** **Optimize Earthwork within Bond Amount**	***Alternative L3,*** **Improved Pit Drainage Drill Hole**	***Alternative L4,*** **Remove & Backfill L85/86 Leach Pad (Preferred Alt.)**	***Alternative L5,*** **Pit Backfill to Cover Sulfide Highwalls**	***Alternative L6,*** **Pit Backfill to Restore Pre-Mine Contours**
Montana Gulch Drain	2 acres	None.	2 acres	None.	None.	None.
Seepage Capture and Water Treatment:						
Water Treatment Plant	Continue to use at current location. Upgrade with biocircuit for nitrates and selenium.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.
Capture Systems	Upgrade as indicated by monitoring to meet MPDES discharge requirements.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.
Reclamation Schedule and Labor:						
Reclamation Timeframe	1999-2004	1999-2003	1999-2003	1999-2004	1999-2005	1999-2008
Direct Reclamation Employment	16-21 people	10-21 people	10-21 people	16-21 people	16-21 people	17-25 people

2.8 IMPACT SUMMARY COMPARISON TABLES

The following tables compare the environmental impacts of the existing conditions and the various reclamation alternatives for each mine. Table 2.8-1 compares the six reclamation alternatives analyzed for the Zortman Mine. Table 2.8-2 compares the six reclamation alternatives analyzed for the Landusky Mine. Additional detail on the impacts of each alternative is provided in Chapter 4.

Table 2.8-1. Summary of Environmental Impacts, Zortman Mine Reclamation

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative Z1***, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	***Alternative Z2***, Optimized Water Treatment within Bond Amounts	***Alternative Z3***, Optimize Source Control within Bond Amounts	***Alternative Z4***, Added Backfilling with Barrier Reclamation Covers	***Alternative Z5***, Extensive Backfilling with Soil Reclamation Covers	***Alternative Z6***, Optimize Grading for Source Control (Preferred Alt.)
Geotechnical Conditions (stability, erodibility and maintainability)							
Z79/80, Z83, Z84, & Z89 Leach Pads:							
Dikes	Intermediate, current condition is stable.	No Change.	No Change.	No Change.	No Change.	No Change.	No Change.
Heaps	Somewhat good. Interim reclamation has reduced heap slopes.	No Change.	No Change.	No Change.	No Change.	No Change.	No Change.
Liners	Intermediate, current liner is functioning.	No Change.	No Change.	No Change.	No Change.	No Change.	No Change.
Z82 Leach Pad:							
Heaps, Dike and Liner	Good. Leach pad was removed and backfilled during interim reclamation.	No Change.	No Change.	No Change.	No Change.	No Change.	No Change.
Z85/86 Leach Pad:							
Dike	Somewhat poor condition. Needs buttress for long-term stability.	Somewhat good. Dike resloped to 2.5H:1V would improve stability.	No Change.	Somewhat good.	Somewhat good.	Good. Removal of pad dike for backfill eliminates stability concerns.	Somewhat good.

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative Z1***, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	***Alternative Z2***, Optimized Water Treatment within Bond Amounts	***Alternative Z3***, Optimize Source Control within Bond Amounts	***Alternative Z4***, Added Backfilling with Barrier Reclamation Covers	***Alternative Z5***, Extensive Backfilling with Soil Reclamation Covers	***Alternative Z6***, Optimize Grading for Source Control (Preferred Alt.)
Heap	Somewhat poor. Contains ungraded slopes.	Intermediate with heap slopes reduced to 3H:1V.	Somewhat poor with minimal reclamation cover and regrading	Intermediate with regrading and reclamation cover.	Intermediate due to partial removal and slopes reduced to 3H:1V.	Good. Removal of heap backfill eliminates stability concerns	Intermediate due to partial removal and slopes reduced to 3H:1V.
Liner	Intermediate, current liner is functioning.	No change.	No change.	No change.	No change.	Good due to removal of leach pad.	No change.
Waste Rock Dumps:							
Alder Gulch Waste Rock Dump	Somewhat poor due to history of past erosion problems on dump slope.	Good stability conditions with dump removal and placement as pit backfill.	No change.	No change.	Same as Alt. Z1.	Same as Alt Z1.	Somewhat good due to partial removal and improved reclamation cover.
O.K. Waste Rock Dump	Intermediate stability condition. Dump has not been reclaimed.	Good stability conditions with dump removal and placement as pit backfill.	No change.	No change.	Somewhat good stability with regrade to 3H:1V slopes and revegetation.	Same as Alt Z4.	Same as Alt. Z4.
South Ruby Waste Rock Dump	Good condition. Dump removed and used for backfill in interim reclamation.	No change.	No change.	No change.	No change.	No change.	No change.
Open Pits:							
North Alabama Pit	Intermediate stability condition.	No change.	No change.	No change.	Good stability due to partial backfilling.	Good stability due to total pit backfilling.	Somewhat good stability due to partial backfilling.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6*, Optimize Grading for Source Control (Preferred Alt.)
South Alabama Pit	Somewhat good stability due to highwall reduction and partial backfilling.	No change.	No change.	No change.	Good stability due to additional backfilling.	Good stability due to additional backfilling.	No change.
O.K./Ruby and Mint Pits	Condition intermediate due to interim reclamation.	No change.	No change.	No change.	No change.	Condition improved to good with additional backfill.	No change.
Ross Pit	Intermediate stability condition.	No change.	No change.	No change.	Condition improved to good with additional backfill	Condition improved to good with additional backfill.	No change.
Tailings:							
Ruby Gulch Tailings	Existing tailings highly erodible.	Removal and use of tailings would reduce erodibility to a low condition.	No change.	No change.	Same as Alt. Z1.	Same as Alt Z1.	Condition improved to average erodibility with most of the tailings removed.
Water Resources and Geochemistry							
Infiltration of Precipitation:							
Total Mine Ave. Infiltration (gpm)	266	126	156	149	138	143	127
% Reduction from Existing Infiltration	0%	53%	41%	44%	48%	46%	53%
Total Pit Ave. Infiltration (gpm)	55	17	33	31	22	29	21

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6*, Optimize Grading for Source Control (Preferred Alt.)
% Reduction from Existing Infiltration	0%	70%	40%	44%	60%	47%	62%
Sulfate Load Reduction (% of existing load):							
Lodgepole Creek	0%	40%	8%	18%	increases by 2,500%	increases by 3,150%	52%
Carter Gulch	0%	88%	0%	0%	87%	88%	88%
Alder Spur	0%	0%	0%	0%	0%	0%	0%
Ruby Creek	0%	46%	10%	7%	34%	27%	34%
Surface Water Quality:							
Alder Spur	Moderately low impacts due to capture system operation.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.
Carter Gulch	Intermediate impacts due to capture system operation.	Moderately low impacts with removal of Alder Gulch waste rock.	No change from existing conditions.	No change from existing conditions.	Same as Alt. Z1.	Same as Alt. Z1.	Moderately low impacts with partial dump removal and improved reclamation cover on dump top.
Ruby Gulch	Moderately high impacts due to uncaptured pit recharge.	Moderately low impacts due to significant reduction in pit and mine recharge.	Moderately high impacts due to lower quality covers and uncaptured pit recharge.	Moderately high impacts due to lower quality covers and uncaptured pit recharge.	Moderately low impacts due to use of HDPE/PVC liners resulting in decreased infiltration in the pits.	Moderately low impacts with use of water barrier covers and removal of the Z85/86 leach pad and dike.	Intermediate impacts with use of water balance water barrier covers and removal of the tailings.

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative Z1***, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	***Alternative Z2***, Optimized Water Treatment within Bond Amounts	***Alternative Z3***, Optimize Source Control within Bond Amounts	***Alternative Z4***, Added Backfilling with Barrier Reclamation Covers	***Alternative Z5***, Extensive Backfilling with Soil Reclamation Covers	***Alternative Z6***, Optimize Grading for Source Control (Preferred Alt.)
Lodgepole Creek	Moderately low impacts due to runoff routed away from drainage.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	Intermediate impacts due to poor quality backfill in Ross pit.	Same as Alt. Z4.	Low impacts due to use of thicker reclamation covers.
Surface Water Quantity:							
Alder Spur	High impacts due to need for ongoing seepage capture.	Moderately high impacts with increases in runoff from reclamation covers.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.
Carter Gulch	Moderately low impacts due to stream water diversions and low flows into capture system.	Low impacts with removal of Alder Gulch waste rock dump and capture system.	No change from existing conditions.	No change from existing conditions.	Same as Alt. Z1.	Same as Alt. Z1.	No change from existing conditions.
Ruby Gulch	Moderately low impacts with release of treated water in upper Ruby Gulch.	No change from existing conditions.	Moderately high impacts from moving treatment plant and release point to Goslin Flats.	No change from existing conditions.	Intermediate impacts from moving treatment plant and release point to Goslin Flats.	Intermediate impacts from moving treatment plant and release point to Goslin Flats.	No change from existing conditions.
Lodgepole Creek	Moderately low impacts to water quantity due to the relatively small area impacted by Ross pit.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	Low impacts to water quantity with restoration of the small runoff area into Lodgepole Creek.	Same as Alt. Z4.	No change from existing conditions.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6*, Optimize Grading for Source Control (Preferred Alt.)
Groundwater Quality:							
Alder Spur	Intermediate impacts with function of capture system.	No change from existing condition.	No change from existing condition.	No change from existing condition.	No change from existing condition.	No change from existing condition.	No change from existing condition.
Carter Gulch	Intermediate impacts with function of capture system.	Low impactswith removal of Alder waste rock dump contaminant source from the drainage.	No change from existing condition.	No change from existing condition.	Same as Alt. Z1.	Same as Alt. Z1.	Moderately low impacts due to partial removal of the Alder waste rock dump from the drainage.
Ruby Gulch	Moderately high impacts with infiltration through pit floors reporting to Ruby Gulch.	Moderately low impacts with barrier cover on pit floors and use of water capture system.	Intermediate impacts with soil covers in pit areas and capture system.	Same as Alt. Z2.	Moderately low impacts with barrier covers over backfilled pit areas and use of water capture system.	Intermediate impacts with soil covers and removal of Z85/86 leach pad from drainage.	Moderately low impacts with improved grading and reclamation covers.
Lodgepole Creek	Moderately low impacts with routing of surface flow away from Lodgepole Creek which limits infiltration in the pit.	Low impacts due to covering sulfide pit benches and floors with NAG material and soil.	Same as Alt. Z1.	Same as Alt. Z1.	Intermediate impacts due to increased backfill in Ross pit at head of the drainage.	Same as Alt. Z4.	Same as Alt. Z1.
Water Management:							
Stormwater Control (stability and maintainability)	Intermediate stability of existing stormwater controls.	Somewhat good long-term stability of stormwater controls.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.	Same as Alt. Z1.

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative Z1***, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	***Alternative Z2***, Optimized Water Treatment within Bond Amounts	***Alternative Z3***, Optimize Source Control within Bond Amounts	***Alternative Z4***, Added Backfilling with Barrier Reclamation Covers	***Alternative Z5***, Extensive Backfilling with Soil Reclamation Covers	***Alternative Z6***, Optimize Grading for Source Control (Preferred Alt.)
Seepage Collection (operating and maintenance difficulty)	High operating requirements due to unreclaimed conditions. Intermediate maintenance needs.	Somewhat high operating requirements. Intermediate maintenance needs.	Intermediate operating requirements. Somewhat low maintenance needs due to easier pumping to Goslin Flats site.	High operating requirements. Intermediate maintenance needs.	Somewhat low operating requirement. Somewhat low maintenance requirements.	Somewhat low operating requirements. Possible need for capture facility in Ross Gulch. Somewhat low maintenance requirements.	Same as Alt. Z1.
Water Treatment Plant Operations (operating and sludge disposal difficulty)	High operating requirements. Somewhat easy sludge disposal.	Somewhat low operating requirements. Somewhat easy sludge disposal.	Intermediate operating requirements with easy access at Goslin Flats site. Sludge disposal somewhat difficult due to transport back to mine site.	Intermediate operating requirements. Somewhat easy sludge disposal.	Somewhat low operating requirements. Somewhat difficult sludge disposal.	Same as Alt. Z4	Same as Alt. Z3.
Water Treatment Plant Acidity Load	High.	Intermediate.	Somewhat high.	Somewhat high.	Intermediate.	Intermediate.	Intermediate.
LAD Water Quality and Quantity	High quality due to acid, metal, nitrate & selenium pretreatments. Volume would be somewhat high due to unfinished heap reclamation.	Same quality as existing conditions. Volume somewhat low with use of barrier reclamation covers on heaps.	Same quality as existing conditions. Volume somewhat high with soil covers on heaps.	Same quality as existing conditions. Volume reduced to intermediate with better covers on heaps.	Same quality as existing conditions. Volume somewhat low with barrier reclamation covers on heaps.	Same quality as existing conditions. Volume somewhat low with Z85/86 and Z82 heaps used for backfill.	Same quality as existing conditions. Volume intermediate with improved reclamation covers on heaps.

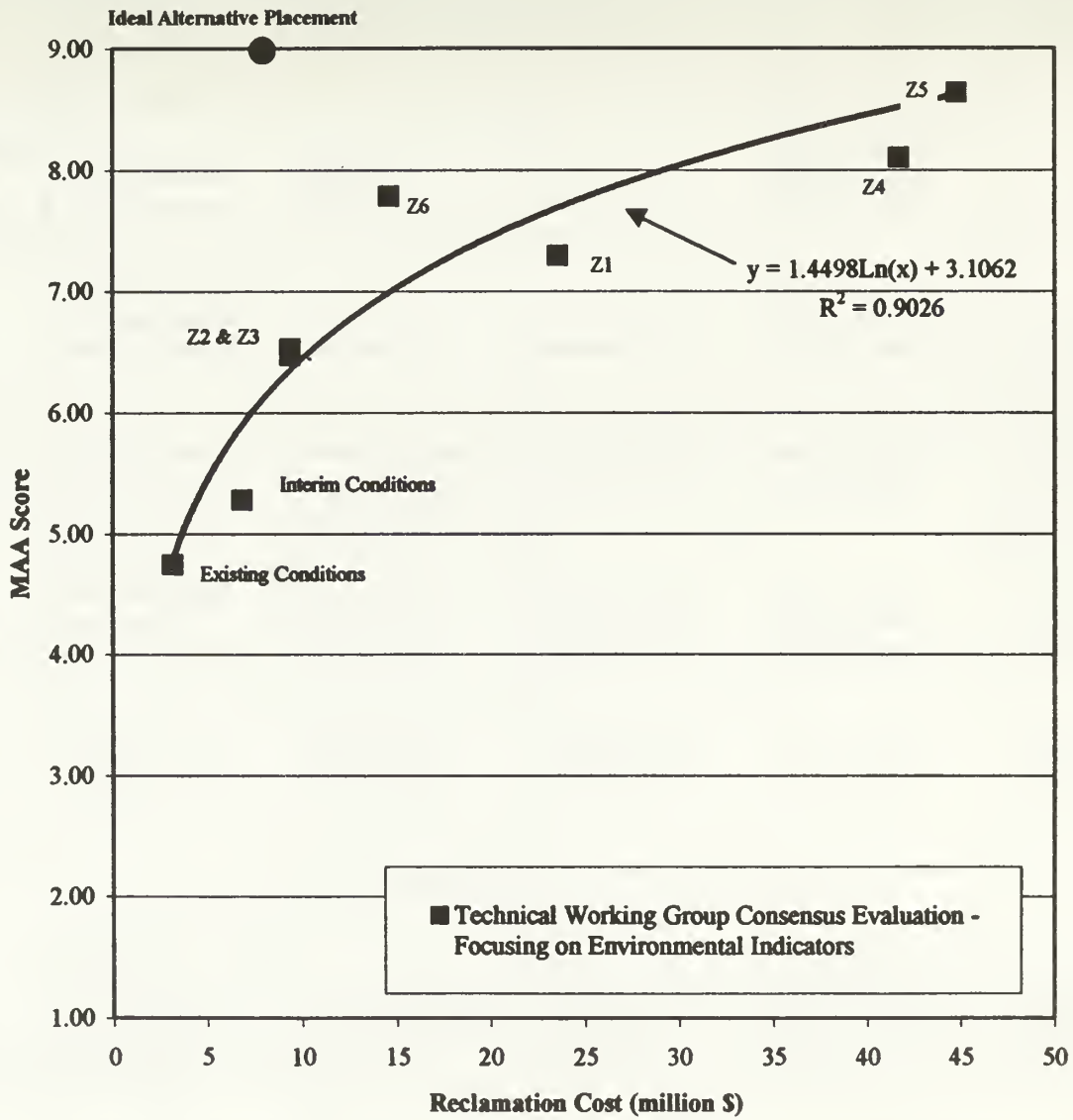
Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6*, Optimize Grading for Source Control (Preferred Alt.)
Soil and Reclamation Materials							
Reclamation Cover Durability	Somewhat good long-term durability of the present covers (which are just rock).	Somewhat poor durability due to potential breakdown of GCL.	Somewhat good durability with use of soil covers.	Same as Alt. Z2.	Somewhat poor durability due to potential breakdown of synthetics in barrier cover.	Same as Alt.Z2.	Intermediate long-term durability with the combination of reclamation covers.
New Disturbances	3.2 acres of new disturbance for construction of the Z85/86 drainage notch during interim reclamation.	Development of an 11-acre limestone quarry to supply reclamation material. 8-acre soil borrow Goslin Flats.	New 8 acres disturbance on Goslin Flats to relocate water treatment plant.	Same as existing conditions.	New 13-acre disturbance for limestone quarry and to move water treat-ment plant. 8-acre soil borrow Goslin Flats.	Same as Alt. Z2.	Same as existing conditions.
Vegetation and Revegetation							
Disturbance Area Revegetated	34%	83%	76%	76%	84%	87%	76%
Revegetation Density, Diversity and Sustainability	Somewhat poor. Not all areas adequate.	Somewhat good.	Intermediate.	Somewhat good.	Good.	Good.	Good.
Wildlife and Aquatics							
Reclamation Value as Wildlife Habitat	Somewhat low.	Intermediate.	Intermediate due to removal of water treatment plant and associated light and noise to Goslin Flats.	Intermediate.	High.	High.	Somewhat high.

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative Z1***, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	***Alternative Z2***, Optimized Water Treatment within Bond Amounts	***Alternative Z3***, Optimize Source Control within Bond Amounts	***Alternative Z4***, Added Backfilling with Barrier Reclamation Covers	***Alternative Z5***, Extensive Backfilling with Soil Reclamation Covers	***Alternative Z6***, Optimize Grading for Source Control (Preferred Alt.)
Land Use							
Long-Term Management Needs	High. Continual care and maintenance for unreclaimed lands.	Somewhat high with barrier cover maintenance and uphill pumping.	Intermediate.	Somewhat high due to maintenance of pumping system and uphill pumping.	Same as Alt. Z2.	Same as Alt. Z2.	Somewhat high.
Mineral Development Potential	Potential reduced from somewhat high at mine closure to intermediate with interim backfilling.	Somewhat low with increased backfilling of pit area.	Intermediate. Similar to existing conditions.	Same as Alt. Z2.	Low potential for future mineral development with the added backfill.	Low potential for future mineral development with the extensive backfill.	Somewhat low with partial backfilling of all pits.
Recreation and Visual Resources							
General Aesthetic Condition of Reclaimed Mines	Somewhat low due to unreclaimed areas and pit highwalls.	Intermediate due to backfilling of some pit areas.	Somewhat low.	Intermediate. Impact similar to Alt. Z1, though less backfilling.	Somewhat high with the added pit backfilling.	High due to restored landform and elimination of pit highwalls	Somewhat high with the added grading and pit backfilling.
Hunting, Tourism or other Recreational Suitability	Low to somewhat low suitability.	Intermediate.	Intermediate to somewhat high.	Same as Alt. Z1.	Somewhat high.	Same as Alt. Z4.	Intermediate to somewhat high.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6*, Optimize Grading for Source Control (Preferred Alt.)
Cultural Resources							
Usability for Traditional Cultural Practices	Low. Areas still unreclaimed. Equipment active.	Somewhat low.	Somewhat low.	Somewhat low.	Intermediate.	Somewhat high.	Intermediate.
Social and Economic Conditions							
Study Area Economy	Year 2000 averaged 31 jobs and $622,000 in total industry output.	27-40 jobs and $830,000 to $1.1 million annually in total industry output over 3-year period (2001-2003).	46 jobs and $1.3 million annually in total industry output over 1 year (2001).	54 jobs and $1.9 million annually in total industry output over 1 year (2001).	41-48 jobs and $1.1 million annually in total industry output over 4-year period (2001-2004).	38-47 jobs and $970,000 to $1.2 million annually in total industry output over 6-year period (2001-2006).	47-54 jobs and $1.1 to $1.9 million annually in total industry output over 2-year period (2001-2002).
Zortman Community Infrastructure Condition	Low.	Intermediate. Removal of tailings through town would improve distribution water system and reduce flooding potential.	No change.	No change.	Intermediate. Same as Alt. Z1.	Intermediate. Same as Alt. Z1.	Somewhat low with no tailings removal through town.
Reclamation Worker Health and Safety	High level of worker protection with just interim reclamation work.	Somewhat low protection. Alder Dump removal difficult.	Somewhat high protection with this reclamation effort.	Same as Alt. Z2.	Somewhat low protection due to increased amount of reclamation duration.	Somewhat low worker protection. Similar to Alt. Z4.	Intermediate.
Public Health and Safety Post-Reclamation	Intermediate. Existing conditions contain hazards.	Intermediate.	Intermediate. Similar to Alt. Z1.	Intermediate. Similar to Alt. Z1.	Somewhat high with reduction of pit highwall height.	High public safety with elimination of pit highwalls.	Somewhat high with the reduction of the pit highwall height.

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative Z1***, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	***Alternative Z2***, Optimized Water Treatment within Bond Amounts	***Alternative Z3***, Optimize Source Control within Bond Amounts	***Alternative Z4***, Added Backfilling with Barrier Reclamation Covers	***Alternative Z5***, Extensive Backfilling with Soil Reclamation Covers	***Alternative Z6***, Optimize Grading for Source Control (Preferred Alt.)
Long-Term Employment Value	Somewhat high due to need for continual water treatment plant operation.	Intermediate. Less need for water treatment plant operation over existing conditions.	Somewhat low. Treatment plant at Goslin Flats would require less personnel to operate.	Intermediate. Similar to Alt. Z1.	Somewhat low. Similar to Alt. Z2.	Somewhat low. Similar to Alt. Z2.	Intermediate. Similar to Alt. Z1.
Total Reclamation Expenditures	$6.9 million spent on interim reclamation.	$26.3 million.	$10.0 million.	$10.0.million.	$43.0 million.	$46.2 million.	$15.1 million.
Percentage of Reclamation Costs Attainable within Bond Amount	100%	38%	100%	100%	23%	22%	66%
Long-Term Water Collection and Treatment Costs (net present value trust needed)	$9.85 million	$9.3 million.	$8.3 million.	$9.8 million.	$8.1 million.	$8.1 million.	$9.3 million
Long-Term Water Management Costs Attainable with Present Trust Fund	77%	81%	77%	77%	81%	81%	81%

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative Z1*, Existing DEQ Reclamation Plans (FEIS Alt.3 & 1998 ROD)	*Alternative Z2*, Optimized Water Treatment within Bond Amounts	*Alternative Z3*, Optimize Source Control within Bond Amounts	*Alternative Z4*, Added Backfilling with Barrier Reclamation Covers	*Alternative Z5*, Extensive Backfilling with Soil Reclamation Covers	*Alternative Z6*, Optimize Grading for Source Control (Preferred Alt.)
Alternative Ranking from Multiple Account Analysis Scores (from Appendix A)							
Technical Working Group's Overall Evaluation	7	6	5	4	3	2	1
Technical Working Group Evaluation Using only Environmental Performance	7	4	6	5	2	1	3
Cost-Benefit Evaluation Ranking. (environmental benefit vs. cost)	7	5	2	3	6	4	1



Interim conditions and Alt Z1 not included in logarithmic curve fitting

FIGURE 2.8-1 - MAA SCORES VERSUS RECLAMATION COST FOR THE ZORTMAN RECLAMATION ALTERNATIVES

Table 2.8-2. Summary of Environmental Impacts, Landusky Mine Reclamation

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Geotechnical Conditions (stability, erodibility, & maintainability)							
Lower Leach Pads L79, L80/81/82, L83, L84:							
Dikes	Somewhat good. Interim reclamation has improved stability.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.
Heaps	Somewhat good. Interim reclamation has improved stability from somewhat poor.	Somewhat good but more difficulty maintaining barrier covers.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.
Liners	Intermediate durability.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.
L85/86 Leach Pad:							
Dikes	Intermediate stability.	Improve stability to somewhat good with buildout to 2.5H:1V slopes.	Same as Alt. L1.	Same as Alt. L1.	Stability improved to good with removal of dike.	Same as Alt. L4.	Same as Alt. L4.
Heaps	Interim reclamation improve stability from somewhat poor to intermediate.	Intermediate with GCL in reclamation cover.	Somewhat good with no GCL.	Same as Alt. L2.	Heap stability improved to good with removal and placement as backfill.	Same as Alt. L4.	Same as Alt. L4.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Liners	Intermediate functioning.	Same as existing condition.	Same as existing condition.	Same as existing condition.	Removal of liner improves function to good.	Same as Alt. L4.	Same as Alt. L4.
L87/91 Leach Pad:							
Dikes	Intermediate stability.	Somewhat good with built out L91 dike.	Same as existing conditions.	Same as existing conditions.	Same as existing conditions.	Somewhat good due to slight reduction in load behind dikes and additional revegetation.	Somewhat good due to reduction in load behind dikes and additional revegetation.
Heaps	Intermediate stability due to some regrading.	Stability improved to somewhat good with 3H:1V slopes.	Intermediate stability with regrade to 2.5H:1V slopes.	Same as Alt. L2.	Same as Alt. L2.	Stability improved to good with some heap material removed.	Similar to Alt. L5.
Liners	Intermediate, functioning.	Same as existing condition.	Same as existing condition.	Same as existing condition.	Same as existing condition.	Same as existing condition.	Same as existing condition.
Waste Rock Dumps:							
August #1 and #2 Waste Rock Dumps	Somewhat good as dumps are reclaimed or graded.	Somewhat good. Partial removal but reclaimed on steep slopes.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Good stability with use as backfill.
Montana Gulch Waste Rock Dump	Intermediate condition with top disturbed.	Somewhat good condition with partial removal and top reclaimed.	Intermediate with top reclaimed.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.
Mill Gulch Waste Rock Dump	Somewhat good condition.	Somewhat good condition with added revegetation.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Gold Bug Repository	Existing condition is intermediate.	Intermediate with grading and covering of dump top.	Somewhat good with grading and covering of dump top.	Same as Alt. L2.	Same as Alt. L2.	Good with dump removed.	Good with dump buried in pit backfill.
Open Pits:							
Queen Rose Pit	Somewhat poor stability conditions.	Somewhat poor with grading limited to the pit floor.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Somewhat good due to backfilling.	Good due to large amount backfilling.
August/Little Ben Pit	Somewhat poor stability conditions.	Somewhat poor with grading limited to the pit floor.	Same as existing conditions.	Somewhat poor with limited highwall backfilling.	Intermediate with more backfilling on pit floor and walls.	Somewhat good due to backfilling.	Good due to large amount backfilling.
Gold Bug Pit	Somewhat poor stability conditions.	Intermediate with grading limited to pit floor and highwall reduction to cover sulfides.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Somewhat good due to backfilling.	Good due to large amount backfilling.
South Gold Bug Pit	Somewhat poor stability conditions.	Somewhat poor with grading limited to the pit floor.	Same as Alt. L1.	Same as Alt. L1.	Somewhat good due to highwall reduction.	Somewhat good due to backfilling.	Good due to large amount of backfilling.
Water Resources and Geochemistry							
Infiltration of Precipitation:							
Total Mine Ave. Infiltration (gpm)	747	233	299	301	294	287	188
% Reduction from Existing Infiltration	0%	69%	60%	60%	61%	62%	75%

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Total Pit Ave. Infiltration (gpm)	194	73	100	100	93	84	34
% Reduction from Existing Infiltration	0%	62%	48%	48%	52%	57%	82%
Sulfate Load Reductions (% of existing load):							
King Creek	0%	8%	2%	2%	2%	2%	increases by 330%
Swift Gulch	0%	29%	22%	19%	20%	increases by 170%	increases by 220%
Montana Gulch	0%	52%	21%	21%	22%	20%	27%
Mill Gulch	0%	47%	5%	5%	5%	5%	33%
Sullivan Gulch	10%	12%	0%	0%	0%	0%	0%
Surface Water Quality:							
Upper Swift Gulch	Intermediate impacts due to worsening shear zone water quality from unreclaimed pit area.	Moderately low impacts due to GCL covers over Queen Rose pit and pit benches.	Intermediate impacts due to water balance covers but no barrier covers. Pit sulfides still exposed.	Moderately low impacts due to thicker water balance covers on pit benches and NAG highwall cover.	Same as Alt. L3	Intermediate impacts due to backfill of sulfide rock into Suprise and Queen Rose pits.	Moderately high impacts due to possible leaching of sulfide backfill and drainage to north.
King Creek	Intermediate impacts due to the presence of the August #2 waste rock dump.	Moderately low impacts with removal of the east lobe of the August 2 rock dump.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Moderately high impacts due to possible leaching of the pit backfill.
Sullivan Gulch	Intermediate impacts due to occasional ARD bypasses of capture system.	Intermediate impacts if acid generating materials are used to buildout the L91 dike.	Moderately low impacts with the added revegetation on the L91 dike.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2	Same as Alt. L2.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Mill Gulch	Intermediate impacts due to occasional ARD bypasses of capture system..	Moderately low impacts with the enhanced covers.	Same as Alt. L1	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.
Montana Gulch	Moderately high impacts due to presence of L85/86 leach pad and underdrains and existing highwalls.	Moderately high impacts due to excavation of the pit drainage notch exposing sulfides.	Intermediate impacts with reclamation of leach pad surface.	Same as Alt. L2, but directional borehole provides backup feature to help prevent formation of pit lake.	Low impacts due to L85/86 pad removal, restoration of natural drainage, and more coverage of pit highwalls.	Moderately low impacts due to L85/86 pad removal and creation of a free-draining pit. Sulfides placed in pit increases risk over L4.	Same as Alt. L5.
Surface Water Quantity:							
Upper Swift Gulch	Moderately high impacts to flow due to interception by mine pits.	No change due to surface drainage routed to south.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Moderately low impacts with restored pit topography which restores runoff flows.
King Creek	Moderately high impacts to flow due to interception by mine pits.	No change due to surface drainage routed to south.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Low impacts due to restored pit topography which restores runoff flows.
Sullivan Gulch	Moderately high impacts to flow due to interception by leach pad.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.
Mill Gulch	Moderately high impacts to flow due to interception by leach pad.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.

Affected Resource or Mine Feature	**Existing Condition** (February 2001)	***Alternative L1***, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	***Alternative L2***, Optimize Earthwork within Bond Amount	***Alternative L3***, Improved Pit Drainage Drill Hole	***Alternative L4***, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	***Alternative L5***, Pit Backfill to Cover Sulfide Highwalls	***Alternative L6***, Pit Backfill to Restore Pre-mine Topography
Montana Gulch	Low impacts to flow with water treatment plant discharges.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	Moderately low impacts due to less capture for treatment.
Groundwater Impacts:							
Upper and Lower Swift Gulch	Intermediate impacts due to reduced recharge to seeps in Swift Gulch from interim reclamation liner on pit floor.	Moderately low impacts due to barrier cover over pit backfill.	No change from existing conditions. Soil covers are minimal.	Moderately low impacts due to sulfides in Suprise pit being covered with backfill and improved soil covers.	Similar to Alt. L3, but less impact due to thicker reclamation covers.	Moderately high impacts with placement of sulfidic L87 spent ore backfill at head of drainage.	Moderately high impacts from large amount of L87/91 spent ore backfilled at head of drainage and more shallow seepage to north.
King Creek	Intermediate impacts due to August #2 waste rock dump and poor quality pit rim infiltration.	Moderately low impacts with removal of August #2 waste rock dump.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Moderately high impacts from acidic backfill at head of drainage and potential shallow seepage to creek.
Sullivan Gulch	Intermediate impacts due to occasional ARD bypasses of capture system.	Intermediate impacts if acid generating materials are used to buildout the L91 dike.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.
Mill Gulch	Intermediate impacts on alluvial and bedrock aquifers due to occasional capture system bypasses.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.	No change from existing conditions.

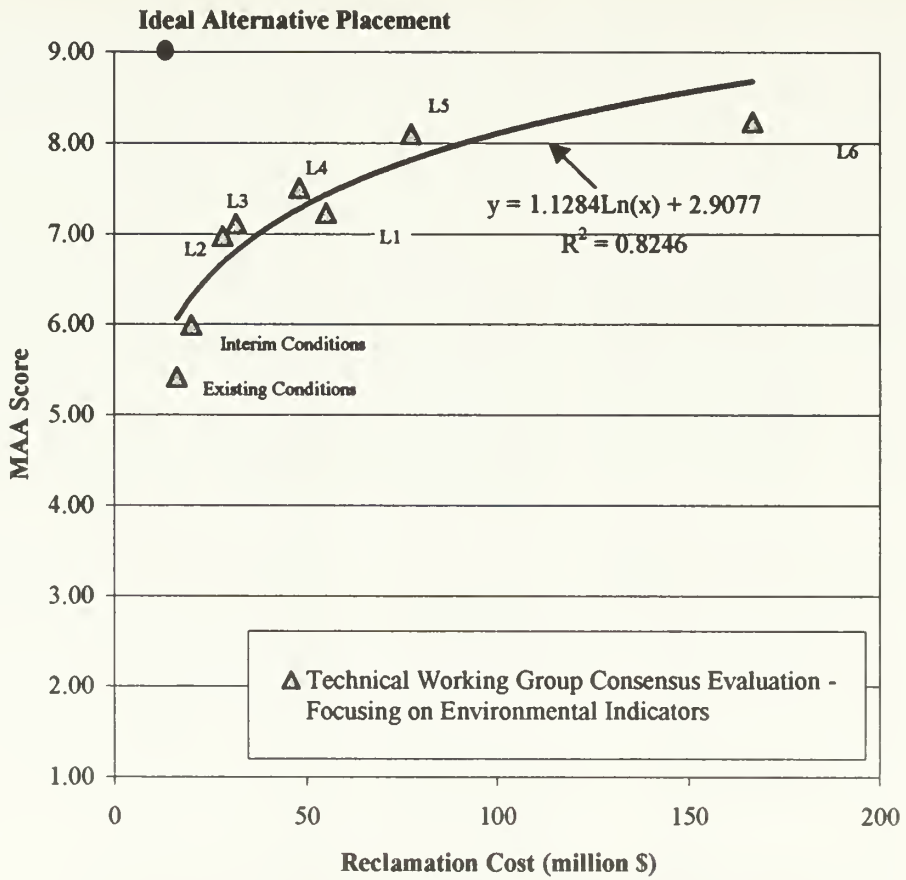
Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Montana Gulch	Intermediate impacts from high infiltration to August and Gold Bug pit areas and some uncaptured groundwater flow.	Low impacts with extensive GCL cover use and free-draining pit.	Moderately low impacts with reclamation covers over pits and other areas.	Same as Alt. L2.	Low impacts with removal of L85/86 leach pad from the drainage, improved covers and partial highwall coverage.	Intermediate impacts due to removal of the L85/86 leach pad offset by use of acid-forming backfill.	Same as Alt. L5.
Water Management:							
Stability of Workings Used for Pit Drainage	Somewhat poor. Artesian well only.	Somewhat good with use of drainage notch.	Somewhat poor with soil cover over the pit floor.	Intermediate, with backup drainage borehole.	Intermediate, similar to Alt. L3.	Good. Most drainage via surface runoff.	Same as Alt. L5.
Stormwater Control Maintenance Requirements	Intermediate.	Somewhat low.	Somewhat low.	Somewhat low.	Somewhat low.	Somewhat low.	Intermediate. Backfilled slopes may be difficult to manage.
Seepage Collection (operating and maintenance difficulty)	Intermediate. System functioning adequately.	No change.	No change.	No change.	No change.	Difficulty increased to somewhat high with added capture system in pit area.	Same as Alt. L5.
Water Treatment Plant Operations (operating requirements and sludge disposal)	Somewhat high operating requirements. Somewhat easy sludge disposal.	Somewhat low operating requirements with less volume. Somewhat easy sludge disposal.	Intermediate operating requirements. Sludge disposal is somewhat easy.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L1.	Same as Alt. L1.
Water Treatment Plant Acidity Load	High.	Intermediate.	Somewhat high.	Somewhat high.	Somewhat high.	Somewhat high.	High.
LAD Water Quality and Quantity	High load and somewhat high volume.	High load and intermediate volume.	Same as Alt. L1.	Same as Alt. L1.	High load and somewhat low volume.	Same as Alt. L4.	High load and low volume.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Soil and Reclamation Materials							
Reclamation Cover Durability	Somewhat good.	Somewhat poor with use of GCL.	Somewhat good.	Somewhat good.	Somewhat good.	Somewhat good.	Somewhat poor due to synthetic.
New Disturbances	Gold Bug highwall 3.6 acres.	Possible two new limestone quarries. 2 acres for Montana Gulch drainage.	No new disturbances.	2 acres for Montana Gulch drainage.	Same as Alt. L2.	Same as Alt. L2.	Same as Alt. L2.
Vegetation and Revegetation							
Disturbance Area Revegetated	40%	81%	78%	78%	81%	85%	92%
Revegetation Density, Diversity, and Sustainability	Somewhat poor density with intermediate diversity and sustainability.	Somewhat good density with intermediate diversity and sustainability.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Good density with somewhat high diversity and sustainability.	Same as Alt. L5.
Wildlife and Aquatics							
Reclamation Value as Wildlife Habitat	Intermediate.	Somewhat high.	Somewhat high.	Somewhat high.	Somewhat high.	High.	High.
Land Use							
Long-Term Management Needs	High. Unreclaimed areas would need a lot of maintenance.	Somewhat high. Long term water treatment need indefinite.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Mineral Development Potential	Somewhat high. Not much backfill over deposit.	Intermediate.	Intermediate.	Intermediate.	Intermediate.	Somewhat low. Backfilling makes future mining unlikely.	Low. Extensive backfill make future mining unlikely.
Recreation and Visual Resources							
General Aesthetic Condition of Reclaimed Mine	Somewhat low due to unreclaimed areas.	Somewhat low due to highwall areas.	Same as Alt. L1.	Same as Alt. L1.	Intermediate.	Somewhat high with more backfilling in pits.	High, backfilling eliminates pit highwalls.
Hunting, Tourism or other Recreational Suitability	Somewhat low. Area closed to public use.	Intermediate. Some use restrictions would still be needed.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Somewhat high. Minor use restrictions needed.	Somewhat high. Minimal use restrictions needed.
Cultural Resources							
Usability for Traditional Cultural Practices	Low. Existing disturbance not suitable.	Somewhat low due to remaining pit highwalls.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Intermediate with partial backfilling.	Somewhat high due to increased backfilling.
Social and Economic Conditions							
Study Area Economy	Year 2000 average employment of 31 jobs and $622,000 in total industry output.	35-48 jobs and $1.2 to $1.4 million annually in total industry output over 4-year period (2001-2004).	31-50 jobs and $1.1 to $1.5 million annually in total industry output over 3-year period (2001-2003).	30-50 jobs and $1.1 to $1.5 million annually in total industry output over 3-year period (2001-2003).	36-49 jobs and $1.2 to $1.5 million annually in total industry output over 4-year period (2001-2004).	35-48 jobs and $1.2 to $1.4 million annually in total industry output over 5-year period (2001-2005).	43-54 jobs and $1.2 to $1.5 million annually in total industry output over 8-year period (2001-2008).
Landusky Community Infrastructure Condition	Somewhat high. Water supplies not impacted.	Same as existing conditions.	Same as existing conditions.	Same as existing conditions.	Same as existing conditions.	Same as existing conditions.	Same as existing conditions.

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Health and Safety of Reclamation Workers	Somewhat high.	Intermediate. Cutting drainage notch is difficult.	Somewhat high.	Somewhat high.	Somewhat high.	Somewhat low.	Low due to extensive amount of work over time.
Public Health and Safety Post-Reclamation	Intermediate.	Somewhat high.	Somewhat high.	Somewhat high.	Somewhat high.	High with elimination of pit highwalls.	Same as Alt. L5.
Long-Term Employment Value	Somewhat high if site to be maintained in existing condition.	Intermediate value with continued site maintenance and treatment needs.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.	Same as Alt. L1.
Total Reclamation Expenditures	$10 million spent on interim reclamation.	$46.2 million.	$19.6 million.	$22.2.million.	$36.6 million.	$67.9 million.	$157.3 million.
Percentage of Reclamation Costs Attainable within Bond Amount	100%	42%	100%	88%	54%	29%	12%
Long-Term Water Collection and Treatment Costs (net present value trust needed)	$9.85 million	$8.9 million.	$9.5 million.	$9.4 million.	$9.4 million.	$9.4 million.	$9.3 million.
Long-Term Water Management Costs Attainable with Present Trust Fund.	77%	81%	77%	77%	77%	81%	81%

Affected Resource or Mine Feature	Existing Condition (February 2001)	*Alternative L1*, Existing DEQ Reclamation Plans (FEIS Alt. 3 and 1998 ROD)	*Alternative L2*, Optimize Earthwork within Bond Amount	*Alternative L3*, Improved Pit Drainage Drill Hole	*Alternative L4*, Remove & Backfill L85/86 Leach Pad (Preferred Alt.)	*Alternative L5*, Pit Backfill to Cover Sulfide Highwalls	*Alternative L6*, Pit Backfill to Restore Pre-mine Topography
Alternatives Ranking from Multiple Account Analysis Scores (from Appendix A)							
Technical Working Group's Overall Evaluation	7	6	1	1	3	4	5
Technical Working Group Evaluation Using only Environmental Performance	7	4	6	5	3	2	1
Cost-Benefit Evaluation Ranking. (environmental benefit vs. cost)	7	5	2	1	3	4	6



Interim & Alt L1 not included in logarithmic curve fitting

Figure 2.8-2 - MAA Scores Versus Reclamation Cost for the Landusky Mine Reclamation Alternatives

CHAPTER 3
EXISTING CONDITIONS

3.1 STUDY AREA

The SEIS study area is generally the area encompassed by the Little Rocky Mountains. The study area for each environmental resource varies depending upon the extent of potential impacts to that resource. For example, impacts to soils and vegetation are generally confined to the area of direct disturbance; while impacts to economic, social or visual resources may extend many miles beyond the project area.

This chapter describes the existing resource conditions at or near the Zortman and Landusky Mines that would be affected by the various alternatives. Since the purpose of the analysis is to consider the effectiveness of alternatives to reclaim existing disturbance, this chapter includes both a description of the affected environment and a description of the existing impacts that have been created by the mining activity. The chapter focuses on resource conditions that are relevant to reclamation by describing existing impacts which could be mitigated by the reclamation alternatives. The cumulative impacts from past mining actions are included in the description of existing conditions. Additional information on the affected environment around the mines can be found in Chapter 3 of the 1996 FEIS.

3.2 GEOLOGY and GEOTECHNICAL CONDITIONS

Geology has influenced the pattern of patented and Federal lands in the Little Rocky Mountains. The majority of the mine pits are located on private lands since they define the most valuable mineralized zones. The unpatented Federal lands are, conversely, the nonmineralized areas that were used for location of the mine facilities such as waste rock dumps, heaps, ponds and water treatment plants. This section describes the geology of the Little Rocky Mountain area in general with specific detail focused on the mine area without regard to land ownership.

Since completion of the FEIS in 1996, a detailed geology report was completed by ZMI. The "Geologic Evaluation of the Zortman and Landusky Mine Sites and Surrounding Little Rocky Mountains" (1996) includes detailed geologic maps and associated cross sections illustrating relationships between the hydrostratigraphic units, structures, and associated mine facilities. While this study was not available for the FEIS, the location of shears and underground workings and their impact on groundwater flow was well known. The Groundwater Study (WMCI 1998) incorporated results of the ZMI study.

3.2.1 Geology and Topography

The Zortman and Landusky Mines are found within the Little Rocky Mountains of northcentral Montana. Gold mining has taken place in the Little Rocky Mountains for over 100 years; as a result, an extensive database of information exists concerning the geology of the mountains and the ore deposits contained therein. This section describes the regional geologic setting of the Little Rocky Mountains, the mineralogic associations and occurrences within the study area, and the structural forces which have played a major role in both the shape of the mountains and the locations of ore deposits.

The Little Rocky Mountains are within the Northern Great Plains geographic region, which is distinguished by rolling prairies that are dissected by drainage systems. Mountains disrupt the landscape abruptly in this region and like the Little Rocky Mountains, are called "island mountain ranges" because they rise up out of the relatively flat plains like islands in an ocean. Other island mountain ranges in this region include the North and South Moccasin Mountains, the Bears Paw Mountains, the Sweet Grass Hills, and the Judith Mountains.

The Little Rocky Mountains rise in dramatic relief more than 2500 feet above the surrounding plains. Old Scraggy Peak, located about 1.5 miles east of the Zortman Mine, is the highest point in the Little Rocky Mountains at approximately 5700 feet amsl. In contrast, Goslin Flats south of the town of Zortman is at an elevation of approximately 3800 feet amsl. The surrounding plains are significantly lower. Fort Peck Lake, 50 miles east of the Little Rocky Mountains, sits at about 2300 feet amsl. The topography within the Little Rocky Mountains is rugged, marked by high outcrops of erosion resistant rocks and steep, V-shaped valleys with little accumulation of soil or alluvial materials.

The plains north of the Little Rocky Mountains slope gradually into the Milk River bottom which occupies the pre-glacial channel of the Missouri. To the south, the surface water drainage has carved steep narrow channels into a badlands-type topography. Southwest and south of the Little Rocky Mountains, the topography is strongly influenced by the post-glacial channel of the Missouri River. Intermittent streams and coulees coalesce to form tributaries of the Missouri River, and the topography becomes more broken as the drainages easily incise through the relatively soft sedimentary rocks which make up most of this region.

The topography in the mining area has been altered by excavation of the open pits and construction of the waste rock dumps and leach pads. A three dimensional simulation of the topography around the mines is shown in Figures E-1 and E-8, in Appendix E.

Historical Geology

The Little Rocky Mountains are found in a region exhibiting geologic extremes in rock types, history of rock formation and emplacement, and age of materials. The regional geology ranges from upland prairie which was glaciated as recently as 10,000 years ago, to the nearly 3 billion year old rocks exposed in mountainous areas (BLM 1992).

The oldest rocks in the region are Precambrian Era (greater than 650 million years old) metamorphic gneisses and schists. Metamorphic rocks are those which have been altered in texture or composition due to temperature, pressure, and/or chemical processes. These very old rocks outcrop only in some of the mountain ranges, including the Little Rocky Mountains, where magma upwelling from below the earth's surface has pushed older rocks up through younger strata.

Thick sequences of Paleozoic Era (570 to 240 million years ago) sedimentary rocks are found in the mountain ranges and on the plains. Sedimentary rocks are those which have formed by the accumulation of sediments or minerals precipitated from water. These rocks are predominantly limestones and dolomites which typically formed in marine environments, but sandstones and shales also occur. These are the rock types which usually do not contain much gold or precious metals, but they are still important because they can be used in construction or as reclamation materials. Limestones, dolomites, and other "calcareous" rocks (those containing significant amounts of calcium carbonate) are very useful because they can neutralize or buffer water which has been acidified by mine operations. These rocks are very resistant to erosion and form some of the spectacular cliffs in the mountain ranges; they also contain some important cave formations, such as Azure Cave on the south side of the Little Rocky Mountains.

Mesozoic Era (240 to 66 million years ago) rocks comprise another sedimentary sequence in this region. Sedimentary rocks from the Jurassic period of the Mesozoic are typically calcareous sandstones and shales. Gypsum and coal have been mined from Jurassic sediments in the region. Cretaceous period rocks are typically sedimentary, with the different rock formations representing episodes of advance and retreat of a large inland sea which covered much of North America at that time. These sediments include sandstones,

shales, and limestones. Coal and bentonite have been mined from various Cretaceous formations. Thick carbonaceous shales from the Cretaceous also provide for oil and gas development in the region.

The geology and topography of the region have been determined by two activities during the Cenozoic Era (66 million years ago to the present). Extensive igneous activity during the Tertiary period of the Cenozoic Era resulted in the formation of island mountain ranges described earlier. This igneous activity in Montana appears to follow the structural controls of a regional feature known as the Great Falls Tectonic Zone. Described by O'Neil and Lopez (1985), the Great Falls Tectonic Zone is a belt of northeast-trending geologic features that can be traced from the Idaho Batholith in northcentral Idaho and western Montana, across the overthrust belt structures of southwestern Montana, through central Montana and into southwesternmost Saskatchewan, Canada. Geologists believe the Great Falls Tectonic Zone controlled the intrusion patterns and orientation of late Cretaceous to early Tertiary igneous intrusions and dike swarms, including those of the Little Rocky Mountains and other area mountain systems.

More recently, during the Quaternary period of the Cenozoic Era, massive glaciers advanced and retreated over much of the region leaving glacial deposits and debris in most of the area north of the Missouri River. Erosive forces have continued to alter the region's landscape, removing weathered bedrock from mountainous areas and depositing it as unconsolidated deposits in valleys and plains.

The rock types are younger with increasing distance from the Precambrian rocks near the center of the dome. Most of the Paleozoic sedimentary rocks in this area were created in a marine environment. These sedimentary rocks are more resistant to erosion and may form prominent buttes, ridges, and cliffs. The deepest (and oldest) of the sedimentary formations is the Flathead sandstone. It is overlain by approximately 3,000 feet of limestones and dolomites, with lesser amounts of shale, sandstone, and conglomerate. The top sequence of Paleozoic rocks consists of Madison Group limestones, which are found around the margins of all the island mountains in Montana.

The Mesozoic rocks in the area consist primarily of shales, with lesser amounts of sandstones, conglomerates, and limestones. In general, the Mesozoic rocks represent terrestrial and near-marine environments, when sediments from earlier ages were eroded and redeposited in valley floors, river and stream beds, and outwash plains. These sediments are found as bedrock at or near the surface in the areas around the Little Rocky Mountains. A fairly complete stratigraphic section, from Pre-Cambrian metamorphic rocks to Cretaceous (Bearpaw Shale), is exposed along the flanks of the mountains.

Younger rocks of the current Cenozoic Era are igneous intrusives. The igneous rocks in this area occur as syenite porphyries. Emplacement of the Cenozoic intrusive rocks resulted in the formation of the Little Rocky Mountains, as described at the beginning of this section. In addition, intrusion of the igneous rocks mobilized and deposited elements such as gold in sufficient concentrations to make mining them economic.

Sulfide mineralization is associated with gold deposits. The sulfide mineral pyrite occurs along fractures in association with the gold mineralization. Upon mining, the rock breaks preferentially along fractures

exposing not only the gold to leaching, but the pyrite minerals to weathering. Thus, the same mechanism that makes leaching of the gold possible without crushing the ore also exposes more of the sulfide minerals to weathering than would otherwise occur if they were evenly distributed throughout the rock.

Economic Geology

The reason gold and other precious metals have been found in the Little Rocky Mountains is directly related to the solidification history of the igneous porphyry rocks. After upwelling and emplacement of the igneous magmas, a hydrothermal system dominated by low pH, low salinity waters heated by the igneous magma developed (Russell 1991a). This hot, acidic water caused widespread alteration in rocks of the Zortman/Landusky Mining District. Hydrothermal flow of the heated waters was channeled along the existing structural trends of the intrusive rocks. Gold, silver, and associated minerals such as pyrite were dissolved in the hot water because of the low pH. Changes in pressure, fluid chemistry, or reductions in temperature could cause the pH of the water to increase, resulting in precipitation of gold and minerals. The minerals were typically distributed within the structural channels, often in dikes or veins of quartz, or along fracture zones of crushed and broken rock called breccias. Metal sulfide minerals and gold were also disseminated throughout the rocks. Some of the existing environmental impacts at the mines result from what is essentially a reversal of this process. As the minerals in waste rock and ore are exposed to air and water during mining, the sulfides react to form sulfuric acid and lower the pH of the water. This acidification process partially dissolves minerals back into solution. A more detailed discussion of this process can be found in the 1996 FEIS and in the Geochemistry section of this document.

Vein lode deposits of gold were first discovered in the Little Rocky Mountains in 1892. The vein deposits are typically the most heavily enriched in gold or other precious metals; hence, they are the most valuable deposits. They were also relatively easy for the lone prospector or small operation to mine, because mining only required that the vein be followed.

Natural erosional forces also created new, localized areas of concentrated gold. Rain, snow, and seasonal weathering of the mountains and mineralized zones break up rock in the higher elevations and carry it down into stream channels, valleys and basins. Deposits of eroded material from mineralized zones are called placers. Placer deposits were often the first and best indicators to the old prospectors of the last century that ore zones could be found in the higher areas of mountain regions. This is the case for the Little Rocky Mountains. The first placer deposits were developed in Alder Gulch in 1884, while the first lode claims were patented in 1892.

Some very rich "bonanza-type" gold ore was historically produced in the Little Rocky Mountains from the vein deposits described above; however, most modern production has come from relatively low grade ore (typically ranging from 0.022 to 0.028 ounces per ton, although even lower grades have been mined at the Landusky Mine). The mineral deposits occur in the altered syenite porphyries, and are associated with high-angle faults or fractures, the channels along which mineralized hydrothermal waters had access. At the Zortman Mine, gold mineralization has been concentrated at the intersections of north and

northwest-trending mineralized fractures, and occurs as finely disseminated particles. To date, the richest ore bodies have been within the porphyry-hosted "breccia" dikes, the rock type resulting from crushing and grinding along a fault or fracture. Sulfide mineralization in the O.K. pit area, a mineralized breccia 15 to 100 feet wide emplaced along a northwest-trending fracture, was continuous from the mountain top to an average depth of 500 feet. In the Landusky Mine area, economically viable gold deposits are found where the number and/or extent of fractures is greatest. These systems at the Landusky Mine parallel the inferred southwest to northeast trend of the Great Falls Tectonic Zone.

At the Zortman and Landusky Mines, both oxide and sulfide portions of the ore bodies were mined. Oxidation of the ore generally has occurred nearest the surface, and along fractures which have transported surface water and shallow groundwater deeper in the ore zones. Although gold and silver are easier to separate from oxidized ores using cyanide heap leach processes, the nature of the ore bodies in most cases resulted in a mixture of oxide and sulfide ore being mined. This generally resulted in lowered leach recoveries for ores containing larger amounts of sulfide as the precious metals are more tightly bound in the geochemical matrix of the mineralization. Iron sulfides are the most abundant species at the Zortman and Landusky Mines, including minerals such as pyrite, marcasite, arsenopyrite, and others.

Approximately 20 million tons of gold and silver bearing ore were mined at the Zortman Mine during the years 1979 to 1994, and about 125 million tons of ore were mined at the Landusky Mine during the same years. Gold and silver production during the 1979 to 1994 period was approximately 1.7 million troy ounces of gold and 6.6 million troy ounces of silver (FEIS, Table 3.1-1).

Additional resources of gold and silver exist within the Little Rocky Mountains. Other reasonably foreseeable deposits, including one in Pony Gulch which has been estimated to contain about 2 million tons of ore. The deeper sulfide ore zones proposed to be mined by ZMI in the expansion plan contained at least another 1 million ounces of gold resources. Lower grade resources occur in the area but are not economically feasible to mine using current technology. Both the proven and estimated reserves of the mineral development potential are classified as "high" for gold and silver in the Little Rocky Mountains (BLM 1992).

Shear Zones

The Zortman mining area has two major structural zones. The Alabama shear is centered on the South Alabama pit and the Ruby shear zone is centered on the O.K./Ruby pits. These shear zones strike N10°-30°W and dip 75-85° to the west. Other less continuous structures strike about N10°E with near vertical dips. The North Ruby shear is located in the central portion of the Ruby highwall. Major structures are supported by numerous parallel, secondary cross structures. Mineralization is generally concentrated at the intersections of these structures with numerous parallel N70-80°E cross structures (WMCI, p. 147). North-northwesterly shear zones identified in the Zortman mining area include:

- Alabama shear in the South Alabama pit;

- North shear and the Ruby shear in the O.K./Ruby pits;
- Ruby-Ross shear in the O.K. pit;
- O.K. Shear, which may have a more northerly strike and appears to offset the Ruby-Ross shear in the O.K. pit;
- Mint shear, located to the east of the O.K. pit; and
- An unnamed fault, located between the O.K. pit and the North Alabama pit.

Both northeast and northwest faulting are present in the Landusky Mine area. Northeast striking structures exert the greatest control on mineralization, evidenced by the northeast elongation of the Landusky area orebodies. However, intersections with smaller cross faults are more strongly mineralized due to enhancement of fracturing at these locations. Cross faults in the Landusky Mine area have been mapped with N70-80°E orientations. A prominent northwesterly-striking fault, the Narrows fault, transects the Landusky Mine and is unmineralized, as are subparallel associated structures (WMCI, p. 148). Four northeast striking normal faults localize the mineralization in the Landusky Mine orebodies (Figures 3.3-6 and 3.3-7).

Gold Bug Shear: The Gold Bug shear strikes N40-50°E and dips 65-70°NW. Along the southeast half of the Queen Rose pit, this fault juxtaposes Precambrian felsic gneisses in the hanging wall with mainly syenite porphyry in the footwall. A zone of breccia up to 200 feet thick is present in the hanging wall at the fault contact. A southwestern extension of this fault, offset to the south by the Narrows fault, continues on a similar strike in the Niseka/Gold Bug pit. In this area, the fault cuts syenite porphyry.

Niseka Shear: The Niseka shear strikes N50°E and dips about 70°NW. Along the southeast side of the August pit, this fault cuts syenite porphyry, except at its northeast end where it cuts a roof pendant of Emerson Shale.

August Shear: The August shear strikes approximately N45°E and dips 75°NW. This fault cuts syenite porphyry. Several thin, discontinuous trachyte porphyry dikes occur along the fault.

Suprise Shear: The Suprise shear strikes N45°E and dips 70-80°SE. Along the northwest half of the Queen Rose pit, this fault cuts predominantly syenite porphyry, except at its southwest end, where it cuts a roof pendant of Emerson shale and Bighorn dolomite. It is progressively offset in this area, in a left lateral sense, by a series of faults subparallel to the Narrows fault in the Little Ben pit. The hanging wall and footwall consist of syenite porphyry, with small pendants of Bighorn dolomite and a few thin breccia dikes in this area.

Northwest striking faults include the Narrows fault and subparallel adjacent faults, and small cross faults of the northeast faults. The Narrows fault strikes N10-20°W and dips approximately 80°E. It is believed to have a left-lateral component of offset of as much as 1,200 feet, based upon correlation of the Suprise Shear on opposite sides of the Narrows fault. The Narrows fault is unmineralized. It offsets the mineralized

structures, indicating that its displacement took place subsequent to the hydrothermal mineralizing event (WMCI, p. 149).

The Little Rocky Mountains were originally interpreted to be laccoliths, a term used to describe igneous intrusions with flat bases and domed roofs which arch the overlying sediments according to the shape of the igneous dome. However, Russell (1991b) cites field indications that the intrusions were not emplaced parallel to the sedimentary formations which were already present. In addition, he notes that active mining and exploration drilling in the Zortman and Landusky pits has failed to reach a floor or bottom to the intrusion. This cumulative evidence suggests the porphyries were not intruded as laccoliths but as stocks, a type of igneous intrusion which is relatively small in size and which cuts across formation boundaries. The structure of the intrusion displays features of a laccolith (mushroom shaped with a relatively flat floor) and a stock (the intrusion is small and cuts across some lithologic boundaries).

The major controls on the geologic structure of the area are steeply dipping, north-northwest trending fractures. Most faults between the intrusions and surrounding sedimentary rocks are steeply dipping (i.e. more vertical than horizontal) with a relatively large component of up or down movement. Most faults within intrusions are described as shears, suggesting more lateral than vertical movement along the fractures. As noted previously, these fault structures had a major influence on localization of mineral deposits. Faults, joints, and fractures can also play an important role for groundwater transport in the Little Rocky Mountains, particularly in controlling the direction of flow.

Fractures and structural features of the central portion of the Little Rocky Mountains are where the Zortman and Landusky Mine pits are located. It is easy to see that most mineralized fractures (those containing precious metals) trend north-northwest in the vicinity of the Zortman Mine, and north-northeast in the vicinity of the Landusky Mine.

Reclamation Resources

Clay-rich shale formations have had applications for mining construction, operations, and reclamation activities conducted at the Zortman and Landusky Mines. There are three existing sources of this material located on private lands that have been used by the mines. A small clay pit is located a quarter mile west of Zortman in Alder Gulch. A larger source is located seven miles south of Zortman along U.S. Highway 191. A clay source for the Landusky Mine is located 2 miles west along State Highway 66. These clay deposits are from marine shale parent materials deposited in deep waters of Cretaceous age seas. When compacted they form layers that are impervious to water. While these deposits do not have the commercial application of bentonite, they are valuable for use in various mining operations, particularly those where barriers are needed to prevent the migration of leachate (i.e. leach pad liners) or to prevent infiltration of surface water (i.e. reclamation covers). The reason clay minerals provide barriers is the ability to take up and hold water in their chemical structure. In this water absorption process they expand in size, closing off void spaces which are the primary pathways for water flow.

Limestone is used in the construction industry for producing lime, in mining and industrial chemical processes to control pH, and in agriculture as a soil conditioner. There are vast limestone resources in central and western Montana, much of it within the Madison Group of Mississippian-age sedimentary formations. The limestone mining that has occurred in the vicinity of the Little Rocky Mountains has typically been restricted to small, isolated quarries.

Limestone is very hard and resistant to processes of physical weathering such as freezing and thawing, or wind erosion. However, limestone is soluble in water and its dissolution provides conduits for groundwater flow, often through larger openings such as fractures and joints. In fact, the Madison Group of limestones serves as the major deep aquifer surrounding and underlying the Little Rocky Mountains.

Limestone has been and may continue to be used in reclamation activities for both the Landusky and Zortman Mines, in the construction of drains or other facilities where material with a high net neutralization potential is needed. Large outcrops of limestone which are easily recognizable as prominent cliffs and bluffs occur near the Zortman and Landusky Mines. The limestones which could be used in mining and mine reclamation activities would come from the Devonian-age Jefferson Formation or Mississippian-age Madison Formation.

The King Creek quarry site is located about 1/4 mile northwest of the Landusky Mine's Queen Rose pit in the NE¼ of Section 15, Township 25N, Range 24E. The King Creek quarry is on private land and was previously mined by different parties. ZMI was permitted to mine about 50,000 tons of limestone from this site in 1993 for the King Creek cleanup project and for other mine operational uses. Also on the Landusky side, similar material could be mined at the Montana Gulch quarry, located in the NW¼SW¼ of Section 22, Township 25N., Range 24E. This site is on BLM-administered lands and may be used as a source during the reclamation.

Limestone for use in Zortman Mine facilities and reclamation could be mined at a quarry known as "LS-1" in the NE¼SW¼ of Section 6, Township 5N, Range 25E, approximately one-half mile north of the Ross pit. ZMI estimated this source contains approximately one million tons of limestone. Limestone is also available at the site known as "LS-2" in Section 17, Township 25 N, Range 25E.

Sand and gravel pits are found on private and public land throughout the foothills adjacent to the steep rise of the mountains. Ready sources of these materials are available in the glacial and alluvial deposits which cover the bedrock to depths of 50 to 100 feet at the base of the mountains for several miles in all directions. These deposits can be useful in construction of road base, in drains, and as capillary breaks in reclamation covers. The materials have the opposite applications of clay material due to the inability to readily transmit water flow.

3.2.2 Geotechnical Conditions

Seismic Conditions

The Little Rocky Mountains are situated in an area of low earthquake hazard. Based on the probabilistic earthquake acceleration and velocity map for the United States (Algermissen et al. 1990), the Little Rocky Mountains are located within the lowest risk area designated. There are no known unstable areas, although landslides/rockslides are always a potential hazard where steep slopes and ridges are common, such as in the interior of the mountains. Although faults are present as described in the previous section, none are believed to be currently active, or to have been active in recent times.

Subsidence

Another localized hazard at the mines is related to previous mining activities. Underground (stope) mining was prevalent in the Little Rocky Mountains before ZMI conducted open pit mining. As a result, a relatively large network of underground shafts and tunnels exists. The hazard presented by the underground mine workings is that there may be insufficient ground support resulting in surface slumps similar to those commonly associated with sinkhole formations.

Heap Dike Stability

In July 2000, two reports (Womack 2000a and 2000b) were completed on the stability of the various dikes at both mines to determine the risk of failure. The reports concluded that all the dikes are stable and would remain stable into the future. However, the addition of any more rock behind the dikes might result in failure of the structures. The report noted that the Zortman Mine Z89 dike has the greatest potential for failure. The existing dikes meet minimum safety requirements and do not need additional support from reconstruction or buttressing if recontouring and reclamation covers decrease infiltration of precipitation.

Heap and Dump Slope Stability

The same reports concluded that engineering safety factors at all of the heaps and dumps are within the limits of construction design criteria for the facilities. The engineered design of these facilities assumes that the water level in the pore space of the rock does not exceed the top of the dike/liner interface. The greatest risk of failure for these facilities comes from infiltrated precipitation rising above that level. The report pointed out that the sooner the facilities are capped and reclaimed to reduce infiltration of precipitation the more stable they would be.

Mine Pit Wall Stability

The stability of the pit highwalls has not been evaluated beyond the original mine design criteria. Those criteria analyzed short-term stability relative primarily to mine operation and safety considerations. Since

the end of mining in 1996 there have been no mass failures, slumping or settling observed in the highwalls. Over time, weathering and other natural forces tend to reduce the stability of the pit highwalls, making them more susceptible to mass failure, most probably in the form of rock slides. To protect public safety, at least some of the pit highwall areas would be fenced and signed to limit public access to potentially unsafe areas.

3.3 WATER RESOURCES and GEOCHEMISTRY

3.3.1 Description of Supplemental Studies and Information

This section presents information on the water resources and geochemistry of the Zortman and Landusky Mines as a supplement to that in the 1996 FEIS. The FEIS documented water resources and geochemistry changes that occurred over the 17 years from 1979 to 1995. This SEIS provides similar information for the years 1996 to 2000. The principal sources of supplemental information are:

- Public Health Assessment for Kings Creek (a/k/a Fort Belknap Indian Reservation/ Zortman Mining Incorporated (ATSDR 1998). Results of the fourth ATSDR public health study to determine if the Zortman and Landusky Mines were posing a health hazard to the people of the reservation by releasing toxic substances into the environment, especially drinking water sources.

- Zortman/Landusky Project Draft Summary Report for the Groundwater Investigation (WMCI 1998). Results of the Consent Decree mandated groundwater study. Presented in three volumes.

- Zortman and Landusky Mines, Comparison of the Final Environmental Impact Statement, ATSDR Public Health Assessment, and Groundwater Study (Gallagher 1999). An evaluation and comparison of the results of the ATSDR study and the WMCI Groundwater Study with results from the FEIS. This report incorporated the new groundwater information into the existing environmental analysis results, verified whether the findings of the FEIS regarding groundwater characterization were accurate, and identified groundwater data to be obtained or assumed in order to make an informed decision regarding reclamation.

- Zortman Mine Water Balance and Chemical Mass Loading (Spectrum 2000a). This report presents the results of an independent surface and groundwater balance and mass loading evaluation for the mine site. The products of this investigation were used to evaluate and prioritize mine reclamation options.

- Landusky Mine Water Balance and Chemical Mass Loading (Spectrum 2000b). See above description for the Zortman Mine.

- Goslin Flats Land Application Disposal (LAD) Expansion Assessment and 2000-2001 Plan of Operations (HSI and Spectrum 2000). This document describes the information and rationale for expansion of the 410-acre Goslin Flats LAD area to manage leach pad water treatment and disposal for the years 2000 and 2001.

- Field Reconnaissance and Laboratory Testing Program for the Zortman/Landusky Reclamation Project (Robertson 1999, 2000b). A report documenting the results of geochemical testing of 212 samples. Non-acid generating (NAG) material, acid generating materials, and contaminant sources

were identified. A map showing the distribution of various reclamation materials was also produced. This information was important in designing reclamation options for pits and rock dumps, and for reclamation covers, all significant factors in the protection of groundwater quality at the mine sites.

- Cover Performance Modeling, Zortman and Landusky Mine Sites (Robertson 2000c). The results of the cover modeling are important in designing reclamation options for pits, rock dumps and leach pads. This information also assisted in prediction of the relative volumes of water requiring management and the impacts of each alternative to water quality.

- Final Report on the Landusky Mine's Hydrologic Impact to King Creek and Swift Gulch (Spectrum 2000c). This report quantifies potential losses in surface water flow volume to the drainages north of the Landusky Mine. Calculations are based on pre-mining conditions and on the altered surface and ground water divides created by mining.

A more detailed discussion of the content of the listed reports can be found in Gallagher (1999) and HSI and Gallagher (2001). In addition, unpublished groundwater monitoring data collected at both mine sites from 1996 to 2000 were used in this supplemental assessment. These data were collected by ZMI and its contractors, and the DEQ and its contractors, and are available from the Helena office of the DEQ.

3.3.2 Geochemistry/Acid Rock Drainage

General Geochemical Processes

Precious metal mining sites have the potential to degrade water quality through two general types of geochemical processes: (1) generation of alkaline seepage – cyanide-related processes; and (2) production of acid water from acid rock drainage (ARD). These processes were described in detail in the 1996 FEIS (pp. 3-16 to 3-18) and are summarized below.

Alkaline seepage is characterized by high pH values (above 7 s.u. and typically around 9 s.u.) and potentially elevated concentrations of cyanide, nitrogen and sulfur compounds, as well as metals such as iron, arsenic, molybdenum, copper and selenium. This water is related to the gold leaching process; therefore it originates in the leach pads or process circuit. All leach pad waters are treated at the land application disposal (LAD) area. If the leach pad water is acidic it is first sent to the water treatment plant to remove the acidity.

Acid rock drainage, also called acidic mine drainage, is water characterized by low pH values (typically between 2 and 5 s.u.) and elevated concentrations of sulfate, aluminum, iron, copper, manganese, nickel, zinc, etc. This water results from the oxidation of iron sulfide minerals (such as pyrite) and the subsequent dissolution of other minerals by the acidic water.

Existing Conditions

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 (DSL 1979b, pp. 75-76). However, as mining progressed, water quality analyses showed that geological materials at both mines were generating acidic waters. Data from the early 1990s indicated that most of the major southern flowing drainages were showing some degree of impact from mining-related activities. Once detected, the monitoring program was augmented to determine the scope of the impact. The results of that program have shown increasing levels of acidity and metals related to ARD.

In accordance with requirements of the BLM and DEQ, and as part of the Consent Decree, capture systems and water treatment facilities were built at both mines. ARD is collected and pumped to the water treatment plants where acidity and metals are removed by lime addition. Treated water from the Zortman Mine is discharged to Ruby Gulch. Treated water from the Landusky Mine is discharged to Montana Gulch. The detailed water balance and chemical mass loading evaluations for both mine sites demonstrated that the seepage collection systems captured 98% of the total sulfate load and 97% of the total metals load at the Zortman Mine, and 90% of the total sulfate load and 93% of the total metals load at the Landusky Mine (Spectrum 2000a and 2000b). Descriptions of the existing water quality conditions in each drainage at the mine sites are provided in Sections 3.3.6 and 3.3.7.

Geochemical Testing

Rock types include Tertiary syenite porphyry and monzonite, Precambrian amphibolite and felsic gneiss, Paleozoic sedimentary rocks, and quartzites and breccias. A detailed discussion of rock types is found in the FEIS (pp. 3-18 to 3-20).

A great deal of geochemical testing was completed for the FEIS. Over two thousand samples of ore, spent ore, waste rock and other unmineralized local rock types from both mines were tested. Test methods included total sulfur, paste pH, and acid base accounting (ABA), as well as, kinetic tests called humidity cells. The purpose of the testing was to determine the acid generating or acid neutralizing characteristics of different ore and waste rock types. The results and interpretation of these tests are presented in the FEIS (pp. 3-20 to 3-46).

Kinetic tests are designed to assess the acid generating potential of a material by accelerating the effects of weathering in the lab. This is done by leaching moist, hot air through the material in a cell and analyzing the leachate collected from the cell. Much of the kinetic testing completed for the FEIS was done to predict the geochemical characteristics of the material that would have been mined if the mine expansion had been carried out. The tests are designed to simulate weathering and are useful tools for predicting the behavior of 'fresh' material. However, studying the effects of weathering in the field on the actual rock dumps, leach pads and pit walls, rather than in the laboratory with tests such as humidity cells, is the best indication of the geochemical behavior of material that has already been mined and leached.

Since the testing program was completed for the FEIS, the materials on site have continued to weather and their associated geochemistry has evolved. Therefore, a geochemical characterization program was conducted in 1999 and early 2000. The 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 agree with or help to refine the conclusions made in the FEIS.

Over 400 surface samples were collected from the mine facilities and over 200 drillhole samples were collected from within the leach pads. Paste pH and paste total dissolved solids (TDS) were measured on all samples collected. Selected samples were submitted for more detailed laboratory testwork.

Paste pH evaluates the existing pH of the sample and can assess the acidity due to dissolution of reaction products that have accumulated on the rock surfaces. The pH is an expression of the acidity or alkalinity of the material on a scale of 1 to 14 (normally), with 1 being most acidic and 14 most alkaline (rainwater is typically a pH of 5.5 to 5.8 s.u.). A paste pH above 7.0 s.u. may be indicative of high percentages of alkaline minerals.

Paste TDS is a measure of the soluble minerals content in a sample. The TDS is measured indirectly by the electrical conductivity of the paste. The electrical conductivity of the paste reflects the concentration of readily soluble minerals that coat the surface of the rock. These minerals are formed as a result of sulfide oxidation and, sometimes, subsequent acid neutralization. They are typically referred to as "stored oxidation products."

Acid generating samples typically have low pH values and higher TDS 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 s.u.) by adding lime or caustic soda (alkalis) to the leaching solutions. Therefore, many of the samples on the leach pads have 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.

The modified Acid-Base Accounting (ABA) 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.

Interpretation of static test results typically involves using regulatory criteria to classify the samples as to their potential to generate or consume acidity. The evaluation criteria used in the FEIS (pp. 3-20 to 3-22)

was that proposed by the British Columbia Acid Mine Drainage Task Force (1989) as revised by the Montana Department of Environmental Quality based on subsequent kinetic testing (Miller 1995).

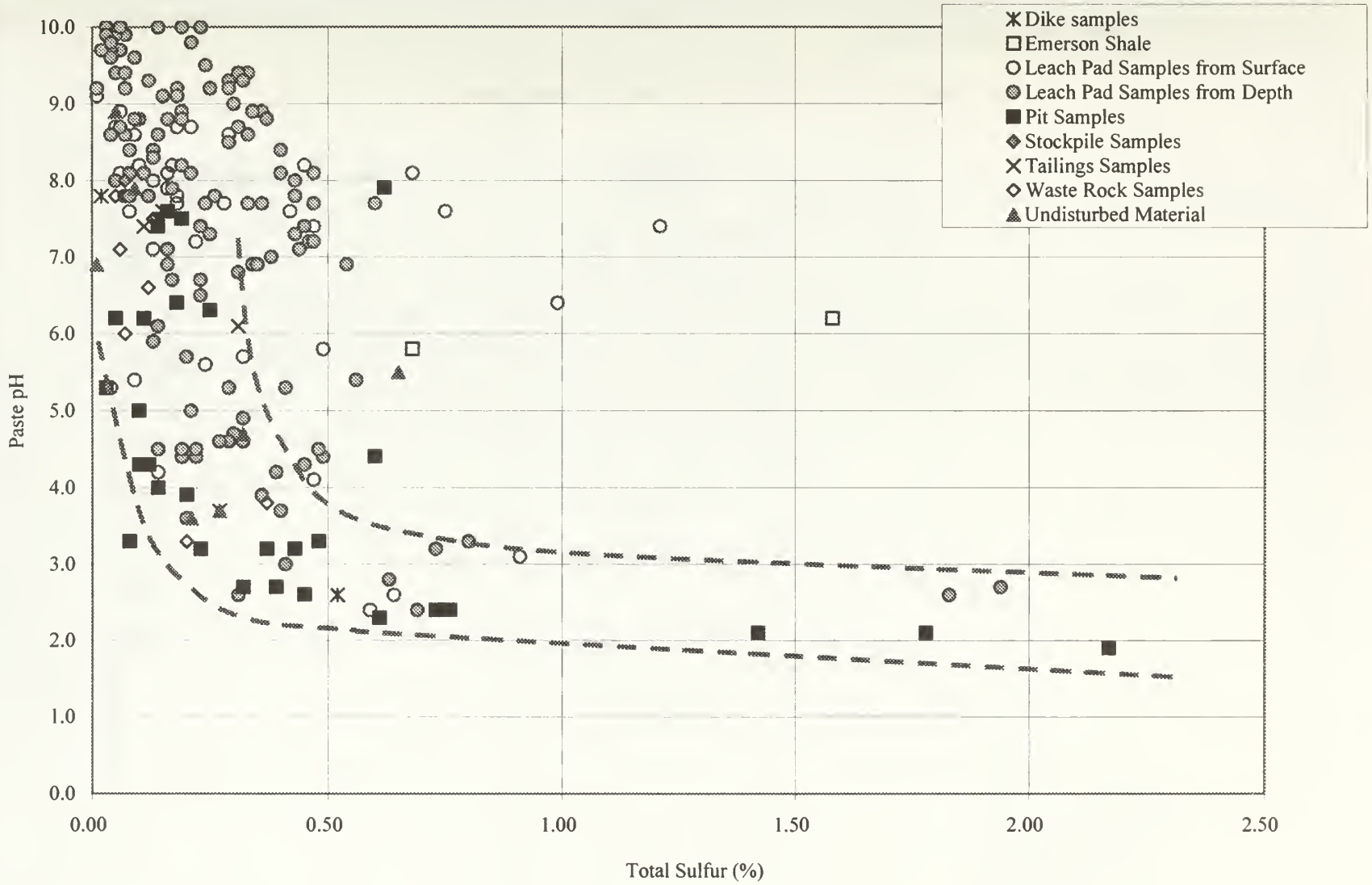
The extensive and thorough testing programs carried out on site for the FEIS and during the follow-up testing have allowed further clarification and, where necessary, revisions to the classification of material on both sites. In general, there is very little neutralization potential in the vast majority of material on-site. Figure 3.3-1 is a plot of total sulfur versus field paste pH. 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. There are also some samples with total sulfur values less than 0.2% that are acidic. 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 (p. 3-43).

The neutralization potential in the leach pad samples 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, these samples would also plot within the dotted lines on Figure 3.3-1, outlining the apparent natural trend of the other materials on site. Some of the leach pads are expected to become highly acid generating over time, including the L87/91, Z82 and Z85/86 leach pads. Others, however, appear to be only very slightly acid generating to neutral with respect to acid drainage. These include the lower Landusky Mine leach pads and the Zortman Mine Z83, Z84 and Z89 leach pads. The L85/86 leach pad may contain excess alkalinity and be a source of non-acid generating material suitable for use in construction of the reclamation covers.

Figure 3.3-2 is a typical plot showing the results of the modified ABA testing plotted as neutralization potential (NP) versus acid potential (AP). Guidelines suggest that samples plotting above the 1:1 line should be considered potentially acid generating, those plotting below the 3:1 line should be considered non-acid generating, and those falling between the two lines should be classified as 'uncertain' with respect to acid generating potential. The vast majority of samples at the mines are classified as potentially acid generating.

Another graph used for interpretation is that shown in Figure 3.3-3, which plots paste pH against the net acid potential (AP minus NP). Those samples with excess acid potential (positive values) 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. The acid generating potential ranges from fairly high to very slight. Actual generation of acidic drainage depends upon the location of the material in the field with respect to water, oxygen, and potentially neutralizing rock material.

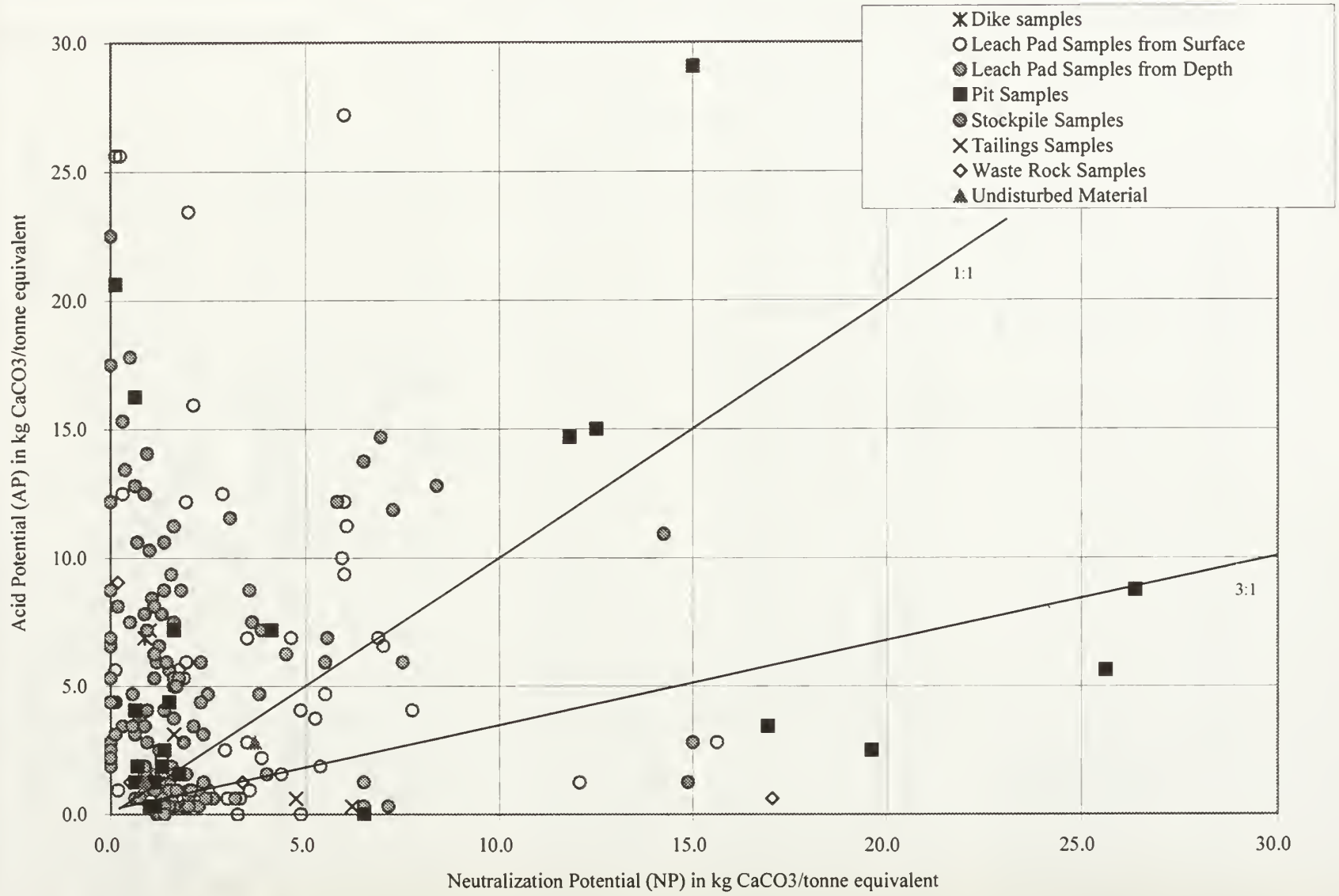
Based on these results, the amount of readily available NAG material on site is limited. Although limited, the NAG material that has been identified is easily segregated from potentially acid generating material. In general, the materials at the Zortman Mine with consistently non-acid generating test results and suitable for use as covers or construction are the topsoil samples, the Ruby Gulch tailings and the Goslin Flats soils.



Source: Robertson GeoConsultants Inc. 2001

PASTE pH VERSUS TOTAL SULFUR

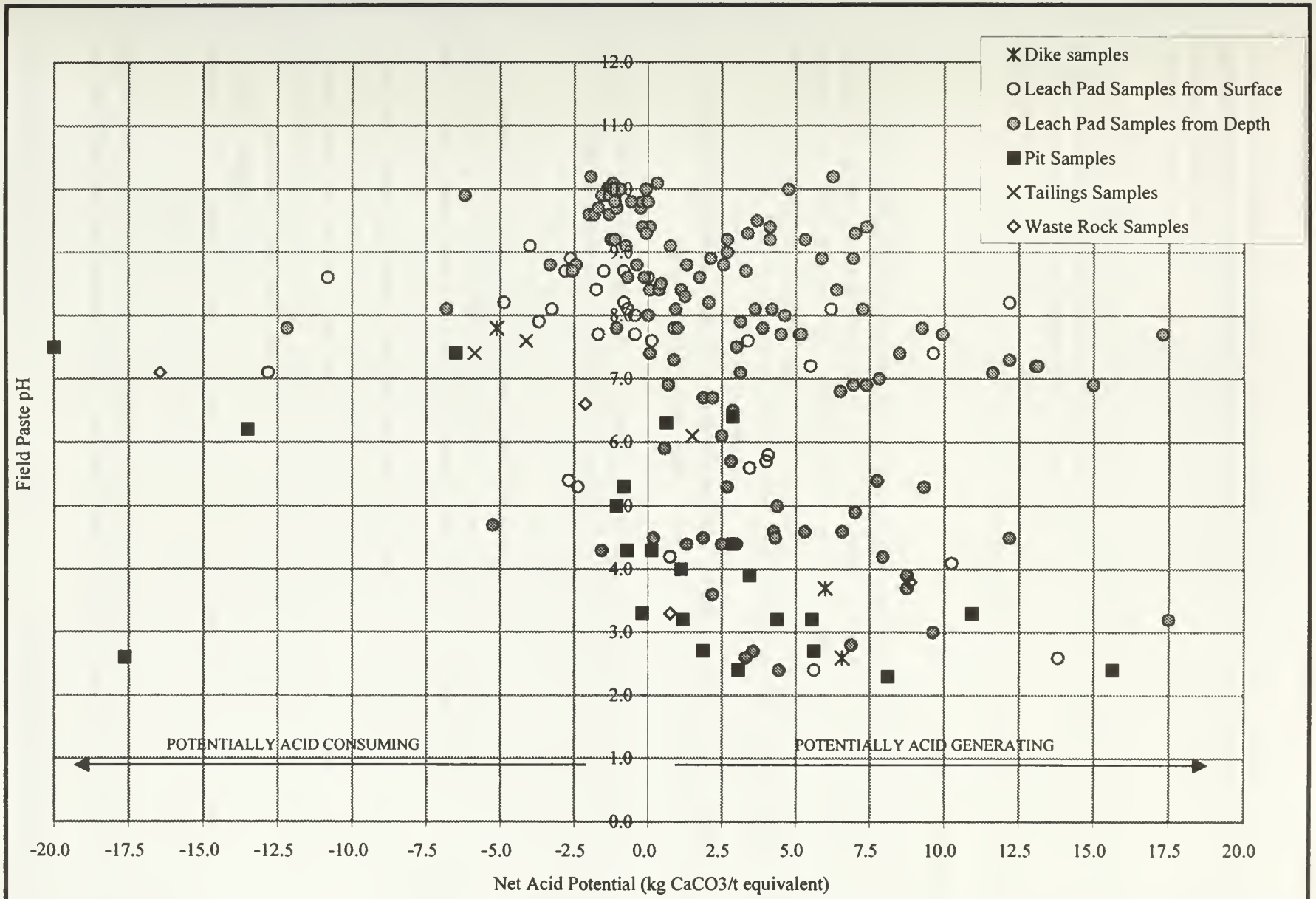
FIGURE 3.3-1



Source: Robertson GeoConsultants Inc. 2001

NEUTRALIZATION POTENTIAL VS. ACID POTENTIAL

FIGURE 3.3-2



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PASTE pH VERSUS NET ACID POTENTIAL

FIGURE 3.3-3

At the Landusky Mine, the material types showing consistent non-acid generating characteristics are the stockpile samples, which include the Gold Bug limestone stockpile, Bighorn dolomite stockpile, Gold Bug blue waste (non-acid generating) stockpile, and the topsoil stockpiles. The L85/86 leach pad material also appears to be non-acid generating, suitable for use as NAG underlying the cover on backfilled material.

Some on-site rock has not been identified as NAG material, but is not necessarily a net acid generating material. The lower Landusky Mine leach pads and the Z83, Z84 and Z89 leach pad complexes appear to fall in this category. In fact, quality control testing completed in conjunction with the interim reclamation measures has identified very few and only surface localized areas on these leach pads that require the addition of lime to maintain neutral pH conditions.

Geochemical Findings

The FEIS contained a section on geochemical findings (pp. 3-45, 3-46). Based on additional studies, many of those findings have been confirmed or slightly revised. Some, however, are no longer appropriate due to the withdrawal of the mine expansion proposal. The findings that apply to current conditions or potential reclamation alternatives under evaluation have been reproduced here. Any edits modifying the results in light of the additional studies are provided in *italics*.

1. 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.

   Not all leach pads should be considered acid-forming. The lower leach pads at the Landusky Mine and the Z83, Z84, and Z89 leach pad material are only very slightly acid generating material, suitable for use in reclamation.

2. The groundwater in the Thermopolis shale at Goslin Flats has naturally high TDS, alkalinity and sulfate. However, the leach pad foundation *(no longer proposed)* is unlikely to be a source of acid due to its fine-grained nature, relative impermeability *and inherent neutralization potential.*

3. 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 *would likely* become acidic and contaminated with dissolved metals. *Certain leach pads have already become acidic (e.g. Z82 leach pad) and the water is first treated in the water treatment plant, or with in-situ lime addition, to raise the pH and remove metals before being applied to the LAD for nitrate treatment.*

4. For waste rock at both mines, there is a direct relationship between percent sulfur and net neutralization potential (NNP). Almost all sulfur is reactive and excluding the limestone,

amphibolite, shale and dolomite, the waste rock has very little neutralization potential. For both mine sites, *use of* waste samples having negative NNP as parameters for *classifying* waste *is* effective.

5. Where the paste pH was 6.0 s.u. or above, acidic pHs in humidity cell leachates were not produced. Samples with a paste pH less than 6.0 s.u. 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.

6. All low to medium sulfur, 0.8 weight percent or less, amphibolite appears to be non-acid forming and could be used for construction, fill or reclamation purposes.

7. Syenite waste rock containing less than or equal to 0.2% sulfur and of 0 T/kT or greater, does not generate acid in sufficient quantities to affect revegetation, but could affect water quality if this waste is placed where contact with surface water is likely to occur.

8. 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 and therefore are not considered suitable for any construction, fill, underdrain or reclamation purposes. *The 'blue waste' comprised of Emerson shale, however, is an excellent NAG source.*

9. 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.* Therefore they have been excluded from use as construction, fill, underdrain, or reclamation purposes.

10. Should an insufficient quantity of suitable waste rock exist, unmineralized limestone, dolomite, and amphibolite with high NNPs would be available for construction, reclamation, or remediation activities in sufficient quantities. *However, to obtain these quantities it is likely that the material will need to be quarried from nearby sources.*

3.3.3 Hydrology

New Hydrological Data

The 1996 FEIS noted that ZMI monitoring wells were predominately located near or at the base of drainages. This distribution made the water table difficult to define (FEIS, p. 3-49). In addition, there was not sufficient groundwater monitoring to the north of the Zortman Mine, where the mine pit expansion was proposed. Therefore, construction of new monitoring wells and surface water monitoring stations were

required in 1996 (FEIS, pp. 2-102, 2-193, 2-208 and 2-235). Also in 1996, ZMI agreed to perform a Groundwater Investigation under the Consent Decree in 1996. Nineteen new wells and six new piezometers were installed for the Groundwater Investigation, along with 19 new surface water stations. Many of the surface water sites were in the Swift Gulch and Lodgepole Creek drainages (WMCI, pp. 41-54).

Besides the data obtained from the new monitoring well and piezometer completions, a considerable amount of new information has been obtained regarding surface and groundwater conditions, from:

- Four synoptic stream surveys utilizing over 90 new surface water stations;
- Regional and local spring and seep surveys - with up to 33 mine sites and regional sites;
- Hydraulic testing of new wells;
- Long-term pump test (68 days) on ZL-302 (located in the northern Zortman Mine area);
- Monthly, bi-monthly, and semi-annual water chemistry samples for all new wells;
- Long-term artesian flow test of WS-3 with water quality data;
- Quarterly or semi-annual groundwater and surface water sampling from Fall 1996 through October 2000;
- Baseline hydrologic studies of the Goslin Flats LAD expansion areas and the proposed Landusky LAD area; and
- Periodic special purpose groundwater and surface water monitoring data collections, e.g. Swift Gulch springs and seeps.

Further information regarding the types and quantity of new data are contained in Gallagher (1999) and HSI and Gallagher (2001).

Regional Hydrology

The hydrology of the area surrounding the Little Rocky Mountains has been investigated in several reports, including Alverson (1965), Feltis (1983), Briar and Oellermann (1993), and Slagle and Christensen (1993). Sedimentary rocks are the primary sources of groundwater along the flanks of the range and on the plains adjacent to the range. A significant difference, however, is that the rock units exposed in the Little Rocky Mountains are typically buried deep beneath the plains. These regional units, specifically the Madison Group, are recharged from 100 to 150 miles to the south and southwest and have significant differences in water chemistry from the locally recharged rock units of the mountains.

The U. S. Geological Survey (USGS) has maintained flow and water chemistry stations on drainages around the mountains, including Little Peoples Creek and Lodgepole Creek. Groundwater that originates within the Little Rocky Mountains appears to provide a small portion of the recharge to the valley fill alluvium in Rock, Little Peoples, Lodgepole, Ruby, Grouse, Dry, and Beaver Creeks. However, water levels in unglaciated portions of Little Peoples and Lodgepole Creeks vary by as much as 33 feet annually, indicating the majority of recharge to the alluvium is from surface water flow in the creeks.

Potential sources for domestic, municipal, livestock, and irrigation water on the north and northwestern flanks of the Little Rocky Mountains include: Quaternary valley fill sediments, the Lodgepole and Mission Canyon Limestones of the Mississippian Madison Group, the Virgelle member of the upper Cretaceous Eagle Sandstone, the basal First Cat Creek Sandstone of the Cretaceous Colorado Group, and the basal Third Cat Creek Sandstone of the lower Cretaceous Kootenai Formation. Other rock units identified as potential aquifers for limited water supplies include the Cretaceous Thermopolis Shale and Judith River Formation sandstones.

Flow directions in the regional units are generally northward (northeast on the eastern side of the mountains and northwest on the western side of the mountains). Many of the deeper regional units are recharged by underlying strata with an upward flow gradient. Briar and Oellermann (1993) found that water level data indicated localized flow in the Virgelle Sandstone away from the northwestern flank of range, suggesting that some recharge to the sandstones may be derived from groundwater discharge from the range.

The IBLA in several administrative reviews conducted in 1998 on the proposed mine expansion and reclamation plan was concerned that too little information was known about the local and regional groundwater flow, including the Madison Group aquifer (IBLA, May 1998, pp. 177, 178, 186 and 197). Because of the importance of this aquifer, the local and regional Madison Group are described in more detail in Section 3.3.8.

Mine Site Hydrology

Surface Water Occurrence

Zortman Mine

The Ruby Creek drainage, which includes the tributaries of Alder Gulch, Ruby Gulch and Goslin Gulch, is the major southern drainage in the Zortman Mine area. Tributaries of Alder Gulch include Carter Gulch, Alder Spur, and Pony Gulch. Lodgepole Creek, Ross Creek and Glory Hole Gulch drain the northeastern side of the Zortman Mine (FEIS, p. 3-46). A map of the Zortman Mine drainage areas is presented in Figure 3.3-4, showing the outline of the current surface water drainage basins and surface drainage features.

Since the 1996 FEIS, additional data have been collected and interpretations have been updated regarding trends in mine site drainage. There have also been significant changes in the surface water drainages near the Zortman Mine due to completion of the permanent capture systems in Ruby Gulch, Alder Spur and Carter Gulch.

Water balance results indicated that the capture systems in Ruby Gulch, Alder Spur and Carter Gulch capture all but 1.2%, 6.6%, and 1.2%, respectively, of the total precipitation falling over these basins. The non-captured water is generally surface water flows during large storm events that are conveyed off-site

by the network of diversion ditches. In extreme precipitation events, some water overflows the capture systems and moves down the drainage. Information regarding the methods used and results of individual capture system water balances at both mines are presented in HSI and Gallagher (2001). A description of the components of the capture systems is also included in HSI and Gallagher (2001).

Captured surface flows from Ruby Gulch, Alder Spur, and Carter Spur are pumped to the Zortman water treatment plant. Due to the intermittent flows in these drainages and the large storage pond in Ruby Gulch, the water treatment plant operates only intermittently. Ruby Gulch receives all treated discharge from the Zortman water treatment plant. This discharge constitutes the majority of flow in the drainage.

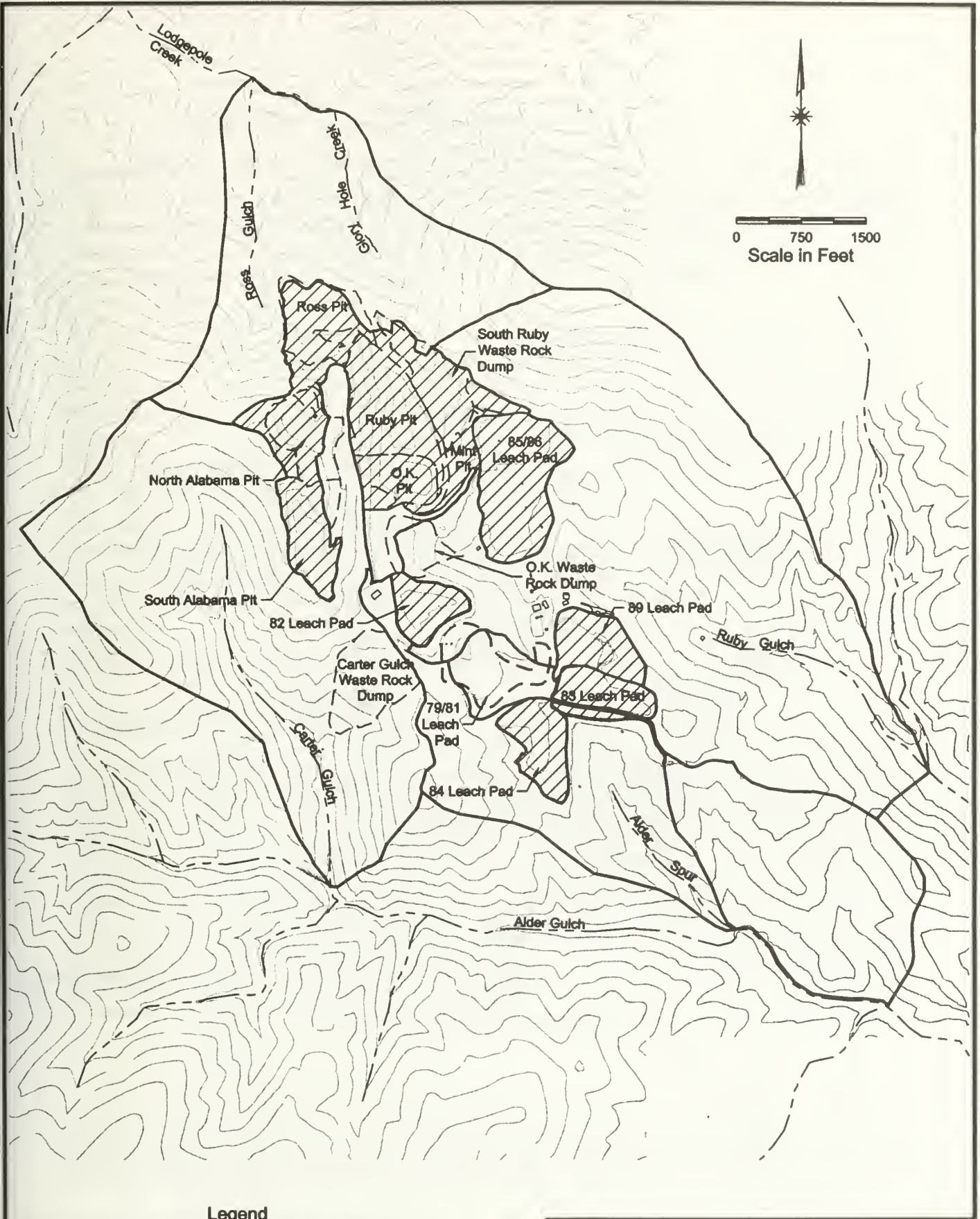
Goslin Gulch originates between Whitcomb Butte and Saddle Butte about one mile south of Zortman and trends south to join Ruby Gulch 2.6 miles south of Zortman. The valley and flat areas around Goslin Gulch are collectively referred to as Goslin Flats. A 410-acre LAD area is located on Goslin Flats. Information on Goslin Gulch water quality is presented in Section 3.3.6.

Landusky Mine

The southern portion of the Landusky Mine area is drained entirely by Rock Creek and its tributaries. Major tributaries to upper Rock Creek include Sullivan Gulch, Mill Gulch and Montana Gulch. The northern portion of the Landusky Mine area is drained by Little Peoples Creek tributaries, South Big Horn Creek and King Creek. Swift Gulch is a tributary to South Big Horn Creek (FEIS, p. 3-47). A map of the Landusky drainage areas is presented in Figure 3.3-5, showing the outline of the current surface water drainage basins and surface drainage features. Seepage capture systems have been constructed in Sullivan Gulch, Mill Gulch, upper Montana Gulch, and lower Montana Gulch. Water balance results indicate that the seepage collection systems captured all but 38.2%, 6.6%, 0%, and 1.2%, respectively, of the total precipitation falling over the above-listed basins. The non-captured water is generally surface water flows during large storm events that are conveyed off-site by the network of diversion ditches. During extreme precipitation events, some water overflows the capture trenches and moves down the drainage.

Captured surface flows from Sullivan Gulch, Mill Gulch, upper Montana Gulch, and lower Montana Gulch are pumped to the Landusky Mine water treatment plant. Water from flowing artesian well WS-3 is also captured and sent to the water treatment plant. Montana Gulch receives all treated discharge from the Landusky Mine water treatment plant.

No seepage collection systems have been constructed in either King Creek or Swift Gulch. There is a small amount of seepage from the August #2 waste rock dump at the head of King Creek and numerous small diffuse seeps in the Swift Gulch drainage. To date, impacts from the seepage in these drainages has not warranted construction of capture systems like those used in the southern drainages. Passive treatment systems may be developed in the future, dependent upon water quality monitoring results at these locations.



Legend

No runoff, Internal Pit Drainage or Contained Leach Pad

Surface Water Basin

ZORTMAN MINE DRAINAGE AREAS

FIGURE 3.3-4

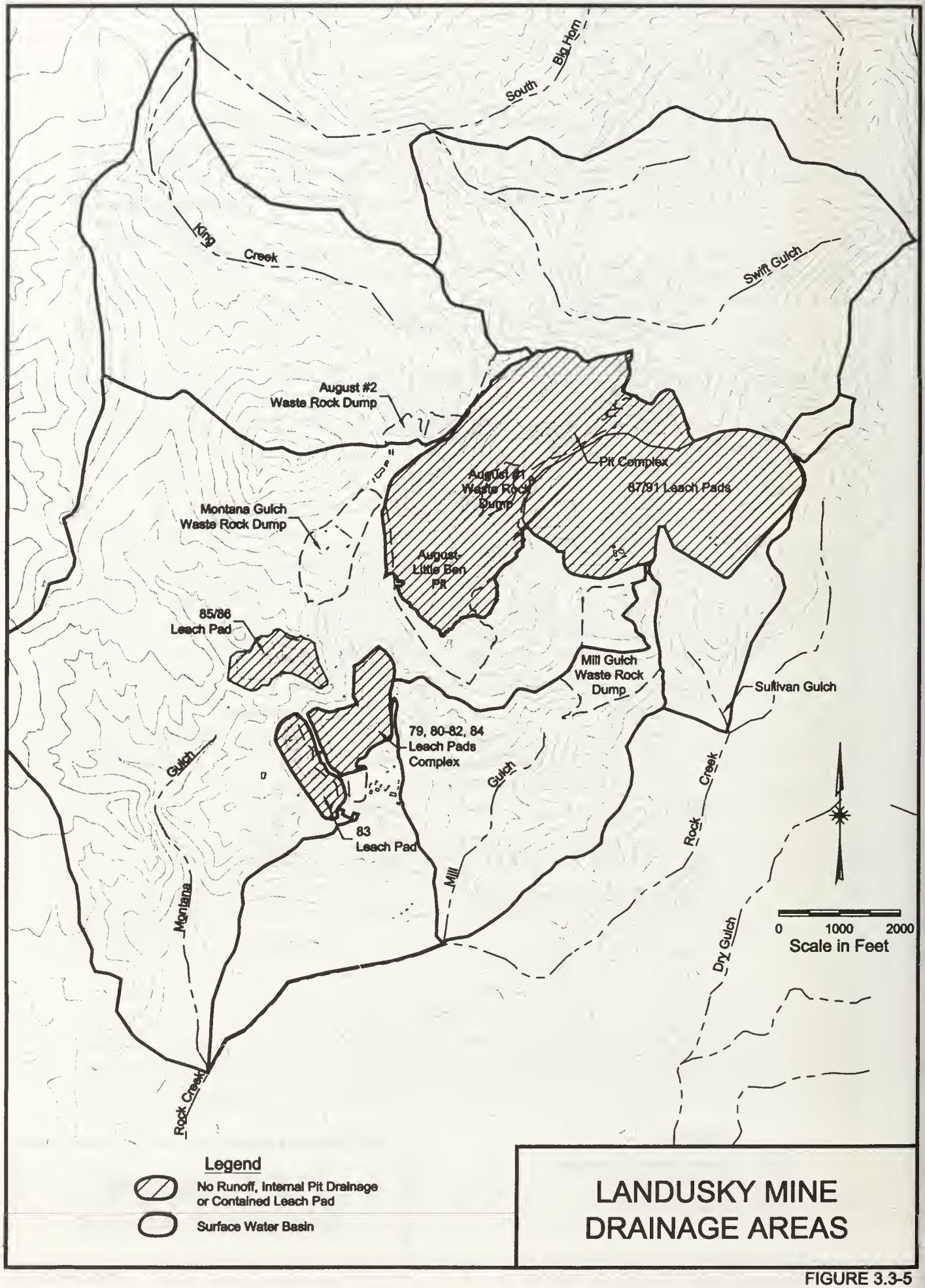

South
Big Horn
King
Creek
Swift Gulch
August #2
Waste Rock Dump
Pit Complex
August #1
Waste Rock
Dump
87/91 Leach Pads
Montana Gulch
Waste Rock Dump
August-
Little Ben
PR
85/86
Leach Pad
Mill Gulch
Waste Rock
Dump
Sullivan Gulch
79, 80-82, 84
Leach Pads
Complex
Gulch
Gulch
Rock
Creek
83
Leach Pad
Mill
Montana
Dry Gulch
0
1000
2000
Scale in Feet
Rock Creek
Legend
No Runoff, Internal Pit Drainage
or Contained Leach Pad
Surface Water Basin
LANDUSKY MINE
DRAINAGE AREAS

FIGURE 3.3-5

Surface Water/Groundwater Interaction

It has long been known that surface water and groundwater are closely tied at the mines (FEIS, p. 3-106). For instance, monitoring data demonstrate that surface runoff infiltrates in the pits to become groundwater recharge. Groundwater flow then leaves the mine pit areas as shallow surface water discharge to the capture systems. At the Landusky Mine, pit infiltration discharges to the Gold Bug adit, August drain, artesian well WS-3 (when flowing), and springs and seepage in Swift Gulch.

In order to more quantitatively address groundwater and surface water interactions, synoptic stream surveys were conducted for the Groundwater Study. The results of these surveys indicate that, in general, the upper portions of the drainages contain gaining reaches, while the lower portions contain losing reaches. This means that flow in the upper reaches of the streams is increased by inflow of groundwater and the streams are losing water to groundwater in the lower portions. Hence, the potential for infiltration to impact deeper groundwater at higher elevations is low (WMCI, p. 184).

The 1995-1997 Groundwater Study analyzed surface water-groundwater interaction. The water balances prepared for the Zortman Mine (Spectrum 2000a) and Landusky Mine (Spectrum 2000b) have quantified recharge, infiltration, evapotranspiration, and discharge as a percentage of available precipitation. This analysis is summarized in Section 3.3.4. Results of the water balance calculations show there is evidence of considerable interaction between groundwater and surface water in the mine areas. The hydrology evaluations indicate that the flow pathways are predominantly shallow.

Groundwater Occurrence

A number of factors influence groundwater occurrence and flow at the mine sites. While the geology lays the framework for groundwater conditions, the rock units must have "recharge" or additions of water. Precipitation and runoff infiltrating through the soil into the rock units are the primary sources of recharge. The surface topography determines where the runoff will flow on the surface and where it will ultimately infiltrate to groundwater. There is less infiltration of water into the subsurface in steep areas with dense vegetation. Conversely, there is more infiltration of water into the subsurface in flatter areas with little vegetation, such as open pits. The amount of infiltration to the subsurface ultimately determines water levels in the aquifer. Once in the subsurface, the geologic structures control water flow, including how quickly and in which direction water will travel. Man-made modifications to geology such as the underground workings beneath the mine sites or the capture systems in the drainages also affect flow directions and rates.

Recharge

The surface and groundwater systems are maintained by annual recharge from precipitation, runoff, and snowmelt. Recharge to groundwater is normally a very small fraction of annual precipitation. However, it is greatly increased by mine facilities, especially open pits, unreclaimed waste rock dumps, and disturbed

ground. Recharge is also enhanced in years of above normal precipitation and during episodes of successively wet or cool weather.

Recharge to the mine site aquifers was estimated in the water balance reports (Section 3.3.4). The water balance for the Zortman Mine (Spectrum 2000a) shows that 52.1% of the precipitation, or 313 gpm (on a mean annual basis over the mine site), becomes runoff (7.8%) or groundwater recharge (44.3%). The water balance for the Landusky Mine (Spectrum 2000b) shows that 45.1% of the precipitation, or 779 gpm (on a mean annual basis over the mine site), becomes runoff (2.1%) or groundwater recharge (43%).

Geology

Once in the subsurface, groundwater flow is controlled by the geologic materials comprising the aquifer. The primary aquifers are bedrock aquifers. These include mineralized and unmineralized syenite and other igneous and metamorphic rock types. Paleozoic sedimentary rocks that serve as aquifers, including the Madison Group, are located downstream from the mine sites (SEIS Section 3.3.8).

The primary permeability of the bedrock aquifers (the rate of water movement through the pores of the rock) is low. Therefore, secondary porosity in the form of faults, fractures and shear zones is necessary for the bedrock units to effectively produce water (WMCI, p. 193).

The IBLA stated the FEIS provided little information on the effects of specific faults, fractures, shears, and other features on groundwater movement (November 1998, pp. 4 and 5; May 1998, pp. 197 and 200). They indicated a lack of analysis of the geology kept the agencies from understanding groundwater flowpaths and where capture systems might intercept contaminated groundwater.

Most of the geologic information currently available was also available for the FEIS, but was not organized into a specific report. The FEIS utilized Water Management Consultants Inc.'s August Pit Study (1995), a report by Golder Associates (1996), and maps of the shear, fault, joint, and underground workings distributions provided by ZMI. Since the FEIS was prepared, the "Geologic Evaluation of the Zortman and Landusky Mine Sites and Surrounding Little Rocky Mountains" (ZMI 1996) was completed. This report includes detailed geologic maps and associated cross sections illustrating relationships between the hydrostratigraphic units, structures, and mine facilities.

The geology and structural geology are described in SEIS Section 3.2, including a discussion of shear zones at the mines. The shears are highly fractured zones which are interconnected within each of the mining areas. Since the shear zones are the primary host environment for gold and other hydrothermal mineral deposits, they were also the target for underground workings. A geologic map with shear zones, underground workings, monitoring stations, and groundwater level contours as of October and November 2000 is available in HSI and Gallagher (2001). The following sections describe the important geologic features affecting groundwater flow.

Geologic Structures Affecting Groundwater Flowpaths

The shear zones and associated underground workings are major controls for groundwater flow at both mine sites. Groundwater flows from the surrounding topographic highs 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 (WMCI, p. 197). Historic and recent 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 (WMCI, p. 147). 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.

While it has long been known that the shears and underground workings influence site groundwater flow, additional data collected during and since the Groundwater Study has emphasized the importance of these structures. The long-term (approximately three month) aquifer test of well ZL-302 at the Zortman Mine showed the hydraulic connection between wells located in the center of the shear zone. Wells located outside the shear zone did not show similar responses (WMCI 1998).

At the Landusky Mine artesian well WS-3, located 0.52 miles from the August pit in Montana Gulch, has been a major discharge point for the shear zone since it was constructed in 1984. When WS-3 was closed, a pit lake formed. When the well was re-opened, the pit lake drained within five months. Monitoring of water levels in other wells identified interconnection through the shear zones. Additional information can be found in HSI and Gallagher (2001).

Similar high conductivity shear zones were 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 (WMCI, p. 194).

Not all faults are effective in the conveyance of groundwater. For instance, the Narrows fault was originally suspected as a possible conduit for groundwater flow from below the Landusky pit complex toward King Creek. However, drilling and testing show that hydraulic conductivities in this shear zone are low and that groundwater elevations are higher along the Narrows fault zone than below the pit area (WMCI, p. 198).

Historic Mine Workings

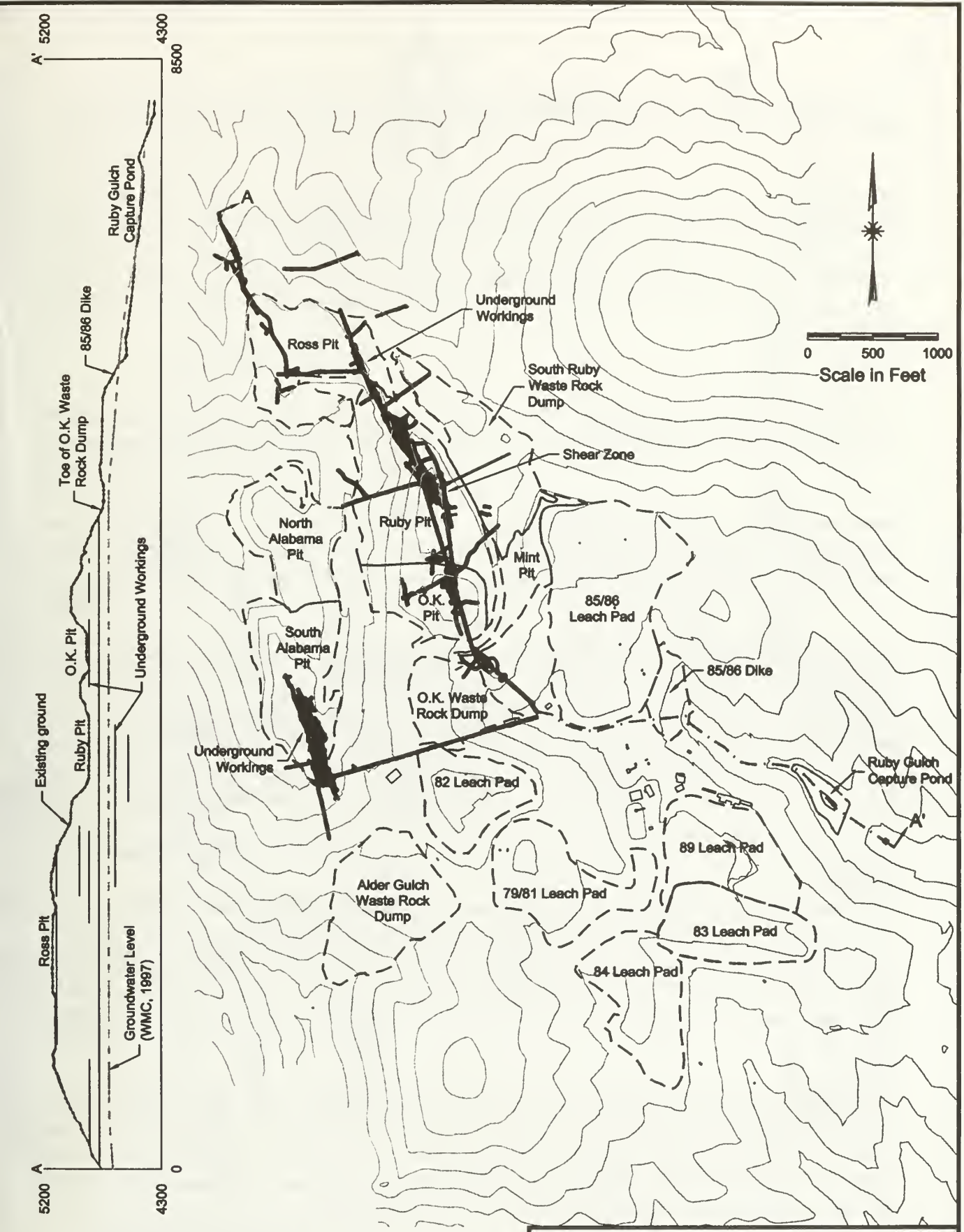
Underground mine workings associated with the shear zones exist at both the Zortman and Landusky Mines. If located below the water level, these underground workings would be conduits for groundwater flow, creating discharge points at the adits. Some adits are located at elevations between the high and low water table elevations. In this case, oxidation products form when the water level is low and become mobilized into the groundwater system with rising levels, causing a decline in water quality. This has been documented in samples from the Zortman Mine water quality monitoring wells located in the shear zone.

Zortman Mine: The USGS topographic map of the area shows 11 mine adits in the vicinity of 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.

Figure 3.3-6 is a cross section through the Ruby shear zone at the Zortman Mine. The cross section shows underground workings ranging in elevation from about 4550 to 5270 feet amsl. The workings were referred to by "levels" below ground surface. According to historic reports (Bryant 1953), significant water was encountered near the 600 level (approximately 4675 feet amsl). At the 700 level (about 4550 feet amsl) water production was reported to reach a steady flow rate of 1,600 to 1,800 gpm. The workings at the 600- and 700-foot levels in the Zortman Mine area are limited in extent and are present only below the South Alabama pit and the north end of the Ruby pit. Therefore, they have limited influence on groundwater movement. Historical information does not indicate the elevation of the groundwater when mining began. However, based on the information above the groundwater level in the shear zone was probably around 4700 feet amsl.

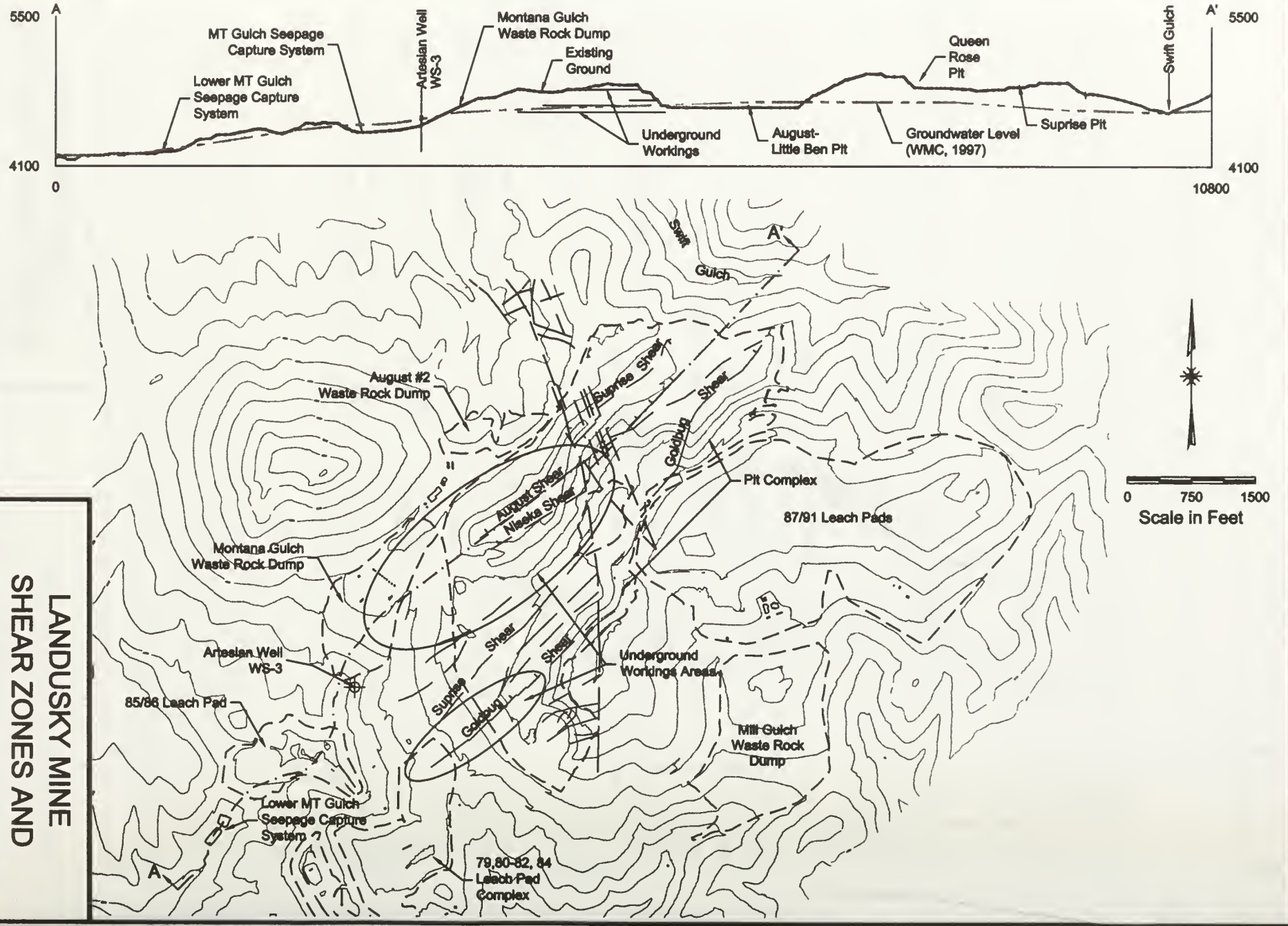
Landusky Mine: Mapped historic underground workings at the Landusky Mine are shown in Figure 3.3-7. These workings range in elevation from about 4576 to 4910 feet amsl and include the former August and Gold Bug Mines. The former August Mine includes underground workings in both the August and Niseka shear zones. Of the five adits, only the Niseka adit is not covered by the Montana Gulch waste rock dump. The August tunnel, which was constructed to drain the former August Mine, discharges beneath the Montana Gulch waste rock dump and its flow cannot be segregated from the total flow at the toe of the dump. Based on daily flow data at the upper Montana Gulch capture system from October 1997 through December 1999, the normal combined discharge from the August tunnel and the Montana Gulch waste rock dump ranged from 50 to 70 gpm.

The former Gold Bug Mine includes underground workings in the Gold Bug shear zone. The full vertical and lateral extent of the Gold Bug workings is unknown, but four levels of workings have been mapped. The Gold Bug adit discharges from the deepest workings (550 level) at an elevation of 4578 feet amsl. Measured discharge from the Gold Bug adit, located approximately 1,700 feet to the south of the August tunnel portal, has varied over a wide range depending on the year, season, and method of measurement. During the period from October 1999 through May 2000, discharge averaged 145 gpm. Flow from the



ZORTMAN MINE
RUBY SHEAR ZONE AND UNDERGROUND WORKINGS

FIGURE 3.3-6



LANDUSKY MINE SHEAR ZONES AND UNDERGROUND WORKINGS

FIGURE 3.3-7

August drain tunnel decreased significantly after construction of the Gold Bug adit, suggesting hydraulic connection between the August and Gold Bug underground workings (WMCI, p. 195).

The August Mine is below the current groundwater surface elevation of about 4620 feet amsl. The current groundwater elevation in the Landusky Mine area indicates that the 550 and 500 level workings are probably flooded on a continuous basis. The 350 level workings (at an elevation of approximately 4674 feet amsl) may be within the zone of seasonal or periodic groundwater level fluctuation. The 300 level (at an elevation of approximately 4812 feet amsl) is always above the current range of groundwater fluctuation.

Groundwater Flowpaths

Defining groundwater flowpaths is important to understanding the migration path and rate of travel of any contaminant entering the flow system. Determining which mine facilities release contaminated water and its flowpath assist in determining appropriate reclamation.

Both the May and November 1998 IBLA decisions contained numerous references to deficiencies in the FEIS regarding groundwater flowpath information. The IBLA stated that without an understanding of groundwater flows at the mine sites, the effectiveness of reclamation measures designed to prevent and control ARD could not be evaluated.

For the SEIS, data used in the FEIS are supplemented by the data and analysis contained in the Groundwater Study's "Detailed Conceptual Hydrologic Models." The following sections contain information on the components of groundwater flow, including the potentiometric surface, groundwater fluctuations, and groundwater divides. The August pit lake and deep and shallow groundwater flowpaths are also discussed. Additional flowpath information can be found in Gallagher (1999) and HSI and Gallagher (2001).

Potentiometric Surface

The potentiometric surface is the horizontal surface showing the potential water level of an aquifer. The water table is the top of the saturated zone of an aquifer. The hydraulic head is the level at which groundwater stabilizes in a tightly cased well open to a specific aquifer. A potentiometric surface map is made by plotting the contours of equal elevation, based on the water level in wells and piezometers, baseflow-fed streams, and springs. Determination of the potentiometric surface allows determination of groundwater divides and flowpaths.

The IBLA indicated there was inadequate data to accurately determine groundwater flow directions at the mine sites (November 1998, pp. 3 and 4; May 1998 pp. 177-179, 185, 187, 193-195, 197, 199 and 200). Since the FEIS was prepared, a significant quantity of data has been collected to assist in determining flowpaths. These data indicate that with the exception of the shear zone areas, the groundwater potentiometric surface generally reflects the topographic surface (WMCI, p. 196). This was

also the conclusion reached in the FEIS (p. 3-49). The shear zones and underground workings have a relatively flat groundwater surface due to the high degree of hydraulic connection and permeability.

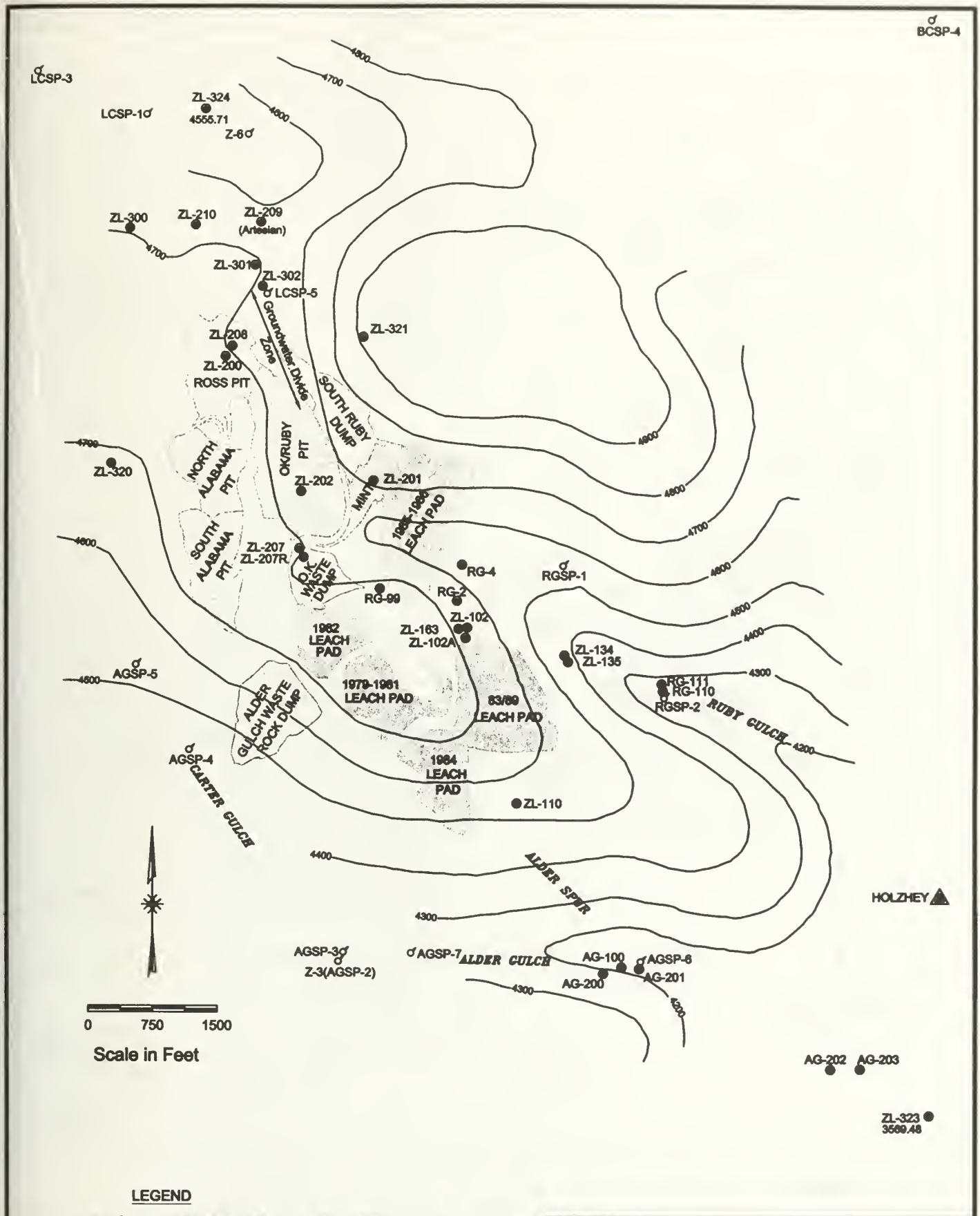
Potentiometric surface maps for the Zortman and Landusky Mine areas were prepared for both the 1996 FEIS (pp. 3-50 and 3-52) and the Groundwater Study (WMCI, Plan 5.2). As discussed above, the potentiometric surface maps show a relatively flat groundwater surface over the shear zones at each mine. To identify variations in the potentiometric surface for the SEIS, two additional maps are provided for the mine areas. Figures 3.3-8 and 3.3-9, and Figures 3.3-10 and 3.3-11 show the potentiometric surface in November 1999 and November 2000 for the Zortman Mine area and in October 1999 and October 2000 for the Landusky Mine area, respectively. The first map shows water levels prior to the start of the WS-3 aquifer test. The second map shows water levels near the end of the one year test. An additional set of maps for a May 2000 monitoring event are provided in HSI and Gallagher (2001).

Flowpaths can be interpreted using the potentiometric map by drawing a line perpendicular to the potentiometric contour. Both the FEIS and the Groundwater Study also utilized water quality data and hydrographs to refine flowpath interpretations. New interpretations about groundwater flowpaths have also been made using the water quality classification results. A discussion of the classification system is presented in SEIS Section 3.3.5 and in HSI and Gallagher (2001). The water balance prepared for each mine also assists in defining the quantity of flows within the mine sites.

Using water level, hydrograph, water chemistry, and water balance data, it is concluded that the vast majority of groundwater from the Zortman Mine flows south into Ruby Gulch and Alder Gulch where it is captured (FEIS, p. 3-109, WMCI, p. 527, Spectrum 2000a, HSI and Gallagher 2001). The results of a long-term pumping test and the similarity of response in long-term hydrographs indicate wells in the shear zone are hydraulically connected. Using the potentiometric map and the hydraulic properties of the aquifer, Spectrum (2000a), calculated that only about 3 gpm is discharged to the north from the Zortman Mine. This is compared to an estimated 175 gpm of groundwater that is captured and sent to the water treatment plant and 12.7 gpm of noncaptured groundwater discharging to the south.

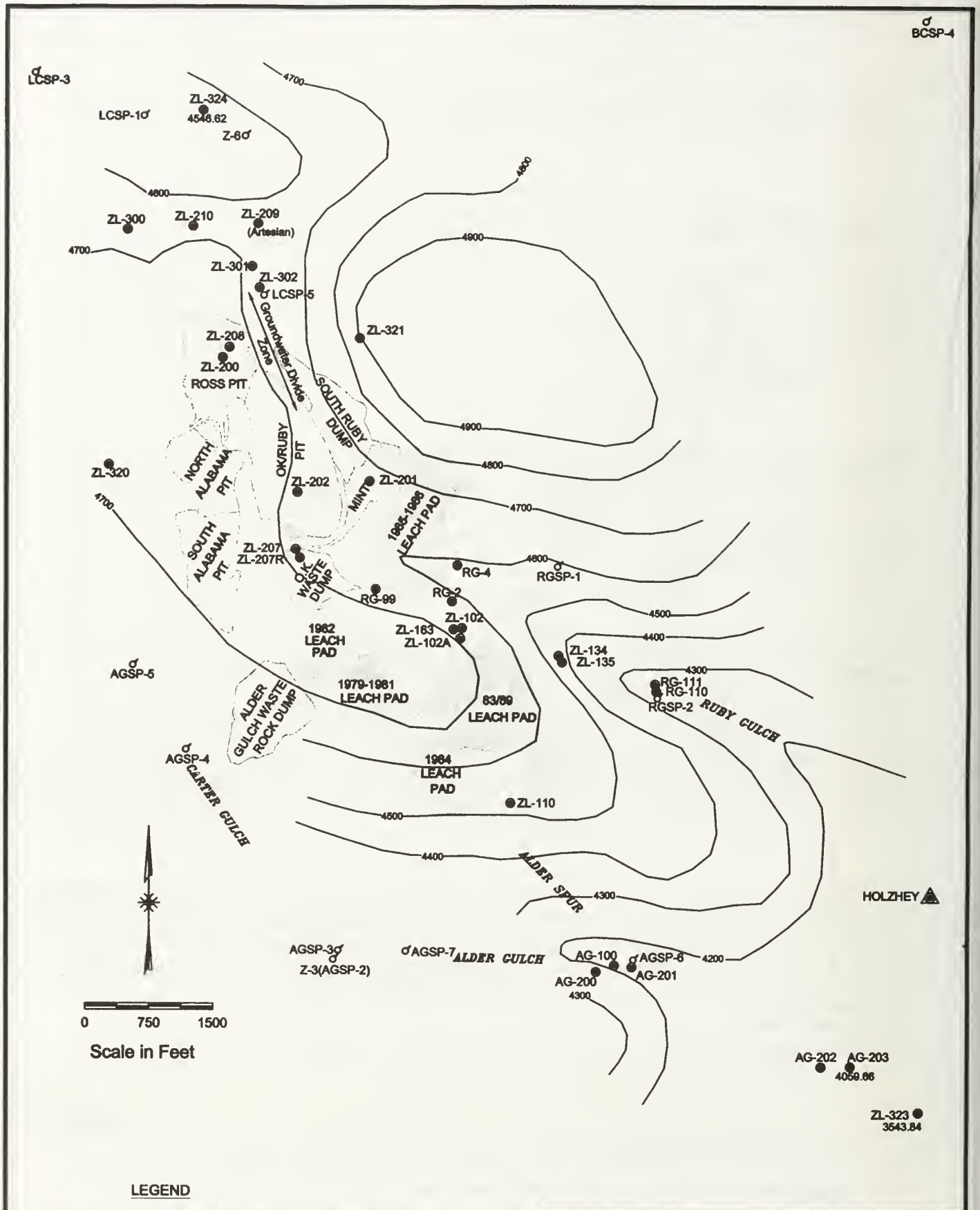
Water quality data for wells, springs and surface water in upper Lodgepole Creek contain limited evidence of mining-related impacts, indicating a minor amount of flow to the north. Acidic pH values and the metals cadmium, copper, nickel and zinc occur occasionally in upper Glory Hole Creek (spring LCSP-5). Elevated nitrate concentrations are found at surface water sites in Glory Hole Creek. However, at the lowest monitoring station (Z-5, located about 1000 feet downstream from the spring) levels are always below the nitrate drinking water standard of 10 mg/l. These nitrate levels are likely related to blasting from mining on the Ruby Gulch-Lodgepole Creek divide, west of Shell Butte. Slightly increasing sulfate levels have also been noted in upper Glory Hole Creek as shown by data from monitoring station Z-5.

At the Landusky Mine, water level data show that most of the groundwater within the shear zone is migrating along the shear zone to the southwest toward Montana Gulch and Mill Gulch (WMCI, p. 197). Southwest flow is further supported by the natural orientation of the shear zone, discharge from structures



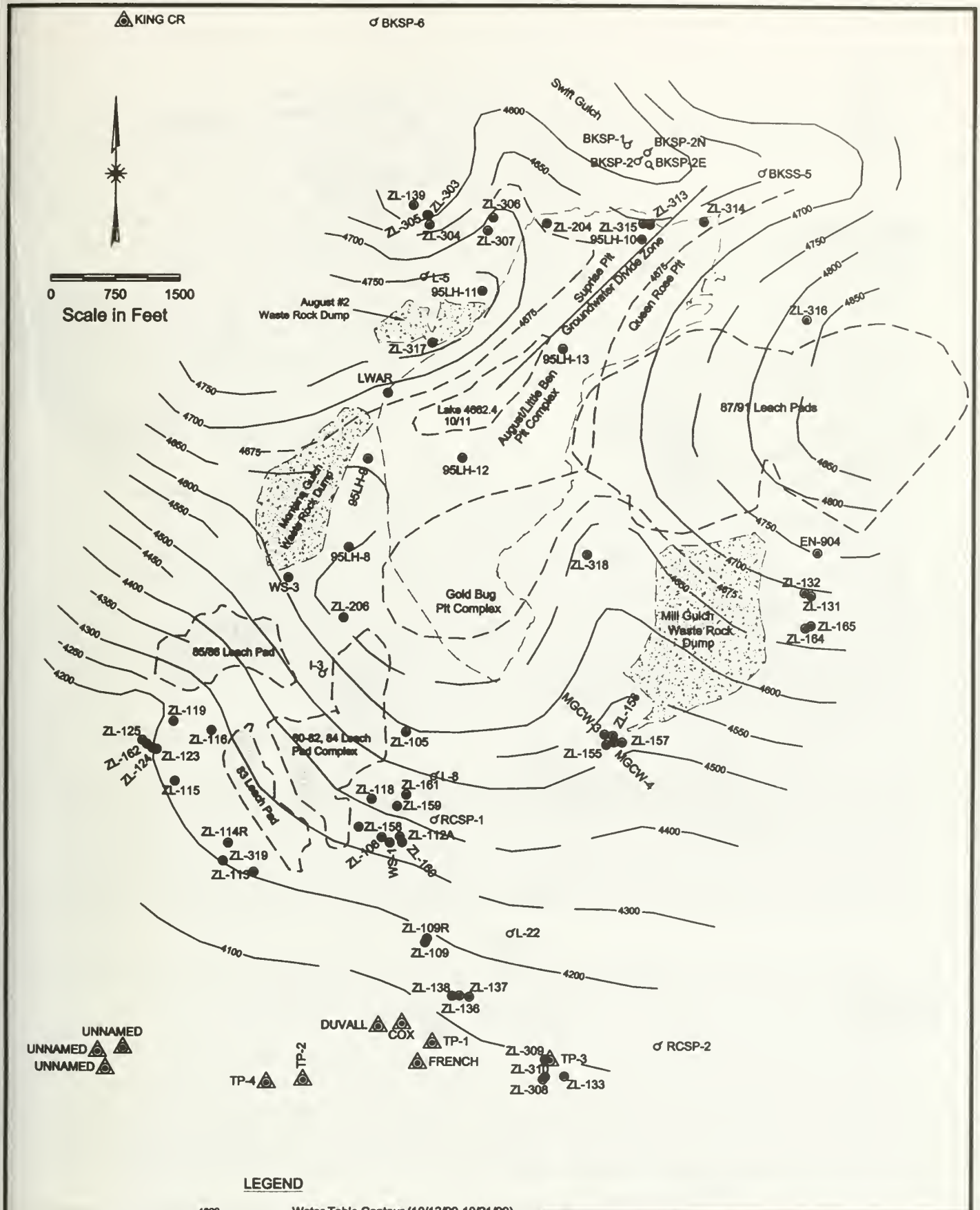
ZORTMAN MINE WATER TABLE CONTOURS NOVEMBER 1999

FIGURE 3.3-8



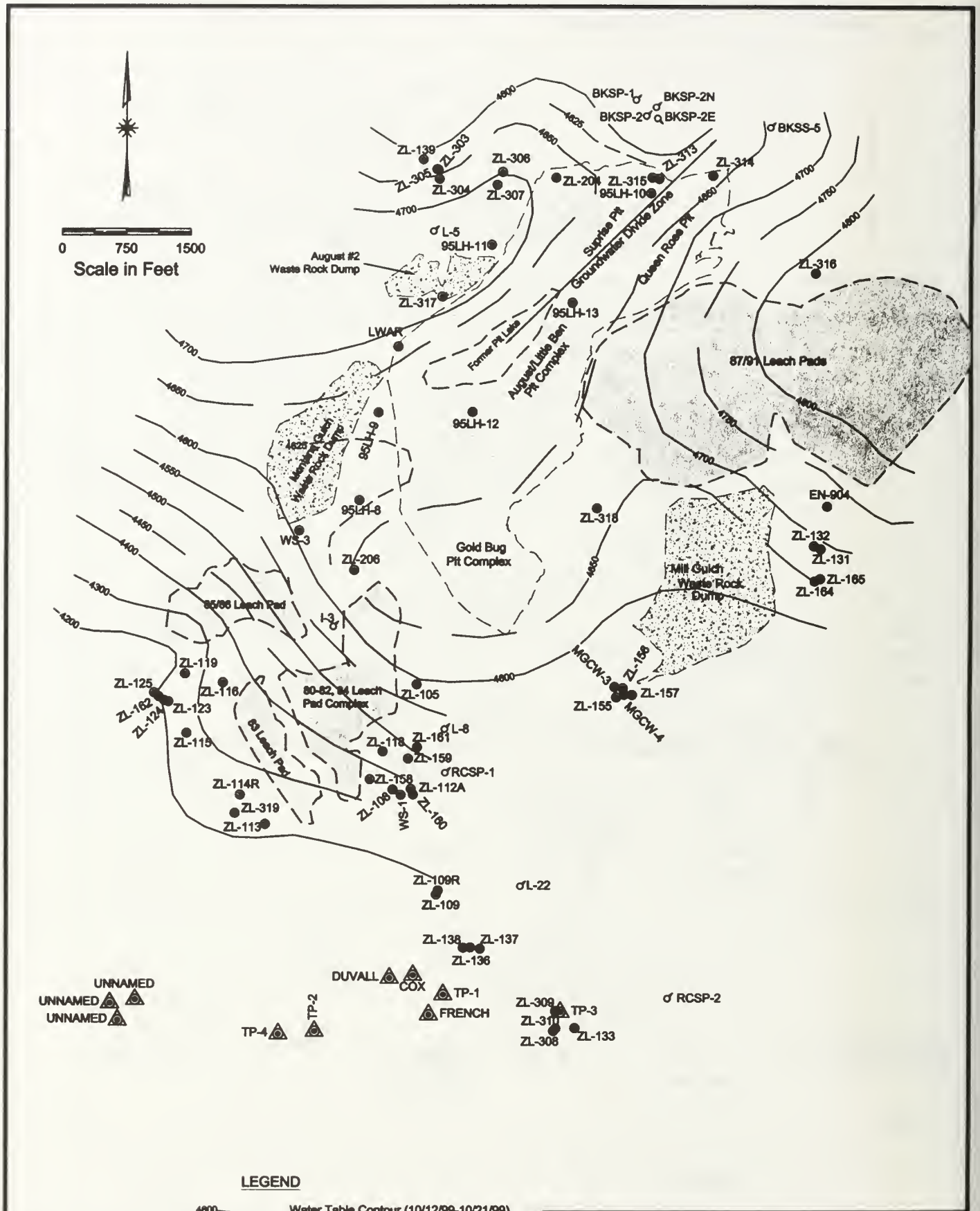
ZORTMAN MINE WATER TABLE CONTOURS NOVEMBER 2000

FIGURE 3.3-9



LANDUSKY MINE WATER TABLE CONTOURS OCTOBER 1999

FIGURE 3.3-10



LANDUSKY MINE WATER TABLE CONTOURS OCTOBER 2000

FIGURE 3.3-11

such as the August drain and Gold Bug adit, and data from dewatering the August pit (WS-3 aquifer test). Flow to the north from the Landusky pit complex shear zones was also identified in the FEIS (p. 3-109, others), WMCI (p. 197), and Spectrum (2000b).

The potential hydraulic connection across the syenite porphyry-Paleozoic boundary in the lower Landusky Mine area was evaluated with aquifer tests conducted in 2000 and 2001. The two Paleozoic wells closest to WS-3, ZL-105 and ZL-116, were monitored prior to and following the 36-day shut-in test and subsequent re-start of artesian flow from WS-3. These two wells are completed in the Ordovician Bighorn dolomite. The water levels in the two Paleozoic wells did not change due to either the shut-in or flow tests, unlike the wells in the syenite porphyry aquifer which clearly responded as expected. Based upon these test results there is a poor degree of hydraulic connection across the syenite-Paleozoic boundary.

Groundwater Level Fluctuations

WMCI concluded that the groundwater elevation in the shear zone at the Zortman Mine has recovered to pre-mining levels, although data indicate that water levels in some wells have been consistently rising since 1991 (WMCI, p. 194). Data from 1996 through 2000 indicate that groundwater levels continued to experience net annual increases up to the year 2000, averaging eight feet per year within the shear zone-pit area. No net increase was seen in 2000, likely due to below average precipitation. Selected well hydrographs for the Zortman Mine are provided in HSI and Gallagher (2001). Accounts of underground miners suggest that the original groundwater level was probably near the 4700-foot level (Botz and Gartner 1978). If so, groundwater has likely recovered to pre-mining levels. However, with the large areas of pits and disturbed ground, and inverted topography, groundwater recharge has also increased dramatically, allowing for higher than original water levels.

Groundwater levels at the Zortman Mine could continue to increase to an average of 4750 to 4775 feet amsl under current site conditions. 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 at the 500 level which serve to transmit water relatively quickly to discharge points. Reclamation activities begun in 2000 would significantly reduce recharge, resulting in groundwater levels which would likely be similar to current levels.

As with the Zortman Mine, there are no pre-mining groundwater level data for the Landusky Mine. There are no available accounts by underground miners clearly indicating groundwater levels. 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. A miner's notes on the "new 400 level" of the August Mine near Montana Gulch state, "high water in drift - 4 feet deep." The 400 level portal is at an elevation of 4812 feet amsl. This notation is at a point within 300 feet of monitoring well 95LH-09. The water level in 95LH-09 has ranged from 4658 to 4637 feet from October 1999 to October 2000. Although it cannot be verified, this information suggests that groundwater levels at the

Landusky Mine are now lower than prior to underground mining. Selected well hydrographs are provided in HSI and Gallagher (2001).

Since extensive workings lie beneath the current water level, groundwater levels at the Landusky Mine will be controlled indefinitely by the mine workings. The use of WS-3 as a passive discharge point for the syenite aquifer is an effective control on groundwater levels. In November 2000, WS-3 was closed and within 2 weeks groundwater started to appear in the pit. The well was opened again in early December 2000 and the levels began to drop. The potentiometric map of October 2000 is an estimate of the equilibrium levels in the absence of reclamation with artesian well open. As with the Zortman Mine, the extensive area of open pits and disturbed ground provides for greatly enhanced groundwater recharge rates. Reclamation would probably result in slightly lower water levels and reduced discharge from WS-3 and the Gold Bug adit. The groundwater divide zone would probably remain on the north side of the pit complex.

August Pit Lake

In mid-1997, groundwater began ponding in the August pit at the Landusky Mine and reached a total depth of about 15 feet by August 1999. The pit lake began to form after the flowing artesian well, WS-3, was closed in late 1995. This 243-feet deep well is completed in syenite porphyry and is located along the alignment of the shear zone. Water levels for the northern shear zone wells had also increased approximately 10 feet coincident with filling of the pit.

Since the pit lake had major implications to reclamation of the pits, a test was conducted to determine whether flow from WS-3 was acting as a shear zone drain. The well was opened and allowed to flow on October 27, 1999. The pit level began to measurably decline after about one week, and was completely dewatered in April 2000, confirming the connection between WS-3 and the pit lake through the shear zone. Water quality in the pit lake was typical of neutralized ARD, while discharge from WS-3 was representative of naturally mineralized groundwater. This indicates that pit lake water was either altered geochemically or diluted along the flowpath. Additional information regarding the WS-3 aquifer test is contained in HSI and Gallagher (2001).

The August drain tunnel was located below the pit lake level, but has been partially collapsed since April 1959. ZMI also drilled and shot the August pit floor after removing the last bench of ore in January 1996. The drain tunnel was about 15 feet below the final pit floor (approximately 4645 feet amsl) and was likely further collapsed when the pit floor was blasted. Aquifer testing shows that the discharge from the Montana Gulch waste rock dump (L-38) was reduced when WS-3 was flowing, and increased again when WS-3 was closed.

Groundwater Divides

A groundwater divide is an imaginary line "dividing" groundwater basins, comparable to "watersheds" for surface water basins. The location of groundwater divides is important in order to determine if mine impacted groundwater is discharging north towards the Reservation. The location of the divide and size of the groundwater basin are key factors related to the potential quantity of water flowing to the north.

The IBLA questioned the interpretation of the groundwater divides presented in the FEIS (see IBLA May 1998 Decision, pp. 178, 194, 195, 198 and 199; and November 1998 Order, p. 3.) They were concerned the limited number of wells in the northern portions of the mine sites precluded accurate location of the groundwater divide.

Since completion of the 1996 FEIS, an additional 15 wells and piezometers have been constructed in the north end of the mining areas, including five at the Zortman Mine and 10 at Landusky Mine (WMCI, pp. 42-43). The additional data collected from the wells refined the interpretation of divides. It should be noted, however, that it is not appropriate to draw a single line on a map signifying the year-round groundwater divide. Data show the water table is relatively flat at the northern end of both mines within the shear zones, and the groundwater divide occurs as a gentle "saddle point." Changes in precipitation, surface drainage, mining and grading patterns, land cover and seasonal trends are all forces that may cause the saddle point to shift north or south. Recent monitoring at the Crown Butte mine in southcentral Montana has also demonstrated that groundwater divides in mountainous fractured rock settings shift seasonally (M. Wireman, EPA, pers. comm.1999).

Based on observations of water quality in springs and seeps near divides, the presence or absence of very discrete fractures trending along the shear zones may cause the "divide" to take sharp, but very narrow deviations north and south. Because the location of these fractures cannot be pinpointed, and because of the seasonal variability in factors discussed above, a single specific line on the map identifying the divide is not an accurate portrayal. The general area of the groundwater divide is known from the existing potentiometric surface map and it is more accurate to consider it a groundwater divide zone.

Zortman Mine Groundwater Divide: A groundwater divide was mapped for the Zortman Mine using May 1995 data (FEIS, Figure 3.2-9). It was noted that little data were available and the divide was debatable (FEIS, p. 3-49). Since completion of the FEIS, five new wells/piezometers were completed in the northern end of the Zortman Mine area in the shear zones (ZL-300, ZL-301, ZL-302, ZL-321, and ZL-324). Water level data were then collected to refine groundwater divide and flowpath interpretations. Using this new data, a potentiometric surface map was produced for the Groundwater Study (WMCI, Plan 5.2). The WMCI map shows a slightly different contour configuration than the FEIS map, but lacks definition of a groundwater divide. Both Hydrometrics (1995) and the Groundwater Study concluded the Zortman Mine groundwater divide roughly approximates the topographic divide and the shear zones complicate the exact location of the divide (WMCI, pp. 196-197).

Using 1997-2000 water level and hydrochemistry data, groundwater divide zones were delineated as shown in Figures 3.3-8, and 3.3-9. The Ruby Gulch-Lodgepole divide zone brackets the original surface water divide situated between the Ruby pit and the Ross pit. Where underground mine workings occur, subsurface water flow in the workings may be different than within the bulk aquifer, particularly when workings are situated near or above the normal groundwater level. This appears to occur at well ZL-200 in the Ross pit. The well penetrates an underground adit and has strong ARD impacted water quality characteristics; however, there is no evidence that this water has migrated northward.

Based on all available information, the Ruby Gulch-Lodgepole divide zone of the syenite porphyry aquifer extends from the north end of the Ruby pit and North Ruby Saddle topsoil stockpile on the south, approximately 1550 feet to the north near well ZL-301. Shallow perched groundwater such as that discharging from the ephemeral spring LCSP 5 discharges and travels in a different direction than the main aquifer flow. LCSP-5 discharges to upper Glory Hole Gulch, while at times, the flow in the main aquifer at that point may be moving south to Ruby Gulch.

Landusky Mine Groundwater Divide: A groundwater divide was also mapped for the Landusky Mine using May 1995 data (FEIS, Figure 3.2-10, p. 3-52). Based on the data at that time, the FEIS concluded flowpaths in the Landusky Mine area are strongly controlled by the shear zones and the Gold Bug and August adits (FEIS, p. 3-53). Some discharge to both Swift Gulch and King Creek was suggested (FEIS, p. 3-53).

Since completion of the FEIS, 10 new wells and piezometers were constructed at the northern end of the Landusky Mine area in the shear zones and King Creek (ZL-303, ZL-304, ZL-305, ZL-306, ZL-307, ZL-313, ZL-314, ZL-315, ZL-316, and ZL-317). Water level data were collected to refine groundwater divide and flowpath interpretations with the resulting map shown in Plan 5.2 (WMCI 1998). The WMCI map revealed an even larger flat area associated with the shear zones.

As with the Zortman Mine, no groundwater divide was delineated for the Landusky Mine by WMCI. Water level data did reveal most of the groundwater within the shear zone is migrating along the shear zone to the southwest towards Montana Gulch and Mill Gulch (WMCI, p. 197). The Groundwater Study also found that groundwater flows toward Swift Gulch, but not toward King Creek as originally suspected (WMCI, p. 197). Flow toward Swift Gulch was further substantiated when the August pit filled after artesian well WS-3 was closed. Observations indicate that the discharge from springs in Swift Gulch increased as pit water levels rose.

Groundwater monitoring in 1999 and 2000 confirm the groundwater divide through the Narrows fault zone acts as a barrier to water flow from the Landusky pit area toward King Creek (HSI and Gallagher 2001). A small amount of mine-impacted water (primarily neutralized ARD) is present in King Creek, but it comes from within the watershed area itself. The primary source is the August #2 waste rock dump. The water balance/mass loading report (Spectrum 2000b) calculated 29 gpm of infiltration to King Creek from the mine area.

Groundwater divide zones for October 1999 and October 2000 are shown in Figures 3.3-10 and 3.3-11. The October 1999 map depicts groundwater levels at their highest, with 15 feet of water in the August/Little Ben pit. On October 27, 1999, artesian well WS-3 was opened and allowed to free flow at approximately 290 gpm. This well is completed in the syenite porphyry aquifer within the same shear zone occupied by the pit complex. It has flowed unabated at 260 to 300 gpm since that date except for aquifer testing purposes. The map for October 2000 shows the potentiometric surface was significantly lowered by the flowing well. Water levels declined from 20 to 46 feet within the pit-shear zone area.

With WS-3 closed and water in the pit, the divide across the shear zone likely cut across or touched on the pit lake. With WS-3 flowing, the divide zone shifted to the north, beyond the Suprise and Queen Rose pits.

Shallow Groundwater Flow Path

Groundwater in the form of seeps, springs and base flow discharge to stream channels in places and at elevations above the regional water table as "perched" groundwater. Perched groundwater zones occur as a relatively thin zone of water saturation, separated from the underlying regional water table by a limiting layer and a zone of unsaturated soil or rock. Perched water tables may be permanent or seasonal. Water that infiltrates beyond the soil primarily moves downward, but may be diverted laterally by geologic features such as bedding planes, fractures, and changes in rock type. Periods of high recharge rates enhance development of perched groundwater if the water enters the perched zone faster than it can infiltrate to lower levels.

Seasonal perched groundwater conditions occur at both mines, particularly in areas of relatively steep terrain. Springs such as LCSP-5 near the Ross pit and stream site Z-30 north of Shell Butte are examples of perched groundwater discharge sites at the Zortman Mine. Stations BKSS-1, BKSS-6, and BKSS-10 are examples of perched groundwater sites at the Landusky Mine. At these sites and certain others, the elevation of the groundwater expression is perched well above the regional water table or potentiometric surface.

Shallow groundwater flow paths at the mines may be different than those in the underlying syenite aquifer. This has been most notably the case in the vicinity of the northern end of the shear zones, where the perched groundwater discharges to the surface drainage to the north, while flow within the main syenite aquifer is directed to the south. To estimate the potential amount of recharge moving to shallow and deep groundwater, three spring/stream monitoring stations with flow records were evaluated: Z-30 at the Zortman Mine; and BKSS-1 and BKSS-10 (both in upper Swift Gulch) at the Landusky Mine.

Criteria from the mine water balances were applied to the drainage area upstream from the three monitoring stations. Estimated surface water runoff was subtracted from the observed average of all flow measurements to provide an estimate of shallow groundwater discharge at each station. This was subtracted from the "Infiltration to Groundwater" component of the water balance for each drainage area

to give the deep groundwater recharge. The shallow and deep groundwater recharge components for the two Swift Gulch stations averaged 42% and 58%, respectively. The averages for the three stations were 56% shallow recharge and 44% deep recharge. These percentages illustrate that the proportion of shallow and deep groundwater circulation can vary substantially; however, they provide an indication of the observed range. A full explanation of the method and data used in the analysis is included in HSI and Gallagher (2001).

Deep Groundwater Flow Path

The 1996 FEIS noted that another component of groundwater flow is a deep, near-vertical recharge route into the porphyry bedrock and eventually into the sedimentary formations surrounding the Little Rocky Mountains (FEIS, p. 3-51). This statement was illustrated in a schematic drawing (FEIS, Figure 5.1) depicting conceptual site flowpaths.

Information collected during the Groundwater Study (WMCI, pp. 196-203), the mine water balances (Spectrum 2000a and 2000b), and monitoring data support the conclusion that virtually all quantifiable groundwater flow leaves the mine sites as discharge from the syenite aquifer to stream channels within or proximate to the mine boundaries. At the Landusky Mine, the syenite aquifer discharge is to the capture systems, Gold Bug adit, August drain, artesian well WS-3 (when flowing), and springs and seepage in Swift Gulch. At the Zortman Mine, the syenite aquifer discharges to the three capture systems and small springs, seeps and baseflow to Lodgepole Creek tributaries. Unaccounted for recharge volumes could conceivably contribute to a conceptual deep flowpath, but these amounts are small enough to be unmeasurable and within the margin of error for the hydrologic calculations employed. While hydrogeologic conceptualizations always include the deep flowpath, in the case of the Zortman and Landusky Mines it is unlikely that the deep flowpath has any significant bearing on the water quality in the sedimentary aquifers off the mine site. Additional information on the deep flowpath can be found in Gallagher (1999).

3.3.4 Water Balance and Chemical Mass Loading

Zortman and Landusky Mines Water Balance and Mass Loading Evaluations

A water balance is a quantitative accounting of all principal components of the water cycle for a defined volume of earth materials or water body. It is analogous to and has much the same purpose as producing a balance sheet for a business. A water balance accounts for evapotranspiration, precipitation, surface runoff, groundwater recharge and runoff, and changes in storage. A chemical mass loading model uses the results of the water balance, along with water quality data to produce estimates of the quantity of chemicals or contaminants being transported or stored in various components of the water balance. Water balances and chemical mass loads for the Zortman Mine (Spectrum 2000a) and the Landusky Mine (Spectrum 2000b) were produced to assist in making decisions regarding the allocation of reclamation resources to produce the maximum environmental benefits.

Estimates of the hydrologic regime at the Zortman and Landusky Mines have been made in several previous studies. The FEIS used HELP modeling to estimate then current water and contaminant loads from mine facilities, and then predicted future loads under various reclamation scenarios. The Groundwater Study (WMCI, pp. 172-173) made estimates of evapotranspiration for each mine facility, and estimated runoff and infiltration using generalized methods or the results of the FEIS. WMCI provided a water balance of the area on a drainage-by-drainage basis for existing conditions. Most of the previous studies used precipitation data collected at the mines. However, the key estimates of evapotranspiration, surface runoff and infiltration to groundwater were not made using on-site data. These were generalized from other basins, studies, literature sources and the HELP modeling.

This water balance is based on observations from 1997, 1998, and 1999. The average annual precipitation for these years was 22.35 inches, while the average annual precipitation over the past thirty years is about 19 inches, depending on the source cited. Maximum annual precipitation for the past thirty years is 29.23 inches and the minimum annual is 10.74 inches.

The water balances rely on daily pumping records of the volume of water captured at the seepage capture systems. These systems allowed entire waste rock dumps and dikes to be evaluated as huge lysimeters, enabling direct estimates of on-site groundwater recharge and evapotranspiration. Weekly water level readings in leach pad sumps enabled water balances to be calculated for many of the pads, which also effectively are huge lysimeters. Surface runoff and groundwater recharge rates were developed for the principle facilities and land cover types. A water balance equation was applied to all basins given the average precipitation over the mine areas.

A large database of laboratory water quality results was created and monitoring locations that best represented each of the mining facilities were selected. Average concentrations at each monitoring station were converted to contaminant loads to groundwater by application of the water balance results. The procedures and limitations of the water balance and mass loading evaluations are described in Spectrum (2000a and 2000b). Additional information can be found in HSI and Gallagher (2001).

Zortman Mine Water Balance

An average steady state water balance, based on data from 1997, 1998 and 1999, and checked with flows through the water treatment plant, was calculated for the Zortman Mine. Records from the Zortman water treatment plant were used to estimate the amounts of captured and uncaptured water leaving the mine site (HSI and Gallagher 2001). Rates of groundwater recharge were calculated based on direct volumetric analysis of the capture systems and leach pads. Infiltration rates (as percent of precipitation) calculated for unreclaimed leach pads, pits, and reclaimed leach pads and rock dumps are 70.5%, 56% and 45%, respectively. These rates are significantly greater than previous evaluations contained in the FEIS and the Groundwater Study. Rates for regraded-topsoiled areas, undisturbed areas and hard-surfaced areas (e.g. roads) are 45%, 33% and 30%, respectively.

The water balance indicated that of the total precipitation input (22.35 inches), the rate of evapotranspiration is 47.9%, infiltration is 44.3% and surface runoff is 7.8%. Of the infiltration component, 10.0% is recharge to leach pads, which is routed to the Goslin Flats LAD, 27.2% enters the capture systems and is sent to the Zortman Mine water treatment plant, 3.8% is off-site groundwater flow, and 3.3% is increased groundwater in storage and/or residual error of the method. Of the surface runoff, 5.2% enters the capture systems, and 2.6% runs off-site. Groundwater monitoring from the early 1990s through present has shown a net increase in the groundwater level within the Zortman Mine shear zones of about eight feet per year, leveling off in 2000. This suggests that with unreclaimed conditions, average precipitation and recharge rates may be greater and/or evapotranspiration rates lower than estimated in the steady state water balance.

Results of the Zortman Mine water balance support the conclusion that the vast majority of groundwater flow leaves the mine as shallow discharge to the capture systems. A very small amount of groundwater (about 3 gpm) from the mine enters the tributaries of Lodgepole Creek. Details regarding the assumptions and limitations of the water balance methodology are provided in HSI and Gallagher (2001).

Landusky Mine Water Balance

A more complicated groundwater flow system is evident at the Landusky Mine. Unlike at the Zortman Mine, surface water basins could not be used as the basic watershed unit. Groundwater basins were defined for each capture system, based on site geology, premining topography, the potentiometric surface map, and annual volume of water reporting to each discharge point. Flow records from the Landusky Mine water treatment plant were used to estimate the amount of captured and uncaptured water leaving the mine site (HSI and Gallagher 2001). Rates of groundwater recharge were calculated based on direct volumetric analysis of the capture systems and leach pads. Infiltration rates (as percent of precipitation) calculated for unreclaimed leach pads and pits, and reclaimed leach pads and rock dumps were 69%, 62% and 48.6%, respectively. These rates are significantly greater than previous evaluations contained in the FEIS and the Groundwater Study. A lower rate of 31.1% was obtained for the Mill Gulch waste rock dump due to the use of geosynthetic and clay liners in the existing reclamation cover. Rates for regraded-soiled areas, undisturbed areas and hard-surfaced areas (e.g. roads), were 48.6%, 24.5% and 37%, respectively.

The water balance for the Landusky Mine was performed for 1998 due to the availability of consistent data and 1998 being a more typical year for precipitation. The water balance predicted that of the total 1998 precipitation input (23.33 inches), the rate of evapotranspiration was 54.9%, infiltration was 43.0% and surface runoff was 2.1%. Of the infiltration component, 12.6% is recharge to leach pads, which is routed to the Goslin Flats LAD, 23.1% enters the capture systems and is sent to the Landusky Mine water treatment plant, and 7.3% is off-site groundwater discharge. Of the surface runoff, 0.5% enters the capture systems or leach pads, and 1.6% runs off-site.

The Landusky Mine water balance (Spectrum 2000b) shows total groundwater capture of 208 million gallons, versus 211.6 million gallons measured in 1998, a difference of 1.68%. The match by drainage

basin is more variable. Details of the assumptions and limitations of the water balance methodology are provided in HSI and Gallagher (2001).

Monitoring well data within the Landusky Mine pit/shear zone area indicate that groundwater levels have risen by as much as 66 feet since the early 1990s (well ZL-206). The rising levels have resulted in formation of the August pit lake and suspected additional seepage to Swift Gulch. This indicates that with unreclaimed conditions, average precipitation and recharge rates may be greater and/or evaporation rates lower than estimated in the steady state water balance.

Discharge from artesian well WS-3 was not included in the 1998 Landusky Mine water balance estimate. When flowing freely, it has the potential to capture an additional 75-150 million gallons per year. Based on monitoring during the aquifer tests, groundwater supplying WS-3 is derived principally from the shear zone, the diversion of water from other discharges such as the August drain and Gold Bug adit, and the area of syenite aquifer on the east side of the Landusky Mine.

The Landusky Mine water balance and monitoring data support the conclusion that the vast majority of groundwater flow leaves the Landusky Mine area as shallow groundwater discharge to the capture systems, Gold Bug adit, August drain, artesian well WS-3 (when flowing), and springs and seepage in Swift Gulch. Details regarding the assumptions and limitations of the water balance methodology are provided in HSI and Gallagher (2001).

Uncaptured Flow

There are a number of methods which may be used to estimate the amount of surface water and groundwater not being captured at the mines, including estimation from direct observations, physical hydrology, and chemical hydrology. This is of interest in evaluating the effectiveness of the current capture systems and whether the reclamation alternatives will vary in their influence on future effectiveness.

The water balance and chemical mass loading reports (Spectrum 2000a and 2000b) use physical hydrology (water table contour maps and hydraulic conductivity) to estimate the amount of groundwater leaving the mine site outside the drainages with capture systems. It assumes that all groundwater in drainages with capture systems is captured. The results of a second technique using a chemical mass balance approach are shown in Chapter 4 and provide estimates of uncaptured flows within all principal drainages, including those with capture systems. This approach is presented in Section 4.3.1, and details are provided in a project report by Robertson (2000d). These two techniques rely on independent data sources and the results are different. There is a large inherent component of variability and uncertainty in all hydrology data, so the differing results should be viewed as being within the range of probable outcomes.

Zortman Mine: The water balance demonstrates that 52.1% of the precipitation becomes surface water runoff or groundwater recharge. On a mean annual basis over the mine site, this is equivalent to 313 gpm. Of the total surface water and groundwater, about 59 gpm (18.5%) is uncaptured. This includes water

moving off undisturbed areas. About 20 gpm (6.4%) of this flows to the southern drainages, Ruby, Alder and Carter Gulches, and 3.1 gpm (1%) to Lodgepole Creek. The remainder, equivalent to about 34 gpm (11.1%), is not accounted for in the water balance. It represents the combination of inherent error and the increase in groundwater storage within the mine site. As noted above, groundwater levels in the Zortman Mine pit area have been rising since the early 1990s.

The chemical mass balance method gives uncaptured flow rates in Zortman Mine drainages of 0.03 gpm in Alder Spur, 1.8 gpm in Carter Gulch, 11.6 gpm in Ruby Gulch, and 0.06 gpm in Lodgepole Creek. The combined uncaptured flow to the south totals 13.4 gpm. The purpose and methods of the chemical mass balance are different from the water balance approach described above, but from the overall hydrologic perspective, the results from the two methods are reasonably consistent.

Landusky Mine: Uncaptured flows from the mine area to King Creek and Swift Gulch are estimated in two ways in the water balance report: actual measurements and application of the water balance equation. The average discharge from the mine area, based on the average for 24 measurements at station L-19 from 1997 through 1999, is 25 gpm. The averages from the measured flows are less than those predicted by the water balance method and are greater that those predicted by the chemical mass load method described below. The water balance demonstrates that 45.1% of the precipitation becomes surface water runoff or groundwater recharge. On a mean annual basis, this is equivalent to 779 gpm. Of the total surface water and groundwater derived from the mine, about 163 gpm (19.9%) is uncaptured. This includes water moving off undisturbed areas. About 48.7 gpm (6.3%) flows from the mine area to Swift Gulch, 29.2 gpm (3.7%) to King Creek, and 76.7 gpm (9.9%) represents the combination of inherent error, uncaptured flow to the south, and increases in groundwater storage.

The chemical mass balance method gives uncaptured flow rates in Landusky Mine drainages of 8.7 gpm in Swift Gulch, 9.65 gpm in King Creek, 0.35 gpm in Sullivan Gulch, 12.1 gpm in Mill Gulch, and 37.5 gpm in Montana Gulch. The combined uncaptured flow to the south totals 49.9 gpm. As with the Zortman Mine results, the purpose and methods of the chemical mass balance for the Landusky Mine are different from the water balance approach, but from the overall hydrologic perspective, the results from the two methods are reasonably consistent.

Chemical Mass Loading Evaluation

Chemical mass loading models of both mines were developed to estimate the total loads of contaminants generated by all mine facilities and to evaluate the ultimate fate of the contaminants. Based on the mines' subbasins and the water balance, contaminant fate was split among that going to the water treatment plant, to the LAD, and to groundwater. Average annual loads of total dissolved solids, acidity, sulfate, nitrate (nitrite plus nitrate), arsenic, selenium and seven cationic metals were calculated. The results demonstrate that the principal sources of mine-related contaminants and their fate can be accounted for. The results are best interpreted by comparison of relative loading rates among the mine facilities. The procedures and limitations of the chemical mass loading evaluations are provided in Spectrum (2000a and 2000b).

Zortman Mine Chemical Mass Loading

Results of the chemical mass loading model indicate that about 32% of the total sulfate load is generated by the Z85/86 leach pad. The Alder Gulch waste rock dump, O.K. waste rock dump, plant process area, and Ruby pit each generate from 5 to 10% of the total sulfate load. In terms of loads per unit area, the Z85/86 leach pad is the strongest source. The O.K. waste rock dump and the rest of the leach pads are the next strongest sources.

Total metals load is the sum of aluminum, cadmium, chromium, copper, iron, lead, manganese, nickel and zinc. As with sulfate, the total metals load is greatest from the Z85/86 leach pad, comprising nearly 22% of the total metals load from the mine. The Alder Gulch waste rock dump and Ruby pit contribute about 11 and 10%, respectively, of the mine's total metals load. Most of the areas high in sulfate load are also high in metals load. On a load per unit area basis, the Z85/86 leach pad ranks as the strongest source. The Z82 leach pad, O.K. waste rock dump, and the pits are the next strongest sources. The average concentration of arsenic is greatest in the Z82 leach pad effluent (4.2 ppm). All of the pit-area groundwater has elevated arsenic at concentrations above the chronic aquatic life standard of 0.15 ppm.

Selenium concentrations at all Zortman Mine facilities are relatively low. The highest average concentration is found in the Z83 leach pad (0.064 ppm). This is the only Zortman Mine facility at which selenium exceeds the drinking water quality standard of 0.05 ppm.

The sources and fate of the Zortman Mine sulfate and metals loads are determined from the water balance and are shown in Figures 3.3-12 and 3.3-13. They indicate that 78% of the total metals load and 66% of the sulfate load is captured and routed to the Zortman water treatment plant. The Goslin Flats LAD receives 18% and 31% of the metals and sulfate loads, respectively. The total metals and sulfate loads entering groundwater that are not captured is estimated at 4% and 3%, respectively.

Landusky Mine Chemical Mass Loading

The difference between the surface water and groundwater basins at the Landusky Mine is much more pronounced than at the Zortman Mine. The Landusky Mine chemical mass loading estimates were developed using the groundwater basins discussed previously.

The chemical mass loading results indicate that the L87 and L91 leach pads produce the greatest overall and the greatest per-unit-area loading rate of sulfate. The next largest total sulfate loads are derived from the upper Montana Gulch capture system, lower Montana Gulch capture system, Gold Bug adit, and Sullivan Gulch capture system, respectively.

The Gold Bug adit discharge has the greatest overall loading rate of total metals, followed by Sullivan Gulch and upper Montana Gulch. On a per unit area basis, the L84 and L83 leach pads rank first and second in total metals production, followed by the Gold Bug adit discharge and Sullivan Gulch. The average

concentration of arsenic is greatest in the Gold Bug adit discharge (0.42 mg/l). It is also above chronic aquatic standards, as are waters from the L79-82, and L85/86 leach pads.

Selenium concentrations are highest in the L87 and L91 leach pads (1.04 and 1.05 mg/l, respectively) and above the chronic aquatic standards in all other leach pads and the capture systems in Sullivan Gulch, Mill Gulch and upper Montana Gulch.

The sources and fate of the Landusky Mine sulfate and metals loads are determined from the water balance and are shown in Figures 3.3-14 and 3.3-15. The sulfate distribution indicates that 66% is collected from the leach pads and routed to the LAD area, 24% enters the capture systems and goes to the water treatment plant, 9% is surface water discharge (primarily lower Montana Gulch), and 1% is uncaptured groundwater. Of the total subsurface metals load, all but 2 to 3% enter the capture systems or leach pads.

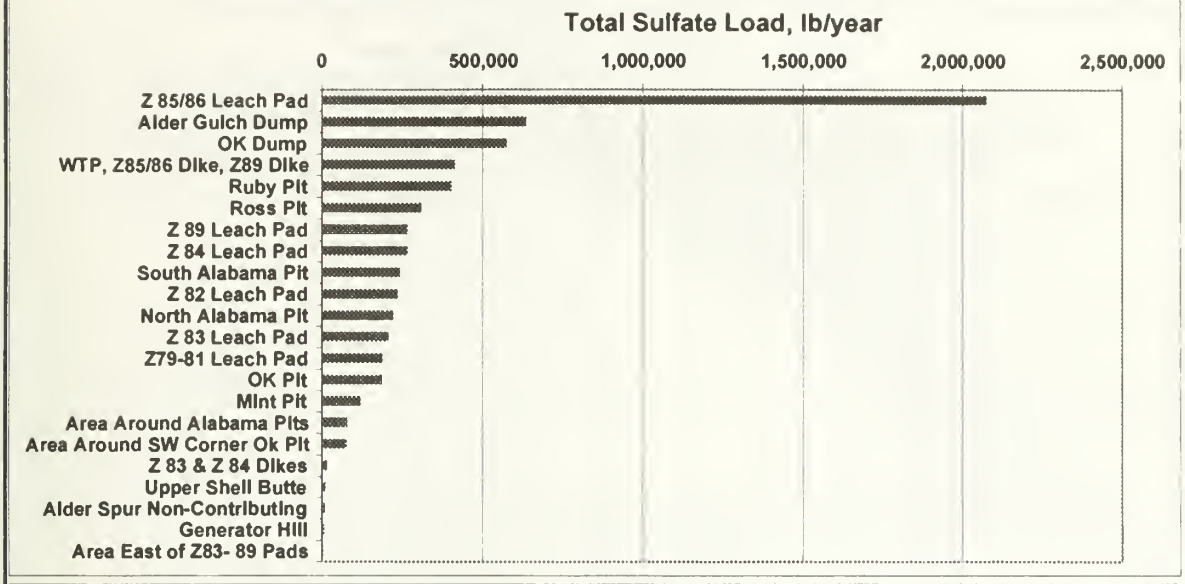
Comparisons Between Zortman and Landusky Mines

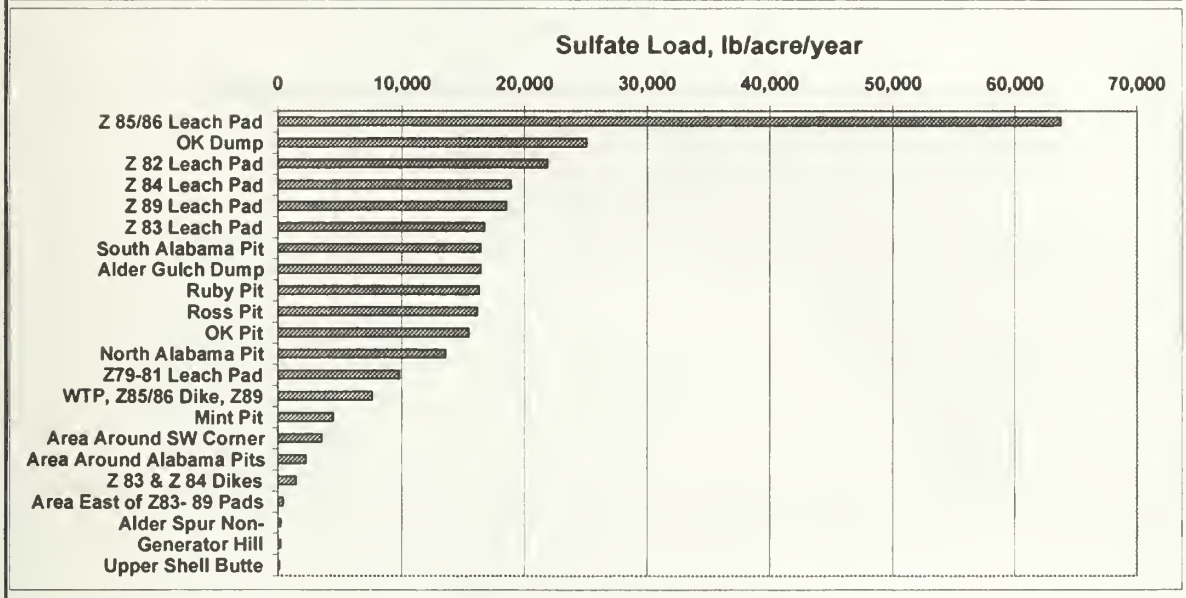
Water balances for the two mines show that the annual volume of groundwater discharge from the Landusky Mine is approximately 2.8 times greater than at the Zortman Mine. However, the contaminant loads are not always proportional to the amount of groundwater. In comparing the contaminant loads at the two mines, the Zortman Mine has the greatest loads of arsenic, iron, manganese, and sum of cationic metals; and the Landusky Mine has the greatest loads of nitrate and selenium.

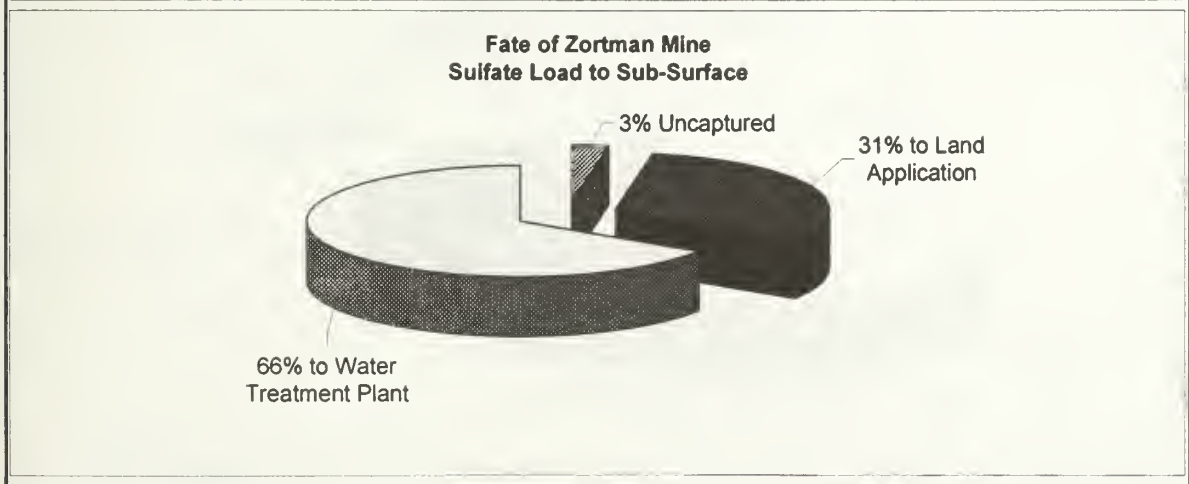
In general, contaminants are more concentrated at the Zortman Mine than at the Landusky Mine. The principle sources of nitrate and selenium at the Landusky Mine are the L87 and the L91 leach pads. The two mines are similar in their annual loads of total dissolved solids. The groundwater acidity data for the mines indicate 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. The pH of surface soils, as measured during reclamation activities, indicates a greater proportion of samples with a pH of less than 4.5 s.u. at the Zortman Mine. A large network of mine workings at the Zortman Mine lying just above the baseline water table become saturated during higher water table conditions and flush oxidation products to the capture systems. At the Landusky Mine, more of the underground workings appear to lie beneath the water table during all seasons, minimizing the degree of oxidation and flushing events.

Although the present-day concentrations of most contaminants are greater at the Zortman Mine, contaminant production from the Landusky Mine is going 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 would become similar to the Zortman Mine today.

Sources and Fate of Zortman Mine Annual Sulfate Loads



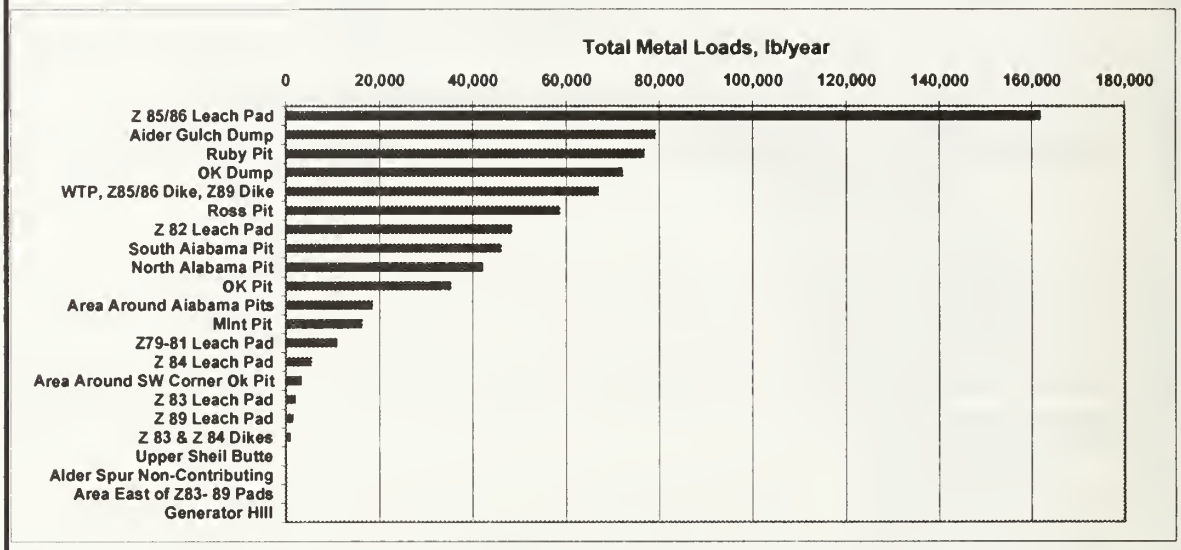


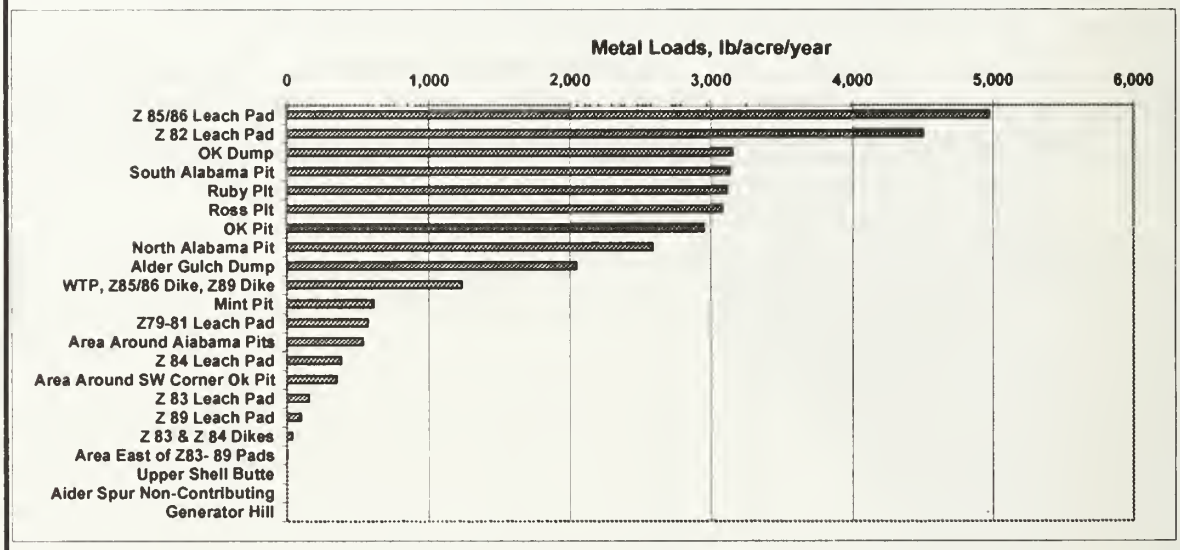


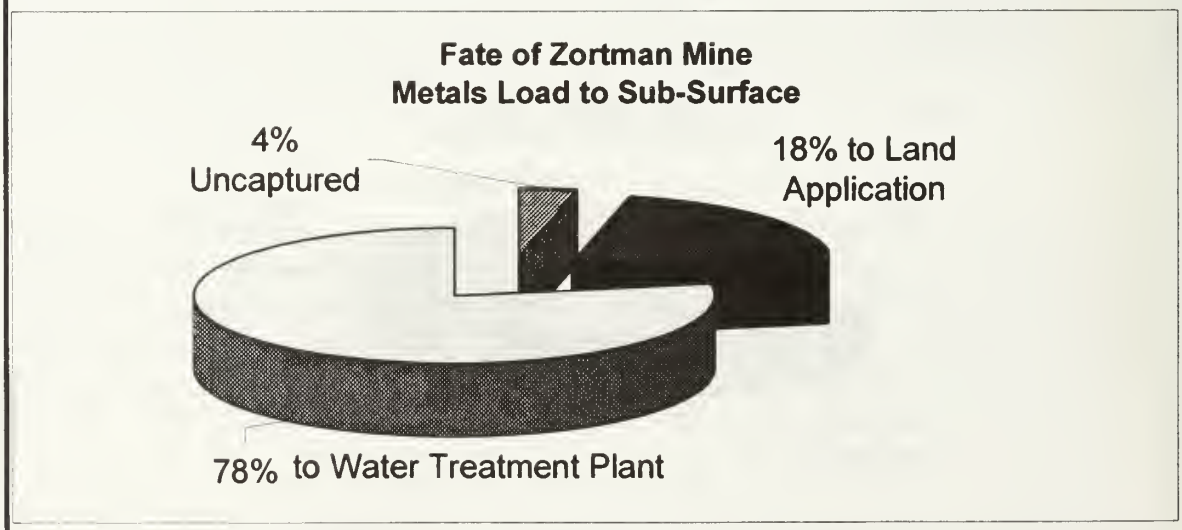
SOURCE: SPECTRUM , 2000e

FIGURE 3.3-12

Sources and Fate of Zortman Mine Annual Total Metal Loads



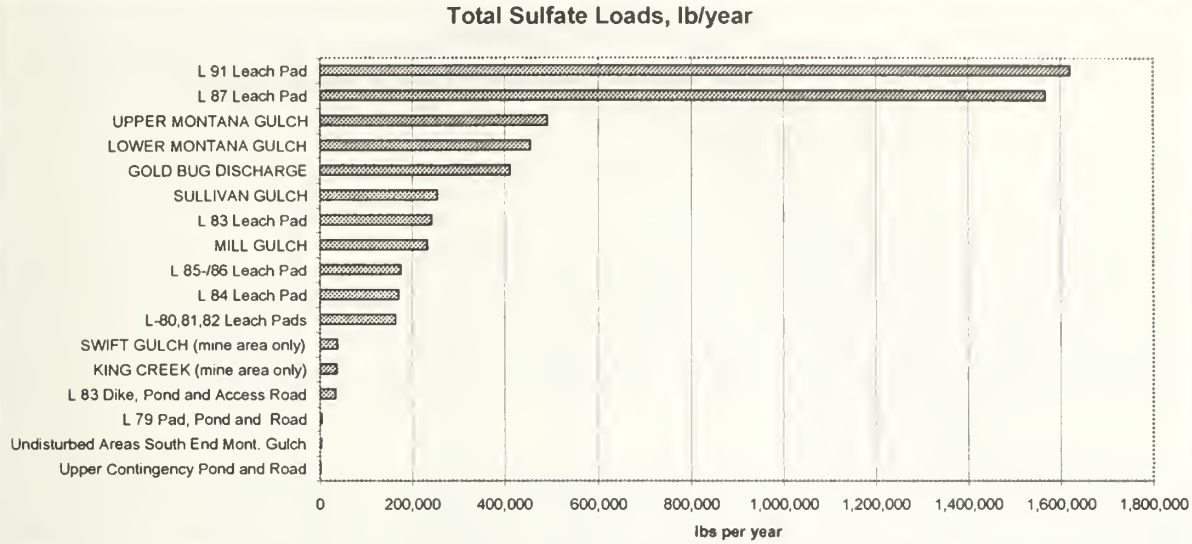


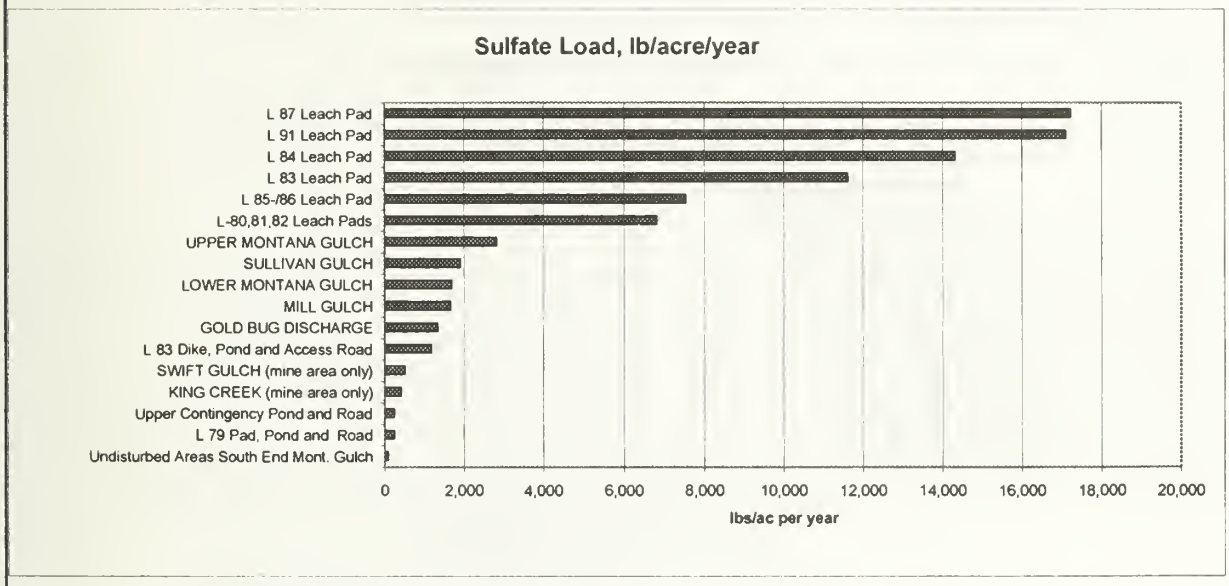


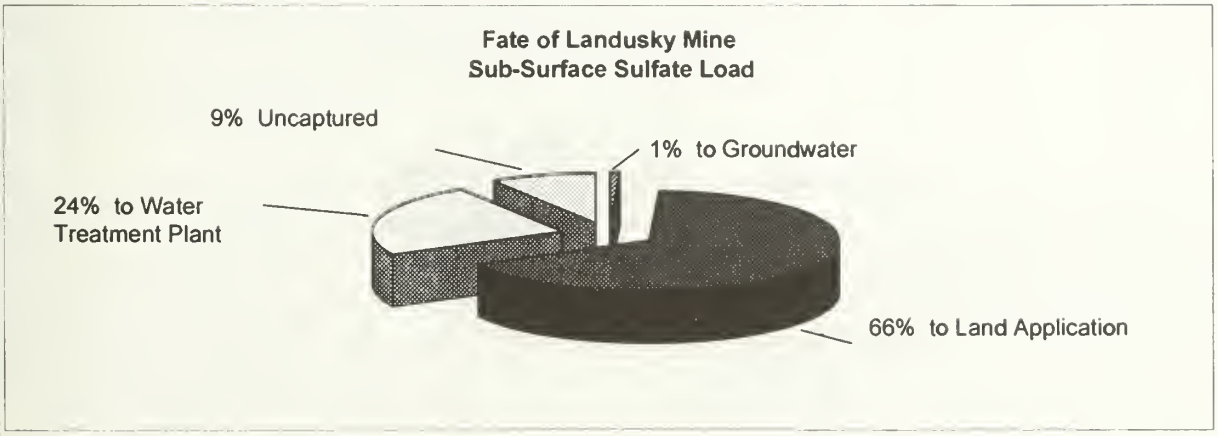
SOURCE: SPECTRUM 2000e

FIGURE 3.3-13

Sources and Fate of Landusky Mine Annual Sulfate Loads



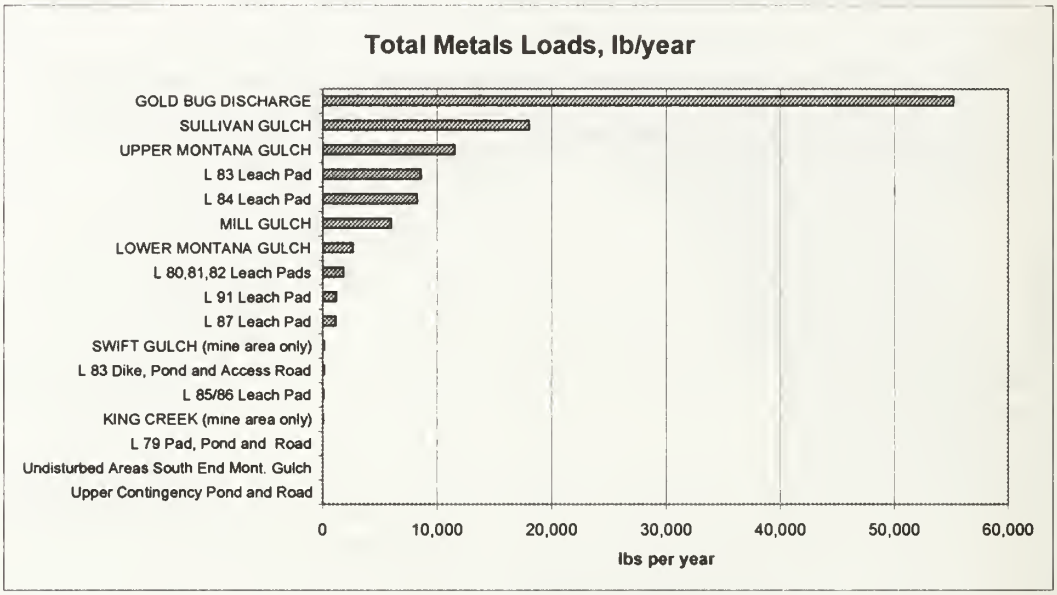


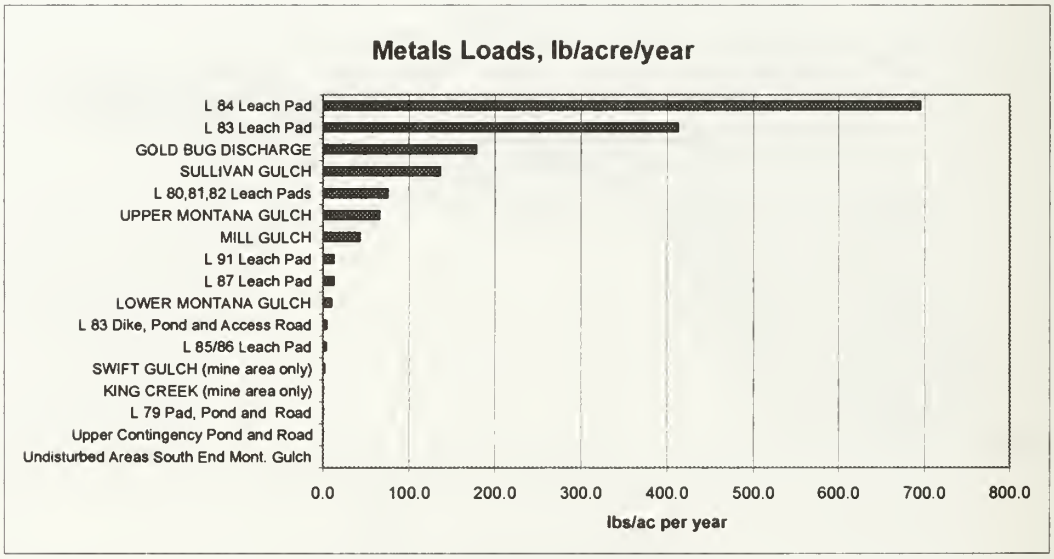


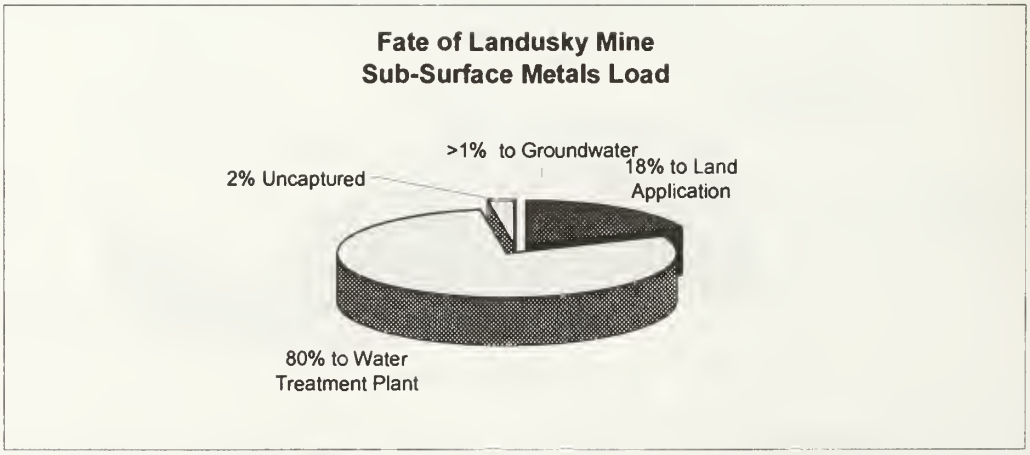
SOURCE: SPECTRUM ENGINEERING, 2000f

FIGURE 3.3-14

Sources and Fate of Landusky Mine Annual Total Metal Loads







SOURCE: SPECTRUM ENGINEERING, 2000f

FIGURE 3.3-15

This could take from tens to hundreds of years. Additionally, the volume of potentially reactive rock material at the Landusky Mine, in particular on the L87/91 leach pad, represents a large storage of potential contamination. Since the material on the L87/91 leach pad is on a lined area, it can be contained, treated and disposed of easier than material in the waste rock dumps or pit areas.

Calculation of Stored Oxidation Products

There is a significantly larger mass of potential contaminants in storage at the Landusky Mine than at the Zortman Mine. With the exception of iron, this is largely a reflection of the volume of material present in the L87 and L91 leach pads. Therefore, although the present contaminant concentrations and loads at the Zortman Mine exceed those at the Landusky Mine, there is a larger volume of soluble contaminants at the Landusky Mine.

A "stored product inventory" was completed based on the results of the lab testing program and the estimated volume of material in each mine facility. This is an accounting of the potential storage of secondary minerals formed as a result of sulfide oxidation and, if alkali minerals are present, subsequent acid neutralization. These secondary minerals are typically soluble in rainwater and are a secondary source of sulfuric acid (H_2SO_4) and metals (copper, cadmium, nickel, zinc, etc.). The stored product inventory was calculated for each of the subbasins for sulfate, arsenic, selenium and seven cationic metals. The results show that the oxidation/neutralization and mineral precipitation reactions that have occurred at the surface to date have produced a significant stored product inventory.

The calculated sulfate load reporting to the Landusky Mine water treatment plant is approximately 2 million pounds per year. Comparing this value with the estimated 202 million pounds of sulfate currently stored in the Landusky Mine heaps and waste rock leads to the generalization that if all sulfide oxidation processes could be shut down on the site today and the only ongoing source of contamination was from the solubilization of current stored products, water treatment would need to continue for about 100 years to treat the estimated storage. If the total amount of sulfate to the LAD, groundwater and the water treatment plant is considered, the stored contaminant inventory at the Landusky Mine would require about 34 years to remove at the rates of water recharge that occurred in 2000.

3.3.5 Water Quality Classification System

Previous Classifications

One of the primary goals of the SEIS is to evaluate the current extent and magnitude of mining-related impacts to groundwater and surface waters in and around the mines. A consistent and comprehensive assessment is difficult, given the geologic and hydrologic complexity of these sites. A water quality classification evaluation of mine waters, using common ions, was previously attempted by WMCI (p. 204). Their focus was to describe water quality associated with the principal hydrogeologic environments at the mine sites on a drainage-by-drainage basis.

New Classification System

While the WMCI analysis was thorough on a drainage-by-drainage basis, it did not attempt to distill the extensive amount of information into a site-wide summary defining the extent and type of mining-related impacts. Subsequent evaluation found that treatment of water quality data on a drainage basis blurs the distinctions that can often be found for specific rock types. In addition, common ion chemistry is not particularly useful in distinguishing between natural waters and impacted waters. Review of the historic and recent water quality data, along with the literature on ARD, revealed that the following parameters are generally definitive of mining impacts:

- Elevated specific conductance, due to enhanced mineral dissolution in ARD,
- Acidic pH, due to pyrite oxidation reactions that produce hydrogen ions,
- Elevated nitrate nitrogen, due to explosives residuals, and fertilizer on reclaimed areas,
- Elevated heavy metals cadmium, copper, nickel and zinc, due to increased solubility with lower pH,
- Elevated sulfate, a byproduct of pyrite oxidation,
- Little to no alkalinity, due to exhaustion by the acidity produced in ARD, and
- Cyanide above 0.01 mg/l, indicating impacts from gold processing chemicals.

Groundwater and surface water baseflow in some locales is affected by natural mineralization. This can make it difficult to distinguish mineralized natural waters from mining impacts. In order to address this issue, data from naturally mineralized areas was compared to known mine impacts. A data set of 36 samples from Swift Gulch was compiled from 1996 to 2000, which contains samples of natural springs, seeps and surface waters within the Suprise and Gold Bug shear zones. These samples were collected from both the south (mine side) and north (unmined) sides of Swift Gulch. The stations sampled are representative of shallow groundwater and surface water baseflow in the syenite porphyry aquifer. The results of these analyses allow differentiation of the following water types and characteristics:

- A "Headwaters" type characterized by very low dissolved solids, low alkalinity, pH of 6 to 7 s.u., and very low metals concentrations (excepting iron).

- A "Mineralized Background" type for the syenite aquifer characterized by specific conductance less than 1,000 uS, pH greater than 6.8 s.u., sulfate of 75 to 400 mg/l, iron greater than 0.3 mg/l and arsenic greater than 0.1 mg/l, very low nitrate and very low cadmium, copper, nickel and zinc concentrations.

- An "ARD/Mining Impacted" type characterized by specific conductance greater than 1,000 uS, pH generally in the range of 4 to 6 s.u., sulfate generally greater than 800 mg/l, little to no alkalinity, and elevated nitrate and metals concentrations.

Evaluation of hundreds of water quality samples from both mine sites revealed four other water types in addition to those above:

- "Non-Mineralized" type,
- "Limestone Background" type,
- "Neutralized ARD" type, and
- "Various Mine-Related Indicators" type.

It was apparent that at any station, water quality could vary seasonally and in response to recharge and runoff events. Surface waters were more apt to be of mixed types. Based on these considerations, a water quality classification system for shallow groundwater and surface water base flow was developed as presented in Table 3.3-1. It is recognized that water quality at some stations is changing, and the water type classification could change. Stormwater runoff was not classified. The reader is referred to Sections 3.3.6 and 3.3.7 for drainage basin information on water quality trends at key stations. Additional information concerning the system, water quality database, and application of the system can be found in HSI and Gallagher (2001).

An entirely different water type exists for natural groundwater in the Goslin Flats LAD area due to the dominance of alluvium and shale bedrock as aquifer materials. A distinct classification was not developed for this location. The reader is referred to SEIS Section 3.3.6 (Goslin Gulch) and HSI and Gallagher (2001) for information on water quality trends.

Water Classification Interpretations

The classification system was applied to 764 samples collected from 104 monitoring stations in 1997 through 1999. The results are presented in Figures 3.3-16, 3.3-17 and 3.3-18. These figures are shaded to indicate the zones of Mine/ARD Impacted waters (Type 3), ARD Neutralized waters (Type 4) and Various Mine-Related Indicators (Type 5). Mine facility boundaries, groundwater basins and geologic boundaries were used to assist in defining the extent of mine impacted areas where data were limited. Areas under leach pads were not classified due to lack of information, except for the Z85/86 leach pad where ARD impacts in the underdrain are known. Groundwater in the unshaded areas in these figures has not been impacted by the mines, and the groundwater conditions would be the natural background. A table with individual monitoring station classifications can be found in HSI and Gallagher (2001).

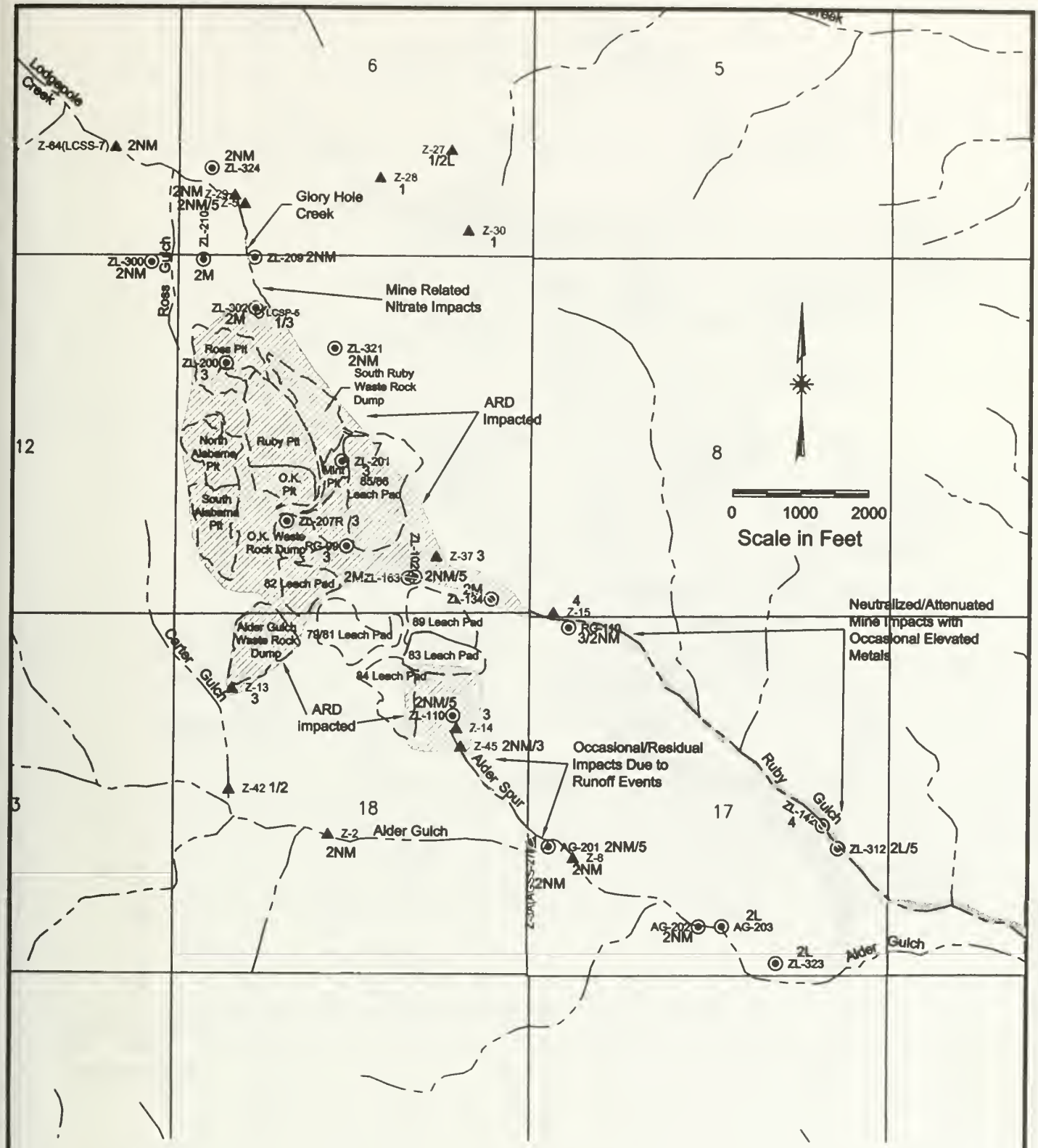
The classification system was not defined with respect to State of Montana water quality standards since interim Consent Decree standards are currently in effect at the mines. Some parameters such as nitrate were indicative of mine impacts at levels below regulatory standards (eg. below the maximum contaminant level of 10 mg/l for nitrate).

The results of the water quality classification demonstrate that ARD impacts from the mines are limited to areas beneath and immediately downgradient of pits, rock dumps and leach pad dikes. ARD-neutralized zones and low level/occasional mine-related contaminants extend downgradient of these facilities. Treated water from the water treatment plants is ARD-Neutralized type. A discussion of current conditions in each drainage, based on the water classification system, follows in Sections 3.3.6 and 3.3.7.

Table 3.3-1. Water Quality Classification System for Zortman Mine and Landusky Mine Water Samples

Water Sample Classification Rules							
TYPE	**1**	**2M**	**2NM**	**2L**	**3**	**4**	**5**
Specific Conductance (uS)	< 250	250 - 1000	< 1000	500 - 1500	≥ 1000	≥ 1000	
pH (s.u.)	6 - 8	≥ 6.8	≥ 6.8	≥ 7	≤ 6	≥ 6.8	
Nitrate (mg/l)	≤ 0.1	< 1.0	< 1.0	< 1.0	> 1.0	> 1.0	>1.0 or
Copper (mg/l)	< 0.05	< 0.05	< 0.05	< 0.05	≥ 0.1	< 0.05	> 0.05
Sulfate (mg/l)	2 - 20	75 - 400	75 - 400	$SO_4 < HCO_3$	> 400	> 400	
Alkalinity (mg/l)	5 - 30	30 - 150	30 - 150	> 150	< 20	> 20	
Arsenic (mg/l)	≤ 0.01	> 0.10	< 0.10	< 0.10	< 0.10	< 0.10	or > 0.10
Iron (mg/l)	≤ 0.5	≥ 0.3	0.01 - 1.0	< 0.1			
Cyanide (mg/l)	< 0.01	< 0.01	< 0.01	< 0.01			or > 0.01

NOTES: 1 - Headwaters Background, Groundwater (GW) & Surface Water (SW)
2M - Mineralized Syenite Background, GW & SW
2 NM - Non-Mineralized Syenite Background, GW & SW
2L - Limestone Background, GW
3 - Mine/ARD Impacted, GW & SW
4 - Neutralized ARD-Mixed, GW & SW
5 - Various mine-related indicators at low levels or occasionally (nitrate, metals, cyanide), non-Type 4 Classification based on Swift Gulch Data, 1996-2000, adjusted for the observed ranges at other sites with pH and SC fixed.



CLASSIFICATIONS

1 - Headwaters Background, GW & SW

2M - Mineralized Syenite Background GW & SW

2NM - Non-Mineralized Syenite Background GW & SW

2L - Limestone Background GW

3 - Mine/ARD Impacted, GW & SW

4 - Neutralized ARD-Mixed GW & SW

5 - Various Mine-related Indicators at low levels or occasionally (NO3-N, As, Metals, CNT), non-Type 4

LEGEND

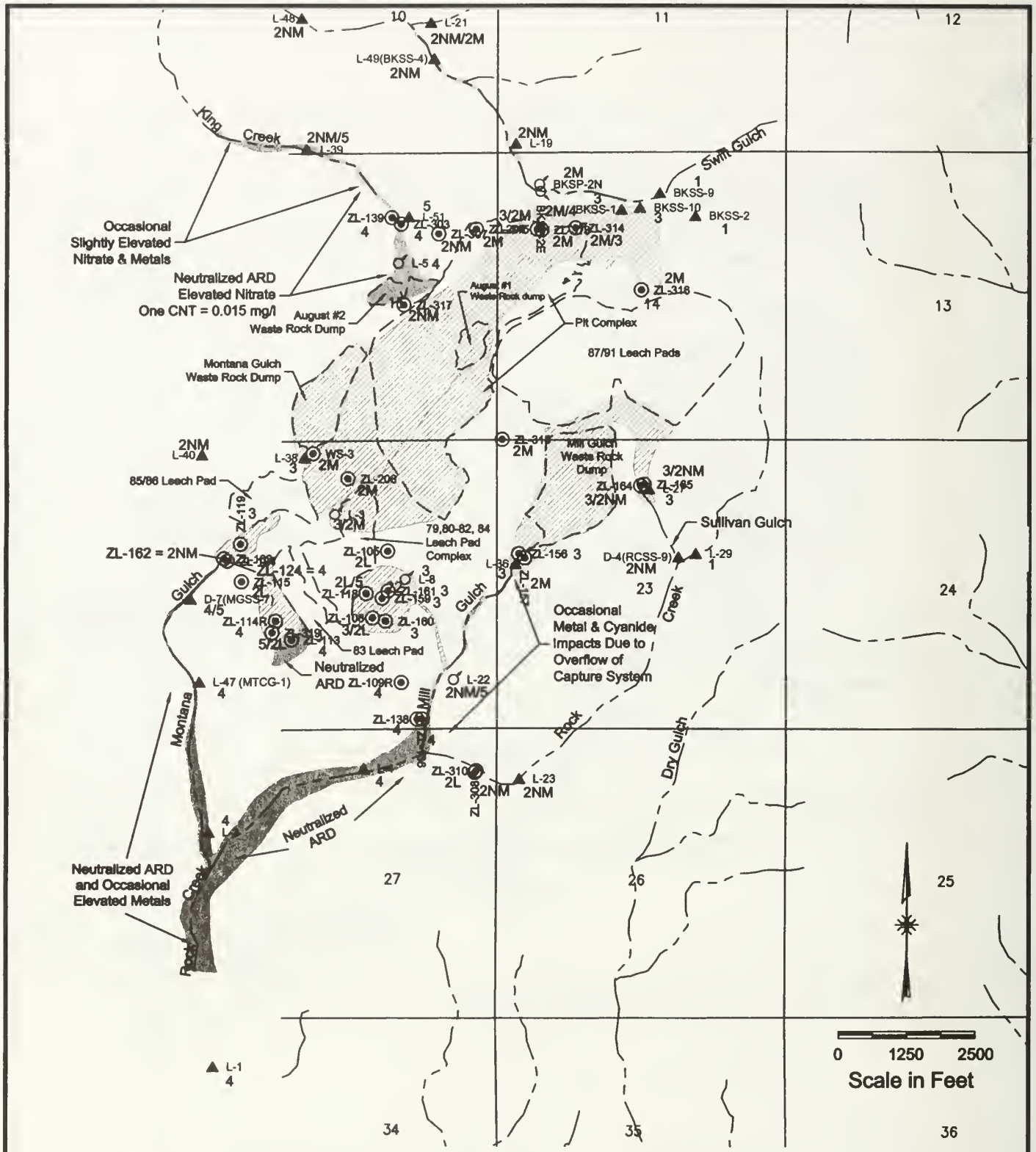
RG-4 Active Monitoring Well

Z-59 Stream Flow Monitoring Station

L-22 Spring, Seep, or Adit Monitoring Station

ZORTMAN MINE WATER CLASSIFICATION SYSTEM

FIGURE 3.3-16



CLASSIFICATIONS

1 - Headwaters Background, GW & SW

2M - Mineralized Syenite Background GW & SW

2NM - Non-Mineralized Syenite Background GW & SW

2L - Limestone Background GW

3 - Mine/ARD Impacted, GW & SW

4 - Neutralized ARD-Mixed GW & SW

5 - Various Mine-related Indicators at low levels or occasionally (NO3-N, As, Metals, CNT), non-Type 4

LEGEND

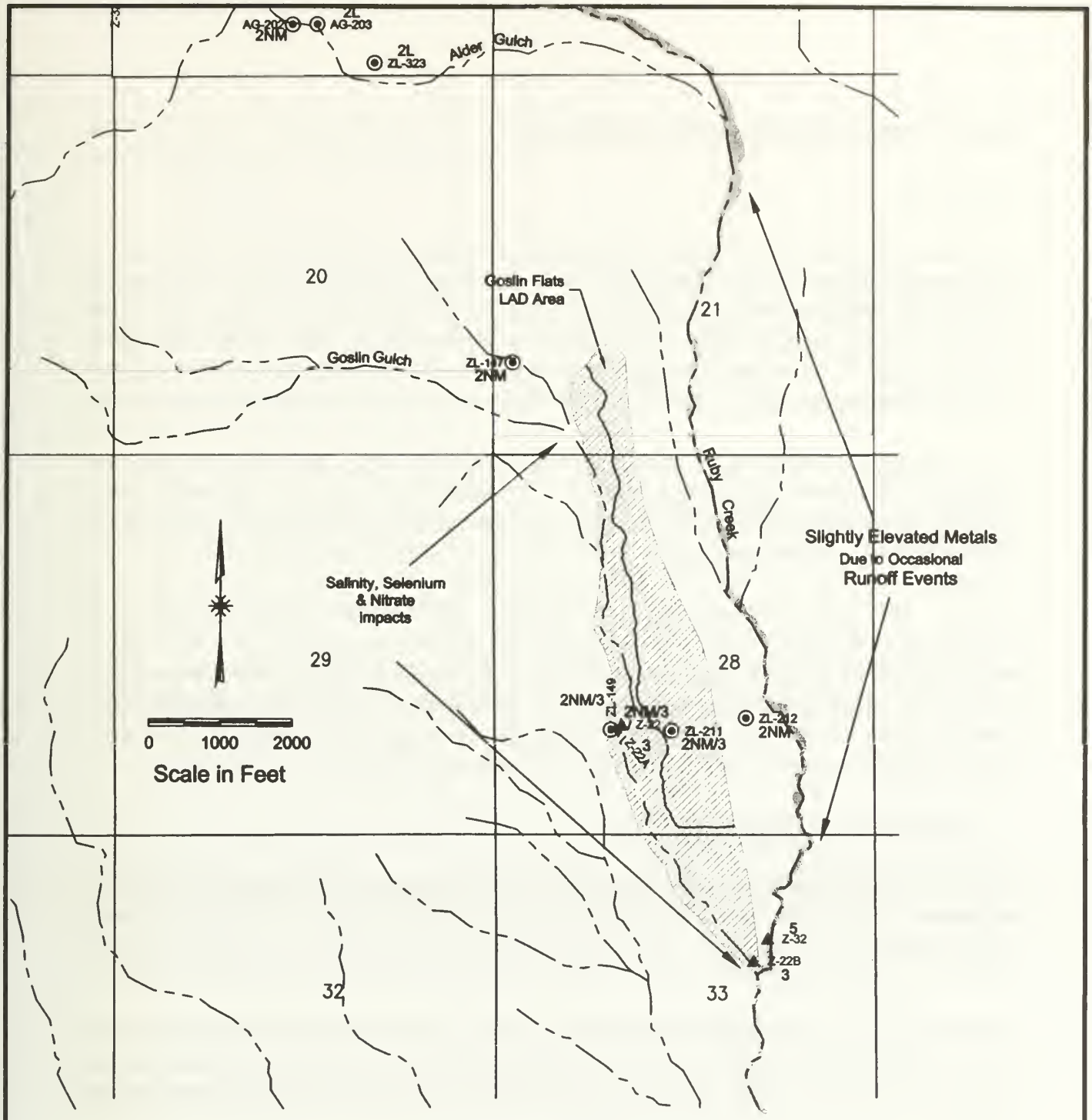
RG-4 Active Monitoring Well

Z-59 Stream Flow Monitoring Station

L-22 Spring, Seep, or Adit Monitoring Station

LANDUSKY MINE WATER CLASSIFICATION SYSTEM

FIGURE 3.3-17



CLASSIFICATIONS

1 - Headwaters Background, GW & SW

2M - Mineralized Syenite Background GW & SW

2NM - Non-Mineralized Syenite Background GW & SW

2L - Limestone Background GW

3 - Mine/ARD Impacted, GW & SW

4 - Neutralized ARD-Mixed GW & SW

5 - Various Mine-related indicators at low levels or occasionally (NO3-N, As, Metals, CNT), non-Type 4

LEGEND

RG-4 Active Monitoring Well

Z-59 Stream Flow Monitoring Station

L-22 Spring, Seep, or Adit Monitoring Station

GOSLIN GULCH WATER CLASSIFICATION SYSTEM

FIGURE 3.3-18

3.3.6 Zortman Mine Drainage Basin Hydrology

Ruby Gulch

Ruby Gulch is located in the northeastern portion of the Zortman Mine area (Figure 3.3-19). The majority of the mine facilities are within the northwestern portion of the Ruby Gulch drainage and include the Ruby, O.K., Mint and North Alabama pits, the northern portion of the South Alabama pit, a portion of the Z79/80/81, and Z83 leach pads, the Z85/86 and Z89 leach pads and dikes, the O.K. and Ruby Gulch waste rock facilities, the Zortman Mine process plant and water treatment plant, the Ruby Gulch capture system and pond, and the Ruby Gulch tailings deposit. The location of facilities is shown on Figure 3.3-19.

A permanent capture system was constructed in 1994 to replace the interim system. This system captures seepage from the Z85/86 leach pad underdrain (at Z-37), buried seeps and springs, and possibly buried adit discharge, as well as upgradient surface mine drainage runoff. Captured water is pumped to the Zortman Mine water treatment plant.

In addition, Ruby Gulch receives discharge from the Zortman Mine water treatment plant, which treats water captured in upper Ruby Gulch, Alder Spur, and Carter Spur. The flow of Ruby Gulch, ranging from 0 to 2 million gallons per day, is almost wholly provided by discharge from the water treatment plant. Due to the low flows in these drainages during much of the year,and the capacity of pre-treatment holding ponds, the water treatment plant only operates intermittently. A dramatic improvement in the quality of the surface water has been observed since initiation of capture and treatment.

Ruby Gulch Tailings

The Ruby Gulch tailings deposit was generated by historical mining operations predating the open pit operations. The mine tailings deposit overlies the native alluvium of Ruby Gulch. The tailings extend from the Ruby Gulch capture system downstream through the town of Zortman. Between the capture system and the mine gate, the tailings cover approximately 19.4 acres at an average depth of six feet.

The tailings are composed primarily of oxidized syenite porphyry. Acidity testing of the tailing material was performed by Robertson (1999). Field pH values ranged from 5.8 to 7.6 s.u. TDS ranged from 70 to greater than 2,000 mg/l, with a mean of 800 mg/l. The results of geochemical testing using ABA methods indicate that the Ruby tailings are NAG material.

Two monitoring wells, RG-110 and ZL-143, are screened through the Ruby Gulch tailings and underlying alluvium. Water quality data from these wells indicates that the water is primarily classified as neutralized ARD, with occasional elevated metals and nitrate. Water quality in these wells is probably influenced by the discharge from the Zortman water treatment plant. However, it has lower TDS than the treatment plant discharge, indicating the input of other non-mine recharge. On rare occasions, spikes of ARD-impacted water apparently reaches these wells, resulting in temporary elevated sulfate, TDS and metals, and

depressed pH and alkalinity. Due to the apparent association with spring and early summer, mine runoff is the likely source of these short-term events.

Monitoring Locations

Surface Water: Eleven upper and lower Ruby Gulch monitoring stations were used to evaluate surface water conditions in the FEIS (p. 3-58). The 11 surface water monitoring stations used for interpretations in the Groundwater Study included four FEIS stations and seven additional sites (WMCI, pp. 397-398). Station locations are shown in Figure 3.3-19. Many of the surface water stations were temporary gauging sites and have a limited period of record. In accordance with the Consent Decree, only one station located below the water treatment plant (Z-15), is routinely monitored.

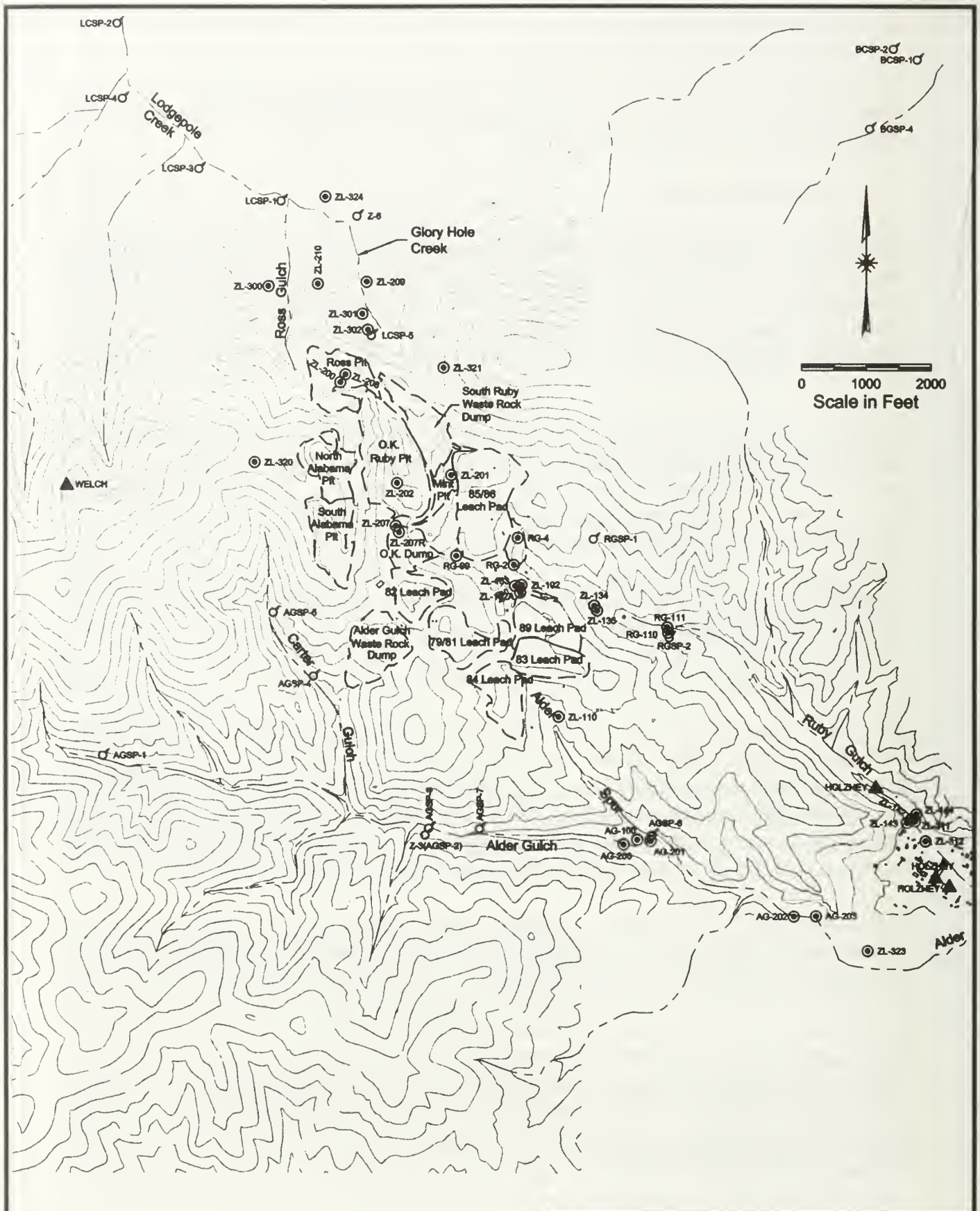
Groundwater: One new monitoring well, ZL-312, and one piezometer, ZL-311, were installed in lower Ruby Gulch for the Groundwater Study. ZL-312 is a deep well (screened interval 656-697 feet below ground level (bgl)) completed in the top of the Mission Canyon Formation. A total of 26 wells, including the two new wells, were used in the Groundwater Study evaluation. The FEIS evaluation used 13 of these wells. Well locations are shown on Figure 3.3-19.

Additional information regarding surface and groundwater monitoring stations can be found in Gallagher (1999) and HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Conditions: The 1996 FEIS noted declining surface water quality in the upper Ruby Gulch drainage, mostly due to deepening of the pits into the sulfide (FEIS, p. 3-58). Impacts to downgradient surface water quality in the vicinity of the Zortman townsite were much less severe but included elevated concentrations of sulfate, TDS, SC and metals, and depressed pH conditions. After extreme rainfall or snowmelt, impacts to water quality were seen 1.5 miles downstream from the town of Zortman at Z-32, before the Ruby Gulch capture system was installed (FEIS, p. 3-61).

FEIS Groundwater Quality Conditions: The FEIS concluded that groundwater beneath and immediately downgradient of the pits in upper Ruby Gulch has been impacted by mining operations (FEIS, p. 3-98). Groundwater beneath the pits exhibited the poorest quality with low pHs (generally below 4 s.u.), and high SC, sulfate and metals concentrations. Groundwater between the pits and the town of Zortman had variable water quality, but was generally less impacted than beneath the pit area. Water in a shallow Madison Group well (ZL-142) near the Zortman Mine had a neutral pH, but elevated specific conductance (SC) and sulfate, suggesting the water recharging the limestone was impacted by neutralized ARD (FEIS, p. 3-98). Additionally, cyanide was detected a number of times at trace concentrations in water from the adjacent alluvial well, ZL-143. The Zortman townsite water supply well, Z-8A, was not affected by discharges or seepage from the mine.

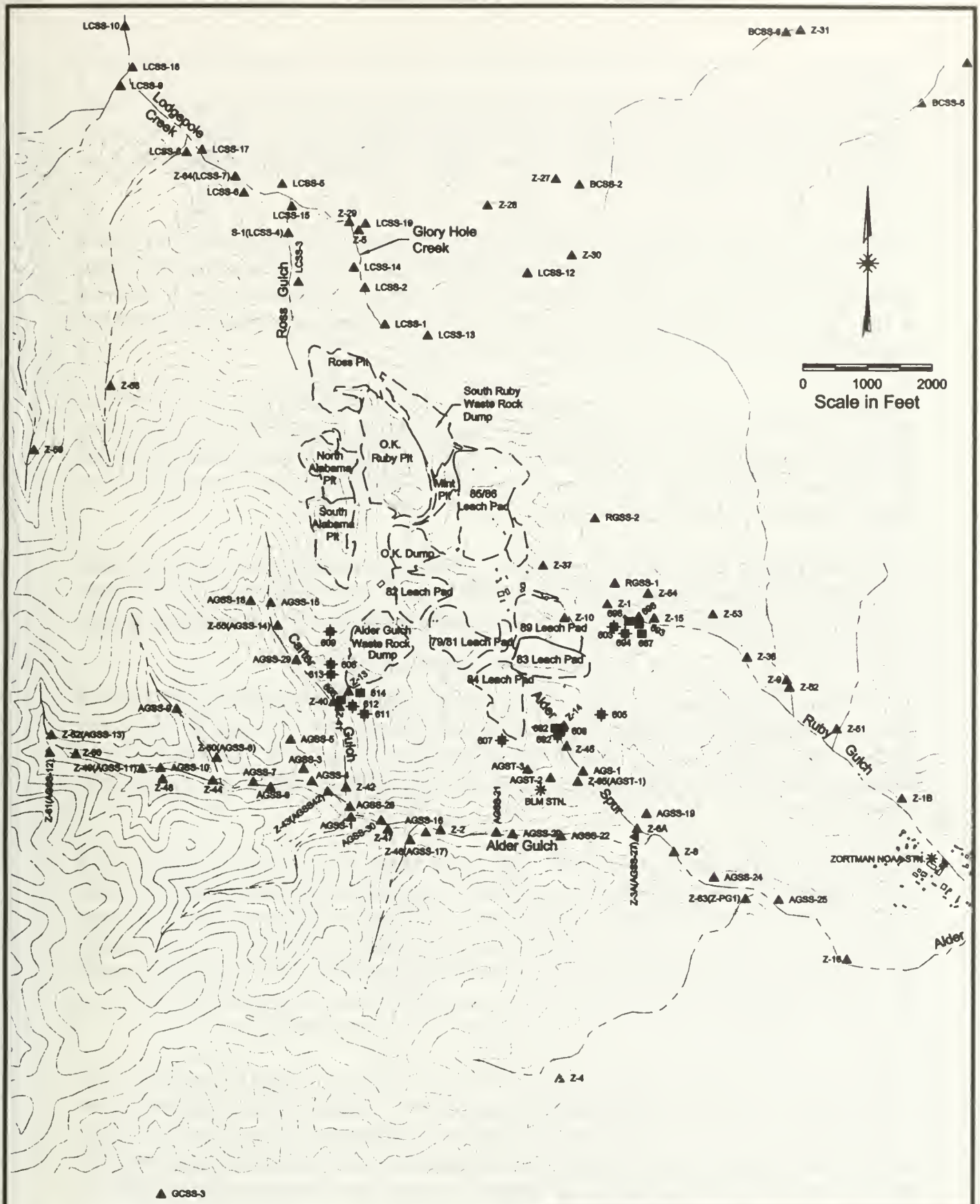


LEGEND

RG-4	Active Monitoring Well
L-22	Spring, Seep, or Adit Monitoring Station
BLM	Water Supply Well

ZORTMAN MINE MONITORING SITES (Groundwater)

FIGURE 3.3-19a



ZORTMAN MINE MONITORING SITES (Surface)

FIGURE 3.3-19b

Current Water Quality Conditions: Figure 3.3-16 shows the area of impacted surface and groundwater in Ruby Gulch based on the classification system described in Section 3.3.5. A summary of post-1995 water quality trends is presented in Table 3.3-2. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-20 and 3.3-21.

Current Surface Water Conditions: Seepage from the Z85/86 pad underdrain, buried springs and/or discharge from the buried mine adits is captured at station Z-37 and pumped to the Zortman Mine water treatment plant. This seepage represents the most concentrated ARD on either mine site, and is classified as Type 3 water quality (SEIS, Section 3.3.5). Since 1995, the captured seepage quality has remained generally stable, with only a slightly increasing sulfate trend.

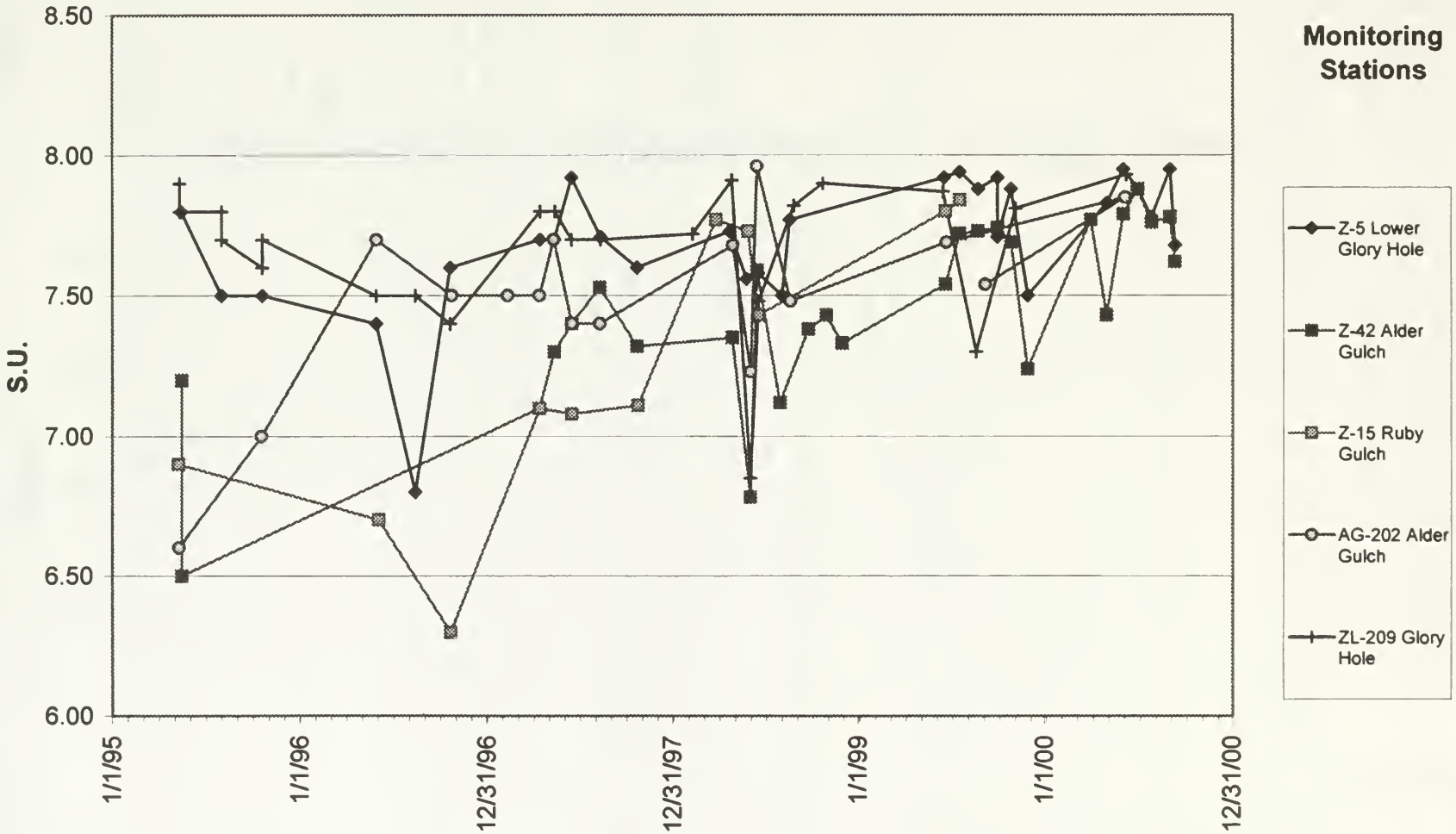
Since the flow in Ruby Gulch is generally the result of controlled discharge from the Zortman Mine water treatment plant (except during wet periods), water quality in the drainage at station Z-15 typically is classified as neutralized ARD (Type 4). The treated water meets the effluent limits specified by the Consent Decree, as shown by data from outfall samples (#667). The characteristics of the treated water include elevated total dissolved solids, sulfate, hardness, and nitrate.

Ruby Creek below the Zortman Mine flows only in response to major runoff events so it is sampled infrequently. Elevated metals concentrations were evident in two post-1995 runoff events. Otherwise, there is no evidence of mining-related impacts down to the confluence with Goslin Gulch, about three miles south of the town of Zortman.

Current Groundwater Quality Conditions: Groundwater (up to 500 feet bgl) beneath the pits is impacted by the pits, exhibiting low pH values and elevated SC and metals concentrations. Post-1995 data indicate that the groundwater pH in the vicinity of the pits is generally stable. However, SC, sulfate and metals are increasing (Table 3.3-2). All groundwater in the vicinity of the pit is classified as Type 3, mine/ARD-impacted quality.

As noted, water discharged from the Zortman Mine water treatment plant represents neutralized ARD quality (Type 4). Alluvial groundwater immediately below the water treatment plant discharge represents a mixed type (Type 3/2NM) with most samples exhibiting ARD-related impacts as shown by data from well RG-110. Deeper syenite bedrock groundwater is not impacted by mining activities and is classified as non-mineralized background quality (Type 2NM) based on data from RG-111, located adjacent to RG-110. Near the mouth of Ruby Gulch, shallow groundwater in alluvium, and in bedrock aquifers in contact with alluvium (ZL-142), reflects treated water quality, i.e. neutralized ARD (Type 4).

Deep groundwater (more than 655 feet bgl) in the Madison Group Mission Canyon Formation (ZL-312) near Zortman mostly resembles natural limestone water quality. However, it contains elevated arsenic concentrations (more than 0.1 mg/l), although values have declined and stabilized since June 1997. Slightly elevated levels of iron and manganese have also been detected, although no other ARD or neutralized ARD indicators were seen. Well logs for ZL-312 indicate this well was screened through pyritized limestone,



pH Trends Below Zortman Mine

FIGURE 3.3-20

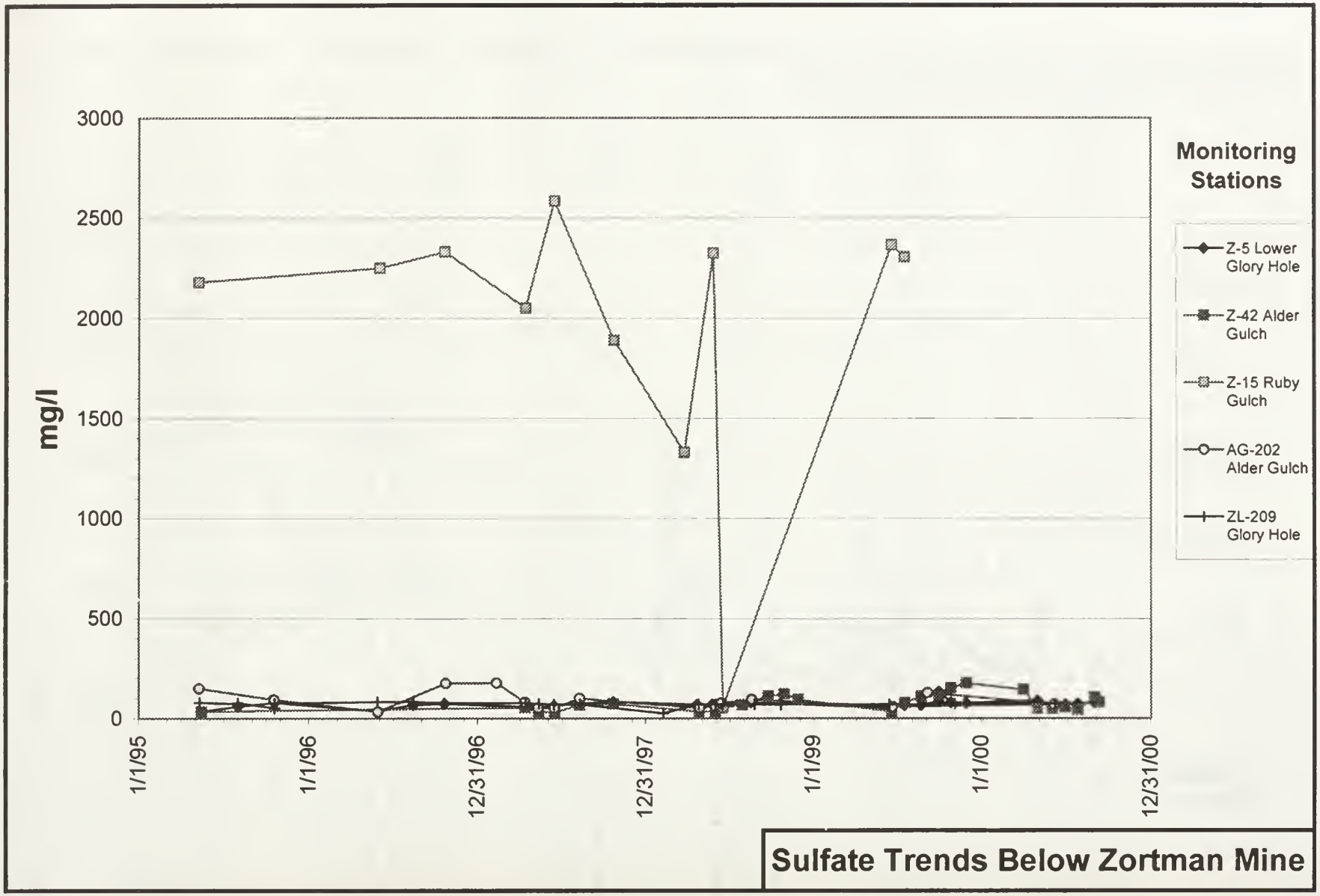

3000
2500
2000
1500
1000
500
0
mg/l
1/1/95
1/1/96
12/31/96
12/31/97
1/1/99
1/1/00
12/31/00
Monitoring Stations
Z-5 Lower Glory Hole
Z-42 Alder Gulch
Z-15 Ruby Gulch
AG-202 Alder Gulch
ZL-209 Glory Hole
Sulfate Trends Below Zortman Mine

FIGURE 3.3-21

indicating natural mineralization of the limestone in this area. The water quality of this aquifer is classified as natural limestone background with mining-related impact indicators. However, natural mineralization may be responsible for some or all of the metal detections.

Based on monitoring results at alluvium/bedrock well pairs RG-110/RG-111 and ZL-142/ZL-312, the worst-case locations for potential mining impacts, vertical migration of contaminants into deeper groundwater flow systems in Ruby Gulch may have occurred, but only to a minor extent.

The Zortman Water Balance and Mass Loading report (Spectrum 2000a) defined current loads of metals and sulfate to the subsurface, which included loading to groundwater, and to groundwater that becomes surface water within or near the mine site. Mass loading calculations indicate nearly 70% of the Ruby Gulch metals and sulfate loads are contributed by the mine pits (Spectrum 2000a). However, the majority of seepage to the subsurface is collected and treated. Including the leach pads, the Ruby Gulch drainage contains an estimated 78% of the total sulfate load and 82% of the total metals load produced by the entire Zortman Mine. Of the total mine contaminant load in the groundwater, excluding leach pads, Ruby Gulch contains an estimated 73% of the sulfate load and 76% of the total metals load. These estimates include mine-related and natural background loads. Over the entire Zortman Mine site, the total metals and sulfate loads to groundwater not captured is estimated at 3% and 2%, respectively.

Alder Gulch

The Alder Gulch basin in the southern portion of the Zortman Mine has several tributaries, including Carter Gulch, Carter Spur, Alder Spur and Pony Gulch (Figure 3.3-19). Zortman Mine facilities located in the Alder Gulch drainage basin include the Z83/84 leach pads and dikes, the Alder Gulch waste rock dump, the majority of the Z79/80/81 leach pads, the Z83 leach pad, a portion of the Z82 pad, the west half of the North Alabama pit, and the South Alabama pit. The locations of facilities are shown in Figure 3.3-19.

In late 1996, permanent capture systems began operating below the Z83/84 dikes in Alder Spur, and below the Alder Gulch waste rock dump in Carter Spur. The Alder Spur capture system was designed to capture water penetrating the Z83 and Z84 dikes that surfaced at the toe of the facility. The Carter Gulch seepage capture system was designed to capture water penetrating the Alder Gulch waste rock dump that surfaced at the toe of the dump. Captured seepage is pumped to the Zortman Mine water treatment plant. The treated water is then released into Ruby Gulch.

Improvements in water quality were evident in downgradient surface and groundwater after installation of the capture systems. Seepage from the Alder Gulch waste rock dump and the Z83/84 leach pad underdrains was the major contributor to poor water quality downgradient from these facilities. Seepage from the waste rock dump continues to be of poor quality, while that from the leach pad underdrains has improved somewhat. Mining impacts are not present in surface and groundwater near the mouth of Alder Gulch.

Monitoring Locations

Surface Water: Seven monitoring stations were used to evaluate surface water conditions in the FEIS (p. 3-61), while 54 stations were reviewed for the Groundwater Study, including 30 new sites (WMCI, p. 360). Many of these sites were temporary stream gauging stations used for the synoptic stream surveys to evaluate losses to or gains from groundwater along the stream channel. All stations used for the FEIS were also used in the Groundwater Study. Surface water station locations are shown in Figure 3.3-19. Many stations have a limited period of record.

Groundwater: One new well, ZL-323, and one piezometer, ZL-320, were installed in Alder Gulch for the Groundwater Study. A total of 10 monitoring points, including the new well and piezometer, were used in the Groundwater Study. The FEIS used six of these wells. Locations are shown in Figure 3.3-19. Additional information on surface and groundwater monitoring stations can be found in Gallagher (1999) and HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Quality Conditions: The 1996 FEIS noted impacts in Alder Gulch due to seepage from the waste rock dump. Impacts include decreasing pH and elevated sulfate, TDS and SC concentrations (FEIS, pp. 3-68 and 3-70). Surface water quality was also affected by spills and land application of process chemicals, with cyanide detections below the Alder Spur confluence. The FEIS noted that the capture and pumpback systems at that time were improving water quality in Alder Gulch below Alder Spur (Z-8).

FEIS Groundwater Quality Conditions: The FEIS concluded that alluvial groundwater near the mouth of Alder Spur had been impacted by the land application disposal used in 1986/87 (FEIS, p. 3-98). Deeper groundwater (160-200 feet bgl) under the Alder Gulch waste rock dump (located in Carter Spur) was not impacted by seepage from the dump, as indicated by decreasing levels of SC, TDS and hardness at ZL-107R. Deeper bedrock groundwater in Alder Spur did not show impacts due to mining (ZL-110). Most alluvial water showed a period of degraded water quality during 1991 with improvements since that time to 1995 (FEIS, p. 3-98).

<u>Current Water Quality Conditions</u>: Figure 3.3-16 shows the area of impacted surface water and groundwater in Alder Gulch based on the classification system described in Section 3.3.5. A summary of current water quality conditions and post-1995 water quality trends is presented in Table 3.3-2. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-20 and 3.3-21.

Current Surface Water Quality Conditions: Water quality at the Carter Spur pumpback, station Z-13, shows a continuing decline in pH to near 3 s.u., and widely fluctuating, but continuing increases in sulfate, specific conductance and metals concentrations. In contrast, since 1995 at the Alder Spur pumpback station (Z-14), pH has increased to around 6 s.u., metals concentrations have declined, and sulfate and

specific conductance have leveled off. While these waters are both consistent with the Type 3 (mine/ARD impacted) classification, ARD from the waste rock dump is more concentrated than ARD from the underdrains. Surface water in the mainstem of Alder Gulch, downgradient from the Carter Gulch and Alder Spur confluence (Z-8), is typical of unimpacted non-mineralized water quality (Type 2). 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 s.u., low SC, low metals concentrations, and no nitrate detections.

Current Groundwater Water Quality Conditions: Water quality in Alder Gulch has improved since construction of the capture systems. 1997-2000 data indicate that alluvial groundwater near the mouth of Alder Gulch (AG-201, AG-202) does not exhibit impacts from mine activities, nor does groundwater in the deeper limestone aquifer. With the exception of one slightly elevated nitrate value (1.5 mg/l), deeper groundwater in Alder Spur is representative of non-mineralized syenite background water quality.

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.

The Zortman Water Balance and Mass Loading report (Spectrum 2000a) defined current loads of metals and sulfate to the subsurface, which included loading to groundwater, and to groundwater that becomes surface water within or near the mine. Mass loading calculations indicate over 44% of the sulfate load and 68% of the metals load in Alder Gulch are contributed by the Alder Gulch waste rock dump (Spectrum 2000a). However, the majority of seepage to the subsurface is collected and treated. Including leach pads, Carter Gulch contains approximately 13% and 17%, respectively, of the total Zortman Mine sulfate and total metals loads to groundwater. Excluding leach pads, Carter Gulch contains an estimated 25% of the sulfate load and 23% of the total metals load, representing the portions of the mine loads that reach groundwater. Alder Spur contains about 8% of the sulfate load and 1% of the total metals load produced by the Zortman Mine. Of the total mine contaminant load in the groundwater, excluding leach pads, Alder Spur contains an estimated 2% of the sulfate load and 0.2% of the metals load.

Goslin Gulch

Goslin Gulch is located approximately one mile south of the town of Zortman, and joins Ruby Creek approximately three miles south of the town of Zortman. Goslin Gulch is an ephemeral drainage with several low-yielding springs. Discharge from the springs and ponds produces short reaches of surface flow and/or standing water; however, the channel is typically dry. There are at least three stock ponds in the creek that are fed by springs and runoff water.

Alluvial terraces flanking Goslin Gulch were identified in 1991 as potential LAD areas for leach pad waters. The baseline groundwater conditions in the Goslin Flats LAD area were investigated and reported by Hydrometrics (1991) and WMCI (1998). Groundwater occurs in the alluvium of Ruby Creek and Goslin Gulch, and in the underlying Thermopolis shale bedrock.

A 55-acre LAD area was developed within the Goslin Gulch basin by ZMI, beginning in June 1998. It was expanded to 96 acres in 1999, and to 410 acres during 2000. Leach pad solutions from the mines have been applied through sprinklers to the LAD for treatment of metals and nitrate. A total of 107, 108 and 137 million gallons of leach pad solutions were applied to the LAD area in 1998, 1999, and 2000, respectively. The location of the LAD area is shown in Figure 3.3-22.

The initial LAD area was not originally designed as a zero discharge system, and seepage of groundwater from the LAD area to Goslin Gulch occurred from 1998 to 2000. The discharge of spring Z-22 on the southwest edge of the original LAD area increased, and the concentration of salts, nitrate and trace elements also increased. New springs and seeps appeared on the west side of the LAD, near Goslin Gulch. Selenium, which is present in the L87 and L91 leach pads at concentrations up to 1.2 mg/l, was detected in samples of springs in Goslin Gulch.

The expansion of the LAD to 410 acres in 2000 led to a decline in the amount of discharge and contaminants reaching Goslin Gulch, surface water and groundwater. A water management plan for the Goslin Flats LAD is in the Goslin Flats Land Application Disposal Expansion Assessment and 2000-2001 Plan of Operations (HSI/Spectrum 2000). Continued monitoring of surface water, groundwater, soils and vegetation in the LAD area is part of the present operating plan.

Monitoring Sites

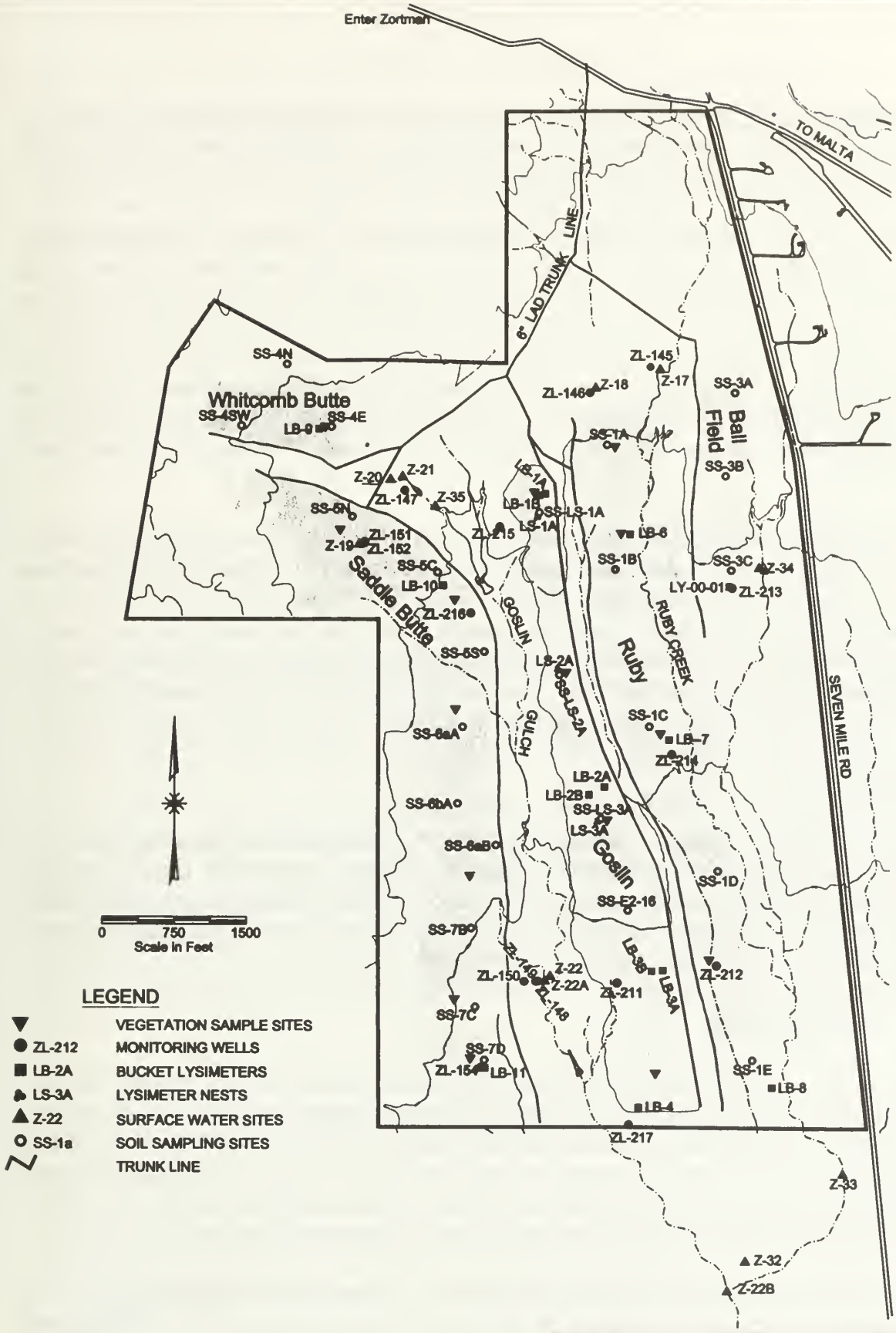
Surface Water: A total of 14 surface water monitoring stations (including springs) have been established in the Goslin Flats LAD area. Some of these only flow seasonally or in response to large storm events. Monitoring station locations are shown on Figure 3.3-22.

Groundwater: A total of 15 monitoring wells have been installed in the Goslin Flats area. Well locations are shown on Figure 3.3-22. Detailed information regarding surface water and groundwater stations can be found in HSI/Spectrum (2000), and in HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Quality Conditions: The 1996 FEIS noted that surface waters in Goslin Gulch were near neutral in pH, but had elevated sulfate, SC and TDS. This was attributed to water interacting with the marine shale bedrock beneath the area (FEIS, p. 3-67).

FEIS Groundwater Quality Conditions: The FEIS concluded there were no mining-related impacts to Goslin Flats groundwater. Elevated TDS and sulfate concentrations in the alluvial and shallow bedrock aquifers in Goslin Flats are the natural result of the interaction of water with the underlying mineral-rich shales (FEIS, p. 3-98).



GOSLIN GULCH LAD MONITORING SITES

FIGURE 3.3-22

Current Water Quality Conditions: Figure 3.3-18 shows the area of impacted surface and groundwater in Goslin Gulch based on the classification system described in Section 3.3.5. A summary of post-1995 water quality trends is presented in Table 3.3-2.

Current Surface Water Quality Conditions: Baseline studies in Goslin Gulch show that many parameters were naturally above drinking water standards (WMCI, p. 487). WMCI reported naturally occurring elevated levels of aluminum, arsenic, iron, lead, manganese and selenium in springs within the basin. Ruby Creek below the confluence with Goslin Gulch has been impacted by mining-related contaminants since the Goslin Flats LAD was placed in operation in 1998. These contaminants have included nitrate, selenium, cyanide and salinity. Expansion of the LAD and modified operations began to reduce impacts in the summer-fall of 2000. The impacts to lower Ruby Creek are generally limited to the zone from Goslin Gulch to the county "cut-across road," located approximately two miles below Goslin Gulch, where Ruby Creek is typically dry.

Current Groundwater Quality Conditions: Discharge from the LAD has impacted shallow alluvial groundwater in Goslin Flats with increases in nitrate, selenium, cyanide and salinity. Deeper groundwater in the Thermopolis shale is of naturally poor quality, with TDS in the range of 1,700-1,900 mg/l due to soluble salts within the formation. Groundwater in the bedrock aquifer has generally not been impacted by LAD operations. One bedrock well (ZL-149 in the Thermopolis shale) showed LAD-related impacts, with nitrate concentrations at 11.5 mg/l and small amounts of selenium and cyanide in a sample from August 2000. Water quality trends in Goslin Gulch are summarized in Table 3.3-2.

Lodgepole Creek

Lodgepole Creek, and headwater tributaries Glory Hole Creek and Ross Gulch, drain the northern end of the Zortman Mine (Figure 3.3-19). The Ross pit is located in this area of the basin. At least two historic adits, including the Pink Eye Pearl adit, daylight in upper Ross Gulch. The location of the mine facilities is shown in Figure 3.3-19. The surface water and groundwater in the mainstem of Lodgepole Creek are not impacted by mining activities.

Monitoring Sites

Surface Water: Surface water quality in Lodgepole Creek was evaluated in the FEIS using results from five monitoring stations (FEIS p. 3-67). The Groundwater Study utilized 29 stations to evaluate surface water conditions, including the FEIS stations and 22 new stations (WMCI, pp. 437-439). Station locations are shown in Figure 3.3-19. Many of these were temporary stream gauging stations and have a limited period of record. In accordance with the Consent Decree, Z5, located at the mouth of Glory Hole Creek, and S-1 (LCSS-4), located in Ross Gulch, are the only stations routinely monitored.

Groundwater: A total of five new wells and piezometers were drilled in the Lodgepole Creek drainage for the Groundwater Study. These include ZL-300, located in the Ross Gulch area; ZL-301 and ZL-302,

completed in syenite porphyry in Glory Hole Gulch; ZL-321, a Precambrian gneiss well located upgradient of Glory Hole Creek on Shell Butte; and ZL-324, also a Precambrian gneiss well located north of Lodgepole Creek. A total of 7 monitoring points, including the new well and piezometer, were used in the Groundwater Study. The FEIS used two of these wells. Locations are shown in Figure 3.3-19. Additional information regarding surface and groundwater stations can be found in Gallagher (1999) and HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Quality Conditions: The 1996 FEIS reported that surface water quality impacts in Lodgepole Creek have been minimal and are restricted to Glory Hole Creek at Station Z-5. Neutral pH values, low TDS and sulfate, and no cyanide detections indicate that impacts to Lodgepole Creek have only been short-term (FEIS, Table 3.2-32).

FEIS Groundwater Quality Conditions: The FEIS concluded there were few, if any, impacts to groundwater in Lodgepole Creek from mining activities (FEIS, 3-98). This conclusion was based on analytical data from wells ZL-209 and ZL-210, and spring Z-6.

Current Water Quality Conditions: Figure 3.3-16 shows the area of impacted surface water and groundwater in Lodgepole Creek based on the classification system described in Section 3.3.5. A summary of current conditions and post-1995 water quality trends are presented in Table 3.3-2. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-20 and 3.3-21.

Current Surface Water Quality Conditions: Surface water in the mainstem of Lodgepole Creek does not show impacts from mining activities, with surface waters classifying as non-mineralized syenite background (Type 2NM). Minor and transient impacts have been detected in both Ross Gulch and Glory Hole Creek as shown by water quality at stations LCSS-3 and Z-5, respectively. The upper portions of these drainages are classified as mixes of headwaters water quality (Type 1) with events of non-ARD related mine impacts (Type 5), primarily due to nitrate (1 to 2 mg/l), and slightly elevated metals. No mining impacts are present in Lodgepole Creek below the confluence with Ross Gulch or Glory Hole Creek.

Current Groundwater Quality Conditions: Mining activities have impacted groundwater beneath the Ross pit. This is confirmed by data from monitoring wells ZL-200 and ZL-208, and exploration hole 97ZH-018. Data show decreased pH, elevated SC, sulfate, and metals typical of Type 3 (mine/ARD impacted) water quality at these locations. Shallow groundwater impacts extend north approximately 500 feet downgradient from the Ross pit in upper Glory Hole Gulch where mine-affected water discharges at spring LCSP-5. However, deeper groundwater in this area represents naturally mineralized syenite water quality (Type 2M) as evidenced by data from ZL-302. Deeper groundwater in Ross Gulch (ZL-300) does not show any mining impacts and currently represents non-mineralized syenite background (Type 2NM) water quality.

The Zortman Water Balance and Mass Loading report (Spectrum 2000a) defined current loads of metals and sulfate to the subsurface, which included loading to groundwater, and to groundwater that becomes surface water within or near the mine site. The mass of sulfate and metals loads reaching Lodgepole Creek from the mine cannot be quantified to the same degree as drainages with capture systems. An approximation was made that relied on the water balance (Spectrum 2000a) estimate of 1.653 million gallons of annual groundwater discharge from the mine area to Lodgepole Creek, and the infiltration and chemical loads calculated for the Ross pit. The annual groundwater discharge to Lodgepole Creek represents about 26% of the total annual recharge to the Ross pit (7.9 million gallons). Using this ratio, the annual sulfate load to Lodgepole Creek is approximately 1%, and the total metals load 2% of the total loads produced by the Zortman Mine. Removing leach pads from the estimate, the percentages of mine-area sulfate and metals loads reaching groundwater are 1.9% and 2.3%, respectively. These estimates include contributions by natural mineralization and mining.

Beaver Creek

The headwaters of Beaver Creek are located northeast of the Zortman Mine area (Figure 3.3-4). No mine facilities exist within this drainage. Surface water and spring data for Beaver Creek show the drainage is not impacted by mining activities, and the water quality is representative of baseline conditions.

Table 3.3-2. Current Water Quality Conditions and Trends in Zortman Mine Drainage Basins

Drainage	Area Summary	Station Type	Current Water Class.	Trends				Remarks
				pH	Alkalinity	Sulfate/SC	Metals	
Ruby Gulch	Mine Area/ Pits	Source	3	stable, low	stable, 0	sl + to +	stable to +	ARD is strong and may be approaching maturity.
	Lower Ruby Creek	Down-gradient	4/3/5	stable	stable	stable, + Lower Ruby	stable, low	Ruby Creek has episodic impacts, little effect on beneficial uses.
Alder Gulch	Alder Spur	Source	3	variable	variable	sl +	variable	Seasonal fluctuation/event driven changes in water quality evident.
	Carter Spur	Source	3	stable to sl -	stable, 0	+	+	
	Lower Alder Gulch	Down-gradient	2NM/2L	stable	stable	stable	stable	
Goslin Gulch	Goslin LAD Summary	Source	3	stable, low	stable, high	+	metals low, selenium elevated	Occasional impacts from nitrate, selenium, cyanide and salinity.
	Goslin Gulch below LAD Summary	Down-gradient	3	stable	stable, high	-2	metals low, selenium elevated, declining in 2000	Impacts from nitrate, selenium, cyanide and salinity, but decreasing trend in 2000.
Lodge-pole Creek	Upper Glory Hole	Source	1/3 - shallow 2NM-deeper	stable	stable	stable	stable, low	Spring LCSP-5 (Z-302).
	Upper Ross	Source	1/5, 2NM, 2NM/5	variable	stable	stable, var.	stable, low	Some elevated metals at LCSP-5 (zinc, iron, manganese; nitrates greater than 1.
	Lodgepole below Ross & Glory Hole	Down-gradient	2NM	stable, sl -	stable to sl -	stable to -	stable, low	Most metals are less than detection level at Z-64. Increases in metals appear to be event driven.
Beaver Creek	Headwaters	Down-gradient	1/2L	stable	sl -	stable, v. low sulfate	iron variable, other metals non-detectable	Mixture of headwaters and limestone background, iron up to 1.2 mg/l, but other metals non-detectable; non-detectable nitrate.

Current Conditions: 1=Headwaters Background; 2M=Mineralized Syenite Background; 2NM=Non-Mineralized Syenite Background; 2L=Limestone Background; 3=Mine/ARD Impacted; 4=Neutralized ARD; 5=Various Mine-Related Indicators. Trends: + increasing; - decreasing; sl=slight

3.3.7 Landusky Mine Drainage Basin Hydrology

Rock Creek/Sullivan Gulch

The Rock Creek drainage, including Sullivan Gulch, is located on the southeastern side of the Landusky Mine area (Figure 3.3-23). This drainage includes the L91 leach pad and pad dike (located in the uppermost reach of Sullivan Gulch) and the Sullivan capture system. The location of these facilities is shown in Figure 3.3-23.

The Sullivan capture system became operational in 1997 and is designed to capture subsurface flows penetrating the L91 dike and surfacing at the toe of the facility. Captured water is routed to the Landusky Mine water treatment plant. More information on the capture systems can be found in HSI and Gallagher (2001).

Surface water and groundwater data show that contaminants are not migrating beyond the capture system. However, contaminants have reached the bedrock aquifer below the capture system, as shown by data from well ZL-165.

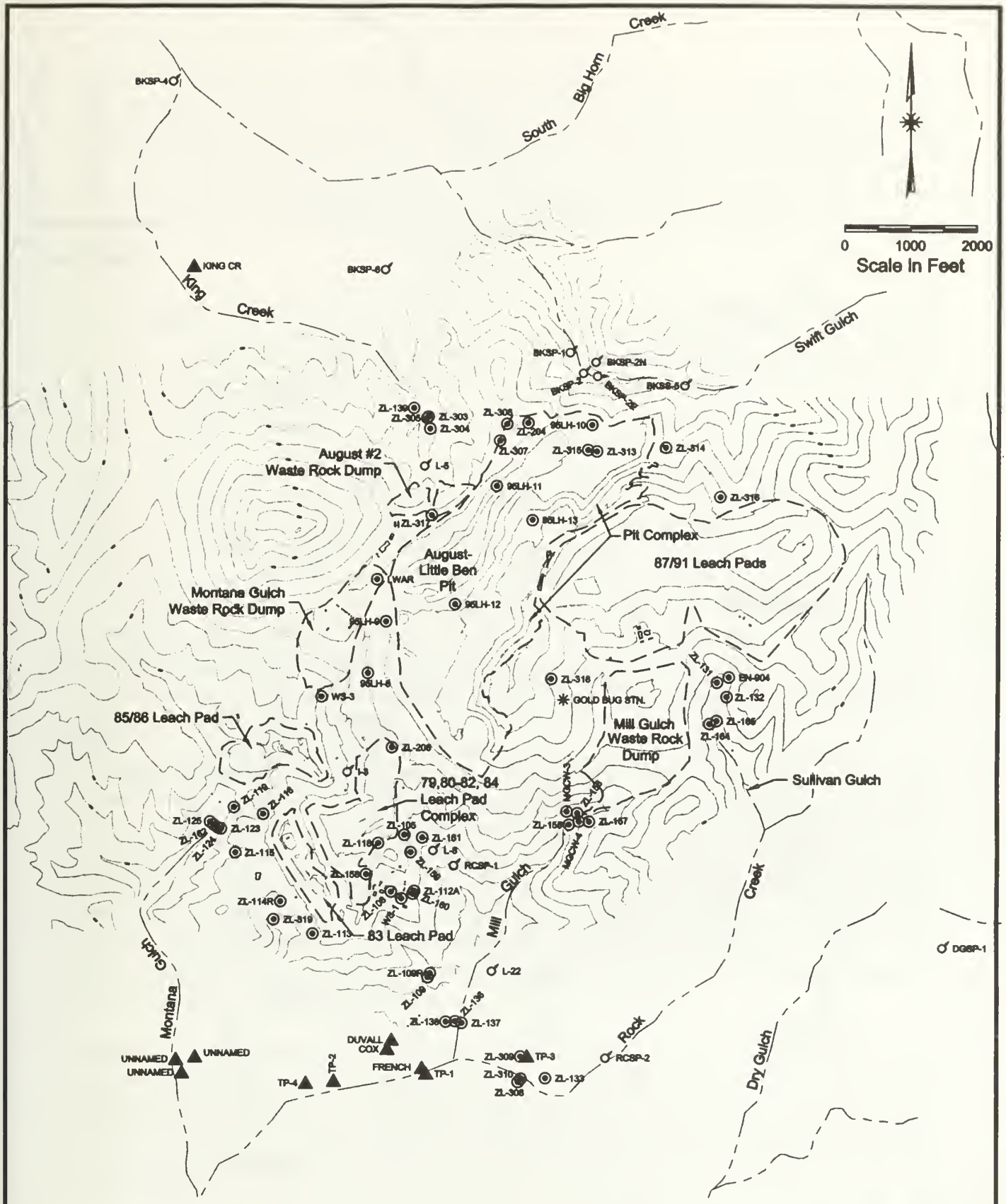
Monitoring Sites

Surface Water: A total of seven upper and lower Rock Creek stations were used in the FEIS to evaluate water quality conditions (p. 3-73). The 22 surface water stations used for interpretations in the Groundwater Study included the seven FEIS stations and 15 additional sites (WMCI, pp. 258-260). Surface water stations are shown in Figure 3.3-23. Many of the surface water stations were temporary gauging sites and have a limited period of record. In accordance with the Consent Decree only one station, D-4 (located in Sullivan Gulch) is routinely monitored.

Groundwater: Two new wells, ZL-308 and ZL-310, and one piezometer, ZL-309, were installed in Rock Creek above the town of Landusky for the Groundwater Study. ZL-308 is completed in alluvium, while ZL-309 and ZL-310 are deeper completions in the Madison Group limestones. A total of 13 wells, including the three new installations, were used in the Groundwater Study (WMCI, p. 259). The FEIS evaluation focused on six of these wells. Well locations are shown on Figure 3.3-23.

Water Quality

FEIS Surface Water Quality Conditions: Surface water quality downstream of the L91 leach pad was intensely affected by ARD, as evidenced by low pH and elevated concentrations of sulfate, TDS and SC at station L-28 (FEIS, p. 3-73). Impacts to surface water quality were evident up to 2.5 miles downgradient from the pad at station L-1. However, by 1995 downstream surface water near Landusky (L-4) and downgradient from the Montana Gulch/Rock Creek confluence (L-1) showed no or slight impacts from mining activities (FEIS, p. 3-73).

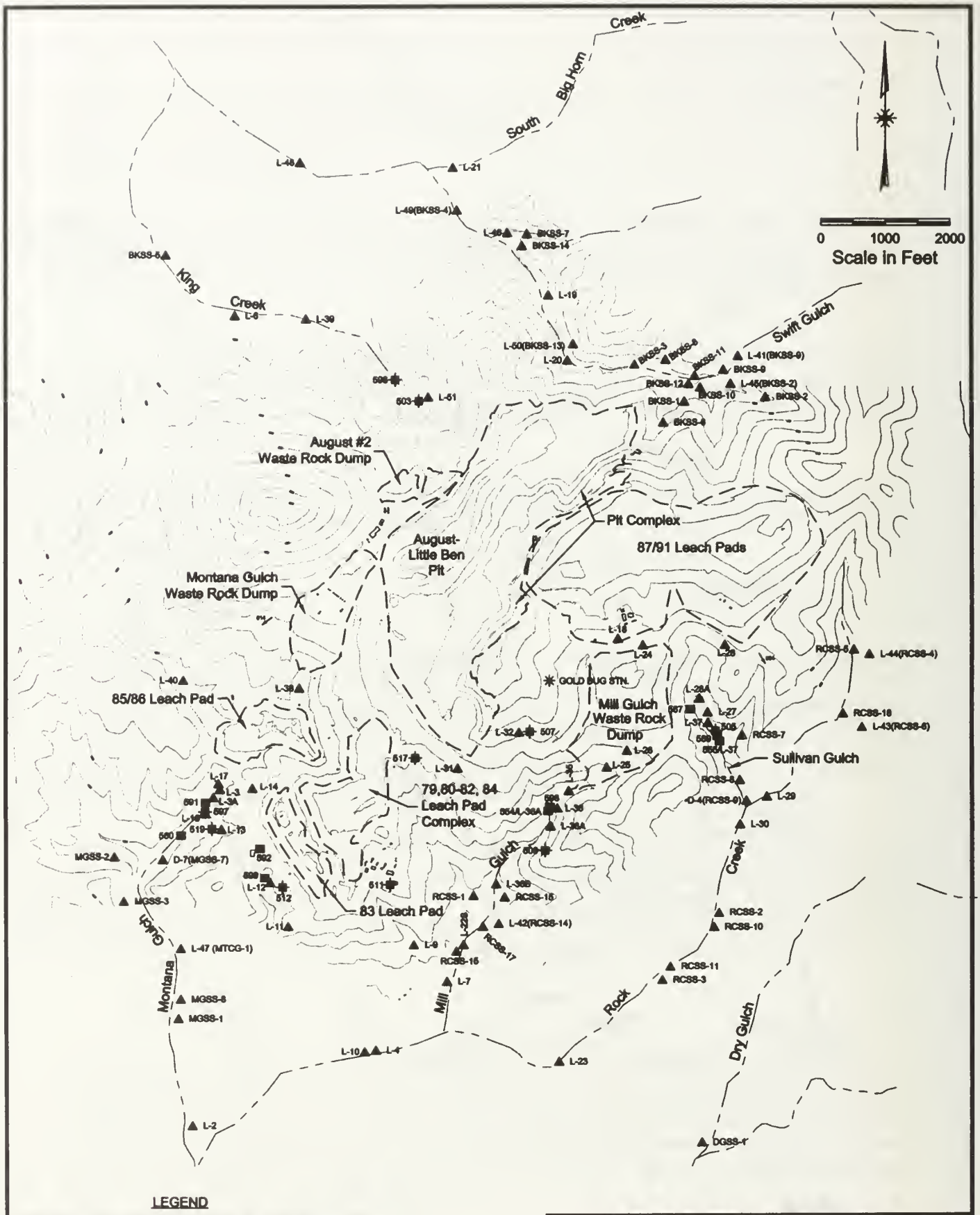


LEGEND

RG-4	Active Monitoring Well
L-22	Spring, Seep, or Adit Monitoring Station
BLM	Water Supply Well

LANDUSKY MINE MONITORING SITES (Groundwater)

FIGURE 3.3-23a



LANDUSKY MINE MONITORING SITES (Surface)

FIGURE 3.3-23b

FEIS Groundwater Quality Conditions: 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 decreased pH and increased SC, sulfate and metals concentrations in samples from alluvial well ZL-132 and bedrock well ZL-131. No impacts were identified in Rock Creek in and near the town of Landusky, although it was noted that the groundwater quality data was questionable (FEIS, p. 3-99).

Current Water Quality Conditions: Figure 3.3-17 shows the area of impacted surface water and groundwater in Sullivan Gulch and Rock Creek, based on the classification system described in Section 3.3.5. A summary of current conditions and post-1995 water quality trends is presented in Table 3.3-3. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-24 and 3.3-25.

Current Surface Water Quality Conditions: The Sullivan Gulch capture system (L-27) collects ARD-impacted waters characterized by low pH, and high TDS, sulfate, metals, nitrate and cyanide. Water quality trends indicate gradually worsening ARD characteristics in 1997 and 1998, with more stable conditions to present. At the confluence with Rock Creek, Sullivan Gulch water quality is typical of unmineralized syenite (Type 2NM), as evidenced by data from D-4. There may be a slightly increasing trend in sulfate and TDS, but metals are stable, and pH and alkalinity appear to be slightly increasing. Below Mill Gulch (L-4), surface water is characteristic of neutralized ARD. The pH and alkalinity have remained stable since 1995; however, surface water in this area is not routinely sampled and there is little post-1995 data for sulfate and metals. Below Montana Gulch (L-1) Rock Creek water quality represents neutralized ARD (Type 4) and exhibits upward trends in sulfate, TDS, and selected metals such as copper and zinc.

Current Groundwater Quality Conditions: Upstream of the Sullivan Gulch capture system, the alluvial aquifer and bedrock aquifer are ARD-impacted (Type 3), with pH of 4 to 6 s.u., high sulfate and TDS, and elevated metals. The capture system intercepts the entire thickness of alluvial aquifer, sending this groundwater to the Landusky treatment plant. 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 (Type 2L) as evidenced by data from ZL-308, ZL-310, and ZL-133. 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.

Based on the water balance results and average concentrations of parameters, average annual sulfate and total metals loads were evaluated for each facility at the Landusky Mine (Spectrum 2000b). Sullivan Gulch contains approximately 4.3% of the total sulfate load, and 15.7% of the total metals load produced by the Landusky Mine, inclusive of leach pads and background loads. Excluding leach pads, Sullivan Gulch contains 12.9% of the total sulfate load, and 19.2% of the total metals load in the groundwater at the Landusky Mine.

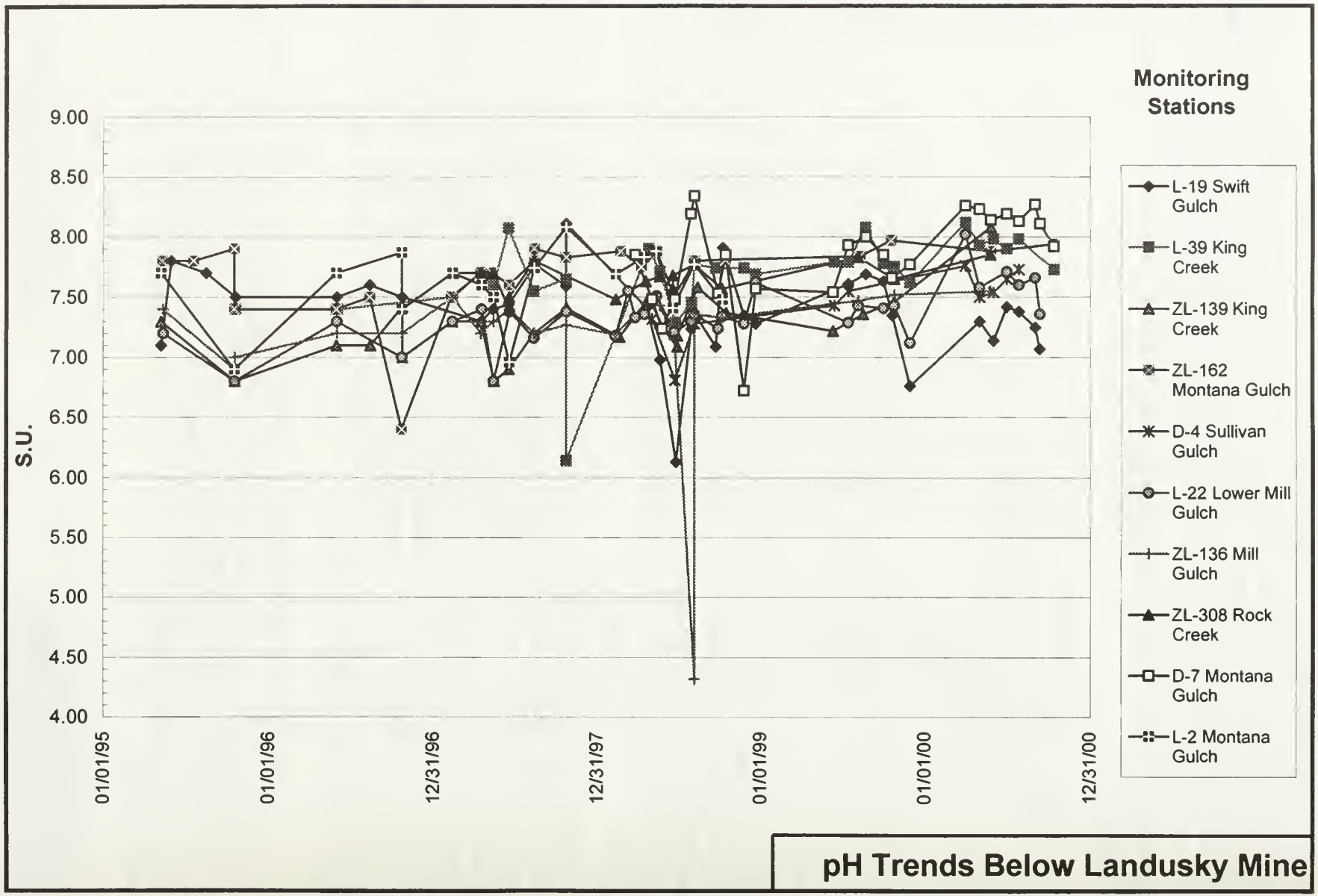

Monitoring Stations
L-19 Swift Gulch
L-39 King Creek
ZL-139 King Creek
ZL-162 Montana Gulch
D-4 Sullivan Gulch
L-22 Lower Mill Gulch
ZL-136 Mill Gulch
ZL-308 Rock Creek
D-7 Montana Gulch
L-2 Montana Gulch
S.U.
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
01/01/95
01/01/96
12/31/96
12/31/97
01/01/99
01/01/00
12/31/00
pH Trends Below Landusky Mine

FIGURE 3.3-24

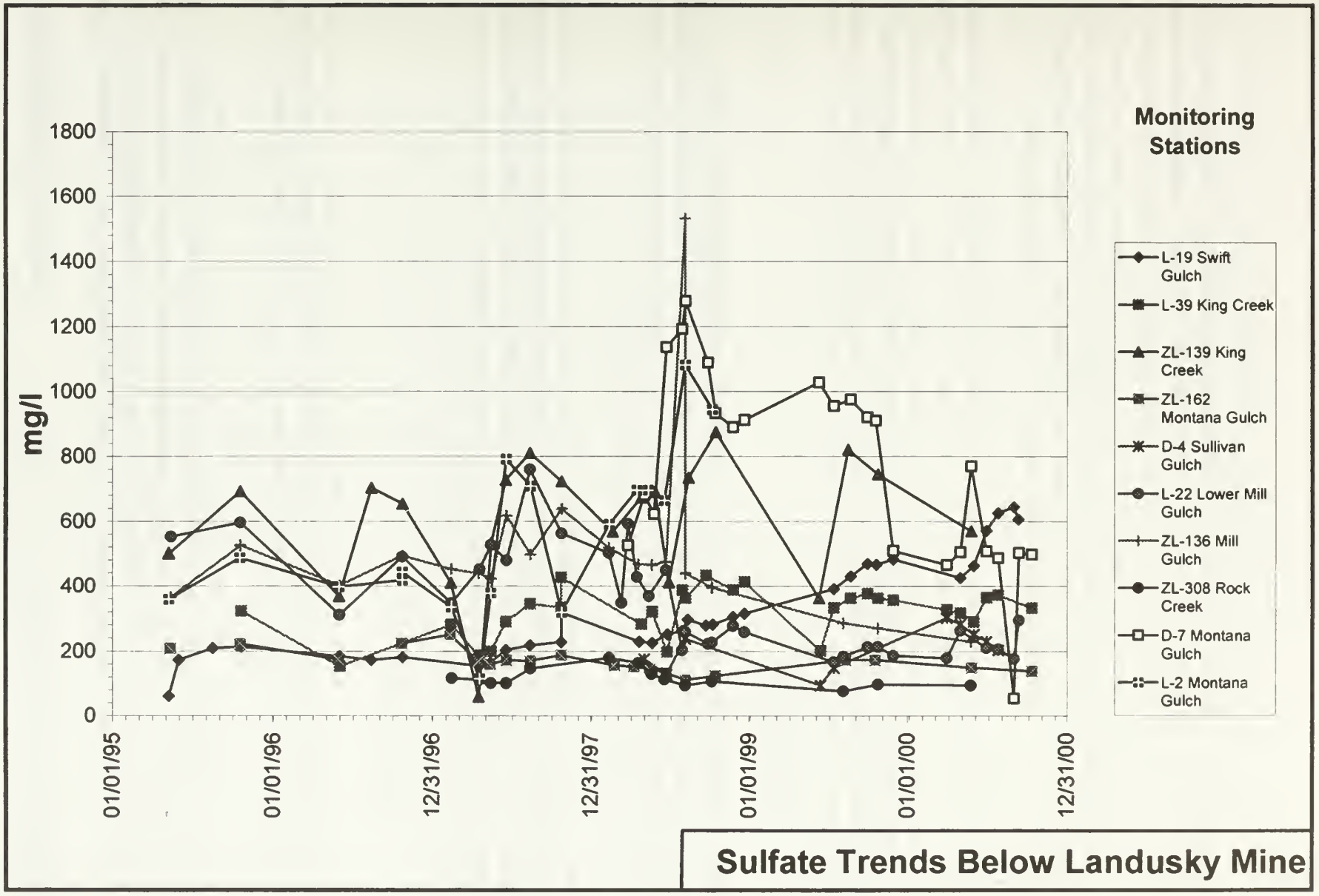

Monitoring Stations
L-19 Swift Gulch
L-39 King Creek
ZL-139 King Creek
ZL-162 Montana Gulch
D-4 Sullivan Gulch
L-22 Lower Mill Gulch
ZL-136 Mill Gulch
ZL-308 Rock Creek
D-7 Montana Gulch
L-2 Montana Gulch
mg/l
1800
1600
1400
1200
1000
800
600
400
200
0
01/01/95
01/01/96
12/31/96
12/31/97
01/01/99
01/01/00
12/31/00
Sulfate Trends Below Landusky Mine

FIGURE 3.3-25

Mill Gulch

The Mill Gulch drainage is located on the southern side of the Landusky Mine, directly northeast of the town of Landusky (Figure 3.3-23). Mine facilities located in the Mill Gulch drainage include portions of the L79-82, L84 and the L87 leach pads, portions of the Gold Bug pit backfill, the reclaimed Mill Gulch waste rock repository, and the Landusky Mine processing plant. Facilities are shown on Figure 3.3-23. The permanent Mill Gulch capture system became operational in 1997 and was designed to capture subsurface flows penetrating the Mill Gulch waste rock repository and reporting to the toe of the facility. Additional information regarding capture systems is included in HSI and Gallagher (2001).

Areas of surface and groundwater impacted by ARD, nitrate and cyanide exist in Mill Gulch due to acidification of the Mill Gulch waste rock dump, several overflow events in the past four years of the capture system, and spills in the process pond/plant area. A narrow band along the mainstem of the drainage shows a mix of non-mineralized background waters with a lesser amount of impacted surface and groundwater. Below the sedimentary rock outcrops, surface and groundwater in Mill Gulch is neutralized ARD water quality (Type 4).

Monitoring Sites

Surface Water: Nine surface water stations in Mill Gulch were used in the FEIS (p. 3-73) to evaluate water quality conditions, while 17 stations were reviewed for the Groundwater Study, including five new sites. Surface water stations are shown on Figure 3.3-23. Many of the surface water stations were temporary gauging sites and have a limited period of record.

Groundwater: One new monitoring well, ZL-318, was completed in syenite porphyry on the flanks of Gold Bug Butte. A total of 26 wells, including the new well, were used in the Groundwater Study evaluation (WMCI, p. 219). The FEIS evaluation used 20 of these wells (p. 3-99). Well locations are shown on Figure 3.3-23. Additional information on surface and groundwater monitoring stations can be found in Gallagher (1999) and HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Quality Conditions: The FEIS identified impacts to surface water quality from mining activities throughout the length of Mill Gulch (FEIS, p. 3-77). These impacts were due primarily to the L87 leach pad underdrain, the Mill Gulch waste rock dump, and the Landusky Mine processing plant.

Construction of the L87 leach pad had an immediate impact on the surface water quality of Mill Gulch, with significant decreases in downgradient pH and increases in sulfate, TDS, and SC concentrations (FEIS, p. 3-73). Seepage from the Mill Gulch waste rock dump contributed ARD to downgradient surface water as evidenced by low pH and elevated sulfate, TDS, and SC values at station L-25. In 1995, about 40 gpm

of water draining from the waste rock dump was captured and recirculated onto the L87 leach pad. Several spill events and a process pond leak in the Landusky Mine process plant area were responsible for cyanide detections in surface water downgradient from the plant at L-8 (FEIS, p. 3-77). The ARD-impacted surface waters originating in the headwaters of the drainage were being effectively neutralized by the time they flowed to the lower reaches of Mill Gulch.

FEIS Groundwater Quality Conditions: Impacts to alluvial, shallow and deeper bedrock aquifers also resulted from the L87 pad underdrain, the Mill Gulch waste rock dump, and the Landusky Mine processing plant. The alluvial aquifer experienced increases in sulfate, SC and TDS concentrations and declining pH values throughout the length of the drainage. Wells in lower Mill Gulch indicate there is an upward vertical gradient in groundwater flow. Water quality in the alluvial aquifer in this area reflects neutralized ARD (FEIS, p. 3-102).

Cyanide was commonly detected in the shallow and deeper bedrock aquifers downgradient from the processing plant due to spills and liner leaks at this facility. ARD impacts were noted in shallow and deeper bedrock aquifers throughout Mill Gulch. However, the limestone and calcareous formations in lower Mill Gulch appear to neutralize the ARD impacts, as evidenced by water quality conditions in ZL-136 (FEIS, p. 3-102).

Current Water Quality Conditions: Figure 3.3-17 shows the area of impacted surface and groundwater in Mill Gulch, based on the classification system described in Section 3.3.5. A summary of current conditions and post-1995 water quality trends is presented in Table 3.3-3. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-24 and 3.3-25.

Current Surface Water Conditions: The water quality indicators upgradient from the Mill Gulch capture system (L-35) were fairly steady from 1993 to 1997, with pH values around 4 s.u. and elevated sulfate (1,500 to 3,000 mg/l). At the capture system (L-36) pH values increase, ranging from 4 to 7 s.u., and sulfate decreases (500 to 1,500 mg/l). The improvement in water quality from L-35 to L-36 probably reflects the influence of groundwater inflow, which is generally of better quality at this location. Trend data for the capture system indicates decreasing pH and alkalinity, and increasing sulfate, TDS and metals. This area had the greatest number of total cyanide detections, with 14 detections equal to or greater than 0.01 mg/l.

Monitoring in a tributary drainage leading from the Landusky Mine process ponds was performed in 1997 and 1998. Based on data from L-8, water quality in this drainage represents neutralized ARD (Type 4), with cyanide detections and elevated nitrate. Lower Mill Gulch surface waters are monitored at spring L-22 and stream station L-7. The spring currently exhibits background water quality (2L) except for cyanide detections above 0.01 mg/l. There has been significant improvement since 1997. Just above the confluence with Rock Creek, Mill Gulch water quality is typical neutralized ARD, with a pH in the range of 7 to 8 s.u., sulfate ranging from 250 to 900 mg/l, and low metals. The range of these parameters is similar to those measured during 1995-96.

Current Groundwater Quality Conditions: Shallow groundwater quality near the toe of the Mill Gulch waste rock dump is ARD-impacted (Type 3), with low pH and alkalinity and high sulfate, TDS and metals. Trend data indicate decreasing pH and alkalinity, and increasing sulfate, TDS and metals during 1997-98. Deeper groundwater in bedrock beneath the toe of the waste rock dump is characteristic of naturally mineralized groundwater without ARD impacts or neutralized ARD indicators. Water quality parameters, including pH, alkalinity, sulfate, SC, and metals in the bedrock groundwater are all stable. Groundwater in the Landusky Mine process area is mine/ARD impacted with elevated sulfate, TDS, nitrate and cyanide. The pH and alkalinity is typically high and metal impacts are not observed. This is due to leakage from processing facilities.

Shallow bedrock groundwater quality in lower Mill Gulch is classified as a mixture of neutralized ARD with a rare occurrence of ARD indicators (Type 4/3), as evidenced by data from ZL-136. The most significant characteristic is the marked decline in TDS and sulfate since mid-1997 when the permanent capture system became effective. Recent data trends at this station indicate stable pH and alkalinity, decreasing sulfate and TDS, and no trend in metals concentrations. Groundwater in the alluvial aquifer (ZL-137, ZL-138) is typical of neutralized ARD water, with slightly elevated sulfate and TDS, and no metals, cyanide or nitrate impacts.

Based on the water balance results and average concentrations of parameters, the average annual sulfate and total metals loads were evaluated for each facility in the Landusky Mine (Spectrum 2000b). Mill Gulch contains approximately 35.5% of the total sulfate load, and 14.4% of the total metals load produced by the Landusky Mine, inclusive of leach pads and background loads. Excluding leach pads, Mill Gulch contains 12.1% of the total sulfate load, and 6.4% of the total metals load of the Landusky Mine.

Montana Gulch

The Montana Gulch drainage is located on the southwestern side of the Landusky Mine (Figure 3.3-23). Mine facilities located within Montana Gulch include major portions of the L80-83, L84, and L85/86 leach pads and dikes, the majority of the Gold Bug pit backfill, portions of the August and Little Ben pits, the Montana Gulch waste rock dump, and the Landusky Mine water treatment plant. Facility locations are shown in Figure 3.3-23.

The upper Montana Gulch capture system became operational in 1997. It was was designed to capture subsurface flows that originate primarily from within the recharge area of the main Landusky pit complex, the August drain tunnel, and the Montana Gulch waste rock dump. The lower Montana Gulch capture system became operational in 1997. It was designed to capture subsurface flows from the L85/86 leach pad underdrain, seepage not captured by the upper Montana Gulch system, and seepage from the L85/86 dike. The West Fork of Montana Gulch is blocked by the L85/86 leach pad, creating a small impoundment whose only outlet is a rock underdrain beneath the leach pad leading to the lower Montana Gulch capture system. Additional information on capture systems is contained in HSI and Gallagher (2001).

The Landusky Mine water treatment plant discharge comprises the majority of the baseflow in Montana Gulch. Impacted waters are present beneath much of the upper Montana Gulch drainage. Below the Landusky Mine water treatment plant outfall, a narrow band of neutralized ARD-type surface waters is present within the Montana Gulch alluvium, extending downstream to the confluence with Rock Creek.

Monitoring Stations

Surface Water: Five new surface water monitoring stations were established for the Groundwater Study. The FEIS described water quality conditions at six stations (p. 3-77), while 18 stations were presented in the Groundwater Study (WMCI, pp. 290-292). Station locations are shown in Figure 3.3-23. Many of the surface water stations were temporary stream gauging sites and have a limited period of record.

Groundwater: One new monitoring well, ZL-319, was completed in Devonian limestone downgradient from the L83 pad in Montana Gulch. A total of 19 wells, including the new well, were used in the Groundwater Study (WMCI, pp. 290-291). The FEIS evaluation utilized 11 of these wells (p. 3-102). Well locations are shown on Figure 3.3-23. Additional information on surface and groundwater monitoring stations can be found in Gallagher (1999) and HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Quality Conditions: The FEIS identified impacts to surface water quality from the Montana Gulch waste rock dump, L84, L85/86, and L83 leach pads, and the Gold Bug pit (FEIS, pp. 3-77 to 3-81). Impacts to water quality were caused by a rupture in the L86 leach pad liner, a pipeline rupture below the L83 leach pad in 1992, construction of the leach pads, and seepage through the pits. The largest surface water discharge in Montana Gulch was from the Gold Bug adit (L-3). Although the discharge is entirely derived from groundwater, it was treated as surface water in the FEIS. The FEIS indicated a gradually worsening of water quality from the Gold Bug adit from 1979 to 1995, as evidenced by decreasing pH and increasing SC values (FEIS, p. 3-77). Surface water quality in lower Montana Gulch above the confluence with Rock Creek declined since baseline measurements in 1979, as evidenced by increasing sulfate, SC, and TDS concentrations at stations ZL-113 and ZL-114 (FEIS, p. 3-81).

FEIS Groundwater Quality Conditions: The FEIS concluded that Montana Gulch alluvial groundwater downgradient of the L85/86 leach pad has been degraded by ARD and cyanide contamination. These impacts are likely derived from the Montana Gulch waste rock dump, a breach in the L86 pad liner, discharges from the Gold Bug and August adits, and a leak in a process fluid line in 1992 (FEIS, p. 3-106). Alluvial groundwater was also affected by pre-ZMI mining activity at least as far downstream as the Montana Gulch campground, as evidenced by elevated arsenic concentrations from a now abandoned well at the campground (FEIS, p. 3-104). Groundwater in the limestones represents neutralized ARD, as evidenced by some cyanide detections, neutral pH, and low metals concentrations (FEIS, p. 3-104).

Current Water Quality Conditions: Figure 3.3-17 shows the area of impacted surface and groundwater in Montana Gulch, based on the classification system described in Section 3.3.5. A summary of current conditions and post-1995 water quality trends is presented in Table 3.3-3. Trends in pH and sulfate for key downstream stations are shown in Figures 3.3-24 and 3.3-25.

Current Surface Water Quality Conditions: The quality of water discharged from the Gold Bug adit declined from 1995 to 2000, as evidenced by decreasing pH values and increasing sulfate and SC concentrations. Since 1997, the Gold Bug discharge has been continuously collected and routed to the Landusky Mine water treatment plant prior to discharge into Montana Gulch. The water quality from the upper Montana Gulch capture system (L-38) has remained relatively static since 1997, exhibiting mild to moderate ARD conditions. Recharge through the Montana Gulch waste rock dump and the August drain tunnel discharge (now buried by this dump), and discharge from artesian well WS-3 report to the upper capture system. The August pit lake was drained in April 2000, but when sampled in October 1999, it was characteristic of Type 4, neutralized ARD, with slightly elevated manganese, nickel and zinc.

The lower Montana Gulch capture system operated from October 1997 to October 1998 when operations were temporarily discontinued. Results of monitoring confirmed that because most of the water reporting to this site originated in the undisturbed West Fork of Montana Gulch, the water quality of the lower Montana Gulch capture system was acceptable for surface discharge without treatment. Water captured by this system is periodically tested to determine whether the water is acceptable for release or if it must be sent to the Landusky Mine water treatment plant for treatment.

Discharge from the Landusky Mine water treatment plant (Station 591) continues to be good quality neutralized ARD water. Station 591 includes not only Landusky Mine water treatment plant discharge, but also overflow from the lower Montana Gulch capture system (L-17), which typically has not been pumped to the Landusky Mine water treatment plant since 1998. The quality of the treatment plant discharge generally improved in November 1999 with the initiation of the WS-3 aquifer test. The addition of water from WS-3 decreased TDS, sulfate and nitrate concentrations by about one-half in the plant discharge. Arsenic concentrations increased to a general range of 0.01 to 0.02 mg/l due to naturally higher levels in WS-3. Current surface water quality downgradient of the Landusky Mine water treatment plant outfall is classified as neutralized ARD, as evidenced by data from D-7 and L-2. Lower Montana Gulch exhibits gradually increasing sulfate and TDS, due to similar trends in the Gold Bug adit and water treatment plant discharge. Other mine contaminants, including metals and cyanide, have infrequently increased due to large runoff events.

Current Groundwater Quality Conditions: Groundwater quality in Montana Gulch is variable, depending on the location and depth monitored. Groundwater from the Gold Bug adit (L-3), beneath the Montana Gulch waste rock dump (L-38), and immediately downgradient of the L85/86 and L83 leach pad dikes (ZL-119) is ARD-impacted. Groundwater flowing from WS-3, which is recharged by the August pit and surrounding area, is typical of the naturally mineralized syenite aquifer (Type 2M). Although the reasons for the different water quality are not fully understood, WS-3 is open to the syenite aquifer at a depth from

286 to 369 feet below the typical static water level. As discussed in other sections, deeper groundwater beneath the Landusky Mine is typically not impacted by ARD, or is impacted to only a small degree.

Shallow groundwater quality below the water treatment plant outfall is not monitored, but would reflect that of the Montana Gulch baseflow (neutralized ARD) with occasionally elevated metals.

Based on the water balance results and average concentrations of parameters, average annual sulfate and total metals loads were evaluated for each facility in the Landusky Mine (Spectrum 2000b). Montana Gulch contains approximately 32% of the total sulfate load and 69% of the total metals load produced by the Landusky Mine, inclusive of leach pads and background loads. Excluding leach pads, Montana Gulch contains 71% of the total sulfate load and 74% of the total metals load in the groundwater at the Landusky Mine.

The WS-3 Aquifer Tests: Well WS-3, located in upper Montana Gulch, was drilled in 1984 as a supply well for dust suppression water at the Landusky Mine. It has a total depth of 243 feet in syenite porphyry and is cased to 160 feet below surface, with the remainder as uncased open borehole to 243 feet. When drilled, this artesian well yielded an estimated 1,000 gpm. Although never monitored, the flow reportedly tapered off to a couple hundred gpm. Through field experience and hydrogeologic evaluation, it became clear that WS-3 was connected to the Landusky Mine shear zone system. The well was closed and not used after late 1995. The last blasting in the August pit occurred on January 8, 1996. By the end of January, groundwater began to pond in the pit and continued to rise slowly to a maximum depth of about 15 feet.

On October 27, 1999, a test of WS-3 and the syenite aquifer was initiated. The well flowed continuously and unthrottled until November 6, 2000, at rates of 266 to 311 gpm. Discharge was collected by the capture systems and routed to the water treatment plant. 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.

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 (95LH-8, 95LH-9) 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 (ZL-313, ZL-314) showed measurable recovery within 48 hours. Wells offset or outside the main shear zones showed a delayed response (ZL-206), or no response (ZL-317) in the first two weeks of recovery. The WS-3 tests demonstrate 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. Even in a relatively dry year such as 2000, there was sufficient recharge in the pit area to keep groundwater levels stable throughout the summer and fall while the flow from the well was sustained. More information on the test is provided in HSI and Gallagher (2001).

Potentiometric surface maps (Figures 3.3-11 and 3.3-12) prepared for October 1999 (before the test) and October 2000 (near the end of test) illustrate that WS-3 is an effective tool in controlling groundwater levels in the Landusky pit area. The October 1999 map shows that with the August pit lake present, the groundwater divide zone probably cut through the lake. After WS-3 dewatered the pit, the groundwater divide zone shifted north through the Suprise and Queen Rose pits. Following the start of the test, water levels declined steadily until mid-May 2000 when at least two distinct recharge events led to temporary increases. When the test was terminated in November 2000, groundwater levels were estimated to lie 10 to 12 feet beneath the bottom of the August pit. Monitoring wells lying south of WS-3 in Paleozoic aquifers did not display any noticeable response to the year-long aquifer flow test. 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.

The water quality of WS-3 is classified as Type 2M, characteristic of the naturally mineralized zones of the syenite aquifer. The water has low TDS and near neutral pH, but elevated arsenic and iron. There was a slightly increasing SC trend and slightly declining trend in pH throughout the test. Remarkably, however, WS-3 did not develop ARD characteristics during the one-year test, unlike the Gold Bug adit and Montana Gulch waste rock dump located on either side of WS-3. Although the reason is not entirely clear, the fact that WS-3 is open to the deep portion of the syenite aquifer is the likely explanation.

Swift Gulch

Swift Gulch is a headwaters tributary of South Big Horn Creek, located in the northeastern portion of the Landusky Mine area (Figure 3.3-23). Facilities located within the Swift Gulch drainage area include portions of the Suprise and Queen Rose pits and the Bighorn ramp fill (Figure 3.3-23).

ZMI submitted a Work Plan in January 1997 to address water quality concerns at monitoring site BKSS-1, located in a tributary to Swift Gulch. In response to detection of mine-impacted seepage at BKSS-1, ZMI removed and reclaimed a large-scale road fill (the Bighorn ramp) adjacent to and upgradient from the site. The project was competed in October 1996 and revegetation was established during 1997. In response to continued water quality concerns, evaluation of a passive treatment system is currently underway.

Water quality in Swift Gulch shows indications of increasing sulfate and TDS with a distinct upward trend since 1998. There are indications that the primary source of contaminants is seepage from the Suprise pit. Water quality below the Bighorn ramp is slightly improved since 1997; however, ARD impacts occur to Swift Gulch tributary drainages in response to runoff events.

Monitoring Locations

Surface Water: The FEIS used three monitoring stations to evaluate surface water quality in Swift Gulch and South Big Horn Creek (3-81). Since 1995, a number of new stations have been added. Nineteen

Swift Gulch surface water stations and four South Big Horn stations were evaluated for the Groundwater Study (WMCI, pp. 326-328). Station locations are shown in Figure 3.3-23. Many of the surface water stations were temporary gauging sites and have a limited period of record. Two of the original Swift Gulch stations, L-19 and L-20, are routinely monitored.

Groundwater: New Landusky pit complex wells completed upgradient of Swift Gulch include ZL-313, ZL-314, ZL-315, and ZL-316. With the exception of ZL-316, drilled in Precambrian gneiss, these deep wells are completed in syenite porphyry. A total of seven wells, including the four new wells, were used in the Groundwater Study evaluation. Swift Gulch groundwater is not described in the FEIS. Well locations are shown on Figure 3.3-23.

Water Quality

FEIS Surface Water Quality Conditions: The FEIS concluded there were impacts to Swift Gulch surface water quality from the Landusky Mine, as evidenced by rising concentrations of sulfate and hardness, and fluctuations in nitrate in samples from stations L-19 and L-20 (FEIS, p. 3-81). Despite rising sulfate and hardness concentrations since 1990, surface water in South Big Horn Creek is of good quality and not impacted by present or historic mining activity (FEIS, p. 3-86 and Table 3.2-32).

FEIS Groundwater Quality Conditions: No groundwater data were available during FEIS analysis. Surface water was assumed to reflect groundwater conditions.

Current Water Quality Conditions: Figure 3.3-17 shows the area of impacted surface and groundwater in the Swift Gulch, based on the classification system described in Section 3.3.5. A summary of current conditions and post-1995 water quality trends is presented in Table 3.3-3. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-24 and 3.3-25.

Current Surface Water Quality Conditions: Surface water baseflow just above South Big Horn Creek (L-49) and below the Suprise pit in Swift Gulch (L-19) exhibit water quality characteristics primarily associated with non-mineralized syenite porphyry (Type 2NM). Since 1998, upward trends are evident at L-19 in TDS, sulfate, iron and manganese, along with a slight downward trend in alkalinity; however, pH has been stable. Two small tributary drainages (stations BKSS-1 and BKSS-10), whose headwaters include the Bighorn ramp, are classified as ARD/mine impacted due to elevated TDS, nitrate and metals, along with low pH and alkalinity. Impacts appear to be associated with runoff events.

Current Groundwater Quality Conditions: Shallow groundwater in the area of the Suprise pit, Queen Rose pit and Bighorn ramp is ARD impacted (Type 3), as evidenced by low pH, elevated TDS, nitrate and metals in wells and springs that lie between the pits and Swift Gulch. The ARD impacts can be traced from the north rim of the Suprise pit (at ZL-315) to springs and seeps on the south side of Swift Gulch (BKSP-2E). ARD indicators at these stations have been increasing since 1997, demonstrated by declining pH and

alkalinity, and increasing sulfate, TDS and zinc. The hydrogeologic data for this area show the Suprise shear zone is the primary mechanism for transport of ARD impacts from the pits to Swift Gulch.

Deep groundwater in the pit area (ZL-313, ZL-204, ZL-316), and groundwater discharge from the north (unmined) side of Swift Gulch (BKSP-2N) exhibits naturally mineralized groundwater quality with no ARD characteristics (Type 2M). This water quality type is distinguished by near neutral pH, SC less than 1,000 uS, alkalinity greater than 30 mg/l, elevated iron, arsenic, phosphorous and fluoride, but very low levels of cadmium, copper, nickel and zinc. The pH, alkalinity and metals are mostly stable in the deep groundwater. However, while TDS and sulfate remain near background levels, there is evidence of a slight upward trend in these parameters on the north side of the pit complex (ZL-313 and ZL-314). Deeper groundwater not directly downgradient of the pits does not exhibit this slight upward trend, as evidenced by data from ZL-204 and ZL-316.

Based on the water balance results and average concentrations of parameters, average annual sulfate and total metals loads were evaluated for each facility in the Landusky Mine (Spectrum 2000b). Inclusive of Landusky Mine leach pads, Swift Gulch contains approximately 0.6% of the total sulfate load and 0.1% of the total metals load. Exclusive of leach pads, total sulfate and total metals loads to Swift Gulch groundwater from the mine are approximately 1.9% and 0.15%, respectively. The loads include those from natural background.

King Creek

King Creek is a headwaters tributary to South Big Horn Creek, located in the northwestern portion of the Landusky Mine (Figure 3.3-23). The August #2 waste rock dump is within the King Creek drainage.

The Consent Decree required installation of a capture system in King Creek. The system was required to capture impacted water, pump water to the water treatment plant, and return treated water to King Creek. ZMI installed a french drain collection system in King Creek in order to intercept shallow seepage, but did not complete the required system prior to bankruptcy. Preliminary consideration of treatment needs and options has been initiated but not yet implemented.

A major tailings removal project in King Creek was completed in October 2000 downstream of the Landusky Mine. This has removed a major source of sediment in the drainage. Water quality in upper King Creek generally represents neutralized ARD with low metals, but with elevated sulfate, TDS and nitrate levels.

Monitoring Locations

Surface Water: Two monitoring stations were used to evaluate conditions in King Creek for the FEIS (p. 3-81). The five stations used for interpretations in the Groundwater Study included these two stations and three additional sites (WMCI, pp. 326-328). Station locations are shown in Figure 3.3-23. Many

of the surface water stations were temporary gauging sites and have a limited period of record. One station located at the Reservation boundary (L-39) is routinely monitored.

Groundwater: Four new wells, ZL-303, ZL-305, ZL-307, and ZL-317, and two piezometers, ZL-304 and ZL-306, were installed in King Creek. A total of nine wells, including the six new completions, were used in the Groundwater Study evaluation. The FEIS evaluation used two of these wells. Well locations are shown on Figure 3.3-23.

Detailed information regarding surface and groundwater stations can be found in WMCI (1998), Gallagher (1999) and HSI and Gallagher (2001).

Water Quality

FEIS Surface Water Quality Conditions: The FEIS concluded there were minimal impacts from historic mining in King Creek at the time ZMI began large-scale mining (FEIS, p. 3-81). However, King Creek surface water quality had been progressively affected by mining activities since 1979 (FEIS, p. 3-86). Increased nitrate levels in surface waters (L-5) were thought to be derived from reclamation efforts in the headwaters or the use of blasting agents. Removal of historic tailings during 1993 has reduced the total suspended solids concentration of surface waters (FEIS, p. 3-86).

FEIS Groundwater Quality Conditions: Alluvial groundwater in King Creek was impacted by mining activities, as shown by slightly elevated nitrate concentrations at ZL-140. Syenite bedrock groundwater had elevated TDS, SC, sulfate and nitrate levels, but a consistently neutral pH (ZL-139), indicating mining-related impacts (FEIS, p. 3-104).

Current Water Quality Conditions: Figure 3.3-17 shows the area of impacted surface and groundwater in King Creek, based on the classification system described in Section 3.3.5. A summary of post-1995 water quality trends is presented in Table 3.3-3. Trends in pH and sulfate for key downstream stations are provided in Figures 3.3-24 and 3.3-25.

Current Surface Water Quality Conditions: With the exception of the headwaters area, the main stem of King Creek does not exhibit significant impacts to surface water quality from the Landusky Mine. Water quality in the headwaters area close to the mine is typical of neutralized ARD, as evidenced by elevated sulfate, TDS and nitrate levels at station L-5. The metals cadmium, manganese and zinc are also slightly elevated. The principal source of these impacts is the August #2 waste rock dump. Dilution by unimpacted water leads to gradual improvement in water quality in the downstream direction. Water quality at the Reservation boundary (L-39) is typical of non-mineralized water and is classified as Type 2NM/5. The secondary Type 5 is due to occasional slightly elevated metals, nitrate and selenium. Trend data show that water quality has been improving since 1997, with stable pH, sulfate and TDS, increasing alkalinity, and decreasing nitrate concentrations.

Current Groundwater Quality Conditions: Shallow groundwater (less than 40 feet) in King Creek is typical of neutralized ARD (Type 4), as evidenced by elevated TDS and sulfate at ZL-139. 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 (ZL-303). Groundwater quality in the deeper aquifer (145-165 feet bgl) is representative of background non-mineralized syenite aquifer water (Type 2NM), as evidenced by data from ZL-307. Monitoring of wells installed in the Groundwater Study led to the conclusion that a groundwater divide exists between the Landusky pit complex and King Creek (WMCI, p. 198). This has been confirmed by additional water level measurements from 1997 to 2000.

Based on the water balance results and average concentrations of parameters, average annual sulfate and total metals loads were evaluated for each facility at the Landusky Mine (Spectrum 2000b). King Creek contains approximately 0.6% of the total sulfate load, and 0.04% of the total metals load produced by the Landusky Mine. Excluding leach pads, the sulfate and metals loads to King Creek groundwater from the mine are estimated at 1.85% and 0.05%, respectively.

Table 3.3-3. Current Water Quality Conditions and Trends in Landusky Drainage Basins

Drainage	Area Summary	Station Type	Current Conditions	Trends				Remarks
				pH	Alkalinity	Sulfate/SC	Metals	
Sullivan Gulch	Above capture system	Source	3	-	-	+	+	Alluvial and bedrock groundwater contaminated
	Below capture system	Down-gradient	2NM	sl +	sl +	sl +	stable to sl +	Station D-4, above Rock Creek
Rock Creek	Sullivan to Mill Gulch	Down-gradient	2NM, 2L	stable	stable	stable	no trend- low	
	Below Mill Gulch	Down-gradient	4	stable	stable	+	no trend	
Mill Gulch	Rock dump to capture system	Source	3	- to stable	- to stable	+ to stable	+	Capture system moved and deepened in late 1997
	Below capture system	Down-gradient	2NM/3	sl + to stable	stable to sl +	-	no trend, low	
Montana Gulch	Mine area/pits	Source	3, 2M	-	- to no trend	+	+	Gold Bug and L-38 declining quality WS-3 non-ARD, stable- slight decline
	Lower leach pads	Down-gradient	3	stable	sl +	+	no trend, variable	Mine impacts due to cyanide, metals and elevated sulfate
	Below mine	Down-gradient	4	stable	stable	+	no trend variable	Trends affected by Gold Bug and Landusky water treatment plant
Swift Gulch	Mine area/pits	Source	3/2M	-	sl -	+	no trend sl +	ARD impacts to shallow groundwater
	Creek	Down-gradient	2M, 2NM	stable	sl -	0	Metals low, selenium elevated, declining in 2000	Impacts from nitrate, selenium, cyanide and salinity, but decreasing trend in 2000
King Creek	Headwaters rock dump	Source	4	stable	stable	+	+	
	Near Reservation	Down-gradient	2NM/4	stable	stable sl +	stable	no trend- stable	Improving water quality- increasing alkalinity, declining metals, nitrate

Current Conditions: 1=Headwaters Background; 2M=Mineralized Syenite Background; 2NM=Non-Mineralized Syenite Background; 2L=Limestone Background; 3=Mine/ARD Impacted; 4=Neutralized ARD; 5=Various Mine-Related Indicators. Trends: + increasing; - decreasing; sl=slight

3.3.8 Madison Group Aquifer

The Madison Group, comprised of the Mission Canyon and Lodgepole Formations, is a dominant feature of the Little Rocky Mountains. These limestones flank the majority of the range and serve as the current water supply source for the town of Zortman, and a potential water supply source for the Hays/White Cow area of the Fort Belknap Reservation. (Information on community water supplies is in SEIS Section 3.3.9.)

For the purposes of the SEIS, the Madison Group is divided into the local unit and the regional unit. The local unit consists of the flanking, exposed limestones of the Madison Group. The regional unit consists of the buried Madison Group. Oil and gas well logs show the Madison Group is buried up to 2,000 feet beneath the surface a short distance from the Little Rocky Mountains. The units are also differentiated by water chemistry and temperature. Water discharging from the regional unit is warm (over 20°C warmer than the local unit) and contains significantly more sulfate than the local unit.

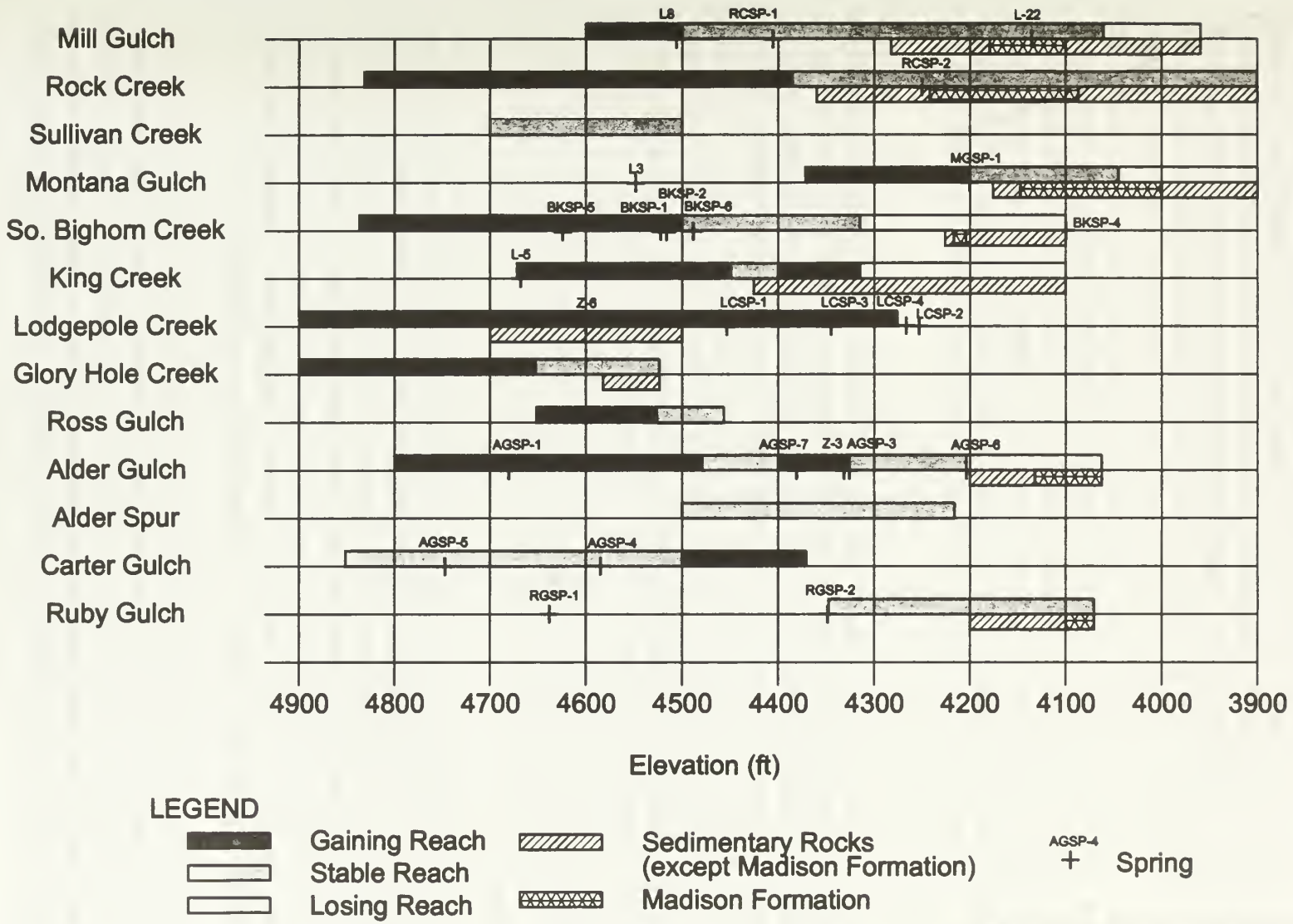
The regional and local units meet at the base of the Little Rocky Mountains where several warm springs discharge. These include Big and Little Warm Springs to the northeast, and Mud Creek Springs and "The Plunge" to the southwest. These springs also have a component of recharge from the local unit, which becomes particularly apparent during large precipitation events (Feltis 1983).

Groundwater Flow

Most groundwater recharge to the local Madison Group aquifer results from surface water, rather than movement between aquifer units (WMCI, p. 184). Recharge occurs across the Madison Group in the drainages where vertical gradients are downward. As shown in Figure 3.3-26, Alder Gulch loses water across the Madison Group, indicating a downward vertical gradient. Streamflow in Ruby Gulch was stable across the Madison Group, despite the vertical downward gradient indicated by paired wells. In the Landusky Mine area, Rock Creek and, to a lesser degree, Mill Gulch exhibit upward vertical gradients in the Madison Group.

Groundwater flow within the Madison Group is typically lateral through karstified bedding planes and fractures along the range front toward the lowest elevation outcrop of the formation (Gallagher 1999). High conductivity zones within the Mission Canyon member of the Madison Formation appear to be associated with karst solution channels within the limestone, as the largest producing wells in the Madison are associated with such features. Many of the these solution channels are infilled with clay, greatly reducing the effective hydraulic conductivity of these features.

However, where these karstic features are encountered in the Mission Canyon limestone below the flat slopes surrounding the Little Rocky Mountains, they appear to remain partially open and can produce significant quantities of water. These karstic features, however, appear to be limited in extent, as evidenced by declining yields in wells completed in these features over time (WMCI, p. 194). Additional information regarding the Madison Group aquifer can be found in Gallagher (1999) at pp. 71-82.



NOTE: The section in lower Rock Creek below station L-23 has been noted as a stable reach due to recent data, but is probably more properly characterized under normal flow conditions as a losing reach followed by a gaining reach due to circulation of groundwater through the alluvium along the stream channel.

Source: Water Management Consultants, 1998

GAINING, LOSING, AND STABLE REACHES OF MINE SITE DRAINAGES

FIGURE 3.3-26

Current Conditions

Impacts to the Madison Group aquifer from the mine sites only result from infiltration of mine-influenced surface water and associated alluvial groundwater near drainage bottoms where steeply dipping beds of Madison Group are exposed (WMCI, p. 530). Some impacts to alluvial groundwater and shallow alluvial-recharged limestone aquifers from ARD and process water contamination are evident near the town of Zortman. These impacts are evident in well ZL-142, which is screened across the alluvium and uppermost Madison aquifer, and include elevated sulfate concentrations. Trace levels of total cyanide were detected in this well on several occasions from 1990 through 1998; however, these were below the accepted significance level of 0.01 mg/l. In the deep Madison well ZL-312, water quality generally resembles the background limestone type. However, elevated arsenic and occasionally elevated sulfate have been identified in samples from this well. Monitoring well ZL-312 is screened over a section of mineralized limestone. At the Landusky Mine, infiltration immediately downstream of the L80/82 and L83 leach pads may have impacted Madison Group limestone water quality.

No mining-related impacts are evident at peripheral springs (e.g. Little and Big Warm Springs) of the Little Rocky Mountains. In order for the Madison Group aquifer to be impacted on the Reservation from the Landusky Mine site, contaminated water would have to travel northward down South Big Horn Creek and Little Peoples Creek to the Madison outcrop in Little Peoples Creek approximately 1.5 miles downstream. From the Zortman Mine site, contaminated water would have to travel about 3 to 4 miles to the Madison outcrops in the Lodgepole Creek drainage. There is no evidence of mine impacts to surface water at the northernmost downgradient stations. Gallagher (1999) found that it is unlikely the flanking Madison Group aquifer would be affected by the mines.

3.3.9 Beneficial Use

Surface Water Use

The 1996 FEIS found little information regarding the impact of mining operations on surface water flows in the Little Peoples Creek and Lodgepole Creek drainages (FEIS, p. 3-109). Data from Little Peoples Creek flow gauging (near Hays) indicated an initial decrease in flow between 1978 and 1980 (FEIS, p. 3-113). Since 1987, no changes in flow were identified in any northern drainages. Although monitoring data are not available, it is expected that surface water flow and spring discharge to the north of the Landusky Mine would have decreased when the August and Gold Bug adits were completed in the 1960s, effectively diverting a large percentage of the catchment to the south (FEIS, p. 3-113).

The Final Report on the Landusky Mine Hydrologic Impact to King Creek and Swift Gulch (Spectrum 2000c) concluded that King Creek lost an estimated 16.1 million gallons per year (31 gpm), while Swift Gulch gained 13.6 million gallons per year (26 gpm) from pre-mine conditions to present due to mining activities. This estimate is based on the assumption that the pre-mine surface water and groundwater basins were coincident, and that artesian well WS-3 was closed. The report did not differentiate how much of

the loss is attributable to the underground workings and how much is due to the present day open pit. Combining the gains and losses in King Creek and Swift Gulch shows that an overall loss of 2.5 million gallons per year (5 gpm) occurs. A second analysis with well WS-3 open and discharging 250 to 300 gpm shows the loss of flow to Swift Gulch at 33 to 45 gpm. The total loss of flow in both King Creek and Swift Gulch due to the Landusky Mine, with WS-3 open, is estimated at 64 to 76 gpm.

Groundwater Use

Community Water Supplies

Domestic water supplies in the communities of Zortman and Landusky depend entirely on groundwater. An updated list of groundwater rights in the Zortman and Landusky area are presented in HSI and Gallagher (2001).

Zortman: The town of Zortman is served by a deep well (Z-8A) completed in the Madison Group limestone. This well was constructed in 1982 after mining activities impacted domestic water supplies for Zortman that were located in the Alder Gulch alluvium. Z-8A has been monitored since 1982 and has shown no indications of mine-related contamination. The primary water quality concern for Z-8A would be from mine-impacted surface water infiltrating to the Madison Group aquifer at the lower end of Ruby Gulch.

However, the geology of the area, including significant structure and low permeability rocks between the town well and the Ruby Gulch drainage, limits the potential for impacts to Z-8A from Ruby Gulch. Geology of this area is described in detail in Gallagher (1999). At present, the community is trying to obtain funds to improve the water distribution system. Many of the pipelines in this system are constructed in the historic Ruby tailings which are unstable during large runoff events, leading to ruptured lines.

Landusky: Few logs exist for Landusky townsite wells. However, most of the town wells are completed in both alluvium and underlying bedrock (WMCI, p. 166). Impacts to the Landusky alluvial groundwater (TP-series domestic wells) have resulted from discharges from the Mill Gulch waste rock dump, as evidenced by high TDS and sulfate waters in the alluvium above the Landusky townsite. Also, minor and transient groundwater impacts have occurred from past releases in Sullivan Gulch, evidenced by slightly elevated and transient concentrations of arsenic, lead and manganese (WMCI, p. 538). No cyanide has been detected in Landusky wells. Impacted water from Mill Gulch and Sullivan Gulch is currently captured and pumped to the Landusky Mine water treatment plant. Only a small portion of the runoff from infrequent large storms and snowmelt events escapes capture and treatment.

Data collected since 1995 indicate water quality in some of the Landusky domestic wells (TP-series) has been affected by mine activities. Using the water classification system, alluvial water quality in Mill Gulch above the confluence with Rock Creek (TP-1), is representative of neutralized ARD with elevated SC, sulfate, and nitrate (Type 4). Data from TP-2 shows an upward sulfate trend, while alkalinity is declining.

The alluvial groundwater also shows erratic, but often high iron concentrations (up to 6 mg/l). This water quality is a mixed type representing neutralized ARD from Mill Gulch diluted by less affected Rock Creek water (Type 2L/5). With the exception of periodically elevated iron concentrations, alluvial water quality in Rock Creek above the town of Landusky does not appear to be significantly different than 1995 values, as evidenced by data from TP-3 (Type 2L). Data show that shallow groundwater in Landusky appears to be influenced by runoff events, as evidenced by a high degree of fluctuations in water quality parameters during wet periods.

Bottled water has been supplied to the residents of Landusky since 1993. Testing of eight Landusky domestic wells in the fall of 2000 showed that water quality meets primary drinking water standards. If resampling of these wells in the spring of 2001 shows that primary drinking water standards are still being met, the State plans to discontinue supplying bottled water to Landusky residents. Additional testing is planned to determine whether reclamation activities improve downgradient shallow groundwater in Landusky.

Two test wells, LNDWS-1 and LNDWS-2, were drilled, but never developed, south of the Landusky townsite. The wells were drilled to locate a community water supply for Landusky. The target aquifer was the Madison Group. However, the wells were drilled to over 400 feet without reaching the top of the Madison, and were screened in what appears to be Jurassic-aged sandstones and siltstones. The wells produced about 35-40 gpm during drilling. Water quality analyses indicated sulfate-rich waters typical of other sandstone, without indications of mine-related contaminants.

Fort Belknap Reservation: Several hydrogeology studies have been completed on the Fort Belknap Reservation by the U.S. Geological Survey and Montana Bureau of Mines and Geology, including Feltis (1983), Slagle (1993) and Briar and Oellermann (1993). The studies found that natural water quality on the Reservation in aquifers away from the mountain front is naturally variable and often quite poor. None of the studies cited mine activities as contributing to the poor quality of the area aquifers.

The Madison Group has the best water quality in the Hays area, but only from wells located close to the Little Rocky Mountain front. A short distance from the mountains, the Madison dips steeply away from the range and is generally located at depths uneconomic for water supply development. Additionally, the deeper regional Madison Group aquifer is moderately mineralized (2,000 to 2,500 mg/l TDS) and warm (30 to 40°C) (values based on maps contained in Downey and Dinwiddie (1988)). The USGS constructed five wells in the Madison Aquifer, including two located in Mission Canyon towards the Landusky Mine and three along the range front near Mission Canyon. Analytical results indicate that water quality meets all the Federal primary and secondary drinking water standards (Slagle 1993).

As part of the Consent Decree settlement, ZMI agreed to complete a water system improvement project for Hays. Two exploration wells (WSIP-1 and WSIP-2) were drilled in the Madison Group aquifer north of Mission Canyon along the range front. Results of drilling indicated that a 250 gpm, good quality water

supply well could be developed. Due to the ZMI bankruptcy, this project was not completed; however, monies were provided to Fort Belknap for water system improvements.

Both the FEIS and the Groundwater Study conclude that the only significant source of contamination to the Reservation would be by the recharge of contaminated surface water to permeable sedimentary formations (i.e. the Madison Group) exposed in the stream channel. While mining-related contaminants have been identified in the headwaters of Swift Gulch and King Creek, tributaries to Little Peoples Creek, the monitoring data indicate that with the exception of selenium, water quality standards are met at the upstream Reservation boundary. Selenium concentrations slightly exceed state water quality standards. This is due primarily to dilution from water contributing to the stream between the mine and the Reservation. The Groundwater Study and additional monitoring since 1996 demonstrate that the much of the elevated iron, manganese, arsenic, fluoride and phosphorous in the headwaters of Swift Gulch and King Creek is caused by the natural mineralization of the area. Ongoing surface water monitoring in Little Peoples Creek upgradient from the mouth of Mission Canyon is maintained in order to identify water that has the potential to impact the domestic water supply.

The ATSDR study concluded that based on a review of the data, there is no apparent public health hazard to the residents of Fort Belknap. The data provided no evidence that people have been, or are being exposed to dangerous levels of environmental contamination in sediments, surface water or groundwater located within the boundaries of the Reservation (ATSDR 1998).

The EPA conducted groundwater sampling of 15 wells on the Fort Belknap Indian Reservation and three wells in the town of Zortman on June 13-15, 2000. The wells included selected public and private water supply wells and monitoring wells. Based on the water classification system discussed earlier, none of the wells appeared impacted by ARD. The pH in all wells was greater than 7 s.u., and alkalinity was 220 mg/l or greater in the wells sampled on the Reservation. Alkalinity of the Zortman townsite wells was 180 mg/l. Sulfate concentrations were less than 400 mg/l in all but one well, ZDW-GW-14, which is located approximately 3.6 miles northwest of Hays, Montana. This well had a high pH (8.81 s.u.), and is likely completed in Cretaceous sandstone or shale.

The water sampling results were reviewed relative to primary or secondary state standards for groundwater. Well ZDW-GW-04 slightly exceeded the copper standard. This well is not in a drainage potentially impacted by either the Zortman or Landusky Mines. Four wells, ZDW-GW-04, ZDW-GW-06, ZDW-GW-13 and ZDW-GW-17 exceeded the secondary standards for iron and/or manganese. Elevated iron and manganese in groundwater is a common occurrence and not related to affects from the mines.

3.3.10 Regulatory Criteria

As noted in the FEIS (p. 3-113), the Montana Water Quality Act (§75-5-402, MCA) requires a Montana Pollutant Discharge Elimination System (MPDES) permit for any discharge of sewage, industrial wastes,

or other wastes to state waters. MPDES permits have established effluent limits, calculated to meet the water quality standards of a water body. Current effluent limits for discharge from the water treatment plants are based on the Consent Decree requirements. Although the MDPES permits have not yet been issued, a copy of the draft discharge permits is in Appendix C.

The waters in Montana Gulch, Alder Gulch, Ruby Gulch, Rock Creek, and Mill Gulch are listed as "C-3" in the Montana Surface Water Quality Standards (ARM 17.30.610). The C-3 classification standards mean the waters are suitable for bathing, swimming and recreation, growth and propagation of non-trout fish species and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.

King Creek is listed as "B-3" in the water quality standards. The B-3 classification standards mean the waters are suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of non-trout fish species and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

Big Horn Creek is listed as "B-1" in the water quality standards. The B-1 classification standards mean the waters are suitable for drinking, culinary and food processing, after conventional treatment; bathing, swimming and recreation; growth and propagation of trout species and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

Total Maximum Daily Loads (TMDLs)

The term "TMDL" stands for Total Maximum Daily Load and originated in the Federal Clean Water Act of 1972. In the years since 1972, the meaning of the term has evolved to include many water quality-related conditions besides the total maximum load of pollutants in a water body. Today, the term TMDL refers to the overall strategy for bringing polluted waters into compliance with standards.

Section 303(d) of the federal Clean Water Act requires states to prepare a list of water bodies not supporting their designated beneficial uses, and submit it to EPA for review and approval every two years. The DEQ Monitoring and Data Management Bureau is the agency responsible for developing the list, which is referred to as the "List of Waterbodies in Need of Total Maximum Daily Load Development." In 1996 Montana Gulch, Mill Gulch, Alder Gulch, Ruby Creek, Rock Creek, Sullivan Creek, King Creek and Big Horn Creek were on the Montana "List of Waterbodies in Need of Total Maximum Daily Load Development."

Montana Gulch was listed as not supporting the beneficial uses of aquatic life support, cold water fishery, drinking water supply and swimming in 1996. The probable causes of impairment were metals from resource extraction and subsurface mining.

Mill Gulch was listed as not supporting the beneficial uses of aquatic life support, drinking water supply, swimming and warm water fishery. The probable causes of impairment were metals and pH from resource extraction and subsurface mining.

Alder Gulch was listed as not supporting the beneficial uses of aquatic life support, cold water fishery, drinking water supply and swimming. The probable causes of impairment were metals, suspended solids and pH from resource extraction and surface mining.

Ruby Creek from the headwaters to one mile below the town of Zortman was listed as not supporting the beneficial uses of aquatic life support, drinking water supply, swimming and warm water fishery. The probable causes of impairment were flow alteration, metals, habitat alterations and pH from resource extraction and surface mining.

Rock Creek near Landusky was listed as partially supporting the beneficial uses of aquatic life support and warm water fishery. It was listed as not supporting the beneficial use of drinking water supply. The probable causes of impairment were metals, nutrients and habitat alterations from resource extraction, agriculture and range land.

Sullivan Creek was listed as not supporting the beneficial uses of aquatic life support, drinking water supply, swimming and warm water fishery. The probable causes of impairment were metals and pH from resource extraction and surface mining.

King Creek was listed as partially supporting the beneficial uses of aquatic life support and cold water fishery. Moreover, it was listed as not supporting the beneficial use of drinking water supply. The probable causes of impairment were metals and habitat alterations from resource extraction activities.

Big Horn Creek was listed as partially supporting the beneficial uses of aquatic life support, cold water fishery, drinking water supply and swimming. The probable causes were metals from resource extraction activities.

In 1997, the Montana Legislature amended the Montana Water Quality Act (§75-5-701 through 75-5-705, MCA) clarifying the authority of DEQ to monitor water quality and bring Montana's water resources into compliance with water quality standards through the TMDL process. The legislation required a comprehensive review of listed waters by 1999 and completion of TMDLs for all waters on the 1996 303(d) list by 2007.

DEQ completed the comprehensive review of listed waters in late 1999 and the results are published in the 2000 303(d) list. The comprehensive review involved collecting water quality data from all State, Federal and local agencies to determine if there was sufficient and credible data to warrant listing an impairment of a water body. Montana Gulch, Alder Gulch, Ruby Gulch, Rock Creek, Mill Gulch, and King Creek had

sufficient and credible data to determine an impairment. Sullivan and Big Horn Creeks did not meet the sufficient and credible data. DEQ plans to reassess these drainages as new information becomes available.

Montana Gulch (headwaters to mouth) is listed on the 2000 list as not supporting the beneficial uses of aquatic life support, cold and warm water fishery. The probable causes of impairment are metals, arsenic, copper, zinc and pH from acid mine drainage and abandoned mining.

Alder Gulch (headwaters to Ruby Creek) is listed in 2000 as partially supporting the beneficial uses of aquatic life support and cold and warm water fishery. The probable causes of impairment are metals, nitrate, pH and habitat alterations from resource extraction, mine tailings, acid mine drainage and abandoned mining.

Ruby Gulch (headwaters to one mile below Zortman) is listed in 2000 as partially supporting the beneficial use of aquatic life support. Probable causes of impairment are metals and pH from resource extraction and abandoned mining.

Rock Creek (headwaters to Missouri River) is listed in 2000 as partially supporting the beneficial uses of aquatic life support and swimming. Probable causes are metals, pH and riparian degradation from resource extraction, inactive mining, and grazing.

Mill Gulch is listed in 2000 as partially supporting the beneficial uses of aquatic life support, warm water fishery and swimming. Probable causes are metals, nitrate, pH and riparian degradation from resource extraction, surface mining and grazing.

King Creek is listed in 2000 as partially supporting aquatic life and cold water fishery. It is listed as not supporting the beneficial uses of drinking water, swimming, and use by agriculture and industry. Probable causes are metals, nitrate, siltation, and habitat alterations from mine tailings and abandoned mining activity.

All alternatives addressed in the SEIS are intended to meet the minimum requirements for a TMDL. The potential differences among the alternatives in achieving varying degrees of water quality restoration from recent mining activities is addressed in Chapter 4.

3.3.11 Summary of Findings

The following list contains the most significant findings related to the water resources and geochemistry of the Zortman and Landusky Mines since preparation of the 1996 FEIS.

- The concepts of the geochemical evolution and maturation of waste rock dumps, dikes and leach pads were developed for specific facilities at each mine. A few facilities at the Zortman Mine have likely reached maturity, but most, including all at the Landusky Mine have not. Reclamation would lessen ARD impacts, but the acid generation process cannot be halted entirely. Water quality

within most mine facilities will continue to worsen for a long period, estimated to range from 10 to 100 years.

- Since 1995, many new wells were installed for the Groundwater Study, which permitted more detailed evaluations of the direction of groundwater flow, definition of groundwater divide zones, and water quality monitoring to define impacts from the mines in space and time. The hydrogeologic interpretations made from these data have allowed a much better understanding of the hydrology and water chemistry at both mines and the surrounding area. For instance, data collected during, and subsequent to the Groundwater Study indicate the majority of groundwater from the mine sites flows along shallow and intermediate flowpaths that discharge to capture systems and surface water within the syenite porphyry aquifer. There does not appear to be a significant deep flowpath.

- Water balances for every facility or basin on both mines were computed using 1997-1999 daily flow records from the new, permanent capture systems, along with mine precipitation data. The capture systems allowed entire waste rock dumps and dikes to be evaluated as huge lysimeters, enabling direct estimates of on-site groundwater recharge and evapotranspiration. Direct calculations of recharge rates to leach pads were made using weekly sump measurements and mine precipitation data. Computed recharge rates were much higher and evapotranspiration was lower than previous estimates. Recharge rates ranged from 45 to 49% on reclaimed waste rock dumps and pads, and 69 to 71% on unreclaimed leach pads. The capture systems were found to be very efficient collectors of contaminated surface water and groundwater runoff from mine facilities and have greatly reduced impacts to water quality.

- Using the water balances and recent water quality data, total annual loads of sulfate and total metals were computed for all mine facilities. This enabled development of estimates of contaminant loads to drainages, and determination of the fate of these contaminants. For the Zortman Mine, it was found that 66% of the sulfate load and 80% of the metals load was collected and sent to the water treatment plant, 31% of the sulfate load and 18% of the metals load was sent to the Goslin LAD, and 3% of the sulfate load and 4% of the metals load reported to uncaptured groundwater. For the Landusky Mine, it was found that 24% of the sulfate load and 79% of the metals load was collected and sent to the water treatment plant, 67% of the sulfate load and 18% of the metals load was sent to the Goslin LAD, and 10% of the sulfate load and 3% of the metals load reported to uncaptured groundwater and surface baseflow (Spectrum 2000a and 2000b).

- Not all of the mine facilities assumed in the 1996 FEIS to be acid generating are so. The Z83, Z84, and Z89 leach pads are near neutral, as are the L80 through L84 leach pads. The L85/86 leach pad is suitable for use as non-acid generating material in construction of the reclamation covers.

- Geochemical characterization of the mine facilities shows there is a large quantity of ARD contaminants stored within the facilities. For example, at the Landusky Mine, if all further sulfide oxidation could be eliminated today, water treatment would need to be continued for approximately 150 years to treat the estimated quantity of contaminants currently stored in the spent ore and waste rock.

- New evaluations of the massive water quality data base for the mines, along with comprehensive hydrogeologic interpretations, led to the development of an empirical Water Quality Classification System. Nearly 800 samples from over 100 stations were classified as natural or mine-impacted. The interpretive map prepared from the classifications was used to depict the extent of mine impacts on shallow groundwater and surface water baseflow.

- Mine-impacted water quality at the Zortman Mine is worse than that at the Landusky Mine, but the extent and magnitude of off-site impacts of the Zortman Mine appear stable for the most part. Although the Landusky Mine ARD is not currently as strong, the extent of the off-site impacts is greater, and the impacts appear to be worsening since 1995 in most of the drainages. Swift Gulch, in particular, has experienced worsening water quality since 1997. King Creek is an exception, and appears to be slightly improving.

- A year-long test of artesian well WS-3 on the Landusky Mine demonstrated that it could be used very effectively to drain the August pit lake and 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. The water quality of WS-3 declined slightly during the test but remarkably, remained unimpacted by ARD.

- Operation of the Goslin Flats LAD began in 1998 for treatment and disposal of approximately 148 million gallons per year of leach pad solutions. As operated, it was undersized and hydraulic overloading occurred. A major expansion of the area used for land application, from 96 to 410 acres, took place in the summer of 2000, and a comprehensive water management plan was developed centering on beneficial uptake of water and nutrients by the grass/hay crop. The high selenium and nitrate concentrations exceed the assimilation capacity of the LAD, and a pilot project was completed to test the efficacy of a biological treatment system for these contaminants. The pilot project was a success and expansion to a full scale pre-treatment plant will occur in 2001.

- Impacts to the Madison Group aquifer from the Zortman and Landusky Mines are only expected to occur where mine-affected surface water and alluvial groundwater infiltrates near drainage bottoms where vertical gradients are downward, recharging the Madison aquifer.

3.4 SOIL and RECLAMATION MATERIALS

Two major landforms and soil groupings are present in and around the mines. The first consists of the unglaciated mountain portion, characterized by steep, V-shaped valleys and gentler ridges. The second landform type is outwash plains and drainage bottoms, the Ruby and Goslin Flats areas.

The mountainous portion was not glaciated. Most soils developed in place from colluvium, but there are some alluvial soils in drainages. The degree of soil development is variable, from minimal development on talus slopes to well developed Mollisols (grassland soils) and Alfisols (forest and some grassland soils). Slopes greater than 50% are common.

3.4.1 General Soil Description

Appendix 3 to the 1992 Proposed Operating Permit is a Soil Survey of the Little Rocky Mountains Environmental Study Area, Phillips County, Montana (Noel and Houlton 1991). It includes a soils map and legend, description of soil series, profile summaries, and laboratory analysis of some chemical and physical parameters as they pertain to reclamation.

In salvaging soils and some subsoil material from disturbed areas for later use in reclamation, this material was stockpiled. In stockpiling, the developed upper horizons are mixed with substrates little modified by biological activity. The mix is different than the pre-disturbance soils described in the pre-mine soil inventory. Among these changes are the loss of distinct horizons with characteristic organic matter concentration, fertility, soil microbe populations, zones of calcium and clay loss and accumulation, base saturation, and coarse fragment content. Anaerobic conditions within stockpiles deplete soil microbe populations except for anaerobic bacteria. For reclamation, the properties of soil stockpiles have a far greater bearing than pre-mine inventories.

Mountain Soils

As part of a revegetation evaluation, Prodgers (2000) described four reference soils selected to characterize a range of mountainous soils with development beyond the Entisol level. The associated plant communities were bluebunch wheatgrass-balsamroot (soil: Loamy-skeletal, mixed, frigid, Typic Haplustoll), bluebunch wheatgrass with a scattered overstory of lodgepole and Ponderosa pine (soil: Fine-loamy, mixed, Ustic Argicryoll), well-developed soil with lodgepole pine overstory (soil: Loamy-skeletal over clayey, mixed, Ustic Haplocryalf), and doghair lodgepole (soil: Loamy-skeletal, mixed, Ustic Dystrocryept). Characteristics of these four soils are detailed in Tables 3.4.-1 through 3.4-3.

The grassland soils are more fertile than soils of coniferous forests (Table 3.4-1). Both grassland reference soils have rather high nitrate levels for early June at the height of the growing season. This indicates the continuous mineralization of nutrients from the organic fraction. Forest soils were less fertile but deeper. Conifers also can grow on fractured paralithic substrates, rooting in the fissures that conduct rainwater and

allow unrestricted root growth. Conifers can meet their nutritional needs by accessing a rather large volume of relatively infertile soil, whereas grasslands require more fertile soils but less rooting volume.

Table 3.4-1. Fertility, Organic Matter Content, and pH of the Uppermost Mineral Horizon of Four Reference Soils near Mine Reclamation

Vegetation Type	Nitrogen (ppm)	Ammonium (ppm)	Phosphorus (ppm)	Potassium (ppm)	Organic Matter (%)	pH (s.u.)
Wheatgrass-Balsamroot	5	72	36	740	17	6.2
Pine/Wheatgrass	6	15	61	240	3	7.0
Productive Lodgepole Pine	2.6	19	10	234	4	6.1
Doghair Lodgepole Pine	0.1	8	5	142	4	5.4

Physical properties of the four reference soils are described in Table 3.4-2. Coarse fragment content (the fraction of soil particles greater than 2 mm) is typically 50-70%. A well-developed soil that is accumulating soils fines, such as the soil of the bluebunch wheatgrass-balsamroot plant community, has fewer rock fragments in the A (upper mineral) horizon than below. A soil influenced by a lot of erosion (e.g. the soil of the pine/bluebunch wheatgrass plant community) loses soil fines (less than 2mm) at the surface, so it has more rock fragments near the surface than below. This is also true for much of the past reclamation at the mines.

Table 3.4-2. Physical Properties of Reference Soils

Vegetation Type	Soil Thickness (inches)	Surface Coarse Fragments (%)	Subsurface Coarse Fragments (%)	Surface Clay Content (%)	Surface Texture
Wheatgrass-Balsamroot	20	10/10	20/50	14	Cobbly loam
Pines/Wheatgrass	15	20/50	5/20	8	Gravelly loamy sand
Productive Lodgepole Pine	44	15	50	20	Channery loam
Doghair Lodgepole Pine	27	15/0	30/40	15	Gravelly sandy loam

The existing soil stockpiles comprise about 2 million loose cubic yards. Stockpiled and previously applied soil materials contain an average of 23% clay and 57% coarse fragments by volume. The texture is a little heavier (more clayey) than optimal for revegetation, but at the same time, more erosion-resistant than a less clayey soil would be. For maximum effectiveness, soil must not be compacted during placement. The tiny, unconnected pores of soils pose enough of a problem for plant roots, so compaction only exacerbates the problem. With good revegetation and microbial populations, soil structure would develop in time and improve growing conditions for vascular plants. The rock content is high and, in many respects, detracts

from the exchange capacity and water-holding capacity of soils, but the high rock content inhibits erosion. The most important consideration is that soil fines not erode away, leaving a rocky erosion pavement that is inhospitable to further plant establishment.

In addition to mixing, stockpiled soils experience the depletion of microbe populations necessary for nutrient cycling. Soil fungi and with a few exceptions bacteria meet their energy and nutrient requirements by feeding on organic substrates, mostly plant matter. In healthy grasslands, the biomass of bacteria and fungi are roughly equal. Protozoa, the most primitive single-celled animals, feed on fungi and bacteria (and sometimes directly on organic matter). One important role of protozoa is transforming nutrients in fungi and bacteria. Nematodes, tiny unsegmented worms, can also be important in nutrient cycling, depending upon conditions.

The abundance of these microbes in reference soils is summarized in Table 3.4-3. The biomass of fungi is greater than that of bacteria in all reference soils, but greatest in the productive forest soil. Protozoa are rather poorly represented in these reference soils, particularly the forest soils.

Table 3.4-3. Microbiological Properties of Reference Soils

Plant Community	Bacteria (ug/g)	Fungi (ug/g)	Ratio Fungi/Bacteria	Protozoa	Nematodes
				Density	
Bluebunch Wheatgrass-Balsamroot	208	293	1.43	1,300	4.0
Pine/Bluebuch ref.	149	298	2.00	1,200	7.3
Wheatgrass (another date)	139	369	2.65	NA	NA
Productive Lodgepole Pine	137	555	4.05	40	4.7
Doghair Lodgepole Pine	151	340	2.25	110	6.4

Goslin Flats LAD-Area Soils

The Goslin Flats LAD area was included in the Order 1 soil survey of the "Little Rocky Mountains Environmental Study Area, Phillips County, Montana" performed for the March 1993 *Application for Amendment to Operating Permit 00096*, submitted by ZMI to the State of Montana (Noel and Houlton 1991). The detailed soils map of Goslin Flats are presented in Exhibit 3-4 of that report. Most of the LAD area soils are Mollisols, with moderately to well developed profiles. The parent materials are alluvial terraces, colluvium and fans of poorly sorted gravel, shale, sandstone and limestone. Soil textures are dominantly gravelly loams, silty loams and clay loams on the surface, and silty clay loams, clay loams and clays in the subsoil. Coarse fragment contents increase in the northern end of the Ruby Creek valley. A summary of the soil types found in the Goslin Flats area is provided in Table 3.4-4.

Nearly the entire terrace constituting the original Goslin Flats LAD area is composed of Winspect cobbly loam soils, according to the soils map of Noel and Houlton. Detailed tabulations of soils classifications and laboratory test results may be found in the Noel and Houlton report contained in Appendix 3 of Volume 2, Application for Amendment to Operating Permit No. 00096.

Table 3.4-4. Soil Types in the Goslin Flats LAD Area

Soil Series Name	Dominant Texture	Major Soil in LAD Use
Judell	Clay loam	
Maiden	Gravelly loam	X
Martinsdale	Gravelly loam	
PAAB	Silty clay loam	
Pachel	Loam	
Riverside	Very gravelly loam	X
SAR	Silty clay loam	
SS	Loam	
Straw	Loam	
TAQ	Loam over very gravelly loam	
TU	Very gravelly loam	
UBB	Loam	
UBF	Loam over very gravelly loam	X
Vanda	Clay	Locally
VAQ	Gravelly loam over very gravelly sand	
Warhorse	Fine loam	
Williams	Loam	
Winham	Very gravelly loam	
Winspect	Cobbly loam	X

The Goslin Flats soil survey (Noel and Houlton 1991) was reviewed for potential limitations to expansion of the Goslin Flats LAD. The two identified potential limitations were slope (erosion concern) and certain soil textures (rapid permeability). The LAD expansion areas were selected to avoid unsuitable slopes. The predominant soil types on the terraces and alluvial valleys of the Goslin LAD area range from loam to very

gravelly loam. Loam and clay loam normally occur in the upper 6 to 12 inches, with increasing coarse fragments with depth. Coarse-textured subsoils with 35 to 60% coarse fragments are common.

These soil limitations were mitigated by making application rates commensurate with evapotranspiration demand, and the integration of soil lysimeter observations as a component of routine LAD management. If water is discovered in lysimeters, immediate reductions in water application occur in the affected area.

The predominant soil types and their water holding capacities are summarized in HSI and Spectrum (2000). The information indicates that the average weighted water holding capacity of the Goslin Flats LAD area soils is 4.55 inches in the upper 36 inches of soil profile. If 50% of this is assumed to be "depletable" for the purposes of irrigation demand, then about 2.25 inches of available water storage capacity is available for irrigation replenishment. At a typical summer evapotranspiration rate of 0.25 inches per day, this represents about 9 days of accumulated depletion, a reasonable irrigation schedule. Soil infiltration rates range from 1.3 to 2.7 inches per hour, and do not limit irrigation for sprinkler systems.

Additional sampling of soils in the Goslin Flats LAD area was conducted in March and May 2000 using backhoe test pits. Four locations distributed across the original LAD area were sampled. The samples were collected prior to pad water application, with a total of 19 samples collected from test pits, composited by subarea, by soil horizons. The objectives of the sampling were to prepare or confirm textural descriptions of the soil profiles and collect samples for chemical analysis. The test pit locations, details of methods, and results are provided in the report, "Goslin Flats Land Application Disposal Expansion Assessment and 2000-2001 Plan of Operations" (HSI and Spectrum 2000).

Table 3.4-5 presents trends in soil salinity parameters at the original Goslin Flats LAD area before and after the 1999 application season, and in early 2000. The data confirm that soil salinity and sodicity have increased to levels suitable only for salt tolerant plants. Fortunately, western wheat grass, the primary grass in the original LAD area, is salt tolerant. Soil salinity and sodicity are at levels requiring special management on the original LAD. Water application rates per unit area were significantly reduced in 2000 as the expansion areas were brought on line.

The 2000 soils analyses include acetic acid-extractable metals and trace elements from the original LAD area and expansion areas. All concentrations were below the suggested threshold levels, except aluminum. As discussed in HSI and Spectrum (2000), the laboratory analytical procedure detects colloidal aluminum, which is not considered bio-available. Based on previous experience, aluminum is not actually available to plants at these levels.

The soils within the Goslin Flats LAD area are generally considered suitable for land application of mine waters. The principal limitations are the high percentage of coarse fragments and rapid permeability of the subsoils. This limitation has been addressed in development of a comprehensive management plan as described in the Goslin Flats LAD Expansion Assessment report (HSI and Spectrum 2000).

Table 3.4-5. Soil Salinity and Sodium Hazard Calculations at Goslin Flats LAD

Date	Location	Depth (inches)	pH (s.u.)	EC mmhos/cm	SAR (%)	Calculated ESP (%)	Soil Condition (see key)
03/10/99	LS1A	4-12	6.02	1.653	11.1	13.13	4
03/10/99	LS1A	13-24	6.04	1.678	2.9	2.93	4
12/14/99	LS1A	0-6	6.3	11	19.8	21.84	2
12/14/99	LS1A	6-24	6.9	9.29	20.7	22.64	2
03/23/00	LS1A	0-6	6	7.67	17	19.23	2
03/23/00	LS1A	6-18	6.7	7.13	15.2	17.46	2
03/10/99	LS2A	5-12	6.07	2.77	16.11	18.37	3
03/10/99	LS2A	13-24	6.56	3.08	17.93	20.12	3
03/23/00	LS2A	0-6	6.7	7.01	16.1	18.36	2
03/23/00	LS2A	6-24	7.5	8.15	19.5	21.57	2
03/10/99	LS3A	5-12	5.97	1.544	3.36	3.56	4
03/10/99	LS3A	13-24	6.37	1.255	1.15	0.43	4
12/14/99	LS3A	0-6	6.1	2.95	5.08	5.87	4
12/14/99	LS3A	6-24	7.1	2.54	1.68	1.20	4
03/23/00	LS3A	0-6	6.5	6.82	16	18.26	2
03/23/00	LS3A	6-24	7.5	7.02	15.1	17.36	2
03/23/00	E2	0-6	6.1	6.57	16.1	18.36	2
03/23/00	E2	6-24	7.7	7.33	17.9	20.09	2

Notes: EC = Electrical Conductivity
SAR = Sodium Adsorption Ratio
Calc. ESP = Calculated Exchangable Sodium Percentage
Location E2 is near monitoring well ZL-211.

Key to Soil Salinity and Sodicity Levels:

Soil Condition	Soil Classification	Plant and Soil Response
1. EC>4 ESP<15	Saline-Nonsodic	Osmotic stress; well aggregated
2. EC>4 ESP>15	Saline-Sodic	Osmotic stress; potential dispersion
3. EC<4 ESP>15	Nonsaline-Sodic	No osmotic stress; dispersed
4. EC<4 ESP<15	Nonsaline-Nonsodic	No osmotic stress; well aggregated

Source: American Petroleum Institute, 1997; Remediation of Salt-Affected Soils at Oil & Gas Production Facilities

3.4.2 Soil Reclamation Potential

In addition to the reference soils discussed in the preceding section, Prodgers (2000) characterized soil stockpiles and soils that have been vegetated for five to ten years. Comparing reference soils to placed soils formed the basis for many aspects of the revised revegetation plan. Prodgers found that the soils were

not inherently limiting to reclamation, but that the soils' suitability or need for amendment/special practices varied among plant growth forms. For grasses and some forbs, the chief limitation is soil infertility. For other forbs, such as Cicer milkvetch, there is no limiting factor. For pine trees, the chief limitations are soil compaction and soil thickness.

A coarse fragment content of 50% or more is a limitation because rock fragments limit root penetration and hold virtually no water or exchangeable nutrients. Reference soils, however, have similar coarse fragment contents, so soils are suitable in physical respects although there is a limitation. Soils can be satisfactory growth media for grasses (with fertilization or nitrogen fixation) and forbs. For conifers, soils can be satisfactory growth media as long as they are uncompacted and adequately deep. The rooting depth can include non-acid generating substrates below the soil proper. A fungal dominance among soil microbes would promote healthy trees.

Soil Suitability and Availability

In evaluating suitability, the physical, chemical, and microbiological properties of soils are important. The general physical and chemical properties of the Montana Gulch and Mill Gulch soil stockpiles, which together comprise 77% of the stockpiled soil, are:

Organic Matter 0.8%	Clay Content (in the fine earth fraction) 23%
Nitrate Concentration 1.5 ppm	Coarse Fragment Content by Volume (by visual inspection) 57%
Ammonium Concentration 4 ppm	Plant-Available Phosphorus 14 ppm
Plant-Available Potassium 170 ppm	pH 6.8 s.u.

Soil Stockpile Suitability

The high coarse fragment content of the soils (Table 3.4-6) is a limitation in some respects, but it also has positive effects. For example, coarse fragments decrease the erosiveness of placed soils. However, if the soil fines are eroded away, the development of a rocky surface inhibits the establishment of arriving seeds.

Apart from the coarse fragment content, the texture of soil, ranging from sandy loam to sandy clay loam, is nearly optimal. One qualifier is that care must be taken not to compact soils which contain about 20% or more clay. Conifers would do best on the lighter (sandier) soils, whereas grasses and especially some forbs are well adapted to the heavier (more clayey) soils.

Table 3.4-6. Particle Size and Texture of Two Soil Stockpiles

Soil Stockpile Location	Coarse Fragment Content (%)	Sand Content (%)	Silt Content (%)	Clay Content (%)	Texture
Montana Gulch	65	NA	NA	24	Very gravelly sandy clay loam
Mill Gulch	65	NA	NA	24	Very gravelly sandy clay loam
Mill Gulch (top)	35	54	29	17	Very gravelly sandy loam
Mill Gulch (bottom)	42	50	34	16	Extremely gravelly loam

Soil fertility and organic matter content are summarized in Table 3.4-7. The nitrate levels seem good, but would quickly be immobilized by establishing revegetation. In soils, at least near the surface, the microbial mineralization of nitrogen and lack of vascular plants together result in concentrations of a few parts per million. Phosphorus and potassium are adequate, but higher levels would be optimal for revegetation. Summing up, fertilization with nitrogen and, to a lesser degree, phosphorus and potassium would make fertility optimal for grasses and forbs. Except for nitrogen, the stockpiled soil fertility is adequate for pine trees.

Table 3.4-7. Soil Stockpile Fertility and Organic Matter Content

Soil Stockpile	Nitrogen (ppm)	Phosphorus (ppm)	Potassium (ppm)	Organic Matter Content (%)
Mill Gulch (April)	5	14	190	1.0
Mill Gulch (June)	2	15	160	1.0
Montana Gulch (April)	1	14	160	1.0
Montana Gulch (April)	0.3	8	204	0.7
Average	2	13	180	0.8

When compared to reference soils (Table 3.4-3), microbiological data for the soil stockpiles shown in Table 3.4-8 reveal a deficiency of fungi. Five- to ten-year-old vegetated soils also exhibited this tendency. Protozoa are actually more abundant than in reference soils, and nematode density is similar to that of vegetated soils, although less than reference soils.

Table 3.4-8. Microbiological Properties of Two Soil Stockpiles

Plant Community	Bacteria (ug/g)	Fungi (ug/g)	Ratio Fungi/ Bacteria	Protozoa	Nematodes
				Density	
Mill Gulch Stockpile (June)	141	38	0.27	30,000	0.1
Montana Gulch Stockpile (June)	131	55	0.42	6,200	0.8

Soil Availability

The four existing soil stockpiles at the Landusky Mine comprise about 2.67 million tons or 1.78 million loose cubic yards. At an assumed bulk density of 1.8 g/cc for placed soil (a no-compaction scenario), this volume could cover 730 acres to a depth of 18 inches. An additional 0.3 million tons of soil is stockpiled at the Zortman Mine.

In addition, about 75,000 cubic yards of King Creek alluvium/tailings is to be placed on the L80-82, L83, and L84 leach pads, providing about 6 inches of cover material. Four out of five King Creek samples were sandy (droughty, low cation exchange capacity), and the remaining sample was silty, which is better for growing plants but erosive (Table 3.4-9). King Creek material could augment the soil resource if mixed with soil or placed between soil and underlying substrate. For pine tree vegetation only, it could be placed on the surface of rocky substrates.

Table 3.4-9. Two Methods of Textural Analysis of the King Creek Alluvium/Tailings

Sample	Gravel Content (%)	Sand Content (%)	Silt Content (%)	Clay Content (%)	Silt+Clay* Content (%) and Texture
KC-01	28	68	2	2	4
Fine earth fraction	--	94	3	3	Sand
KC-02	27	69	2	2	4
Fine earth fraction	--	94	3	3	Sand
KC-03	27	60	7	6	13
Fine earth fraction	--	82	10	8	Sandy loam - loamy sand
KC-04	26	40	32	2	34
Fine earth fraction	--	54	43	3	Sandy loam
KC-05	24	61	9	6	15
Fine earth fraction	--	80	12	8	Sandy loam

* Something like 15% (silt + clay) in the total volume – not just the fine earth fraction – is a reasonable value to identify minimally acceptable plant growth media. If the material is mixed with soils that have around 20% clay content, even coarse material can be beneficial.

Ruby Gulch alluvium may be used to augment the soil resource at the Zortman Mine. This material is gravelly (Table 3.4-10). The fine earth fraction is better suited to plant growth than King Creek tailings, but due to the "extremely gravelly" character, it also would function better mixed with soil or placed between soil and the underlying substrate.

Table 3.4-10. Two Methods of Texture Analysis of the Ruby Gulch Tailings (Prodgers 2000)

Sample	Gravel Content (%)	Sand Content (%)	Silt Content (%)	Clay Content (%)	Silt+Clay Content (%) and Texture
Z1	63	16	19	2	21
Fine earth fraction	--	43	51	5	Silt loam
Z2	60	20	17	3	20
Fine earth fraction	--	50	43	8	Loam
Z3	50	31	15	4	19
Fine earth fraction	--	62	30	8	Sandy loam

* Something like 15% (silt + clay) in the total volume – not just the fine earth fraction – is a reasonable value to identify minimally acceptable plant growth media. If the material is mixed with soils that have around 20% clay content, even coarse material can be beneficial.

3.5 VEGETATION

The study area includes mountainous portions of the Little Rocky Mountains and the prairie plant communities of the Goslin and Ruby Flats areas. Mining activities have removed some vegetation, and some disturbed areas have been revegetated.

3.5.1 General Vegetation Patterns

Culwell et al. (1990), in Appendix 4 of the 1992 Operating Permit Application, identified 25 types of plant communities in the study area (FEIS Table 3.4-1). Most of this diversity is attributable to riparian and lowland plant communities, whereas the upland forest zone has fewer types. Their vegetation map indicates the distribution patterns on a topographic base map. This diversity of communities is attributable to the variety of substrates, range in elevation, topographic features, hydrologic regimes, and land use histories. These communities can be grouped into seven vegetation types:

Vegetation Type	Pre-Mine Acreage
Grasslands	2,700
Shrublands	800
Lodgepole Pine Forest	7,300
Ponderosa Pine Forest	300
Douglas Fir Forest	300
Deciduous Forest	1,300
Rock/Scree/Disturbed	1,700
Total Pre-Mine Acreage	14,400

When mining ceased, a total of 851 acres at the Landusky Mine and 404 acres at the Zortman Mine had been disturbed. Since then, about 248 acres of mining disturbance have been revegetated at the Landusky Mine and 104 acres at the Zortman Mine, with another 21 acres of ancillary revegetation (clay pits, etc.). This acreage was seeded primarily to grasses and forbs to promote revegetation. In portions of the same acreage, 62,282 conifers (lodgepole and Ponderosa pine and Douglas Fir) and 21,918 shrubs were transplanted.

Culwell et al. (1990) provide a wealth of descriptive information for pre-mine vegetation, including a vegetation map, canopy coverage/species composition, productivity, tree and shrub densities, and species list. For forest types, data also was compiled for tree diameters, height, age, site index, and yield capability for each type.

Mine revegetation was monitored by various investigators. In general, the revegetation progress has been increasing plant cover for a few years, followed by subsequent shift in species composition and decline in

plant abundance. Prodgers (2000) sampled canopy coverage and computed species composition for most revegetated areas. The revegetation condition is summarized by the following weighted averages (weighted by acreage). The last three parameters are measures of plant diversity.

37.5%	Vascular Plant Canopy Coverage (Daubenmire 1959)
12 species	Species Richness (per 20½ m^2 plots)
5.4 species	Species with less than 1% Canopy Coverage (based on 20½ m^2 plots)
1.46	Equitability (Shannon ln)

Forestry

Most of the area in the mountainous landform was (and remains) lodgepole pine forest, with smaller areas of Douglas fir, Ponderosa pine, and mountain grasslands. Potential for commercial forestry is limited by tree size (mostly saplings and post-and-pole size timber) and distance to a processing facility. Minimally developed forest soils seem capable only of producing dense stands of small trees. Commercial use of these "doghair" stands is not feasible.

Riparian Areas, Wetlands, and Other Waters of the United States

Riparian Vegetation

Riparian vegetation was inventoried by Culwell et al. (1990). Examples of riparian plant communities are deciduous forest such as quaking aspen and paper birch, hawthorne thickets, and stands of chokecherry in coulees and on floodplains and grasslands. While some of these species can indicate the "hydrophytic vegetation" component of jurisdictional wetlands, wetland hydrology is often lacking in riparian areas, as are hydric soils.

Jurisdictional Wetlands

The study area contains some swampy areas and a small amount of riverine wetlands. These are identified in the FEIS. In wetland accounting, the acreage of wetlands lost or gained is often accompanied by an assessment of wetland functions and values. While values are subjective and changeable, and functions are more often inferred than measured, the FEIS has five pages of tables documenting wetland functions and values.

Noxious Weeds

Canada thistle and spotted knapweed were the two species on the noxious weed list for Phillips County which were observed in the study area when the 1996 FEIS was written. Prodgers (2000) did not observe any others, and in particular did not observe any noxious weeds in revegetated mined areas. The only

weed of note there, and it is not a noxious weed, is mullein (Verbascum thapsus). There is some localized cheatgrass (Bromus tectorum), and spotted knapweed is common in the community of Zortman. Even the attractive "sweet rocket" (Hesperis matronalis) in Zortman, no doubt a garden escapee, is considered a weed by some.

When weeds invade, it indicates that the arriving species can utilize resources that the existing plant community are not using efficiently, and that natural checks on the weed population are absent. For example, a weedy species may use soil moisture while other species remain dormant, or its rooting characteristics may allow use of resources at a different depth, etc. Poor grass revegetation, which characterizes much existing mine revegetation, is probably an open habitat to several species of arriving weeds. Dalmation toadflax, a forb of stoney slopes, is one prime candidate for the mountainous areas and rocky soils.

So far, weed control measures have been effective in the mine-affected portion of the Little Rockies. This success is attributable to both weed control measures and limited vehicular access. As public access increases, weed invasion of reclaimed areas is inevitable, but the degree of infestation and associated cost of control depend on many variables: which weeds are introduced, how well adapted they are, how promptly and effectively they are controlled, etc.

Plant Species of Special Concern

Sensitive Species

A specimen of a species of goundsel (a genus of the aster family), Senecio eremophilus, was collected near the head of Ruby Gulch in 1978 but has not been seen since. It retains its rating of S1 in Montana but this is a widely distributed species, ranging from British Columbia to Ontario and south to Arizona and New Mexico. Van Bruggen (1976) says of this species in South Dakota, "rare in wet soil along roadsides and in ravines in the black hills." This sounds like an opportunist of narrow niche breath -- an impermanent species locally. Dorn (1992) mentions its occurrence in several portions of Wyoming.

An attractive species of figwort, Penstemon grandiflorus, has become common in some revegetated Zortman units that were reclaimed. It may have originated as a contaminant in a revegetation seed mix. This species is uncommon in Montana although previously collected. It has not been assigned a status by the Montana Natural Heritage Program but is being tracked. Large penstemon, as it is known, is common in portions of Wyoming and South Dakota.

Ethnobotany

Ethnobotany refers to the study and use of plants by the different races of man. Species in the study area that have been used by local traditional cultures include chokecherry, juniper, snowberry, Oregon grape, bearberry, wild rose, and all tree species. One of the most avidly sought native species for ceremonies and

other uses, sweetgrass, has not been observed in the study area.

3.5.2 Metal Concentrations in Plant Tissues

Application of leach pad waters to the Goslin Flats LAD began in 1998 and continued through 2000. Residual metals and other trace elements remain in the pad waters applied to the LAD. Some of these contaminants have the potential to accumulate in plant tissues, raising concerns about toxicity and palatability for livestock and wildlife.

Vegetation sampling was conducted in 1999 and 2000 to evaluate the levels of metals in LAD plants and to assess forage quality. Grass and forb samples were collected for bioassay analysis from the original Goslin Flats LAD. Samples were collected from the expansion areas prior to pad water application. Vegetation samples were collected in the fall of 1999 from a potential LAD site south of Landusky and at the Goslin Flats LAD area. The analyses test included aluminum, arsenic, boron, cadmium, copper, manganese, molybdenum, nickel, lead, selenium and zinc, calcium, sulfate, magnesium, sodium and chloride.

Comparison of the vegetation bioassay results between background sites and LAD areas leads to the following general observations:

- Values for the background samples at the Landusky LAD and Goslin Flats LAD expansion areas are generally consistent with "normal" ranges for unaffected vegetation, as presented by various authoritative sources (HSI and Spectrum 2000). Copper tends to be in the upper end of these ranges, with the grass sample from expansion area 7 (22 ppm) exceeding the normal range.

- Four elements were significantly elevated (above control values) in affected samples: copper, manganese, selenium and zinc. Copper increased from less than detection limits (5 ug/g) in control samples to 5-6 ug/g in affected samples. Manganese increased by a factor of about 7 from a range of 9-19 ug/g in control samples to 87-124 ug/g in affected samples. Selenium increased from less than detection limits (5 ug/g) in control samples to 6-15 ug/g in affected samples. Zinc increased by a factor of about 4 from a range of 7-13 ug/g in control samples to 31 - 40 ug/g in affected samples.

- Copper, manganese and zinc are generally within normal ranges, however, manganese and zinc are higher than mean values listed for grasses in Montana (HSI and Spectrum 2000). Selenium in affected samples exceeds the accepted normal ranges.

- Samples from the original Goslin Flats LAD were generally at the upper end of, or exceeded the "normal range" for cadmium, copper, manganese, zinc and selenium.

- Crude protein and total nitrogen averaged 57% higher in the original Goslin Flats LAD samples, compared to the background samples from the expansion areas.

- Sodium content was much greater, and iron somewhat lower in the original Goslin Flats LAD samples, compared to the background samples.

- Trace element levels in forbs generally equaled or exceeded that for grass in the same sample area.

- Bio-concentration of selenium by native grasses on the original Goslin Flats LAD have resulted in levels reaching 5 to 8 ppm, based on samples of grass and forbs collected in June 2000. The commonly recommended selenium guidelines for livestock consumption range from 2 to 5 ppm (HSI and Spectrum 2000). Some wildlife and aquatic organisms are known to be more sensitive to selenium uptake than livestock.

The US Forest Service and BLM in Idaho have issued interim guidelines for grazing on public lands affected by selenium, based on data collected at phosphate mines in Idaho, as follows:

- 50% of the vegetation sampled from a site must have selenium concentrations less than 5 mg/kg (ppm) selenium, dry weight;

- 45% of the vegetation sampled may contain concentrations of selenium between 5 mg/kg and 10 mg/kg dry weight; and

- No more than 5% of vegetation sampled may exceed 10 mg/kg dry weight, and no more than 0.5% of samples may exceed 20 mg/kg selenium dry weight.

Based on this guidance, the levels of selenium in vegetation on the Goslin Flats LAD area found in 2000 are at the lower level of concern for cattle grazing. The results for the expansion areas would pass the interim guidelines for Federal lands in Idaho. Samples from the original LAD would meet the third criteria, but not the first two. Most of the samples (6 of 8) exceeded 5 ppm selenium as dry weight, but the average of those samples greater than 5 ppm was 6.6 ppm, slightly over the 5 ppm criteria. Since the source of the selenium is application through sprinkler irrigation, the levels found in the LAD soils are more uniform than those found in the reclaimed phosphate mines in Idaho. This should make evaluation of toxicity risks somewhat easier for the LAD.

The LAD areas are fenced and unauthorized use by livestock is precluded. The Square Butte Grazing Association maintains grazing rights in the area. An grazing operator began grazing a small herd of steers on the original LAD area in September 2000. No ill effects had been observed by December 2000.

Copper and cadmium have bio-accumulated in the vegetation of the original LAD area, but are at levels generally below those adverse to livestock. Copper was present at an average concentration of 18.3 ppm in grasses and forbs, and cadmium averaged 0.85 ppm dry weight. These levels are at the upper end of the "normal" ranges (HSI and Spectrum 2000). Compared to background levels, copper was enriched by only a factor of 1.3, while cadmium was enriched by a factor of 3 to 4.

3.6 WILDLIFE and AQUATICS

3.6.1 Wildlife Resources

The Little Rocky Mountains provide important mountainous habitat for mule deer and white-tailed deer, elk and bighorn sheep. Mule deer are common throughout the mountains from spring through fall. During winter months, mule deer are confined to southern exposures at lower elevations. White-tailed deer are also found year long in the mountains. Deciduous-shrub vegetation found in major creek bottoms, including Camp Creek, Alder Gulch, Beaver Creek and Lodgepole Creek, provide excellent cover as well as forage for white-tail deer. The Little Rocky Mountains provide moderate to high value habitat for elk. Herd size is limited due to the small size of the mountain range and hunting pressure. Current use of the area by elk results from dispersal from the Missouri River Breaks area to the south. Bighorn sheep are also found in the area. Saddle Butte, Silver Peak and Sugar Loaf Butte along the southern edge of the Little Rockies make up the primary winter range for bighorn sheep. The sheep use a wider range of the Little Rockies at other times of the year and have been sighted within the Zortman and Landusky Mine areas. Pronghorn antelope use the prairies that surround the Little Rocky Mountains but do not use the mountainous areas.

Black bears are occasionally sighted in the Little Rocky Mountains. Dispersion from the nearby Missouri River Breaks probably accounts for these observations. Coyotes and mountain lions are the two most common predators in the Little Rocky Mountains. Bobcats are sighted occasionally. Gray wolves are not known to occur in the area.

Blue grouse and a small population of wild turkeys can be found in the Little Rocky Mountains. Sage grouse, sharp-tailed grouse, grey partridge and ring-necked pheasant can be found in the foothills surrounding the planning area.

Golden eagles, red-tailed, ferruginous, and rough-legged hawks, American kestrel and great-horned owls are common through out the area at various times of the year. Cooper's hawk, northern goshawk and prairie falcon are occasionally observed.

At least seven species of bats use the area. Azure cave is one of several bat hibernaculums in the Pacific Northwest, and may be the northernmost hibernaculum in the United States. Current surveys of hibernating bats estimate the cave's population to be between 1100 and 1300 bats.

Numerous small mammal species and a few reptile and amphibian species may be found in the Little Rocky Mountains. None of them are considered to be a special status species.

Historical and potential habitat for seven species of wildlife, which are federally classified as threatened or endangered, occur within Phillips County. These species are bald eagle, peregrine falcon, black-footed ferret, least tern, piping plover, whooping crane and the gray wolf. In addition to these species, the

mountain plover and the black-tailed prairie dog are candidate species for classification as threatened or endangered.

Bald eagles have been recorded within the Little Rocky Mountains on one occasion during the Audubon Society Christmas Bird Count. However, there are no known bald eagle nests or essential habitat in the Little Rocky Mountains, and open water bodies that could provide nesting or foraging habitat do not exist.

There have been no reported sightings of gray wolves within the Little Rocky Mountains, which do not contain habitat suitable for maintaining a permanent wolf pack. There is no suitable habitat in the Little Rocky Mountains for the black-footed ferret, black-tailed prairie dog, least tern, piping plover, mountain plover and whooping crane.

The peregrine falcon is the only one of these species which has potential to be affected by the project. The high walls of the mine pits may provide artificial nesting habitat for the peregrine falcon. Higher quality nesting habitat is available for peregrine falcons in undisturbed areas within the Little Rocky Mountains, but to date there are no known peregrine falcons that nest within the mountains. It is doubtful that any nesting habitat at the mine site would be destroyed by reclamation activities.

Townsend's big-eared bat, a BLM species of special concern, are an insectivorous bat species that is known to occur in the Little Rocky Mountains. This bat may travel 6-8 kilometers from its roost site for foraging. Townsend's big-eared bat require water after roosting all day. Calm water bodies such as livestock ponds should be protected near roosting sites. Townsend's big-eared bat prefers to use caves around evergreen forests but is known to use abandoned mines for roosting. Azure Cave provides high value habitat for both maternity and hibernacula. (Rauscher 2000).

More detailed accounts of wildlife species present in the project area can be found in Section 3.5.1 of the 1996 FEIS.

3.6.2 Aquatic Resources

Fisheries habitat in the Little Rocky Mountains is limited, due to the fact that 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. In 1990 and 1991, ten streams were sampled for macroinvertabrates: Beaver Creek, upper Lodgepole Creek, lower Lodgepole Creek, Alder Gulch, Mill Gulch, Rock Creek, Montana Gulch, Bull Gulch, Big Horn Creek, and King Creek. On July 6, 1995, the BLM sampled Alder Gulch and Montana Gulch for macroinvertabrates. The findings on these two streams were similar to the 1990-1991 sampling. The dominant taxa were fly larvae (Chironomidae and Simuliidae), mayflies, stoneflies and flatworms.

The overall low total macroinvertebrate numbers, low diversity of taxa, and abundance of pollution- tolerant organisms reflect both natural changes and affects from previous mining activities (FEIS 1996).

A biological assessment of streams in the Little Rocky Mountains was conducted by Chadwick Ecological Consultants Inc. in 1996. Fourteen study sites were established on drainages surrounding the Zortman Mine site. Nine study sites were established on drainages surrounding the Landusky Mine site.

The fourteen study sites at the Zortman Mine were established as follows: Alder Gulch (4 sites), Alder Spur (1 site), Ruby Gulch (2 sites), Camp Creek (1 site), Lodge Pole Creek (2 sites), Beaver Creek (2 sites), Pony Gulch (1 site), and Carter Gulch (1 site). Of these fourteen sites, only nine had surface flows. The five sites which did not have surface flows are: The most downstream site on Alder Gulch, Alder Spur, Pony Gulch, and both sites on Ruby Gulch. At the nine sites with surface flows, physical habitat data was collected as well as a biological inventory. Of these nine sites, physical habitat data shows that these streams are relatively small, providing limited habitat. These streams had narrow channel widths, shallow water depths and low flows. The lower part of Alder Gulch, lower Beaver Creek and lower Lodgepole Creek had wider, deeper water channels with slightly higher flows. Only two sites had fish populations: the most downstream location on Beaver Creek, and the most downstream location on Lodgepole Creek. Brook trout (*Salvelinus fontinalis*) was the only species present at both locations.

Sixty-one brook trout were collected at Lodgepole Creek. These fish appeared to have recently completed spawning activity and were in below average condition. At Beaver Creek, 124 fish were collected at Beaver Creek. These fish were in full spawning readiness and average condition. Several size classes were present, indicating that this population was naturally reproducing.

Benthic macroinvertebrates were also collected at these nine sites. Numerically important invertebrate groups included stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), and true flies (Diptera). Shannon-Weaver diversity values at all locations indicate healthy invertebrate communities (Chadwick 1996).

The nine sites associated with drainages at the Landusky Mine are as follows: Rock Creek (4 sites), Sullivan Park (1 site), Mill Gulch (1 site), Montana Gulch (1 site), King Creek (1 site), and South Big Horn Creek (1 site). Of these nine sites, eight had surface flows. The site with no flow was located on Rock Creek upstream from Montana Gulch but downstream of Mill Gulch. At the eight sites with surface flows, physical habitat data was collected as well as a biological inventory. Streams near the Landusky Mine were generally small with narrow, shallow channels and low flows. Montana Gulch and Rock Creek downstream of Montana Gulch had larger channels with somewhat higher flows. The most downstream site on Rock Creek was the only site where fish were present. Brook trout was the only species present. Two fish were collected, and both were in full spawning readiness and above average condition.

Benthic macroinvertebrates were also collected at these eight sites. Numerically important invertebrate groups included stoneflies, mayflies and true flies. Shannon-Weaver diversity values indicate balanced communities at most locations (Chadwick 1996).

3.7 AIR QUALITY and METEOROLOGY

3.7.1 Air Quality

The FEIS reported that air resources at the mines are generally of good quality. No air quality data for the mines was available prior to 1990, and no data were collected prior to mining (FEIS, p. 3-178). Monitoring data concerning respirable particulates (PM10) were collected from March 1990 to April 1995 at up to 10 locations within the mine areas. The maximum 24-hour PM10 concentrations in the area was 102 ug/m^3. The Montana and Federal 24-hour ambient air quality standard for PM10 is 150 ug/m^3, and is not to be exceeded more than once per year. The annual Montana and Federal standard is 50 ug/m^3. The background concentrations measured at the site are below the Montana and Federal ambient air standards.

There have been changes in the air emission point sources at the Zortman and Landusky Mines since the FEIS. The gold assay lab is no longer processing gold samples in Zortman, thereby eliminating a source of lead emissions. The refinery at the Zortman Mine process plant is not functioning. Hydrogen cyanide gas emissions from the heap leach pads may still occur, but most of the cyanide has decayed and such emissions are very small. When measured in 1990, hydrogen cyanide concentrations did not exceed 1 ppm. The Threshold Limit Value for hydrogen cyanide in air is 10 ppm (ACGIH 1991). Particulate and gaseous emissions from vehicle operations are still occurring on the mine sites, but to a lesser extent than during mining operations.

3.7.2 Climate and Meteorology

The FEIS described the climate of the Little Rocky Mountains as semi-arid and continental. Additional details regarding ambient tempertures, wind speed and direction were summarized in the FEIS (p. 3-184).

A number of metereological monitoring stations lie in the vicinity of the Zortman and Landusky Mines. The NOAA weather station in the town of Zortman has been in operation since 1965. The BLM-Zortman station has operated since 1987 at the Zortman Mine. Other weather stations (Seven Mile Road, Gold Bug Butte, and Sullivan Park) were maintained by ZMI from 1990 to 1996 as part of an air monitoring program. The Zortman NOAA station and Gold Bug Butte station have been continuously operated from 1995 to the present, and provide the basis for the water balance presented in Section 3.3.

Other, more distant stations like Mocassin and Malta, Montana (operated by Montana State University) have been useful due to the lengthy or specialized records collected. The Mocassin station, located about 90 miles southwest of Zortman, has a long period of pan evaporation and other meteorological data useful for correlation to the mine sites. The Malta AGRIMET station was established in 1997 for farm irrigation scheduling by the U.S. Bureau of Reclamation in cooperation with Montana State University. It is a fully automated system with hourly satellite uplinks to a central processing station in Billings, Montana. Meteorological data and crop water use estimates may be accessed on a next-day basis via the internet.

This station was used in the Goslin Flats LAD area irrigation scheduling.

Precipitation

The average annual precipitation at the Zortman townsite (1965-1995) was 18.7 inches. Of the years since 1995, 1996 was about average (-0.07 inches), 1997 and 1998 above average (+7.13 and +5.25 inches, respectively), 1999 below average (-2.32 inches), and 2000 below average (-2.31 inches). The Gold Bug Butte station was established in 1991, where the average annual precipitation through 1995 was 21.8 inches, compared to 19.93 inches for the Zortman NOAA station in the same period.

About half of the annual precipitation falls in the spring and early summer months (May-July) when intense thundershowers or snowstorms occur. The majority of total annual precipitation (~80%) occurs during the growing season (April-October).

The data indicate significant local variations in precipitation. The data suggest that the Landusky Mine receives on average more precipitation than the Zortman Mine. The various stations near the Zortman Mine also showed significant variations, both month-to-month and year-to-year. The Seven Mile Road station received significantly less precipitation than the other three stations near Zortman, which is likely due to the geographic location. Elevation does not appear to be the dominant factor, as the Zortman townsite and the Seven Mile Road stations are at similar elevation yet differed significantly in total annual precipitation. The climate data also indicate that through the early 1990s, wet and dry years alternated, with 1993 one of the wettest years on record (29.23 inches at the Zortman NOAA station). A succession of four years, 1995 through 1998, saw average to above average precipitation (25.83 inches in 1997), followed by relatively dry years in both 1999 (16.38 inches) and 2000 (16.39 inches).

Potential Evaporation

Potential evaporation (pan evaporation) was measured by ZMI from 1991-1997. Pan evaporation rates ranged from 24.5 to 40.4 inches at the Gold Bug Butte station, to 28.0 to 49.5 inches at the Seven Mile Road station (WMCI, p. 170). The nearest weather station with similar climate conditions and a pan evaporation record is at Mocassin. Monthly pan evaporation rates for the period 1992 to 1997 were compared. The data indicate a generally good agreement of monthly evaporation rates for the years 1994-1996. However, in 1992 and 1993 the monthly pan evaporation rates at Mocassin were typically higher than at the Zortman Mine and, in particular, at the Landusky Mine. Pan evaporation is generally greater than that from a large open water body due to absorbed heat. Literature sources indicate that the expected lake evaporation rate for the Zortman Mine area is 38 to 43 inches per year.

Evapotranspiration

Evapotranspiration is the actual amount of water removed by evaporation and transpiration from soils and plants. It is smaller than the potential evaporation rate since it is often limited by lack of available moisture.

Calculated mean annual evapotranspiration for the Zortman and Landusky Mines by the Thornthwaite equation is 19.4 and 21.0 inches, respectively. It is highly variable depending on temperatures, precipitation, ground cover, vegetation type and quality, and other factors.

The Malta AGRIMET station was used as the basis of real-time irrigation scheduling for the Goslin Flats LAD in 2000. The Bureau of Reclamation processes the hourly data and computes water use rates by various vegetation cover types on a daily, monthly and annual basis. The computed consumptive water use rates for pasture for the years 1998, 1999 and 2000 (April through September) was 24.8, 23.9 and 26.8 inches, respectively. The actual rates for pasture in the Zortman and Landusky areas are probably somewhat lower than at Malta. The evapotranspiration rates on the mine sites was estimated to be much lower than these values in the water balances (Spectrum 2000a and 2000b). This is due to cooler temperatures, thin or absent soil, and lack of vegetative cover over much of the mine sites.

3.8 LAND USE

The land use around the Little Rocky Mountains and near the mine sites is described in Section 3.7 of the 1996 FEIS, and in Chapter 3 and Appendix B. 2 of the environmental assessment prepared for the locatable mineral withdrawal application in the Little Rocky Mountains.

Public Land Order 7464(PLO), creating a locatable mineral withdrawal on a portion of the Little Rocky Mountains, was signed on September 18, 2000. PLO 7464 was published in the Federal Register on October 5 , 2000 (Volume 65, Number 194, Page 59463), which is the effective date of the withdrawal. The purpose of withdrawing 3,530.62 acres in the Little Rocky Mountains is to facilitate reclamation activities being conducted by the State of Montana and BLM at the bankrupt Zortman and Landusky Mines. The withdrawal is needed to secure the project area and sources of potential reclamation materials from mining claimants in order to complete reclamation as quickly and efficiently as possible, thereby preventing unnecessary or undue degradation. The withdrawal segregates Federal minerals in the Little Rocky Mountains from the location of mining claims for five years. The land remains open to mineral leasing and mineral material disposal.

There are 14 communication rights-of-way issued by the Bureau of Land Management on Antoine Butte, which is adjacent to the mining area. There are six communication buildings on Antoine Butte. The rights-of-way issued to Everett F. Tyrrel and TCI Microwave, Inc. are authorized to sublease to other communications users. Access to the Antoine Butte communication site is by verbal permission using the main access road between the mines. Communication buildings, BLM rights-of-way serial numbers, and the users are listed below.

<u>Newer BLM Building</u>	
MTM-00590	Bureau of Land Management
MTM-08800	Bureau of Indian Affairs (Indian Health Service)
MTM-33660	Fish and Wildlife Service
MTM-38849	Phillips County
MTM-52008	Department of Health and Human Services
MTM-52860	Big Flat Electric Co-op., Inc.
MTM-58707	Montana Department of Justice
MTM-66582	Montana Department of Natural Resources and Conservation
MTM-88925	Montana Department of Transportation
<u>Older BLM Building</u>	
MTM-08800	Bureau of Indian Affairs (BIA, Forestry Department)
MTM-45075	Hill County Electric Co-op., Inc.

Everett F. Tyrrel Building
MTM-35478 Everett F. Tyrrel

TCI Microwave Inc. Building
MTM-00998 TCI Microwave, Inc.

Phillips County TV Co-op. Building
MTM-01328 Phillips County TV Co-op.

United States Department of Justice Building
MTM-02340 United States Department of Justice (Border Patrol)

Forest resources in and around the Little Rocky Mountains consist mostly of ponderosa pine and Lodgepole pine. There are stands of Douglas-fir in and around the moister areas. Much of the area is overstocked with second growth ponderosa pine in the 3-8 inch diameter range with an overstory of 16+ inch mature ponderosa pine. Many of the natural meadows have an encroachment of ponderosa pine seedlings and saplings that are 25 years old or less.

In 1988 the Monument Peak Fire burned approximately 8,000 acres. Much of this area has regenerated naturally to Lodgepole pine. Walk-through surveys revealed as many as 10,000 seedlings per acre, ranging in size from a few inches to approximately two feet or less in height.

Past use of the forest resources include Christmas tree gathering, firewood use, sales of post and pole material and minor amounts of sawtimber.

There have been no grazing permits issued for the Little Rocky Mountains on or near the Zortman or Landusky Mines.

The Judith Valley Phillips Resource Management Plan EIS (BLM 1992) allows for the gathering of reasonable amounts of commonly available, renewable resources such as flowers, berries, nuts, seeds, cones and leaves for non-commercial use in accordance with BLM regulations at 43 CFR 8365.1-5. Commercial gathering or haying requires a contract or permit issued by a BLM-authorized official in accordance with 43 CFR 3610 or 5400.

3.9 RECREATION and VISUAL RESOURCES

3.9.1 Recreation Resources

A wide range of recreational opportunities exist in the area from picnicking, sightseeing and watching wildlife to hunting and fishing. These opportunities meet a diversity of visitor preferences. Participation in specific recreational activities varies according to the season of the year, with hunting and fishing dominating the fall scene and limited snowmobiling and cross-country skiing during the winter. Springtime activities include fishing, sightseeing and photography. Camping, picnicking, pleasure driving, sightseeing, fishing, hiking, collecting, and shooting prairie dogs dominate recreation during the summer months along with some dispersed off-road vehicle use. Overall, the area supports some type of recreational activity throughout the year, with the heaviest use occurring during the fall hunting seasons.

3.9.2 Visual Resources

This section identifies and describes the visual resources of the study area, which includes those areas that viewers may travel through, recreate in, or reside in, or where existing views may be affected by the proposed action.

The description of the visual resources of the study area is based on the methodology described in the BLM's Visual Resource Inventory Manual. The visual inventory consists of three factors: (1) scenic quality evaluation, (2) sensitivity analysis, and (3) distance zone analysis. The scenic quality evaluation involves the rating of the scenic beauty of an area, which takes into consideration such factors as landform, vegetation, water, color, adjacent scenery, scarcity and cultural modifications. Sensitivity analysis is a measure of the public's concern for the scenic quality of an area, and is based on factors such as number of viewers, type of users (e.g. commuters or recreationists), public interest, and adjacent land use. Landscapes are also classified into distance zones based on visibility from travel routes or other possible sensitive viewing locations. Three distance zones are noted, including the foreground/middleground (0-5 miles), background (5-15 miles), and a seldom-seen zone (more than 15 miles or not seen).

Based on these three factors, lands are placed into one of four resource inventory classes. These Visual Resource Management (VRM) classes represent the relative value of the visual resource and provide a basis for considering visual values in the resource management planning process. Each VRM class has specific visual objectives defining how the visual environment is to be managed, with VRM Class I the most protective of the resource, and VRM Class IV allowing the most modification to the existing character of the landscape. The objective of each class is defined as follows (BLM 1986):

- Class I is intended to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.

- Class II is intended to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

- Class III is intended to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

- Class IV is intended to provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high. These management activities may dominate the view and be the major focus of viewer attention. However, every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repeating the basic elements.

Baseline Visual Conditions

The study area is in the Missouri Plateau section of the Great Plains physiographic province (Fenneman 1931). Located between the Missouri and Milk Rivers, the Little Rocky Mountains are an isolated group of domed mountains in an area roughly 10 miles in diameter. Their rounded crests rise nearly 3,000 feet above the surrounding plain, with steeply tilted hogbacks encircling the higher mountains. The topographic relief, colors, and textures of the mountains and their vegetation provide a contrast to the relatively homogenous terrain, lines, forms, colors and textures of the adjacent plains. In an assessment of the visual quality of the Little Rocky Mountains done by the BLM in 1979, the area was evaluated as Class A scenery, high sensitivity level, and distance zones ranging from foreground/middleground to seldom-seen views from several key observation points (KOPs) (BLM 1979). An analysis of these existing factors resulted in a VRM Class II visual determination for the BLM lands. The Judith Valley Phillips Resource Management Plan reaffirmed the VRM rating on these these lands (BLM 1992). A separate visual study was conducted in 1995 for the draft EIS. Twenty-one different KOPs (visual points) were utilized in this analysis. Private lands affected by the proposed project are not included in the BLM visual resource designation.

The project study area includes a mountainous visual landscape. This area is highly visible to viewers on U.S. Highway 191, State Highway 66, and the county road (Seven Mile Road) leading to the town of Zortman, as well as from several of the surrounding buttes and peaks.

As the viewer travels into the project area in the foothills and mountains where the Zortman and Landusky Mines are located, the scenery changes from rolling grasslands to steep slopes and drainage bottoms. The landforms, colors and textures of the landscape have become more varied than the plains, and represent a unique scenic resource within the High Plains province. Forms are more distinct, and range from sharply

angular along ridges separating the many drainages, to the more rounded forms of the tops of the buttes. Coniferous vegetation provides year-round green color. The scattered open, grassy areas, rock outcroppings, and areas with dense tree cover provide variation in the overall textures and patterns of the landscape.

Current disturbances to the landscape include those activities associated with the Zortman and Landusky Mines. These visual contrasts include open pits, waste rock dumps, heap leach pads, plant facilities, and changes in vegetation pattern caused by logging and forest fires. Roads built for mine exploration and access, and for past BLM logging and fire-fighting activities, crisscross the surrounding slopes. Contrasts created by the existing facilities include color contrasts between the exposed soil and rocks and the surrounding vegetation, and contrasts caused by the alteration of topography. These contrasts, especially the surface disturbance at the Landusky Mine, are visible from many vantage points in the vicinity of the project area, as well as from more distant viewing locations, including areas along the Missouri River over 20 miles to the south, the CMR National Wildlife Refuge, and portions of the BLM Missouri Breaks Back Country Byway.

A simulation of the existing topography around the mining areas is shown in Figures E-1 and E-8 of contained in Appendix E.

3.10 CULTURAL RESOURCES

The following excerpts from the FEIS are intended to provide a summary of the cultural resources in the project area. Refer to the FEIS, (p. 3-241, et seq.) for a more complete discussion.

3.10.1 American Indian Cultural Resources

Prior to the exploration and occupation of northern Montana by Euro-Americans, the Little Rocky Mountains were a place of particular importance to the Native Tribes of the Northern Plains. Due to topography, climate, and location, the Little Rocky Mountains provided a unique habitat for subsistence, social, and religious activities. In addition to the Gros Ventre and Assiniboine, a number of other Plains tribes used the mountains for these same activities. Included were the Sioux, Chippewa-Cree, Blackfeet, and Crow.

Early travel accounts lack specific reference to the Little Rocky Mountains, or "Island Mountains" as they were known to the native inhabitants of the area, although visitors to the Fort Belknap area just after the turn of the century note the use of the area for religious activities. Both the Gros Ventre and Assiniboine retain fasting, prayer, and the vision quest as primary individual rites. In particular, accounts of Gros Ventre ceremonies include the Feathered Pipe, Flat Pipe, and Sacrifice Lodge (Sundance). The most important group ceremonies for the Assiniboine were the Sundance and the Horse Dance. Vision Questing is described as paraphernalia and plants used by the Gros Ventre and the Assiniboine for ceremonial purposes. The diary and accounts of John Galen Carter, for example, detail the use of red, green, and yellow cloth, a cottonwood center pole, sweetgrass, willow branches, chokecherry bush, eagle feathers and body paints as some of the accessories of the Sundance celebration (Carter 1906-1907 cited in Deaver and Kooistra 1992).

Interviews with contemporary Gros Ventre and Assiniboine conducted by Deaver and Kooistra (1992) and Strahn (1992, 1993) also document use of the Little Rocky Mountains during the 1800s and 1900s. Citing oral history interviews with Assiniboine and Gros Ventre at Fort Belknap and literature sources, Strahn notes that small autonomous bands got together in the Little Rocky Mountains during the winter where food, water, and other necessary resources were readily available. During the summer, complex social activities were conducted here by a number of different tribes (Strahn 1993). In 1875, large numbers of Sioux held a grass dance on the eastern slopes of the Little Rocky Mountains and the Gros Ventre held their Old Man's Dance in approximately the same location four years later. This was also an important place for religious activities where supernatural knowledge and assistance was petitioned through prayers, offerings, fasting, and sacred dances. Annual Sundances were held here because they afforded the tribes a place to gather collectively and contained all the necessary natural resources to construct the lodge and undertake the ceremony. Strahn notes that "as a natural storehouse, marketplace, battleground and sacred shrine, the Little Rocky Mountains were, quite literally, a center of tribal being on the northwestern plains" (Strahn 1993).

The affected environment for the Little Rocky Mountains includes both its spiritual and physical characteristics, which are traditionally seen as inseparable. The Little Rocky Mountains are one of a set of island mountain ranges recognized as the lodges/homes of the spirits, which are inhabited by eagles (spirit messengers), and contain various peaks (spirit lodges) symbolizing tipis in an American Indian camp. The mountains are currently viewed as one of the last refuges where traditionalists can practice spiritual activities such as prayer, fasting, and making offerings. A portion of the Little Rocky Mountains is the main watershed for the Fort Belknap communities. Warm water springs are exploited for their healing powers and are often chosen as sweatlodge locations by the Gros Ventre and Assiniboine. In addition, resource procurement was and continues to be an important activity in the Little Rocky Mountains.

Early ethnographers conducting research at Fort Belknap around the turn of the century also documented use of the Little Rocky Mountains for fasting and plant gathering. Kroeber (1908) describes Gros Ventre fasting in the hills and high places up on mountains to receive powers or become doctors and provides a list of 35 plants gathered for medicinal purposes. Lowie describes similar practices (Deaver and Kooistra 1992).

The Gros Ventre and Assiniboine have historically and continue today to gather and use portable resources from the Little Rocky Mountains. Deaver and Kooistra (1992), Flemmer (1990,1991), McConnell (1990) and others have described and documented the past and present importance of resource procurement. Included are the use of trees, shrubs, plants, grasses, animals and animal products, fossil remains, and minerals for domestic, food, medicinal, and ceremonial purposes. Virgil McConnell testified at the public hearings for mine expansion held in Lodgepole on April 15, 1993, that there are over 100 plants gathered in the Little Rocky Mountains. Other Fort Belknap tribal members also testified to the importance of resource procurement in the Little Rocky Mountains. Deaver and Kooistra (1992) provide a list of 41 grass, plant, shrub, and tree resources, many of which have multiple uses. Thirty of these resources are used for medicinal purposes, 15 for ceremonial purposes, 5 have domestic uses, and 2 are used for food. Trees, which themselves are sacred, provide fuel and building material, and have been used historically for tipi poles (lodgepole pine), sweatlodges (willow), and Sundance lodges (cottonwood center pole). Sweet pine and juniper are used as well. The area is also used for hunting, fishing, and domestic animal grazing. Primary plants include sweetgrass, sages, larb, peppermint, prickly pear, rose roots, cherry bark, chokecherries, and certain fungi.

Culwell et al. (1990) include a section on ethnobotany in their study of vegetation resources conducted for the proposed mine expansion. They note that the Little Rocky Mountains have historically been and are currently a source of plant materials for ethnobotanical uses, that the mountains provide a variety of species associated only with isolated mountain or forest grassland ecotones like the Little Rocky Mountains, and that the relatively small size of the range situated within a prairie setting provides an extensive list of useful plants within a small geographical area. They identify 428 species of grasses, plants, forbs, shrubs, and trees within the Area of Potential Effect defined for vegetation resources for the project. They note that ethnobotanical use is documented for 200 of these species based upon research conducted in similar areas such as the Bears Paw Mountains, Cypress Hills, Sweetgrass Hills, Judith Mountains, Moccasin Mountains,

and others. These species can be expected to occur throughout the Little Rocky Mountain range. Ethnobotanical studies have not been conducted for the Little Rocky Mountains. Of the 41 vegetation resources identified by Deaver and Kooistra, however, 25 (64%) are included by the Culwell et al. study.

There has always been a preference for resources procured from the mountains since a great variety of species can be gathered in a fairly restricted geographical area and are considered more potent than their counterparts gathered from lower elevations. Flemmer (1991) notes that currently this preference includes the lack of dust along with agricultural chemical contamination prevalent at the lower altitudes. McConnell (1990) notes that Native Americans come from all over, including Canada, to gather plants in the Little Rocky Mountains. For the Fort Peck Assiniboine, the Little Rocky Mountains are the closest source of sweetgrass necessary for ritual purification smudging ceremonies. A wide variety of birds are reported in the area, including several types of hawks and golden eagles which are spiritually significant to both groups.

The Madison Limestones, which form a series of near vertical cliffs that encircle the Little Rocky Mountains, provide a material source for stone tool manufacture. The limestones form caves, many with Native American rock art, as well as crevasses, many of which contain burials respected and revered by the people of Fort Belknap. Fossils with traditional cultural uses include ammonites or "buffalo stones" and belemnites (used by prehistoric groups for ornaments and fetishes), as well as crinoid stars (used by modern Sundance leaders for rattles). A white clay substance (probably bentonite) is used by the Gros Ventre (known as the White Clay People) for staining their clothes and, today, to prepare hides. The Gros Ventre collect red and yellow paint pigments in the Little Rocky Mountains for use in a face painting rite. Rocks, especially granite, are also collected in the Little Rocky Mountains for use in the sweatlodge. Rocks are assigned spirits and are, in general, respected.

The Little Rocky Mountains as a Traditional Cultural Property District

A joint position on National Register eligibility was developed by the Fort Belknap Community Council, the Bureau of Indian Affairs, and the Bureau of Land Management, which also entered into a Memorandum of Understanding in June 1994 to form a special task force to further study the potential of the Little Rocky Mountains as a Historic District. The eligibility position paraphrases Bulletin 38 (Parker and King 1990) in stating that the Little Rocky Mountains are eligible as a TCP because they are:

> *a location associated with the traditional beliefs of Native American groups about its origins, culture history, and the nature of the world; are a location where Native American religious practitioners have historically gone, and are known to go today to perform ceremonial activities in accordance with traditional cultural rules of practice; and are a location where an identifiable community has carried out economic, artistic, and other cultural practices important in maintaining its historical identity.*

The BLM and the Montana State Historic Preservation Office have concurred that the district is eligible under criterion (a) of 36 CFR 60.4, "associated with events that have made a significant contribution to the

broad patterns of our history." It was also recognized, however, that other sites and smaller districts within the Little Rocky Mountains District may be individually eligible under other criterion. The task force also recognized that the boundaries were "working boundaries" and could be amended at a later date dependent on additional information and consultation.

Traditional Cultural Practices

Several scholars have reported the continued practice of traditional ways in the Little Rocky Mountains documenting sacrifice alone in the hills, fasting, and plant gathering (Cooper 1957), and, fasting in the hills during mourning, and experiencing visions of supernatural significance in the hills (Flannery 1953). Verne Ray disputes the notion of rapid acculturation and cultural disintegration, noting that the Gros Ventre have maintained a unique ethnic identity, different from Euro-American culture even though they have adopted material items of the Euro-American tradition (Ray 1975). Later researchers have focused on how the Indians have reacted and adjusted to change (Miller 1987) and the differing viewpoints of elderly Indians and younger Indians trying to learn and live in a traditional way (Fowler 1984,1987).

The literature published prior to 1988 lacks many specific statements about the sacredness of the Little Rocky Mountains and generally fails to identify specific vision quest locations. Deaver and Kooistra (1992) explain this apparent contradiction according to a combination of four factors: (1) vision questing is intensely personal and the experience and location are not to be discussed with others; (2) the religious practitioners and elders interviewed during the earlier studies withheld information from others not only because it was sacred, but because it was discouraged and at times illegal to engage in traditional religious rituals; (3) the Gros Ventre and Assiniboine believe that all places have spiritual qualities so that the identification of specific sacred places may be seen as nonsensical and arbitrary; and (4) researchers of the time were not particularly interested in particular localities.

In more recent times, many writers have noted a strong revival of interest in traditional cultural practices, including the sacrifice lodge (Sundance) and vision questing in the Little Rocky Mountains. Deaver and Kooistra (1992) surmise that this practice has become more common in the last 5-10 years; Flemmer (1990,1991) documents the practice and identifies some locations through interviews and field reconnaissance with tribal members; and Melton (1990,1993) provides similar kinds of information. Strahn (1992) also documents this resurgence of traditionalism, noting a relationship between this and environmental awareness and activism. Individual use of the Little Rocky Mountains for traditional practices was also apparent from the testimony of various tribal members during the public hearings for mine expansion held in Lodgepole on April 15-16, 1993 and in meetings and conversations with tribal members undertaken during that same time period (Woods 1993).

Mining in the Little Rocky Mountains can be characterized as heavy during the late 1800s through the turn of the century, cyclical from the 1920s through the 1940s and sporadic through 1951. The forest fire in 1936, subsequent loss of terrain to heavy rains in 1937, and a hiatus during World War II contributed to the absence of the intensive mining activities which characterized the earlier periods. After 1951, little

serious activity occurred in the Little Rocky Mountains until modern surface mining operations were initiated in 1979. (See FEIS Section 3.12.3.2)

The consequence of mining on vision questing and other traditional activities in the Little Rocky Mountains has been described in an Affidavit by Virgil McConnell, an Assiniboine elder and religious leader:

> *"Fasting Sites in the Little Rocky Mountains prior to the opening of the early mines in the 1800's consisted of many mountains: Gold Bug Butte, Mission Peak, Indian Peak, Silver Peak, Old Scraggy, Bear Mountain, Saddle Butte, Shell Butte (modern names). All of or most of these sites were lost by the mining operations of the 1800's. The start of heap mining in 1978 caused loss of McConnell Mountain, Damon Hill, McMeal Ridge, Monument Peak, all cliffs near the north side of the Little Rocky Mountains between Coming Day Butte and Whitehorse Canyon. At the present time, the people in the Hays area have only Eagle Child Peak and Otter Robe Ridge for fasting. Near Lodgepole, they only have cliffs between Brown Canyon and Kunnyhard Canyon, Coming Day Butte and Travois Butte. Expansion of the existing mines will threaten the remaining few sites. There is a resurgence of interest in traditional religion and the few remaining sites are even in more demand. Loss of fasting sites will take away the ability of local traditional people to practice their religion." (McConnell 1990)*

The onset of the period of modern mining (1979 to 1994) saw a sharp increase in activities which compromised the use of the Little Rocky Mountains for traditional cultural practices at the same time that a revival of interest in such activities was taking place. McConnell notes that a number of sites were "lost" prior to 1979 and others "lost" after 1979 with the initiation of heap leach mining. Prior to 1979, significant physical disturbance had occurred in Montana Gulch, Beaver Creek and Pony Gulch, and mill tailings were deposited in King Creek, Alder Gulch, and Ruby Gulch. Visual and noise disturbance to these and adjacent areas was ongoing. All of these previously disturbed areas are at or near important ethnographic sites. Since 1979, there has been additional physical disturbance to these areas and extensive physical disturbance by mining near or on Antoine and Shell Buttes, and Gold Bug Butte and Mission Peak.

It is important to point out, however, that while some of these sites have been physically disturbed and altered, and others rendered less desirable because of the ongoing visual and noise disturbances, some are still in use, and some of those in use are within a mile of the Zortman and Landusky Mines. The best information available indicates that favored spiritual locations continue to be used by some individuals, even though they are in the vicinity of the mines. On Mission Peak, for example, there is evidence of recent vision questing on the west side of the peak, away from the mining activities to the east.

3.10.2 History

Early recorded intrusions by non-Indians into the general area were by the Lewis and Clark expedition of 1805, although Lewis and Clark did not explore the Little Rocky Mountains. The archaeological and ethnographic records indicate that the general area had been occupied for thousands of years previously, and was occupied at the time of Euro-American exploration and use. Following exploration, early

Euro-American use of the Little Rocky Mountains in the first part of the 19th Century was by fur trappers, with prospectors following in the last decades of the century.

Beginning in the middle of the 19th Century, the U.S. Government initiated the first of several treaties with the Plains Indians, first to facilitate exploration and trading by delineating tribal territories and discouraging intertribal warfare, and later to open up former tribal lands to settlement for purposes of farming, ranching, and mining. The Fort Laramie Treaty of 1851 gathered all the Plains tribes together and "mapped out the domain of each tribe and obligated each tribe to respect the lands of its neighbors" (Malone and Roeder 1976). Stemming from the efforts of Isaac I. Stevens, the 1855 Treaty created a vast Indian Reserve in northern Montana which was shared by Gros Ventre and Assiniboine with the Blackfeet. This Reserve included the Little Rocky Mountains.

In 1887, the Northwest Commissioners negotiated the formation of the Blackfeet, Fort Belknap, and Fort Peck Reservations. The reservation underwent one reduction in 1896 after gold was discovered in the Little Rocky Mountains. Under the Grinnell Agreement, the tribes ceded 14,758 acres of land (Act of June 10, 1896, 29 Stat. 321, 350) in the mountains at the southern end of the reservation for $360,000 in annuities. There is still controversy among Fort Belknap as to the terms and extent of the agreement.

The first sustained Euro-American use of the Little Rocky Mountains was in 1884, when Pike Landusky and others developed the first paying placer mines in Alder Gulch, leading to the development of the town of Landusky. Landusky later staked the first patented lode claims in the Little Rocky Mountains (recorded in 1892), as the early placer workings had rapidly been depleted. The richest claim was the August, patented in 1893, on the Fort Belknap Indian Reservation.

Mine and mill development proceeded through the first two decades of the twentieth century. Zortman was established as a mining camp in 1903 with the construction of a cyanide mill in Alder Gulch. Other stamp and crusher mills were constructed (the Ruby Gulch Mill as one of the larger ones), processing ore from the Ruby and Independent Mines. Ore processing included the use of cyanide, which had been utilized in the Little Rocky Mountains since the 1890s. Zortman grew faster than Landusky or Whitcomb (abandoned in the 1940s), although growth was as sporadic as work in the mines. From the 1920s through 1942, mining could be characterized as cyclical. Ventures were formed with some development and production; however, production did not usually continue for more than a few years. The ore in the Little Rocky Mountains was not of consistently high quality to sustain most of the mines utilizing the mining techniques of the day. Additionally, sporadic fires impacted both towns and mining operations. Much of Zortman burned in 1929, and the 1936 fire burned over 23,000 acres of timber.

Mining continued sporadically through 1951, with a hiatus during World War II. After 1951, little serious activity occurred here until the modern, surface mining operation opened in 1979. It has been estimated that over 380,000 ounces of gold were mined from the Little Rocky Mountains prior to 1979, contributing significantly to the region's economy.

3.11 SOCIAL and ECONOMIC CONDITIONS

3.11.1 Social Conditions

The study area for social conditions includes Phillips and Blaine Counties. The Zortman and Landusky Mines are located in southwestern Phillips County near the unincorporated towns of Zortman and Landusky. The border of Blaine County and the Fort Belknap Indian Reservation is located directly north of the mines.

The population of Phillips County was 4,601 in 2000, a decline of 11% from 1990. The county lost population due to out-migration in every 12 month period between 1990 and 1999, except between July 1994 and July 1995 when it gained population due to in-migration. The out-migration in the years 1995 to 1998 was associated with the closure of the Zortman and Landusky Mines. The population in Phillips County is projected to decline very slowly (less than 2%) in the next decade.

The population of Blaine County was 7,009 in 2000, an increase of 4% from 1990. The population increase was due to the high birth rate and relatively low level of out-migration. The 2000 population of the Fort Belknap Indian Reservation, which is mostly located in Blaine County, was 2,959, which represents an increase of 18% from 1990. Nearly one-half (47%) of the population in Blaine County is American Indian. The population of Blaine County is expected to continue to increase, although at a slower rate (less than 1% for the decade) than in the 1990s.

Indicators of social well-being for Phillips and Blaine Counties present a mixed picture suggesting the planning area possesses the positive and negative factors associated with rural areas (FEIS 1996). The percentage of persons in poverty (1995 estimates) shows the rates to be higher in both counties than for Montana as a whole. The poverty figures were 27% for Blaine County and 18% for Phillips County, compared to 16% for the state as a whole. The most recent year poverty information is available for the Fort Belknap Reservation is 1989. At that time the Reservation figure was 40.6%, compared to 23.2% for Blaine County, 11.5% for Phillips County and 12.0% for Montana as a whole. The 1999 unemployment rates (7.6%) increased in Phillips County from the 1990 rate (4.9%). In Blaine County, the rate remained relatively stable between 1990 and 1999 (8.5% and 8.0%, respectively). The 1999 unemployment rate for the Fort Belknap Reservation was 22.9%. The unemployment rates in both counties and on the Fort Belknap Reservation were higher than for the state as a whole (5.2%). In 1998, per capita personal income continued to be well below the state figure for both counties in the study area.

The social values and ability to adapt to change by residents of Phillips and Blaine Counties and by the Fort Belknap Indian Community are addressed in detail in the 1996 FEIS. A summary of this information follows.

Residents of Phillips County place considerable value upon self-reliance, small-town life, and the availability of natural resources. Self-reliance is typified by the provision of many essential public safety and health

services through volunteerism. They value the positive attributes of rural, small-town life such as good, friendly people; uncrowded surroundings; good schools for children; access to outdoor recreation; lack of crime; and lack of urban congestion. In Phillips County, commercial mining and oil and gas production have been part of the local economy since the early 1900s. Although Phillips County and Malta are considered progressive and have a good business climate, the economy is stagnant and young people often must leave because of the lack of job opportunities.

A concern to many people is the negative socioeconomic impact that mine closure has had on mine workers and the area's economic base. This had created interest in the economic opportunities that might arise from both reclamation and possible future mining. Specific concerns are the short-term employment opportunities associated with the reclamation earthwork, the longer-term employment opportunities for site care and maintenance, and hiring preferences. Another concern is that the reclamation not preclude the potential for future mining and its associated economic benefits.

Social values in Blaine County vary among the three largest social groups: farmers and ranchers, townspeople, and American Indians of the Fort Belknap Reservation. Blaine County farmers and ranchers are generally political conservatives whose predominant social values are frugality, self-reliance, and hard work. Independence and a close tie to the land are dominant elements of this group's lifestyle. The townspeople of Harlem and Chinook value the attributes of local, small-town life: informal, personal interaction with others; knowledge and awareness of the personal and socioeconomic characteristics of neighbors; a quiet, predictable pace of life; mutual support among families and friends; volunteerism in the provision of essential public safety and social services; and religious affiliation.

The social structure of Blaine County is an adaptive one which addresses local issues through cooperative action and provides mutual support in the face of change that is beyond local control. In Blaine county, one may feel empowered within the local web of civic, social, fraternal and religious organizations. These groups have cooperated with each other to address community issues of housing and neighborhood revitalization and economic development.

The Fort Belknap Indian Community, centered on the Fort Belknap Indian Reservation, includes two tribal groups, the Assiniboine and Gros Ventre, which have distinct tribal histories, experience and concerns. As a group, the Assiniboine characterize themselves as sticking together, getting along with one another, and looking for direction from the oldest, wisest, and most spiritual among them (tribal elders). American Indian religion and traditions are highly valued. As a group, the Gros Ventre characterize themselves as valuing occupational accomplishment, education attainment and, to an extent, economic well-being.

The social structure of the Fort Belknap Indian Community is complex. Although divided in many ways, the community shows increasing evidence of group action on local issues. Most group action to promote economic well-being and solve social problems involves agencies of the Fort Belknap Indian Community Council. Recent examples include a campaign to save the Indian Health Service hospital, and the promotion of hunting, fishing and tourism on the reservation.

Areas within the Little Rocky Mountains, and specific sites near the mines are culturally and historically important to various North American Indian Tribes. The existing mine disturbances have created impacts that affect the use of the mountains for traditional cultural practices. The development of reclamation measures that would make the mountains more conducive to traditional cultural practices is an issue.

3.11.2 Economic Conditions

The study area is situated within Phillips County and adjacent to Blaine County and the Fort Belknap Indian Reservation. The economy of the two-county area, including Fort Belknap, is described in the 1996 FEIS. The Judith Valley Phillips Resource Management Plan EIS (BLM 1992) also contains a description of the economy for a larger geographic area in north-northeast Montana, including the study area, and is not specific to the impacts of a mining proposal. The analysis of the economics of the area contained in those two EIS's is incorporated by reference into this environmental assessment, and is supplemented with more recent data.

Economics topics discussed in this section are employment, income, local economic effects of existing reclamation activities at the Zortman and Landusky Mines. The analysis focuses primarily on Phillips County, since most of the effects are felt in Phillips County. Blaine County is also included in the analysis of employment and income since a portion of the current reclamation workforce resides in Blaine County, some of which reside on the Fort Belknap Reservation.

As described in the 1996 FEIS, the economy of Phillips and Blaine Counties is primarily agricultural. Economic diversity began to increase following the opening of the Zortman and Landusky Mines in 1979. For Phillips County, average annual mining employment gradually increased over time, peaking in 1991 and again in 1994 at about 280 jobs. For the first half of the 1990s, mining employment contributed from 15% to 18% of total average annual employment. Since 1996, average annual employment in mining has steadily decreased as mining activities declined, comprising about 1% of total employment for 1999 (17 jobs of 1,319 total average annual employment for the county), the last year for which average annual employment data are available (Montana Dept. of Labor and Industry, various years (a)). Table 3.11-1 shows detailed 1999 average employment for Phillips County.

For Blaine County, average annual mining employment gradually increased over time as well, peaking in 1992 and 1993 at about 10 jobs. Even at its peak, mining contributed less than 1% of total average annual employment in Blaine County (10 jobs out of about 1,500 in the county in 1992 and 1993). As for Phillips County, Blaine County's mining employment has steadily decreased as mining declined, comprising 3 out of 1,480 jobs in 1999, less than one-half of 1% of all jobs in the county in 1999 (Montana Dept. of Labor and Industry, various years (a)). Table 3.11-1 shows detailed 1999 average employment for Blaine County. It should be noted that the section below describing current reclamation activities at the mines shows that mining-related employment in 2000 has increased once again.

Some of the current employment associated with reclamation activities are categorized as construction (more specifically, heavy construction). County data on average annual construction employment for Phillips County indicates that jobs held relatively steady throughout the 1990s, but then increased from about 34 jobs in 1998 to 49 jobs in 1999. For Blaine County, average annual construction employment has also been relatively steady throughout the 1990s, although there was a one-year spike in 1996 when employment increased from 31 to 46, then decreased again to 36 jobs for 1997.

During peak mining in the early 1990s, the unemployment rate in Phillips County was among the lowest in the state, averaging 3.9% in 1993 and 3.2% in 1994, while the state average was 6.9% and 6.1%, respectively. However, since 1995 the unemployment rate in Phillips County has been above the state average. The 1999 unemployment rate in Phillips County of 7.6% is a full percentage point lower than the county's highest level of unemployment over the past 10 years (8.6% in 1998), but the county still ranks 10th highest out of 56 counties in unemployment.

For Blaine County, the unemployment rate has been consistently higher than the state unemployment rate during the 1990s. The county's lowest unemployment level was 7.1% in 1994, and its highest was 10.2% in 1997. In 1999, Blaine County's unemployment rate was 8%. It ranked 7th highest in unemployment for the year, tied with Musselshell County.

For the Fort Belknap Indian Reservation, detailed employment data by industry is not available after the 1990 Census. However, total employment numbers are. The annual average employment in 1999 was 640 out of a civilian labor force of 830, for an average annual unemployment rate of 22.9%. Though this is far above the state average unemployment rate (5.2%), it does represent an improvement since 1996 when the unemployment rate was 27.2%. It should be noted also that detailed employment information for Blaine County (such as that listed in Table 3.11-1) includes jobs on the Reservation.

Since the mines' closure, the area economy has lost some diversity and the primary economic base is once again agriculture. Industries with the highest level of employment in Phillips County are: government (415 jobs, 31% of total employment, of which 335 are local government jobs and 82 are State or Federal jobs), services (310 jobs, 24%), and retail trade (228 jobs, 17%) (see Table 3.11-1). *Per capita* personal income in 1997, the latest year for which data were available, was estimated to be $17,010, an 11% increase from 1997's peak of $15,260. *Total* personal income for the county for 1998 was $81.6 million, a 9-percent increase over 1997's over 1997's total personal income of $75.1 million. Most of the increase in personal income in the county is due from improvements in farm income.

In Blaine County, like Phillips County, the industries with the highest level of employment are: government (662 jobs, 45% of total employment, of which 441 are local government jobs and 221 are State or Federal jobs), services (326 jobs, 22%), and retail trade (219 jobs, 15%) (see Table 3.11-1). *Per capita* personal income in 1998, the latest year for which data were available, was estimated to be $15,360, a 12% increase over 1997's *per capita* income of $13,760. *Total* personal income for the county for 1998 was $108.9 million, an 11-percent increase over 1997's total income of $98.3 million.

Table 3.11-1. Average Annual Employment by Industry for Phillips and Blaine Counties - 1999

Industry	Phillips County		Blaine County	
	Employment	% of Total Employment	Employment	% of Total Employment
Agriculture, Fisheries, and Forestry	37	3%	41	3%
Mining	17	1%	3	0%
Construction	49	4%	33	2%
Manufacturing	51	4%	21	1%
Transportation, Communication, and Public Utilities	70	5%	13	1%
Wholesale Trade	73	6%	99	7%
Retail Trade	228	17%	219	15%
Finance, Insurance, and Real Estate	55	4%	60	4%
Services	310	24%	326	22%
Government	415	31%	662	45%
Total	1,319	100%	1,480	100%

Source: Montana Department of Labor and Industry, Office of Research and Analysis (various years (a)).

Economic Effects of the Interim Reclamation

There are currently about 30 employees working on interim reclamation activities at the Zortman and Landusky Mines. According to the contractor, about 90% of the current workforce is from the study area and about one-third is American Indian (Spectrum 2000d). Total expenditures for the year 2000 were $5.0 million (Spectrum 2001a). Of that total, about one-third, or $1.5 million, are estimated to be wages and operating expenditures in the two-county study area. Of that $1.5 million, about $1.2 million are estimated to be dollars actually spent in the local area, after deducting for taxes and benefits paid to workers and which are not available to be spent locally.

The $1.2 million are direct local expenditures which create additional rounds of spending, known as the multiplier effect and which represent an additional economic benefit to the study area. Total economic activity associated with local expenditures is estimated through the use of the IMPLAN Input-Output Model, which calculates the multiplier effect to spending. In the study area for the year 2000, it is estimated that total employment would be about 62 jobs, including the number of workers at the mine sites. Sixty-

two jobs represents about 2% of average annual employment in the study area (62 jobs of a total 2,799 in the two-county area). Total employee compensation would be about $311,000. Total output in the study area would be about $1.5 million. Table 3.11-2 shows these impacts. It should be noted that because many of the additional jobs (32 of the 62 total estimated) generated through additional spending already exist (e.g. jobs in retail outlets), additional spending by wage earners and the contractor may not result in more hiring by local businesses.

Table 3.11-2. Estimated Total Economic Impact to Study Area for Year 2000 Interim Reclamation (current $)

Mine	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
Zortman	$622,300	$729,400	$155,400	$329,200	31
Landusky	$622,300	$729,400	$155,400	$329,200	31
Total	$1,244,600	$1,458,800	$310,800	$658,400	62

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were deducted by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees.
Source: IMPLAN Input-Output Modelling System (1999)

3.12 RECLAMATION and BONDING STATUS

At the conclusion of the Pegasus Gold Corporation, Zortman Mining, Inc., bankruptcy proceedings in January 1999, there were seven surety bonds covering the Zortman and Landusky Mines totaling more than $67 million. These bonds cover surface reclamation, water treatment, exploration-related disturbances, and construction borrow source reclamation. In addition to the surety bonds, the bankruptcy court awarded a lump sum settlement to the agencies of $1,050,000. These bonds and settlements are listed in Table 3.12-1. Through December 2000, approximately $16 million has been spent on reclamation-related. These expenditures are also shown on Table 3.12-1.

Table 3.12-1. Reclamation Bond/Funds Summary

Bond/Fund	Beginning Balance	Expenditures through Year 2000	Remaining Balance	Percent Spent	Percent Remaining
Zortman Mine Reclamation Surety Money	$10,024,000	$1,709,173	$8,314,827	17.1%	82.9%
Landusky Mine Reclamation Surety Money	$19,600,000	$3,542,162	$16,057,838	18.1%	81.9%
Consent Decree Construction Bond	$10,100,000	$7,271,150	$2,828,850	72.0%	28.0%
Water Treatment Operation & Maintenance through Year 2017	$14,626,422	$2,925,284	$11,701,138	20.0%	80.0%
Long-Term Water Treatment Trust Fund	$12,300,000	$0	$12,300,000	0.0%	100.0%
Bankruptcy Settlement Funds	$1,050,000	$1,050,000	$0	100.0%	0.0.%
Exploration Bond Amount	$380,000	$0	$380,000	0.0%	100.0%
Open Cut Bond Amount	$295,000	$0	$295,000	0.0%	100.0%
Totals	$67,700,422	$16,497,769	$51,202,653	24.4%	75.6%

Note: The long-term water treatment trust fund was funded with an initial $3,794,000 through December 1999. The fund has a value of $12.3 million at maturity in 2017. Exploration and Open Cut bond amounts are not included in totals.

Since assuming management control of the mine site, the principal reclamation activities have included: overall site management; collection and treatment of seepage and pumpback water; management and treatment of leach pad solutions; interim reclamation involving backfilling and regrading of mine pits and leach pads at both mines; and preparation of engineering investigations and reclamation plan developments.

3.12.1 Overall Site Management

At the conclusion of the Chapter 11 bankruptcy proceedings, the agencies assumed control of the mines on January 15, 1999. Although mining ceased in 1998, the site continues to require active oversight and maintenance. Leach pads still contain solution that does not meet water quality standards for discharge, seepage capture systems need to be monitored and maintained, and site maintenance is required to avoid environmental degradation from such things as surface water runoff. In order to ensure ongoing care and maintenance of the site, the services of a third party contractor were retained to manage the site. Their duties and responsibilities include: site administration, management and maintenance of existing facilities and operations; general engineering support; management and coordination of environmental investigations; generation of final reclamation plans, contracts and bid documents, conduct some of the reclamation activity, and construction supervision and management.

3.12.2 Seepage Capture and Treatment

Seepage collection systems constructed under the terms of the Consent Decree are located in Ruby Gulch, Alder Spur and Carter Gulch at the Zortman Mine; and in Mill Gulch, Sullivan Creek, upper and lower Montana Gulch at the Landusky Mine. These systems intercept potentially contaminated seepage from waste rock dumps and other mine facilities. The seepage is pumped to the treatment plants for processing and discharge. These systems operate year round, with varying flow volume dependent on seasonal changes and rainfall. Money for the continued operation of these systems comes from the water treatment operation and maintenance bond. Operating costs for 2000 averaged $80,300 per month. Total expenditures for the operation and maintenance of the seepage capture systems through December 2000 have been approximately $1.7 million.

3.12.3 Leach Pad Solution Management

As of December 31, 2000 there are approximately 165 million gallons of residual leach pad process solution trapped in the leach pads. This leachate is discharged via the LAD system located in the Goslin Flats area during the summer months. The majority of this water is stored in the L87/89 leach pad. A biological treatment system is currently under construction to treat this water more cost effectively. Each year rain and snowfall add to the total water in the system, and depending on the ability to discharge water over the course of the year via one of the approved discharge systems, the yearly precipitation ultimately determines the amount of water that is either stored or discharged. Capping of the leach pads would reduce but not eliminate water from entering the system, so treatment of the leach pad water needs to continue. Funding for the management and treatment of leach pad waters comes from the surface reclamation bonds. Operating costs for this treatment averaged $80,000 per month in 2000. Total expenditures since the agencies assumed management of the site through December 2000 have been approximately $2.5 million

3.12.4 Interim Surface Reclamation

Beginning in the fall of 1999, the technical working group has identified interim reclamation activities. The recently completed and planned interim reclamation activities at the Zortman Mine will cost approximately $3.5 million, with the money coming from the Zortman Mine reclamation bond.

At the Landusky Mine interim reclamation work occurred mostly during 2000. Costs through December 2000 for this interim reclamation have been approximately $3.3 million and were paid for by the Landusky Mine reclamation bond.

3.12.5 Final Reclamation Plan Development Costs

Since 1999, the technical working group has been investigating reclamation alternatives. The group has collected additional data concerning site geochemistry, reclamation cap performance, revegetation needs, water balance, reclamation costs, prepared the Multiple Accounts Analysis of the reclamation alternatives, and prepared the Draft SEIS. This work was done with the specific aim of using the results to determine the final reclamation plan. Consultants have been retained to assist in this effort and additional field work was required to collect data. Expenditures associated with these efforts have totaled approximately $1 million through December 2000.

3.12.6 Restrictions on the Use of Existing Reclamation Bonds

Surface Reclamation Bonds

The bonds for surface reclamation must be used for reclamation activities at the respective mines. The Landusky Mine reclamation bond is restricted to costs incurred at the Landusky Mine and may not be used at the Zortman Mine. The same conditions apply to the Zortman Mine reclamation bond. In addition, the State of Montana, as holder of the bonds, did not receive the face value of the bonds as a lump sum settlement at the conclusion of bankruptcy. The bankruptcy agreement states that upon the award of a competitively bid contract for surface reclamation, the sureties underwriting the bonds would release $1.5 million each from each mine's bond. After this initial $3 million release, the sureties are to be invoiced for payment of reclamation bills for the balance of the reclamation bond monies. To date, the agencies have been invoicing the sureties for costs incurred associated with interim reclamation.

Consent Decree Construction Bond

This bond is to be used on Consent Decree-related actions and is limited to specified line item amounts associated with specific tasks. These cover the construction of seepage capture systems in designated drainages and monies currently being used for the construction of a biological treatment system for process water containing elevated levels of nitrate and cyanide.

Water Treatment Operation and Maintenance Through 2017

This bond is limited to $731,321 per year (not adjusted for inflation) through the year 2017 for the operation and maintenance of the water treatment plants only. Funds are deposited with the State of Montana on January 1 of each year. Expenditures may not exceed specified line item estimates. Even though the agencies receive the full $731,321 at the beginning of the year, expenditure of this money is bound by specified line items in the agency cost estimate. The agencies may not spend more than what has been estimated for the identified line item, and conversely any surplus from a line item cost may not be carried over to other line items where a deficiency may exist.

Long-Term Water Treatment Trust Fund

This fund is used for the long-term (after 2017) operation and maintenance of the water treatment systems. The interest generated by the fund will be used for this purpose beginning in 2017. There are no restrictions on the use of this fund. It is financed by U.S. Treasury zero-coupon bonds that have a value of $12.3 million upon maturation in 2017. This fund is currently $1 million short of being fully vested to meet the projected $15 million that was calculated in 1996 as necessary to be in the fund in 2017.

Zortman and Landusky Settlement Fund

The $1,050,000 awarded to the agencies from the bankruptcy estate was divided into two parts: $600,000 to be used at either mine; and $450,000 to be spent only on reclamation activities at the Zortman Mine. This fund has been used for interim reclamation at the mines and is depleted.

Exploration Bond

This bond can only be used for the reclamation of exploration-related disturbances. Reclamation of these items has not been conducted to date.

Open Cut Bond

This bond can only be used for the reclamation of open cut-related disturbances that are associated with the clay borrow areas.

3.12.7 Bond Restrictions and Their Potential Influence on Reclamation

The restrictions placed on how and where bond monies are spent may have some bearing on the choice of reclamation plans. Water quality is perhaps one of the more significant long-term reclamation issues outstanding at the site. In order to preserve water quality, two fundamental approaches are evident: (1) prevent water from coming into contact with deleterious materials that may degrade its quality; or (2) assume all water will need to be treated prior to discharge. The former would require a barrier cover over

the waste rock dumps, pits and leach pads to prevent water from coming into contact with acidic rock, while the latter would require a system to collect and treat virtually all water on site. It is technically impracticable to construct a barrier cover system that eliminates 100% of infiltration; therefore, some level of water treatment will continue to be required in the foreseeable future.

Existing water treatment costs currently exceed the annual surety limit of $731,321 that is available over the next 17 years. However, projections concerning anticipated future volumes requiring treatment and the quality of the water to be treated, even with a modest reclamation cover, suggest that the current level of funding may be sufficient to cover the annual treatment cost in time, especially if modifications to treatment plant design and water management can be implemented. The surface reclamation bonds, while restricted to a specific mine site, have no limitations on how the money can be spent. Conceivably, funds from the surface reclamation bond could be directed to modifying the water treatment plants to minimize annual operating costs.

CHAPTER 4
ENVIRONMENTAL CONSEQUENCES

4.1 IMPACT METHODOLOGY

This chapter describes the various environmental impacts (both positive and negative) for each of the reclamation alternatives at the Zortman and Landusky Mines. Many impacts are the same regardless of the alternative; however, others are directly dependent on the reclamation measures in a specific alternative. In most sections, the impacts common to all alternatives are discussed initially, followed by a description of the impacts resulting from a particular alternative.

The impacts are described as positive or negative based upon the change that would occur to the existing resource conditions if the alternative was implemented. Many of the impacts are positive in that they would improve or remediate the already impacted resource conditions that are described in Chapter 3. Often the main difference in the alternatives is not between a positive or negative impact, but the varying degrees of positive impact that each alternative would achieve.

Volume II of the 1996 FEIS contains a detailed discussion of impacts associated with mine reclamation under three distinct alternatives not involving additional mining. The reader is referred to the FEIS for additional detail on reclamation impacts at the mine sites. The information presented in this SEIS supplements or supersedes the 1996 FEIS.

4.1.1 Assumptions

The impact analysis is based upon the following assumptions:

- The respective alternative would be fully implemented as described in Chapter 2. Factors such as the entity performing the reclamation work or the specific source of funding are not critical to an analysis of how the reclamation plans would perform. In other words, the impact analysis evaluates the inherent merits of the different reclamation plans independent of potential implementation problems.

- Any necessary mitigation has been built into each alternative as part of the activity that would occur under that alternative. The impacts described for each alternative are, therefore, the residual impacts left after the application of mitigating measures.

- Certain actions such as monitoring and maintenance of the water capture and treatment systems would occur under all alternatives as needed to meet the requirements of the Montana Water Quality Act and the associated MPDES permits. The amount of effort required to maintain the systems and the ease with which compliance is achieved may vary by alternative.

4.1.2 Multiple Accounts Analysis Methodology

The Multiple Accounts Analysis (MAA) process was used to develop and evaluate the reclamation alternatives for the mines. The process involved a team effort comprised of individuals with technical expertise from the participating agencies and the Fort Belknap government. See Section 2.2 for a discussion on how the MAA process was used to develop the alternatives.

Assessment of the positive and negative impacts, or the relative strengths and weaknesses of each of the reclamation alternatives were evaluated by the technical working group. Input on the initial results of the evaluation were presented at several public meetings and briefings held for Fort Belknap over the course of a year. The final results of the MAA represent the consensus opinion of the technical working group (Section 5.4.2) as to the relative impacts of each alternative.

The MAA was conducted based on four fundamental accounts of activities and impacts: Technical, Project Economics, Environmental and Socioeconomics. While all accounts are important to the evaluation process, the results of the Environmental account served as the basis for this chapter of the SEIS. Appendix A provides the results of the complete MAA. A summary comparison discussion of the MAA results is provided in Section 4.13.

4.2 GEOLOGY and TOPOGRAPHY

There are three geologic aspects covered by this section of the impact analysis: economic geology, geotechnical stability and topographic variations resulting from the reclamation.

4.2.1 Economic Geology

Backfilling of the mine pits would affect the future mineral development potential at the mines. The source of the backfill is the mined material in the waste rock dumps and on the leach pads. The areas where these dumps and heaps are located have low potential for future mining compared to the pits which have high potential for future mineral extraction. The most significant cost in any mining enterprise comes from the ratio of overburden, or waste rock, to ore that has to be physically moved by equipment. As an example, the additional cost to re-mine 370,000 cubic yards of backfill from the Ross pit would be at least one million dollars at current prices.

Alternative Z1

Alternative Z1 would have a negative impact to future precious metal mineral development potential due to the placement of backfill in the mine pit areas. Backfilling the mine pits with mine waste from the Alder Gulch waste rock dump, the Z82 leach pad, the O.K. waste rock dump, and the Ruby dumps would increase the cost of accessing the underlying mineral resources in the future by surface mining methods. In 1992 ZMI sought approval to mine approximately 80 million tons of low grade gold and silver ore from beneath the Zortman Mine pit area (FEIS, pp. 1-9). The placement of additional overburden in the pit areas would decrease the potential for these resources to be developed in the future to the somewhat low category.

Alternatives Z2 and Z3

Alternatives Z2 and Z3 would have a minor negative impact on precious metal mineral development potential. The amounts of pit backfill associated with these alternatives is considerably less than under Alternative Z1 since they would not include backfilling of the Alder Gulch waste rock dump. The resulting mineral development potential for these alternatives would be classified as moderate. This moderate development potential would be similar to the existing conditions. Interim reclamation backfilling has already reduced the mineral development potential from the somewhat high development potential that was present at mine closure to a moderate potential.

Alternative Z4

Impacts from Alternative Z4 to future mineral development potential would be greater than those under Alternative Z1 due to the additional amounts of backfilling. Additional backfill in the North and South Alabama pits and the Ross pit would result in a low mineral development potential at the Zortman Mine.

Alternative Z5

Alternative Z5 would also result in low mineral development potential due to the extensive amount of backfill that would be placed over the mineral deposit in order to restore the pit areas to the approximate original contour. The backfill amounts would be greatest under Alternative Z5 and, therefore, the negative impact on future mineral development would be largest under this alternative.

Alternative Z6 (Preferred Alternative)

Alternative Z6 would have a moderate negative impact on precious metal mineral development potential. The amount of pit backfilling that would occur under this alternative is greater than under Alternatives Z2 and Z3, but less than under Alternative Z4. The additional backfill would be used to cover the sulfide portions of the pit highwall. The mineral development potential of the reshaped area would be slightly less than under Alternatives Z2 and Z3.

Alternative L1

In 1992 ZMI sought approval to mine approximately 7.6 million tons of low grade gold and silver ore from the August and South Gold Bug pits at the Landusky Mine (FEIS, pp. 1-10). This is considerably less than the mineral resources remaining at the Zortman Mine. The placement of additional overburden in the pit areas would decrease the potential for these resources to be developed in the future from the somewhat high potential to the moderate potential category.

Alternatives L2 and L3

The amount of backfilling in the pits would be slightly less than Alternative L1. The negative impacts to mineral development from Alternatives L2 and L3 would similar to those described for Alternative L1.

Alternative L4 (Preferred Alternative)

Alternative L4 would include additional backfilling with placement of the L85/86 leach pad in the pit area. This backfilling would reduce the potential for mining of any resources from the pit area, although the overall impact would be similar to Alternatives L1, L2, and L3.

Alternative L5

The amount of pit backfilling that would be conducted under Alternative L5 would reduce the potential for future mineral development to somewhat low and would make future mining of these resources unlikely in the near term.

Alternative L6

An extensive amount of pit backfilling would be conducted under Alternative L6 to restore the pit area to the approximate original topography. It is unlikely that removal of the backfill would be conducted in order to mine the limited amount of mineral resources previously identified. The development potential for these resources would be classified as low.

4.2.2 Geotechnical Stability

Issues associated with stability include the stability of mine pit highwalls, the stability of backfill placed against the mine pit highwalls, and the long-term stability of the heap leach pad retaining dikes. In general, large volumes of unconsolidated material end dumped at the angle of repose are less stable than steep rock highwalls (NIOSH 1999). Both have geologic hazards associated with them. The solid rock is subject to isolated rock fall events. Fill slopes stacked against highwalls are subject to large-scale mass wasting and long-term soil creep unless graded and stabilized.

Alternative Z1

The highwalls in the O.K., Ruby, and Mint pits would be mostly covered by backfill from the Alder Gulch waste rock dump. Several hundred vertical feet of highwall would remain in the Alabama and Ross pits after placement of the backfill. The highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative Z2

Approximately 200 to 300 vertical feet of highwall would be exposed in most of the pit areas. The highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area. Leaving the Z85/86 dike in nearly its present configuration would result in somewhat poor long-term stability for this structure.

Alternative Z3

Stability in the mine pit areas and highwalls would be the same as described for Alternative Z2. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative Z4

Only a small amount of the pit highwalls would remain exposed and subject to mass wasting. Less than 100 vertical feet would be exposed in the Alabama pits, none in the Ross pit, and 200 to 280 feet of highwall would be exposed in the O.K and Ruby pits. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area. In other areas, any backfill that was end dumped against the highwall would be less stable. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative Z5

Only a small portion of the North Alabama pit highwall would remain exposed. This would present only a minor short-term stability concern. The backfill would be graded at a stable slope in the pit complex, which would eliminate soil creep, but the unconsolidated material would have considerably less stability than the solid rock highwall. Since the entire Z85/86 dike would be removed for use as backfill, the retaining dike would not present a stability concern.

Alternative Z6 (Preferred Alternative)

Impacts would be similar to those described for Alternative Z3. Additional material would be mined from the upper portion of the Alder Gulch waste rock dump and used to backfill the North Alabama pit. The resulting configuration would still include some pit highwalls. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but the long-term stability of solid rock would not pose a safety hazard to future users of the area. The placement of additional fill on the downstream side of the Z85/86 dike would improve the long-term stability of the structure and minimize the potential for mass failures.

Alternative L1

The drainage notch that would be constructed at the southwest end of the August pit would create additional steep walls where cut through bedrock. While the solid rock walls of the notch would be stable in the long term, it would present a hazard to reclamation workers and the public during the short term due to the confined area and potential for isolated rock falls. In addition, the wall rock in the notch contains sulfide mineralization which would be exposed to weathering and could contribute to water quality problems at the site.

Partial backfill of the Landusky Mine pit complex would leave the upper portions of the pit walls exposed in their present configuration. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area.

The placement of additional fill on the downstream side of the L85/86 and L91 dikes would reduce the potential for mass failures and improve the long-term stability of these structures from intermediate to somewhat good conditions.

Alternative L2

Alternative L2 would not involve construction of a drainage notch and the associated negative impacts described under Alternative L1. The regrading of the pit area would leave the majority of highwalls in their existing configuration. These highwalls would be subject to rock falls and some local areas of collapse in the short term, but long-term stability of solid rock would not pose a safety hazard to future users of the area.

The placement of additional fill on the downstream side of the L85/86 dike would improve the long-term stability of this structure and reduce the potential for mass failures. The L91 dike would remain in its present configuration, which is considered to be adequate (Womack 2000a).

Alternative L3

Alternative L3 also would not involve the construction of a drainage notch and the associated negative impacts described under Alternative L1. The construction of a borehole as a backup system for drainage of the pit area would reduce the risk of relying on a single system for preventing the formation of a pit lake. The remaining impacts would be similar to those described for Alternative L2.

Alternative L4 (Preferred Alternative)

The removal of the L85/86 leach pad and dike would improve the long-term stability of this material by taking it out of the drainage bottom and putting it in the mine pit as backfill.

Backfilling the pit complex would cover the lower section of the pit walls. In addition, the blasting of highwalls and the creation of scree slopes would be used to reduce the visual impacts of the mine pits. However, the scree slopes themselves would consist of unconsolidated material that would be subject to surface failures in the form of slides or raveling.

Alternative L5

The removal of the L85/86 leach pad and dike would improve the long-term stability in the same manner as under Alternative L4.

Placement of the material from the L85/86 and L87/91 leach pads would result in a pit backfill configuration where only a minor amount of excavation would be required to construct the drainage notch at the south end of the pit complex. This would result in a more stable notch configuration than under Alternatives L1

and L4. The backfilled material would be placed against the pit highwalls at slopes from 2H:1V to 3H:1V, or flatter. These slopes would be more stable than the rock highwalls or the scree slopes under other alternatives. However, this backfill material also would present an increased geologic hazard due to its acid generating potential.

Alternative L6

The backfilling would result in a configuration that approximates the pre-mine topography. Slopes composed of backfill would be approximately 3H:1V with benches every 100 vertical feet. These slopes would generally be stable and would cover virtually all of the pit highwalls. Minor slope failures due to settlement or saturation of the reclamation would likely occur. The largest geologic hazard associated with the pit areas would be the increased acid generating potential of the backfill material. Despite the inclusion of mitigating measures such as synthetic liners and recovery wells in the backfill design, this alternative would substantially increase the potential for effects from acid rock drainage in the northern drainages.

4.2.3 Topography

The existing conditions constitute a significant change in the original topography of the mining areas. Alternatives would restore the area topography to varying degrees, mostly through removal of mine waste facilities from various locations and placement in the mine pits.

Alternative Z1

Removal of the Alder Gulch waste rock dump would restore the dump footprint to its drainage configuration. Placement of the dump material would partially restore the topography of the pit area. Excavation of a limestone quarry southeast of the mine would lower the elevation of one of the peaks on the limestone ridge by approximately 80 feet. This excavation would be partially visible from the town of Zortman.

Alternatives Z2 and Z3

These alternatives would not significantly restore the topography of the area. All pits would be backfilled and graded to provide positive drainage to Ruby Gulch. This would be consistent with pre-mine drainage patterns.

Alternative Z4

Alternative Z4 would restore the area topography to a greater extent in the Alabama and Ross pit areas than under Alternative Z1. The backfill from the Z85/86 leach pad would improve the topographic conditions in the mine pit areas and at the head of Ruby Gulch.

Alternative Z5

Alternative Z5 would restore the area topography to the greatest extent through backfilling waste rock dumps and leach pads. Total removal of the Alder Gulch waste rock dump and the Z85/86 leach pad and dike would restore the affected drainages to their pre-mine configuration. Backfill placed in the pit areas, sloped shallower than the pre-mine topography due to stability concerns, would still serve to re-create the drainage patterns that existed prior to open pit mining.

Alternative Z6 (Preferred Alternative)

This alternative would restore the area topography to a greater extent than Alternatives Z2 and Z3. Placement of waste rock from the upper portion of the Alder Gulch waste rock dump into the North Alabama pit would conform with the adjacent pre-mine drainage pattern. Contruction of a drainage for surface runoff from the pits to pass into Ruby Gulch would restore the runoff pattern. Highwall reductions by blasting in the South Alabama pit would lower the peak topography at the top of the pit highwalls by 20 to 50 feet, but would create a surface that conforms with adjacent scree slopes in undisturbed areas.

Alternative L1

Alternative L1 would not restore area topography or drainage patterns significantly compared to existing conditions. Surface runoff falling in the mine pit area would be routed to the south and discharge into Montana Gulch via the drainage notch.

The excavation of a limestone quarry on the ridge south of the Landusky water treatment plant would lower the topography at the quarry site by 30 to 40 feet.

Alternatives L2 and L3

Alternatives L2 and L3 would not restore area topography or drainage patterns significantly compared to existing conditions. Surface runoff falling in the mine pit area would still be routed to the south via the artesian well discharging into Montana Gulch.

Alternative L4 (Preferred Alternative)

Alternative L4 would restore area topography or drainage patterns to a minor degree compared to existing conditions. Surface runoff falling in the mine pit area would be routed to the south and discharge into Montana Gulch via the artesian well WS-3. Removal of the L85/86 leach pad and dike from obstructing the Montana Gulch drainage would partially restore the topography in this drainage. Highwall reduction along the pit perimeter through blasting would lower the elevation at the top edge of the pit, and would result in highwalls covered with scree which better resemble adjacent undisturbed topography.

Alternative L5

Alternative L5 would partially restore area topography and drainage patterns. Surface runoff in the mine pit area would still be routed to the south and discharged into Montana Gulch via a drainage notch. Removal of the L85/86 leach pad and dike from obstructing the Montana Gulch drainage would partially restore the topography in this drainage. Backfilling along the perimeter of the pit would result in the pit highwall being covered with scree which better resemble the adjacent undisturbed topography.

Alternative L6

The result would be near complete restoration of area drainage patterns and topography. Placement of backfill in the pit area would restore the drainage patterns and re-establish the surface drainage divide that existed prior to mining. The impact in the pit area would essentially be a rebuilt mountain, though some slopes would be shallower than original ground. Removal of material from the L85/86 and L87/91 leach pads would also be more consistent with the pre-mining topography that existed at these leach pad sites. As it is not physically possible to place all the mined material back into the original excavation, there would still be a considerable variation from the original topography after the completion of backfilling.

4.3 WATER RESOURCES and GEOCHEMISTRY

This section describes the impacts on water resources and geochemistry that would result from the alternatives.

4.3.1 Methodology

Two variables most often used to assess impacts or potential impacts to water resources are changes in water quantity (flow) and changes in water quality (concentrations). The water quantity would change for each alternative depending on the reclamation configuration, cover performance, and the efficiency of the collection systems. Well-constructed reclamation covers would increase the amount of stormwater runoff and decrease the amount of infiltration into the underlying mined material. The establishment of vegetation on the covers would also add to the effectiveness of the covers by promoting the evapotranspiration of near-surface water from the covers. Modeling has been performed to help determine the effects of the reclamation cover types on water quantity for each alternative (see Appendix B for details). To be conservative in the estimates, the modeling was conducted assuming no vegetative cover.

The second variable is water quality. Data collected at the sites in the water monitoring and the geochemical testing programs have provided the information needed to predict long-term water quality trends. Because the accuracy of these predictions depends on many assumptions, the results are most useful for comparative purposes between alternatives.

The following sections describe the methodology used to determine the impacts on water quantity and quality for the various alternatives.

Infiltration Modeling Methodology

Modeling of the reclamation covers has been used (see Appendix B) to estimate the infiltration through the various cover designs. The Hydraulic Evaluation of Landfill Performance, or HELP model, was used in the 1996 FEIS to evaluate the infiltration associated with various reclamation covers. In recent years, software has been developed that is better able to model site-specific materials in a climate like that in northcentral Montana (O'Kane et al. 2000, Morris and Stormont 1997, Meyer and Gee 1999). Two software programs were used to model the performance of the reclamation covers. These were SOILCOVER (for modeling flat surfaces) and SEEP/W (for modeling sloped surfaces). The models were calibrated against the observed field data used in the site water balance investigations. Comparisons were made to the results provided in the FEIS by the HELP model.

The models provide semi-quantitative assessments of the infiltration through the reclamation covers. They take into account climatic conditions, local soil conditions, and design details such as cover thickness, etc. The details of each model's set-up and input parameters are available in Robertson GeoConsultants' Report No. 075001/7 (Robertson 2000c).

Seepage out the bottom of the mine waste facilities is made up of infiltration through the material, surface water draining underneath the material, and groundwater springs or seeps discharging underneath the facility. Placing a cover over the material would reduce the infiltration component of the flow. The other components, surface water draining under the facility and groundwater discharging under the facility, may also be reduced depending on surface water diversion structures and cover placement on areas adjacent to the facility. The modeling results have enabled an estimate of the reduction in infiltration for the various reclamation cover designs. The water and mass balance investigations, completed at both mines (Spectrum 1999, 2000a and 2000b), provide data on infiltration rates and runoff estimates for the undisturbed portions of the mine sites and information on the existing infiltration rates through the various mine facilities. The results from the modeling and these studies were applied to each mine under each alternative. The results are shown in Table 4.3-1 and are discussed in Sections 4.3.3 and 4.3.4.

The modeling results presented in Table 4.3-1provide the amount of precipitation that is predicted to infiltrate the mine facilities spread evenly over time. The range in infiltration rates is primarily dependent on the precipitation pattern and was modeled to represent an average year and a very wet year. It has been observed, and shown through modeling, that the timing of precipitation events plays a significant role in the actual infiltration rates. For instance, in the spring (growing season) a number of rain events can occur when the soils are saturated or near saturation (like a 'wet sponge'). If the rainstorm is heavy, the soils would be unable to hold the additional water and much of the precipitation would infiltrate through the covers. Should a similar heavy rain event occur in the late summer when the soil is unsaturated (a 'dry sponge'), much more of the precipitation would be stored in the soil, resulting in comparatively less water infiltration. The variables affecting the amount of infiltration are discussed in greater detail in Appendix B.

Water Quality Prediction Methodology

The combination of the quantity and quality of water is described as a load. It is on this basis that the effectiveness of the various reclamation covers for each alternative has been evaluated. The results are provided in Tables 4.3-2 and 4.3-3 for the Zortman and Landusky Mines, respectively. Note that these loads are calculated to be the amount of contaminants that are collected in the capture systems, or occur immediately below the mine disturbance. They are not representative of loads in the downstream environment. The load numbers should not be considered as absolute precise predictions, but rather should be considered relative to one another when comparing the alternatives.

The amount of load in post reclamation discharges is not directly measured or regulated. Rather it is the concentration of various elements of concern at some 'compliance point' downstream from the mine that is used to regulate the water quality and to assess the impacts of mining and the effectiveness of reclamation. In order to predict downstream concentrations, an estimate of the amount of water that is not being captured (i.e. bypassing collection) was made (Table 4.3-4). Using the information described above, attempts were made to quantitatively predict water quality below the capture systems at certain monitoring locations. These types of predictions turned out to be extremely difficult, and reliable accurate values were not possible. The results showed a wide range of values for individual contaminants depending upon

whether they were attenuated during transport downstream. This wide range overshadowed any substantial difference between the alternatives, demonstrating that the model could not be used to accurately quantify post-reclamation water quality.

Multiple Accounts Analysis Methodology (MAA)

An impact assessment of post reclamation water quality is included in the Multiple Accounts Analysis (MAA). The MAA assigned a *protection value* for each drainage. The protection value can be thought of as the opposite of risk. If a certain alternative has a low risk of impact to the downstream environment, then the protection value is considered high. The assessment of a protection value was made in a variety of categories including:

- Surface water quality in each drainage;
- Surface water quantity in each drainage; and
- Groundwater quality in each drainage.

The details of the MAA are discussed in Section 4.13. The MAA scoring and protection values are in Appendix A.

Rationale and Factors Considered in Impact Assessment

The evaluation of the reclamation alternatives used the above-described methodologies, previous scientific analysis, or other factors that may have been unique to a particular alternative. A summary of the analytical methods and factors used in the impact assessment, and their relative degree of reliance, is as follows:

- Multiple Accounts Analysis - High
- Effects on the potential quantity and quality of water flow to northern drainages (Lodgepole Creek, Swift Gulch and King Creek) - High
- Experience with existing water capture systems and reclamation at the mines - High
- Overall reclamation experience and professional judgment - High
- Reclamation Cover Infiltration Modeling - Moderate to High
- Water Balances and Mass Loading reports (Spectrum 2000a and 2000b) - Moderate
- Previous hydrology and geochemical studies (WMCI 1998 and others) - Moderate
- Predicted contaminant loads to drainages - Moderate
- The expected long-term versus short-term performance of reclamation covers - Moderate
- Predictions of uncaptured flows bypassing existing capture systems - Low to Moderate
- Predictions of concentrations of contaminants in uncaptured water - Low

This general heirarchy provided the basis for the overall impact rating of the alternatives. Sometimes this resulted in an alternative with a higher numeric rank using one methodology, being rated lower than a lower-

ranked alternative using another method. This was due to the influence of other factors such as expected longevity of the cover material, or the degree of risk of contamination posed to north-flowing drainages.

More weight was placed on those factors that used well-known, verifiable scientific assessments, or on the professional judgement of the interdisciplinary teams. A high amount of weight was given to results which showed potential contaminants reaching north-flowing drainages, since protection of Reservation water quality was a priority and relatively small amounts of contaminants could result in adverse impacts to currently uncontaminated waters, requiring construction of new capture systems. The experience gained with the existing reclamation and operation of the water capture and treatment systems was also given high weight in assessing the impacts of the alternatives since it represents actual environmental performance. Low weight was given to those assessments or analyses that could not be verified with existing information from the mines. Some of these assessments relied on sparse data or extrapolations of limited information for large areas.

Table 4.3-1. Summary of Estimated Reclamation Cover Infiltration by Alternative

Alternatives	Subtotal Projected Pit Area Infiltration			Total Mine Area Projected Infiltration		
	Low Infiltration Rate (gpm)	High Infiltration Rate (gpm)	Average Infiltration Rate (gpm)	Low Infiltration Rate (gpm)	High Infiltration Rate (gpm)	Average Infiltration Rate (gpm)
Zortman Mine						
Existing Conditions			55			266
Alternative Z1	12	22	17	86	165	126
Alternative Z2	23	42	33	107	205	156
Alternative Z3	21	41	31	101	196	149
Alternative Z4	16	28	22	93	183	138
Alternative Z5	19	39	29	97	190	143
Alternative Z6	14	29	21	83	172	127
Landusky Mine						
Existing Conditions			194			747
Alternative L1	57	90	73	161	304	233
Alternative L2	73	126	100	198	401	299
Alternative L3	73	126	100	199	402	301
Alternative L4	65	121	93	182	391	287
Alternative L5	54	113	84	182	391	287
Alternative L6	18	50	34	120	257	188

Total pit area used for Zortman Mine, 94 acres. Total pit area used for Landusky Mine, 243 acres. Total mine area used for Zortman Mine, 419 acres (varies slightly by alternative). Total mine area used for Landusky Mine alternatives, 856 acres (varies slightly by alternative). Existing infiltration conditions based upon mine water balance reports (Spectrum 2000a and 2000b).

Table 4.3-2. Load Estimates for Zortman Mine Reclamation Alternatives

Constituent	Drainage	Existing Conditions	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	Alternative Z6
pH (s.u.)	Lodgepole	6.5 to 7.0	7.0	7.0	7.0	4.0	4.0	7.0
	Carter Spur	3.0 to 3.5	4 to 5	3.0 to 3.5	3.0 to 3.5	4 to 5	4 to 5	3.0 to 3.5
	Alder Spur	4.0 to 6.0	6.0	5.0	5.0	5.0	5.0	5.0
	Ruby Gulch	2.8 to 3.0	3.5	3.0	3.0	3.5	3.5	3.0
Sulfate Load (lbs/yr)	Lodgepole	2,200	1,300	2,000	1,800	54,800	69,000	1,000
	Carter Spur	1,150,000	135,000	1,150,000	1,150,000	155,000	135,000	135,000
	Alder Spur	315,000	315,000	315,000	315,000	315,000	315,000	315,000
	Ruby Gulch	2,650,000	1,400,000	2,400,000	2,500,000	1,700,000	1,900,000	1,700,000
Iron Load (lbs/yr)	Lodgepole	120	75	110	100	445	2,135	60
	Carter Spur	8,500	1,000	8,500	8,500	1,100	1,000	1,000
	Alder Spur	15	15	15	15	15	15	15
	Ruby Gulch	110,000	52,000	99,000	103,000	72,000	81,000	72,000
Aluminum Load (lbs/yr)	Lodgepole	1	0	1	1	5,750	4,500	0
	Carter Spur	123,100	14,350	123,100	123,100	16,450	14,350	14,350
	Alder Spur	2,640	2,640	2,640	2,640	2,640	2,640	2,640
	Ruby Gulch	163,000	88,000	146,000	152,000	107,000	119,000	107,000
Zinc Load (lbs/yr)	Lodgepole	2	1	2	1	190	550	1
	Carter Spur	4,000	470	4,000	4,000	530	470	470
	Alder Spur	175	175	175	175	175	175	175
	Ruby Gulch	3,300	1,800	3,000	3,100	2,200	2,500	2,200
Arsenic Load (lbs/yr)	Lodgepole	1	0	1	1	1	1	0
	Carter Spur	6	1	6	6	1	1	1
	Alder Spur	-	-	-	-	-	-	-
	Ruby Gulch	65	35	60	60	40	50	40
Copper Load (lbs/yr)	Lodgepole	0	0	0	0	110	180	0
	Carter Spur	2300	270	2300	2300	310	270	270
	Alder Spur	125	125	125	125	125	125	125
	Ruby Gulch	5,500	3,000	4,900	5,100	3,600	4,000	3,600
Cadmium Load (lbs/yr)	Lodgepole	-	-	-	-	7	6	-
	Carter Spur	155	20	155	155	20	20	20
	Alder Spur	7	7	7	7	7	7	0
	Ruby Gulch	880	475	790	820	575	645	575

Table 4.3-3. Load Estimates for Landusky Mine Reclamation Alternatives

Constituent	Drainage	Existing Conditions	Alternative L1	Alternative L2	Alternative L3	Alternative L4	Alternative L5	Alternative L6
pH (s.u.)	King Creek	7.0 to 8.0	7.5	7.5	7.5	5.5	5.5	5.5
	Swift Creek	6.0 to 7.0	6.5	6.5	6.5	5.5	5.5	3.0
	Montana Gulch	6.5 to 7.5	7.0	7.0	7.0	7.0	7.0	7.0
	Mill Gulch	5.0 to 6.0	5.5	5.5	5.5	5.5	5.5	5.5
	Sullivan Gulch	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Sulfate Load (lbs/yr)	King Creek	66,000	60,000	65,000	65,000	65,000	151,000	216,000
	Swift Creek	85,000	60,000	66,000	69,000	68,000	143,000	186,000
	Montana Gulch	1,495,000	716,000	1,177,000	1,177,000	1,166,000	1,195,000	1,084,000
	Mill Gulch	308,000	163,000	293,000	293,000	293,000	293,000	207,000
	Sullivan Gulch	879,000	776,000	879,000	879,000	879,000	879,000	879,000
Iron Load (lbs/yr)	King Creek	26	24	26	26	26	60	89
	Swift Creek	1,460	1,030	1,140	1,190	1,170	1,290	1,160
	Montana Gulch	60,000	28,700	47,200	47,200	46,800	47,900	43,500
	Mill Gulch	30	15	30	30	30	30	20
	Sullivan Gulch	10,400	9,200	10,400	10,400	10,400	10,400	10,400
Aluminum Load (lbs/yr)	King Creek	17	16	17	17	17	130	215
	Swift Creek	30	20	25	25	25	110	170
	Montana Gulch	14,350	6,875	11,300	11,300	11,200	11,475	10,400
	Mill Gulch	10,130	5,380	9,640	9,640	9,640	9,620	6,800
	Sullivan Gulch	15,390	13,580	15,390	15,390	15,390	15,390	15,390
Zinc Load (lbs/yr)	King Creek	7	6	6	6	6	65	110
	Swift Creek	60	45	50	50	50	100	125
	Montana Gulch	5350	2560	4210	4210	4175	4280	3,880
	Mill Gulch	925	490	880	880	880	875	620
	Sullivan Gulch	430	380	430	430	430	430	430
Arsenic Load (lbs/yr)	King Creek	1	1	1	1	1	1	1
	Swift Creek	5	3	4	4	4	4	4
	Montana Gulch	225	110	175	175	175	180	165
	Mill Gulch	3	2	3	3	3	3	2
	Sullivan Gulch	125	110	125	125	125	125	125
Copper Load (lbs/yr)	King Creek	1	1	1	1	1	5	8
	Swift Creek	1	1	1	1	1	3	5
	Montana Gulch	330	160	260	260	260	265	240
	Mill Gulch	65	35	65	65	65	65	45
	Sullivan Gulch	265	235	265	265	265	265	265
Cadmium Load (lbs/yr)	King Creek	0	0	0	0	0	1	2
	Swift Creek	0	0	0	0	0	1	2
	Montana Gulch	100	50	80	80	80	80	70
	Mill Gulch	15	10	15	15	15	15	10
	Sullivan Gulch	8	7	8	8	8	8	8

Table 4.3-4. Calculations of Potential Flows Downstream If Bypassing Capture

Background Area	Reference Site	Cm* Downstream Sulfate Concentration (mg/L)		Cb* Background Sulfate Concentration (mg/L)		Qb* Area (acres)	% Infiltration + Runoff	Infiltration (inches)	Infiltration (million gal.)
Swift Gulch	L-19	Undisturbed	391.5	BKSP-1	130	161	25	4.945	21.62
King Creek	L-51	Undisturbed	417	ZL-307	102	87	25	4.945	11.64
Sullivan Gulch	D-4	Below Capture	238.5	L-44	10	59	25	4.945	7.97
Mill Gulch	L-7	Below Capture	910	L-9	294	180	25	4.945	24.14
Montana Gulch	L-47	Below Capture WTP Discharge	625	L40 LWTP	47 635	289	25	4.945	38.86 235.15
Alder Spur	Z-6A	Below Capture	173	Z-65	169.9	36	40	7.912	7.83
Carter Gulch	Z-42	Below Capture Runoff from CG-01	176.7	AGSS-10	17	211 17	40	7.912 0.5	45.40 0.23
Ruby Gulch	ZL-143	Below Capture WTP Discharge	1070	Z-52 ZWTP	53 3000	942	40	7.912	202.38 94.82
Lodgepole Creek	ZL-210	Undisturbed	103	ZL-300	75	38	40	7.912	8.15

Mine Disturbed Area	Reference Site	Ce* Source Sulfate Concentration (mg/L)		Qe* Amount of Source Water Contributing Downstream (million gal.)	Source Water Flow Contributing Downstream (gpm)	Estimated Error in Calculations
Swift Gulch	BKSS-6	Disturbed	1630	4.56	8.68	± 4 gpm
King Creek	L-5	Disturbed	1140	5.07	9.65	± 5 gpm

Table 4.3-4. (Cont.) Calculations of Potential Flows Downstream If Bypassing Capture

Mine Disturbed Area	Reference Site	Ce*		Qe*		
		Source Sulfate Concentration (mg/L)		Amount of Source Water Contributing Downstream (million gal.)	Source Water Flow Contributing Downstream (gpm)	Estimated Error in Calculations
Sullivan Gulch	L-28	Above Capture	10,000	0.19	0.35	± 0.2 gpm
Mill Gulch	L-35	Above Capture	3250	6.36	12.09	± 6 gpm
Montana Gulch	L-38	Above Capture	1645	19.72	37.51	± 15 gpm
Alder Spur	Z-14	Above Capture	1800	0.01	0.03	± 0.05 gpm
Carter Gulch	Z-13	Above Capture	8000	0.93	1.77	± 0.8 gpm
Ruby Gulch	Z-37	Above Capture	4800	6.12	11.64	± 5 gpm
Lodgepole Creek	ZL-202	Disturbed	2500	0.10	0.18	± 0.05 gpm

NOTES:
Precipitation value = 19.78 inches
Sulfate concentrations used were maximum concentrations since 1997.
Water treatment plant volumes taken from 1998 data.
Percent runoff and infiltration taken from Landusky and Zortman surface and groundwater mass balance reports.
Equations used to calculate bypassing flows:

For drainages without WTP discharge flow

$$\frac{CeQe+CbQb}{Qe+Qb} = Cm$$

$$\frac{Qb(Cm-Cb)}{(Ce-Cm)} = Qe$$

For drainages with WTP discharge flow

$$\frac{CeQe+CbQb+CwQw}{Qe+Qb+Qw} = Cm$$

$$\frac{Qb(Cm-Cb)+Qw(Cm-Cw)}{(Ce-Cm)} = Qe$$

*Where:
Ce = concentration escaping capture system
Qe = flow escaping capture system
Cb = concentration of background
Qb = flow from background
Cm = concentration at monitoring well
Qw = flow from water treatment plant discharge
Cw = concentration from water treatment plant discharge

4.3.2 Impacts Common to All Alternatives

Acid Rock Drainage

Acid rock drainage (ARD) is the result of sulfide oxidation, a natural chemical weathering process. As a result of mining the rock is broken and 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 tends to dissolve metals from the adjacent rock into solution. 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. A pH value of 3 s.u. (standard units) is therefore 10 times more acid than pH 4 s.u. and 100 times more acid than pH 5 s.u. While acid water, by definition, is water with a pH below 7 s.u., it is not until the pH is below approximately 4.5 s.u. that metals in significant concentrations (i.e. above water quality standards) generally occur. Rainwater, for instance, typically has a pH in the range of 5.5 to 5.8 s.u., 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 s.u. and above, representing very weak acidic conditions with little potential to dissolve metals. As the pH decreases below 4.5 s.u., the ability to dissolve metals increases rapidly. By the time the pH is below 3 s.u., 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 are 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:

- The amount of sulfides;
- The nature of the sulfides (how quickly they oxidize); and
- The amount of neutralizing minerals.

The condition of the mined rock evolves as oxidation progresses. Some waste materials (those that have little or no sulfides and those with excess neutralizing minerals) do not become acidic, while some become acidic very quickly (those with rapidly oxidizing sulfides and few neutralizing minerals). This evolution of acidic conditions can take a long time (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 (i.e. dissolve quickly in water) 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 down through 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. The reclamation alternatives, to varying degrees, would move some material from its current location to another spot on the mine (typically as backfill). As a result, there would be a short period of time (perhaps a few years) after reclamation when the concentrations of contaminants reporting to the capture systems would actually increase as infiltrating water creates new flowpaths and oxidation products within those flowpaths dissolve. The more material that is moved the greater the potential for short-term water quality impacts from the flushing of the relocated rock.

ARD Maturity

Data collected over the years show that there are different stages of ARD evolution at the mines, and that contaminant concentrations would continue to increase until the final or "mature" state is achieved. Predictions have been made as to the 'mature' ARD conditions for each mine. These predicted concentrations were used as the 'baseline' with which to compare the relative differences that may be achieved by each reclamation alternative. This is a conservative approach that can be thought of as the worst-case scenario. Figures 4.3-1 and 4.3-2 provide a generalized schematic that illustrates how ARD typically evolves on sulfide-bearing mine sites. The stages to which the Zortman and Landusky Mines have progressed are shown on the graph.

Figure 4.3-1 is a schematic graph of pH over time. 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 s.u.). A dashed line shows this increase on the graph. Figure 4.3-2 is a schematic graph of the sulfate concentration over time.

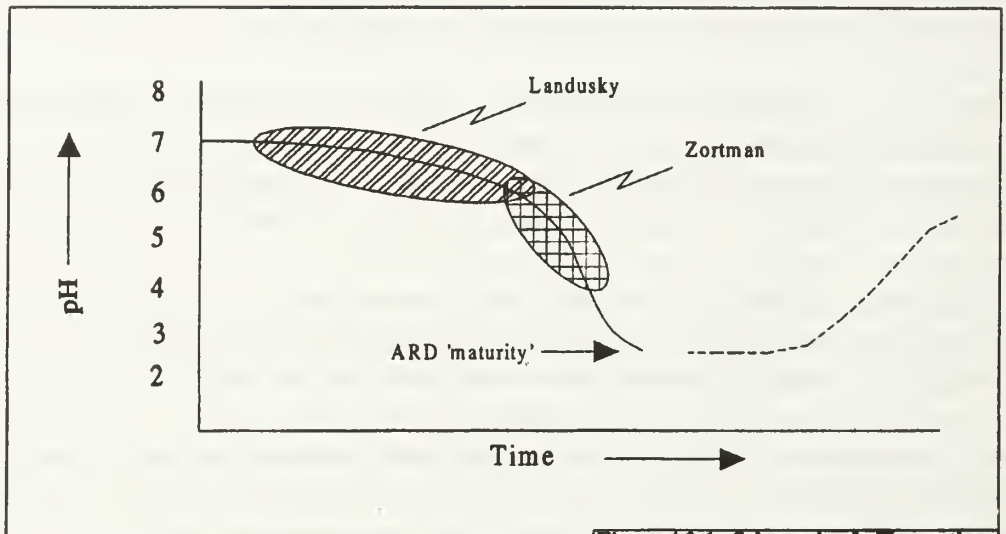


Figure 4.3-1. Schematic of pH over time in ARD impacted waters.

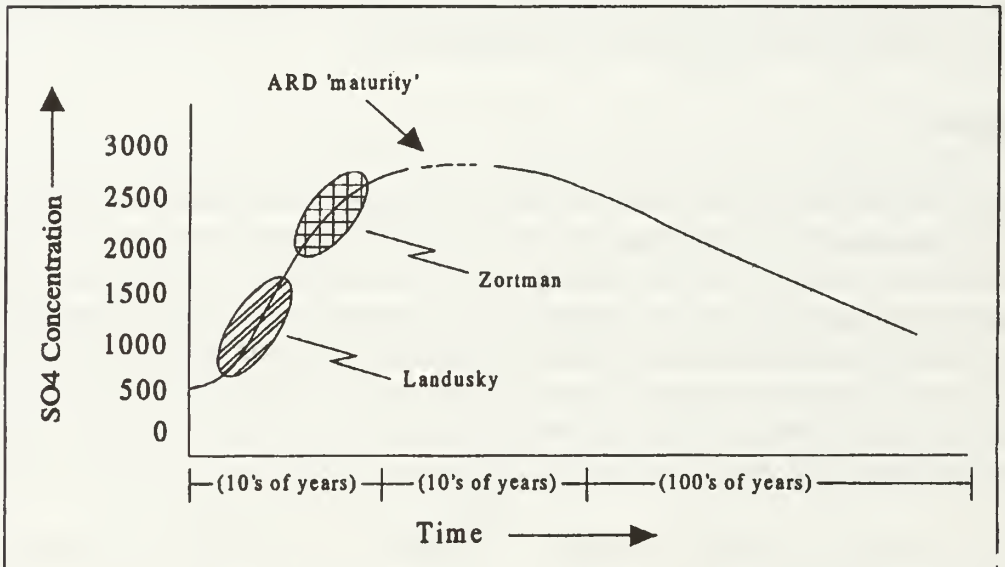


Figure 4.3-2 Schematic of sulfate concentration over time in ARD impacted waters.

As the sulfides oxidize, sulfuric acid is produced; therefore, the concentration of sulfate (SO_4) is typically used as an 'indicator' for water quality impacts. 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. It is anticipated that the full cycle from oxidation initiation to finally reaching the "oxide" state would take tens to hundreds of years. Consequently, all reclamation alternatives provide for long-term water treatment.

Figures 4.3-1 and 4.3-2 show that the ARD conditions at the Zortman Mine are more mature than those at the Landusky Mine. There is a considerable difference in the actual 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 (alkalinity) 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 Landusky Mine (for example in the Bighorn dolomite and the Emerson shale).

The evaluation of the existing groundwater and surface water systems at the mines presented in Section 3.3 concluded that practically all the recharge to groundwater over the mine areas is captured and treated. Hence, the amount of water that migrates from the mines downstream is minimal, particularly in those drainages with capture systems. This small volume of water is contaminated with concentrations similar to the concentrations currently being collected in the capture systems. There are two types of contaminants in these migrating waters, those that <u>do not</u> attenuate and tend to concentrate along a migration path, and those that <u>do</u> 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 s.u., it is unlikely that significant concentrations of metals contaminants would occur. Exposures of the Paleozoic limestones in the area drainages serve to raise the pH and promote metal precipitation.

The placement of reclamation covers over the mine facilities would decrease the amount of infiltration into the underlying mined material. However, while water quantity passing through the mine waste might decrease, the concentration of contaminants is not likely to decrease significantly. Instead, contaminant concentrations probably would continue to increase, at least until ARD 'maturity' is reached. Further, the use of leach pad material as backfill in certain alternatives would increase the contaminant loads in the areas to which the material is moved. Currently, those contaminant loads are retained in the leaching circuit and treated with relative ease in the water treatment plants and/or the land application water treatment systems. Moving mined materials would increase the difficulty of collecting any leachate it may generate. Therefore,

the water quality would degrade in drainages where significant amounts of backfill are placed, even with use of mitigating measures such as liners and capture systems.

Water Treatment Requirements

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 on both mines for a very long time. Further, 65 to 75% of the water treatment costs are fixed and do not vary by the amount of water requiring treatment. This is demonstrated by the fact that since the artesian well at the Landusky Mine was opened up, the volume of water reporting to the water treatment plant has doubled and there has been no increase in the costs.

Geosynthetic Material Degradation

There has been an increase in the general understanding with respect to GCL (geosynthetic clay liner) usage in reclamation cover systems in semi-arid climates. It is now thought that the long-term durability and sustainability of GCL's in these climates is poor (Badman and Daniel 1996, MEND, in progress). Water balance covers, or water barrier covers that utilize HDPE or other geomembranes, rather than GCL, are more suitable for climates such as those at the mines. Infiltration through the reclamation covers has been evaluated using an updated cover modeling program called SOILCOVER. The results are provided in Appendix B.

Capture System Requirements

Implementation of every alternative would decrease the amount of mine drainage water requiring capture and treatment. This would be due to the improved diversion of runon waters and a reduction in infiltration by the reclamation covers. The amount of infiltration predicted to require capture and treatment is addressed under each alternative.

4.3.3 Zortman Mine

Impacts Common to All Zortman Mine Alternatives

All alternatives would improve the overall water quality conditions in the Zortman Mine area. There are essentially three 'primary' reclamation actions that would affect the impacts to water quality:

- The amount of backfill placed in the pits and its geochemistry;
- The type of reclamation cover applied over the regraded mine waste; and
- The location of the water treatment plant.

Geochemistry of Backfill

The geochemistry of the rock used for pit backfill is an issue when material is moved from one drainage into another. In many cases, the backfill is acid generating materials that have been fully oxygenated and exposed to water for years, with a significant store of accumulated oxidation products that are readily soluble. When the material is moved from one location to another, the flowpaths through which water infiltrates are disturbed. New flowpaths are created once the backfill is placed, allowing these soluble oxidation products to be remobilized. This results in increased contaminant loads where the backfill is placed until such time as the new flowpaths are "flushed out." While the loads would decrease in the areas from which the backfill is obtained, they would increase in the areas where the backfill is used. In those alternatives where leach pad material is used as backfill, taking the potentially acid generating material off a liner where water collection is relatively easy, and placing it into pits where water collection is more difficult, would increase the risk of long-term impacts to water quality in the relocation areas.

Since the material at the Zortman Mine is close to geochemical maturity (not likely to get worse), and the capture system bypass volumes are predicted to be relatively small, the downgradient impacts would be minimal. The data show that the current water quality below the capture systems is acceptable. Therefore, it is likely long-term water quality would also be acceptable where acid generating backfill is placed in drainages with existing capture systems.

Reclamation Covers

Due to slope stability concerns, the low permeability water barrier reclamation covers can only be placed on areas of moderate slope (less than 25% grade). The generally steep topography in the area, and the amount of backfill and grading among the alternatives, places constraints on how much of the mined areas can be covered with the water barrier reclamation covers. The reclamation covers used in the alternatives would decrease infiltration of precipitation into the mine waste and would decrease the loads reporting to the capture system. However, none of the alternatives would decrease loads to the point that the water capture and treatment systems could be eliminated.

Infiltration cover modeling is discussed in Section 4.3.1. Table 4.3-1 shows that for the total Zortman Mine area, there is little difference in infiltration rates between alternatives. The calculated difference between the highest and lowest projected infiltration rates are only 19 to 20%, within the margin of error for the model. The projected average infiltration for the alternatives ranges from 126 gpm (Alternative Z1) to 156 gpm (Alternative Z2). Projected infiltration between alternatives for the pit areas is more pronounced, with approximately 50% difference between the highest and lowest pit infiltration rates. The projected average infiltration for the pits ranges from 17 gpm (Alternative Z1) to 33 gpm (Alternative Z2). Additional information on the results of infiltration modeling through the reclamation covers is presented in the following individual alternatives discussions.

Water Treatment Plant Relocation

Relocation of the Zortman Mine water treatment plant to Goslin Flats in some reclamation alternatives would eliminate a significant source of treated discharge to Ruby Gulch. This would also eliminate most of the uphill pumping, thus reducing the risk of system failure and release of impacted waters. However, the gravity pipeline routes to Goslin Flats are much longer and traverse steep, undisturbed, hard-to-access terrain. This could make maintenance more difficult than the current routes. Failure of any component of the water treatment plant system is considered a reasonably foreseeable significant adverse impact.

Water Quantity and Quality Impacts

Water quantities could be impacted by the three reclamation actions described above. In addition, surface water and groundwater runoff, and groundwater flow patterns may be impacted by:

- The sizes and patterns of the reclaimed surface drainage basins;
- Use of water storage and diversion structures;
- Burial of springs, or creation of new springs and seeps;
- Changes in the patterns of groundwater recharge near sensitive areas such as shear zones, basin divides, and northern drainages;
- Long term changes in groundwater levels due to reclamation; and
- Changes in the locations of groundwater divides and divide zones.

The general effect of all reclamation alternatives at the Zortman Mine would be to increase stormwater runoff and reduce infiltration within the mine-affected drainages. Surface runoff would continue to be routed around the capture systems. Minor drainage changes would be made within the Ross pit that direct water to Ruby Gulch instead of draining to Lodgepole Creek. Reclamation would restore larger continuous drainage basins over the top of the previous mine facilities.

In the short term, surface water runoff would probably increase for all alternatives during the reclamation construction period until vegetation is well established. Evaluation of the Zortman Mine water balance criteria and drainage areas (Spectrum 2000a) shows that under all the reclamation alternatives, there would be an increase in surface runoff by 2.5 to 6.3% of annual precipitation over the roughly 200 acres of currently unreclaimed mine pits and leach pads. With average precipitation, this amounts to an increase of 4 to 5 million gallons of runoff per year, which is about 7 to 10 gpm on a year-round flow basis. Although this represents a 50 to 70% increase in total mine area runoff, it is only 1.5% of the total water balance of the Zortman Mine.

No perennial springs would be buried, and no new springs are anticipated to result from any of the alternatives. Springs that were buried may be restored under Alternative Z5 by the removal of the Z85/86 leach pad.

Reclamation cover modeling indicates that surface seepage from the cover could occur where 3H:1V slope lengths approach or exceed 200 feet. Although there are many areas of reclamation with slopes longer than this, all reclamation alternatives use a regular pattern of surface interception ditches to catch seepage from the water storage and drainage layer before it discharges at the surface.

The current rate of recharge to groundwater would be reduced under all of the alternatives due to the large increase in evapotranspiration from the vegetated cover soils. Currently, recharge to the syenite aquifer is focused within the mine pits. The amount of backfill placed in the pits varies with the alternatives; however, all pits at the Zortman Mine would be free draining under all alternatives. Consequently, the groundwater recharge pattern would generally be similar for all alternatives. No significant changes from the current conditions, or significant differences among the alternatives, are foreseen in the directions of groundwater flow or in the location of the groundwater divides, including the groundwater divide zone between Ruby Gulch and Lodgepole Creek.

There are significant differences in the reclamation covers and backfilled slope grades over the Zortman Mine pits and other facilities. The current rate of infiltration over the Zortman Mine, exclusive of leach pads, is 206 gpm. Total mine site estimated infiltration values for the Zortman Mine differ by approximately 30 gpm or 19% among alternatives, which may be within the margin of error for the model. For the Zortman Mine pits, modeled infiltration volumes vary by about 50% between alternatives, corresponding to an average difference of 16 gpm between the low and high infiltration values. Water levels at the Zortman Mine have been increasing for at least eight years. Reductions in infiltration under all alternatives probably would stabilize water levels. Alternatives with lower infiltration rates to the pits (Z1, Z4, and Z6) may result in slightly decreasing water levels. There are no hydraulic controls at the Zortman Mine that would be used to control water levels similar to the use of artesian well WS-3 at the Landusky Mine.

As discussed in Section 3.3.3, the majority of surface water and groundwater within the drainages is collected at the capture systems. Minor amounts of groundwater bypass the capture systems as shown in Table 4.3-4. Uncaptured flows are relatively small compared to the surface or groundwatersheds and, for purposes of impact analysis, are assumed to remain the same in each drainage regardless of the reclamation alternative. This is a conservative approach since decreases in infiltration would likely result in decreases to the amount of water entering the capture systems for treatment, and decreases in the amount of water bypassing the capture systems. Since the relative percentages of uncaptured flows reporting to surface water and groundwater is not known precisely, when assessing impacts it was assumed that all the uncaptured flows would report to both the surface water <u>and</u> to groundwater. While uncaptured flow quality would vary by alternative based on load estimates, the small quantity of poorer quality uncaptured flow would create only minor downgradient impacts.

Despite the differences in total sulfate and metals loads, downgradient water quality predictions showed a wide range of possible concentrations that vary little between alternatives. Since modeling cannot accurately predict if the water quality standards would be exceeded, continued monitoring and provisions for supplemental capture and treatment would be used to prevent significant impacts to water quality.

The following sections describe the water resource impacts of each reclamation alternative. These sections describe the relative ranks of the alternatives with respect to reductions in infiltration, and total sulfate and metals loads. Surface water and groundwater discussions are separate, but it is important to note that surface and groundwater conditions and impacts are closely related.

Alternative Z1

Alternative Z1 would reduce impacts to water resources by the placement of water barrier and water balance reclamation covers over the backfilled or regraded pits and leach pads. The reduction in infiltration over the mine area is estimated at 140 gpm, or 53% from existing conditions. As noted previously, the differences in infiltration reduction between alternatives is not significant. However, relative to the other alternatives, Alternative Z1 ranks with Alternatives Z4 and Z6 as the highest in reducing infiltration in the pit areas, and is comparable to Alternative Z6 as the most effective alternative for reducing contaminant loads to groundwater (Tables 4.3.1 and 4.3.2).

Water Quality and Quantity

The impact of Alternative Z1 on water quality and quantity are described on a drainage-by-drainage basis for the four area drainages: Ruby Gulch, Alder Spur, Carter Spur, and Lodgepole Creek.

Ruby Gulch

Surface Water: The impact to the surface water quality in Ruby Gulch downstream of the capture system is determined by the risk of water bypassing the capture system. An estimated 7 to 17 gpm of groundwater is currently bypassing the capture system and discharging to Ruby Gulch as surface water. Total sulfate and metals loads in this seepage would improve over existing conditions and have a positive impact to Ruby Gulch surface water quality. Removal of the tailings in Ruby Gulch above the town of Zortman would result in long-term improvements in stormwater runoff quality in the form of decreased suspended load and bed load, and lower metals concentrations. The tailings removal would also increase the stability of the stream channel in the long term. The removal of approximately six feet of tailings would change the creek gradient through the removal zone. Sediment ponds would be constructed to slow stormwater flows, limiting impacts of the gradient change. Overall, there would be a positive impact to water quality in Ruby Gulch due to infiltration and load reductions at the mine and removal of the historic mine tailings.

Since Alternative Z1 does not include relocation of the water treatment plant and related systems, the location of streamflow discharge in Ruby Gulch would remain similar to existing conditions. The long-term total annual volume of discharge would decrease due to reductions in the total amount of infiltration to groundwater over the mine area that enters the treatment plant and is discharged in the drainage.

Groundwater: The reclamation covers would decrease infiltration and the resulting contaminant loads reporting to the capture system. However, the load would not decrease to the point where the water

capture and treatment system could be eliminated. The impact to groundwater is primarily due to the amount of backfill put into the pits and the quality of the reclamation covers placed over that backfill. These factors affect the amount of infiltration to the shear zones and underground workings beneath the pits, which in turn influence water levels and contaminant loads from the mine. This alternative includes backfill to a level that would cover the sulfide-bearing highwalls. Water barrier and water balance covers placed over the pit backfill would reduce the amount of water that could infiltrate into the shear zones and underground workings below these pits. This would significantly reduce the impact to groundwater quality in the Ruby Gulch drainage. Alternative Z1 is ranked, with Alternative Z6, as highest among the alternatives in reduction of total sulfate and metals loads to groundwater in the Ruby Gulch drainage (Table 4.3-2).

While Alternative Z1 has relatively low total infiltration rates over the pit area (Table 4.3-1), the decreases in infiltration are due to the use of GCL in the reclamation covers. These covers materials are not as long lasting as the PVC/HDPE materials used under other alternatives. This makes Alternative Z1 lower rated than alternatives using HDPE/PVC in the reclamation covers.

The water infiltrating the Ross pit migrates mostly to the south through old underground workings and emerges in Ruby Gulch, above the capture system. The Ross pit reclamation cover in Alternative Z1 is ranked intermediate among the alternatives with respect to the amount of infiltration that would pass through the cover (approximately 7 gpm compared to a low of 0.02 gpm for Alternative Z4 and approximately 9 gpm for Alternative Z5). A portion of this infiltration would eventually appear as groundwater recharge in the Lodgepole Creek drainage.

Alder Spur

Surface Water: The impacts to surface water quality in Alder Spur are due to runoff or seepage from the Z83 and Z84 leach pad dikes. Water that falls on the leach pads is collected in the lined system and disposed of via land application. The installation of water balance and water barrier covers over these leach pads would reduce the amount of infiltration requiring land application disposal. In effect, the leach pads act like an umbrella at the top of the Alder Spur drainage. The only water entering the capture system is runoff from the dikes, or seepage through the dikes. The estimated amount of water bypassing the Alder Spur capture system is less than 0.1 gpm. This very low flow below the capture system means that the efficiency of this capture system is very good; however, the water captured is of poor quality. In the short term, there would be no improvement in the surface water quality this drainage. The predicted load in Alder Spur is the same for all alternatives.

There would be no change in the existing impact to water quantity in Alder Spur. The existing capture system is extremely efficient, reducing the amount of water in this stream segment. Captured water would continue to be routed to the water treatment plant and discharged to Ruby Gulch after treatment.

Groundwater: Groundwater quality in Alder Spur is dependent on the quality of water that infiltrates through the Z83 and Z84 leach pad dikes. Groundwater recharge in the headwaters of this drainage likely

discharges to surface water above the capture system and is currently being collected. The installation of reclamation covers and revegetation of mine facilities in the Alder Gulch drainage would slightly reduce the recharge to groundwater. Therefore, no changes in impacts to groundwater quality would occur.

Carter Spur

Surface Water: The water collected in the capture system at the downstream edge, or "toe" of the Alder Gulch waste rock dump is of poor quality. Calculations predict that only 1 to 2.6 gpm bypass this capture system. There would be a positive long-term impact to surface water and groundwater quality in Carter Spur with the decrease in loads resulting from removal of the waste rock dump. This could eventually allow for the elimination of the Carter Spur capture system once monitoring shows that runoff from the footprint would not have a detrimental impact to downstream water quality. Short-term impacts to surface water quality would be worse than existing conditions due to sedimentation and mobilization of acidity and metals associated with dump removal activities. Until the amount of contaminants decreases to within discharge standards, the water quality would be protected by routing the flow in this drainage to the water treatment plant. Contaminant load predictions for Carter Spur (Tables 4.3-2) show there would be similar loads under Alternatives Z1, Z4, Z5 and Z6. These predicted loads are much lower than existing conditions, and are lower than Alternatives Z2 and Z3 which leave the Alder Gulch waste rock dump in place.

The amount of water flowing from Carter Spur is currently very small. If the water quality of the reclaimed drainage meets water quality standards, the capture system would be removed. As a result, the volume of surface water in Carter Gulch would increase.

Groundwater: Downstream groundwater quality would improve over the long term with the removal of the Alder Gulch waste rock dump. There would be no changes in groundwater quantity.

Lodgepole Creek

Surface Water: Surface water runoff from the Zortman Mine to Lodgepole Creek is mostly from the occasional discharge of shallow groundwater to the headwaters in the drainage. There has been little mining impact to the quality of the Lodgepole Creek headwaters and this would decrease (see Groundwater below). Even though current discharges from the mine to Lodgepole Creek are very small, decreases in recharge to groundwater in the pit area would result from reclamation, decreasing the amount of groundwater flow to the headwaters of Lodgepole Creek. Since the flows are very low and the drainage basin is large, overall impacts to Lodgepole Creek flows would be negligible.

Surface runoff from the Ross pit would continue to be routed to the south, away from the Lodgepole Creek drainage. Consequently, in the short term no changes in direct surface water runoff would occur from reclamation. Once post-reclamation surface runoff quality is assured, minor regrading could be conducted to route the runoff toward the north, into the Lodgepole Creek drainage. This would be a minor positive impact to water quantity in the upper portions of Lodgepole Creek.

Groundwater: Existing impacts to water quality include minor amounts of nitrate and occasional metals in the headwater tributaries of Lodgepole Creek. Covering the sulfide pit highwalls and benches in the Ross pit would improve the quality of the infiltration water entering groundwater. A very small amount of shallow groundwater flows from the Ross pit to discharge to surface water in tributaries of Lodgepole Creek (0.2 to 3 gpm, see Chapter 3.3.4). By reducing the amount of water infiltrating through the Ross pit floor, spring and groundwater quality would improve in the headwaters of the Lodgepole Creek drainage. Alternatives Z1 and Z6 provide the lowest predicted sulfate and metals loads to the Lodgepole Creek drainage basin.

Alternative Z2

The impacts to water resources would be reduced by the placement of the reclamation covers over the pit areas and leach pads. The enhanced revegetation would also decrease infiltration. The reduction in infiltration over the mine area is estimated at 110 gpm, or 41% of the existing infiltration. This alternative is among the lowest, along with Alternatives Z3 and Z5, in terms of minimizing total volume of infiltration to groundwater from the pit area. This low relative rank is due to the lack of low-permeability synthetic liners and the relatively thin soil covers (mostly 24 inches of NAG and 12 inches of soil). While Alternative Z2 is among the least protective for water resources in Ruby Gulch and Carter Spur, it is ranked intermediate for load reductions in Lodgepole Creek (Table 4.3.2).

Water Quality and Quantity

Ruby Gulch

Surface Water: The impact to surface water quality in Ruby Gulch downstream of the capture system is determined by the risk of water bypassing the capture system. The reclamation covers would somewhat reduce infiltration. Moving the water treatment plant to Goslin Flats would eliminate a significant source of treated discharge water to Ruby Gulch. The discharge of treated water is currently periodic in response to accumulation in the Ruby Gulch capture pond. Any uncaptured groundwater discharging from the mine below the capture system would no longer be diluted by discharge from the treatment plant and would therefore be of poorer quality than under existing conditions. This would be a negative impact to surface water. The diversion ditches that route clean runon water around the mine facilities such as the pit area would reduce the amount of water entering the capture system. This runoff could also add significant flow to Ruby Gulch, but only as the result of storm events. While the clean runoff water from storm events would dilute any poor quality mine drainage, it probably would not significantly change overall water quality in the drainage.

Moving the Zortman Mine water treatment plant to Goslin Flats would reduce the amount of water in upper Ruby Gulch, and increase the amount of water in Goslin Gulch.

Groundwater: The Alternative Z2 reclamation covers for the pits do not include any low-permeability synthetic layers such as GCL or PVC/HDPE. This alternative is comparable to Alternatives Z3 and Z5 in that it would result in the highest infiltration rates for all pits (Table 4.3-1). Reductions in total sulfate and metals loads to groundwater in Ruby Gulch would be among the lowest of all alternatives (Table 4.3-2), similar to Alternative Z3 and existing conditions. Impacts from reclamation of the Ross pit would be similar to those described for Alternative Z1.

Moving the water treatment plant to Goslin Gulch and eliminating a significant source of clean surface water in Ruby Gulch would reduce the amount of downgradient groundwater.

Alder Spur

Surface Water: Impacts would be similar to those described for Alternative Z1.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: There would be no change to the existing water quality or quantity conditions since the Alder Gulch waste rock dump would not be removed or modified during reclamation. The quality of water entering the capture system represents relatively mature ARD. The sulfate and metals loads would remain similar to existing conditions (Table 4.3-2).

The quantity of water in Carter Gulch would continue to be reduced by operation of the pumpback system. This would not be a significant impact to water quantity as the volume recovered by the pumpback system is small compared to the runoff the drainage receives from adjacent undisturbed lands.

Groundwater: There would be no change to the existing groundwater quality or quantity. Although the sulfate and metals loads at the capture systems would be among the highest (i.e. poorest quality) of all alternatives, there is little uncaptured flow in this tributary that would impact groundwater.

Lodgepole Creek

Surface Water: Impacts to Lodgepole Creek would be similar to those described for Alternative Z1.

Groundwater: Impacts to Lodgepole Creek would be similar to those described for Alternative Z1. There would be no reductions in contaminant loads to Lodgepole Creek; therefore, water quality would be similar to existing conditions.

Alternative Z3

The impacts to water resources would be reduced by increasing the thickness of the reclamation covers over the pit areas and leach pads. The enhanced revegetation would also decrease infiltration. The reduction in infiltration over the mine area is estimated at 117 gpm, or 44% of the existing infiltration (Table 4.3-1).

Alternative Z3 is among the lowest, along with Alternatives Z2 and Z5, in terms of its ability to reduce the infiltration to groundwater in the pit area. Although the Alternative Z3 pit reclamation covers would be enhanced over Alternative Z2 pit reclamation covers by the addition of tailings, infiltration in the pit area would not be significantly different than Alternative Z2. The contaminant loads would also be similar to those predicted for Alternative Z2 (Table 4.3-2).

Water Quality and Quantity

Ruby Gulch

Surface Water: The impact to the surface water quality below the capture system would not change over existing conditions. While reclamation covers over the pits would reduce the infiltration by up to 50%, seepage through the pits would still be of poor quality.

The water treatment plant would continue to discharge clean water into upper Ruby Gulch, providing dilution of any uncaptured flows. The reclamation covers may reduce the quantity of treated water being discharged to Ruby Gulch, and the quantity of water bypassing the capture system, by decreasing the amount of infiltration. Therefore, the long-term total annual volume of treated water discharged to Ruby Gulch would decrease.

Groundwater: Groundwater quality would be improved by the reclamation covers placed over the backfill in the O.K./Ruby and Mint pits. This would reduce the amount of water infiltrating through the pit backfill and into acid generating sulfide minerals. The total sulfate and metals loads to groundwater would improve slightly over existing conditions (Table 4.3-2).

Alder Spur

Surface Water: Impacts to Alder Spur would be similar to those described for Alternative Z1.

Groundwater: Impacts to Alder Spur would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: Impacts to Carter Spur would be similar to those described for Alternative Z2.

Groundwater: Impacts to Carter Spur groundwater would be similar to those in Alternative Z2.

Lodgepole Creek

Surface Water: Impacts to Lodgepole Creek would be similar to those described for Alternative Z2.

Groundwater: Impacts to Lodgepole Creek would be similar to those described for Alternative Z1.

Alternative Z4

Alternative Z4 would reduce impacts to water resources by increasing the thickness of the reclamation covers over the pit areas and leach pads and, where slopes permit, using the water barrier covers to reduce infiltration. The reduction in infiltration over the mine area is estimated at 128 gpm or 48% of existing conditions. This alternative has the most area covered with HDPE/PVC liner of all the alternatives. The removal of the Alder Gulch waste rock dump would also decrease impacts to surface water and groundwater.

Relative to the other alternatives, Alternative Z4 ranks with Alternatives Z1 and Z6 in reducing infiltration in the pit areas (Table 4.3-1). However, backfill used in the Ross pit in Alternatives Z4 and Z5 would result in high chemical loads to Lodgepole Creek, making these alternatives the least protective of water quality in the northern drainages.

Water Quality and Quantity

Ruby Gulch

Surface Water: There would be a decrease in surface water quality from the use of the Alder Gulch waste rock dump as backfill in the North and South Alabama pits. However, contaminant loads would be intermediate as under the other alternatives, and similar to those that would occur under Alternatives Z5 and Z6. The use of synthetic liners in the reclamation covers would reduce the infiltration over the pit area to amounts similar to those that would occur under Alternatives Z1 and Z6. The reclamation covers would still not significantly reduce the risk of adverse impacts to water quality, although the covers are more long-lasting than those used in Alternative Z1. The overall impact to water quality in Ruby Gulch would be intermediate. Removal of the tailings in Ruby Gulch would have impacts similar to those described for Alternative Z1.

Moving the Zortman Mine water treatment plant to Goslin Flats would reduce the amount of water in upper Ruby Gulch and increase the amount of water in Goslin Gulch.

Groundwater: The amount of backfill and regrading associated with reclamation of the O.K./Ruby and Mint pits would provide a large, flat area on which a water barrier reclamation cover would be placed. This water barrier cover would reduce the amount of water infiltrating through the pit backfill and into the underground workings below the pits. Alternative Z4 is one of the highest performing alternatives in reducing infiltration over the pit area. The synthetic liner used in the reclamation cover would be more durable than the GCL liner that would be used in Alternative Z1, but would still have a limited life (possibly 100 years). Over the long term, the water barrier covers would become more permeable and function more like the water balance covers.

Alder Spur

Surface Water: Impacts to Alder Spur drainage would be similar to those described for Alternative Z1.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: The removal of the Alder Gulch waste rock dump (as in Alternatives Z1 and Z5) would result in a significant long-term improvement to the surface water and groundwater quality in the Carter Spur drainage. In the short term, there would be increased sediment loads and other contaminants in runoff from the footprint area. During this period water quality would be protected by routing the runoff that did not meet water quality standards to the water treatment plant at Goslin Flats.

The quantity of water flow in Carter Spur is currently very small. The removal of the Alder Gulch waste rock dump and capture system would slightly increase the amount of water in Carter Gulch.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

Lodgepole Creek

Surface Water: The reclamation covers would decrease the amount of discharge to Lodgepole Creek. The surface grading would slightly increase the amount of drainage north toward Lodgepole Creek, which would be a minor increase in water quantity. The surface runoff water would be clean and would not negatively impact water quality. However, the groundwater discharge to surface water in Lodgepole Creek could be of poor quality in the upper tributaries of the drainage. Alternative Z4 ranks low with respect to total contaminant load reductions to Lodgepole Creek (Table 4.3-2).

Groundwater: The placement of the Alder Gulch waste rock dump material in the Ross pit would significantly increase the amount of acid generating material and stored oxidation products in the Lodgepole Creek watershed. This would create short term and, possibly, long-term negative impacts on surface and groundwater quality in Lodgepole Creek. Due to the relatively steep topography, only about 25% of the backfilled area would be covered with a water barrier cover, and approximately 75% would be covered with a water balance cover. Despite the water barrier cover, the backfill used in the Ross pit would increase the amount of contaminant loads entering Lodgepole Creek. While the lined portion of the pit would direct water south toward the Ruby Gulch capture system, poor quality infiltration would likely enter groundwater through the unlined portion of the pit. Since the groundwater divide zone extends through the Ross pit area, during at least a portion of the year poor quality groundwater would flow toward Lodgepole Creek. While a seepage capture system would be constructed to intercept any poor quality water, some seepage would invariably bypass the capture system and enter the drainage, as is the case at other capture system locations.

Alternative Z5

Alternative Z5 would reduce impacts to water resources by backfilling the pits to restore the approximate original topography, lining the floor of the Ross pit with a synthetic liner, placing reclamation covers over the mine facilities in order to reduce infiltration, and removing the Alder Gulch waste rock dump and the Z85/86 leach pad and dike from drainage bottoms. The reduction in total infiltration over the mine area is estimated at 123 gpm, or 46% from existing conditions.

This alternative is among the lowest performing (along with Alternatives Z3 and Z5) in terms of reducing the volume of infiltration to groundwater in the pit area. This is primarily due to the large area of "thinner" reclamation covers and steeper slopes associated with original topography reconstruction. The backfill used in the Ross pit in Alternatives Z4 and Z5 would result in high chemical loads to Lodgepole Creek, making these alternatives the least protective of the northern drainages (Table 4.3-2).

Water Quality and Quantity

Ruby Gulch

Surface Water: Alternative Z5 would achieve a reduction in total sulfate and metals loads to Ruby Gulch similar to Alternatives Z4 and Z6 (Table 4.3-2). The reclamation covers would be of relatively high quality and would decrease the total volume of infiltration, thus decreasing the quantity of contaminated water entering the capture system. Removal of the Z85/86 leach pad and dike from the drainage channel would eliminate a significant source of poor quality water. These actions would improve the surface water quality in Ruby Gulch. However, compared to Alternative Z4, there is less 'flat' area in this alternative that can be covered with the water barrier reclamation covers. As a result there is more infiltration through the mine waste rock that may degrade water quality.

Moving the Zortman Mine water treatment plant to Goslin Flats would reduce the amount of water in upper Ruby Gulch and increase the amount of water in Goslin Gulch. This impact could be offset by other measures that enhance surface water runoff above the capture system and by the removal of tailings in the drainage. Overall, the amount of flow would be somewhat greater than in Alternatives Z2 and Z4, but the net impact would still be a reduction in water quantity.

Groundwater: The greatest potential impact to groundwater quality in Ruby Gulch would be from the acid generating nature of the backfill materials. In order to achieve pre-mining topography, the Alder Gulch waste rock dump and the Z85/86 leach pad and dike, both composed of acid generating rock, would be used to backfill the pits, adding a contaminant source to the Ruby Gulch drainage. Because the water quality from the O.K./Ruby pit and the connected underground workings is already reflective of "mature" ARD, the added acidic material would not likely increase the contaminant concentrations by a great amount. However, this may extend the time period until such soluble oxidation products are flushed out. Overall, total sulfate and metals loads would be similar to those predicted for Alternatives Z4 and Z6.

Alder Spur

Surface Water: Impacts would be similar to those described for Alternative Z1.

Groundwater: Impacts would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: Impacts would be similar to those described for Alternative Z1.

Groundwater: Impacts would be similar to those described for Alternative Z1.

Lodgepole Creek

Surface Water: Direct runoff from the reclaimed topography would be clean and would not impact surface water quality in Lodgepole Creek. However, a component of surface flow in the tributaries of upper Lodgepole Creek is discharge from shallow groundwater via springs. Since the groundwater quality would be impacted by the backfill, there would be a decrease in surface water quality in these tributaries (see "*Groundwater*" discussion below).

Backfilling and contouring of the Ross pit would re-establish the pre-mining divide between Lodgepole Creek and Ruby Gulch. This would increase the amount of surface water in the upper reaches of Lodgepole Creek. However, due to the size of the Lodgepole drainage basin, this would be only a minor increase in flow that would not noticeably change downstream flows.

Groundwater: This alternative provides significantly more backfilling in the Ross pit than any of the other alternatives. The placement of the Alder Gulch waste rock dump material in the Ross pit would significantly increase the amount of acid generating material and stored oxidation products in the Lodgepole Creek watershed. The construction of the Ross pit backfill would include placement of a synthetic liner in the northern portion of the pit prior to backfilling. The backfill would extend to the top of the highwall at a 3H:1V slope, which is too steep for a water barrier cover. The liner would slope toward the south, thereby directing water that infiltrates through the backfill toward the Ruby Gulch capture system. Alternative Z5 would have the highest quantity of infiltration into the backfill of all the alternatives. While the lined portion of the pit would direct water south toward Ruby Gulch, poor quality infiltration water would enter groundwater through the unlined portion of the pit. Since the groundwater divide zone extends through the Ross pit area, during at least a portion of the year poor quality groundwater would flow toward Lodgepole Creek. Although a seepage capture system would be constructed to intercept any poor quality water, some seepage would invariably bypass the capture system and enter the drainage, as is the case at other capture system locations. Overall, Alternative Z5 has the greatest potential to degrade the shallow groundwater at the headwaters of Lodgepole Creek.

Alternative Z6 (Preferred Alternative)

Alternative Z6 would reduce impacts to water resources by increasing the thickness of the reclamation covers over the pit areas and leach pads relative to Alternatives Z2, Z3 and Z5, and, where slopes allow, using water barrier covers. The reduction in total infiltration over the mine area is estimated at 139 gpm, or 53% from existing conditions. Removal of the top portion of the Alder Gulch waste rock dump and capping of that area would also decrease impacts to surface and ground water. Removal of a significant amount of tailings from the Ruby Gulch drainage would improve water quality. Alternative Z6 would perform among the best of the alternatives in total contaminant load reduction to Carter Spur and Lodgepole Creek, and would perform intermediate in contaminant load reduction to Ruby Gulch.

Water Quality and Quantity

Ruby Gulch

Surface Water: Water bypassing the capture system in Ruby Gulch would contain contaminant loads similar to that in Alternatives Z4 and Z5. Since the water treatment plant would remain at its current location, and the amount of water bypassing the capture system is small compared to the water treatment plant discharge to Ruby Gulch, the water quality would not be significantly different than existing conditions. Tailings removal would have similar impacts as those described for Alternative Z1. Impacts to water quantity would be similar to those described for Alternative Z1.

Groundwater: The sulfide highwalls of the O.K./Ruby pit would be covered during reclamation, which would decrease the contaminant load entering Ruby Gulch groundwater. The loads would be similar to those described under Alternatives Z4 and Z5.

Alder Spur

Surface Water: The impacts to Alder Spur would not be substantially different than those described for Alternative Z1. The enhancement of revegetation on the Z83 and Z84 leach pad dikes would have a slight positive impact on the surface water quality.

Groundwater: Impacts to groundwater would be similar to those described for Alternative Z1.

Carter Spur

Surface Water: Total sulfate and metals loads in Carter Spur would be significantly better than existing conditions, similar to other alternatives that include removal of the Alder Gulch waste rock dump. Since only the top portion of the dump would be removed, seepage from the dump would continue to be degraded and require capture. Water quantity in Carter Spur would be similar to existing conditions.

Groundwater: The removal of a significant volume of acid generating waste rock from the Alder Gulch waste rock dump located in the headwaters of Carter Spur would significantly reduce the existing contaminant loads. The reductions in contaminant loads would be similar to those predicted for Alternatives Z1, Z4, and Z5.

Lodgepole Creek

Surface Water: Impacts to surface water quality and quantity would be similar to those described for Alternative Z1.

Groundwater: Alternative Z6 would reduce the sulfate and metals loads entering Lodgepole Creek and would improve groundwater quality similar to under Alternative Z1. The use of reclamation covers thicker than those in Alternative Z1 would reduce the total sulfate and metals loads entering Lodgepole Creek more than under any other alternative, and by one-half when compared to existing conditions (Table 4.3-2).

4.3.4 Landusky Mine

Impacts Common to All Landusky Mine Alternatives

All alternatives would improve the overall water quality conditions in the Landusky Mine area. There are essentially two "primary" types of reclamation actions that would reduce the impacts to water quality:

- The amount of backfill placed in the pits and its geochemistry; and
- The type of reclamation cover applied over the regraded mine waste.

At the Zortman Mine, the location of the water treatment plant and its collection systems plays a role in the potential impact to water resources. However, at the Landusky Mine, relocation of the water treatment plant would not offer any significant environmental or cost benefit because most of the water already flows to the treatment plant by gravity.

Geochemistry of Backfill

The geochemistry of the rock used for pit backfill at the Landusky Mine is an even larger factor in determining the impacts to surface water and groundwater than at the Zortman Mine. The expected increased loads due to the disturbance of acid generating material, the re-establishment of flowpaths and the mobilization of 'soluble oxidation products' would create short-term increases in water quality impacts at the Landusky Mine. In the long-term, the water quality impacts at the Landusky Mine are still developing. Some of the alternatives would use the spent ore from the L87/91 leach pad as a primary source of backfill. Although the water currently collected from the bottom of the leach pad is not acidic, it is predicted that over time, the spent ore on this leach pad would be a significant source of acid generation. Taking the material off the leach pad liner where leachate collection has been relatively easy, and placing it into the mine pits where water collection would be more difficult, increases the risk of long-term impacts to water quality beneath and downgradient of those backfilled pit areas.

Reclamation Covers

Due to slope stability concerns, the low-permeability water barrier reclamation covers can only be placed on areas of moderate slope (less than 25% grade). Because of the generally steep topography in the area, it is not possible to cover much of the mined material with these water barrier type covers. Therefore, the ability to decrease overall infiltration rates is limited. Still, the reclamation covers used in the alternatives would decrease infiltration of precipitation into the mine waste and would decrease the loads reporting to the capture system. However, none of the alternatives would decrease loads to the point that the water capture and treatment systems could be eliminated.

Water Quantity and Quality Impacts

The impacts of each alternative are based largely on the primary reclamation actions described above and on the resulting surface water quality and quantity, and groundwater quality. In addition, surface water and groundwater runoff, and groundwater flow patterns, may be impacted by:

- The sizes and patterns of the reclaimed surface drainage basins;
- Use of water storage and diversion structures;
- Burial of springs, or creation of new springs and seeps;
- Changes in patterns of groundwater recharge near sensitive areas such as shear zones, basin divides, and northern drainages;
- Long-term changes in groundwater levels due to reclamation;

- Changes in the locations of groundwater divides and divide zones; and
- Hydraulic controls such as artesian well WS-3 and directional boreholes.

The general effect of all reclamation alternatives at the Landusky Mine would be to increase stormwater runoff and reduce infiltration within the mine-affected drainages. Montana Gulch, Mill Gulch, and Sullivan Gulch surface runoff would continue to be routed around the capture systems. Minor drainage changes would be made within the Swift Gulch and King Creek drainages. Reclamation would restore larger continuous drainage basins over the top of the previous mine facilities.

No perennial springs would be buried during reclamation, and no new springs are anticipated to result from any of the alternatives. However, Alternatives L5 and L6, which backfill the pits at steeper slopes, may result in shallow intermittent seeps that probably would be of poor quality due to the nature of the backfill material. Reclamation cover modeling indicates that surface seepage from the reclamation cover could occur where 3H:1V slope lengths approach or exceed 200 feet. Although there are many areas where reclamation slopes would be longer than this, all reclamation alternatives would use a regular pattern of surface interception ditches to catch seepage from the water storage and drainage layer before it discharges at the surface.

The current rate of recharge to groundwater would be reduced under all of the alternatives due to the large increase in evapotranspiration from the vegetated cover soils. Currently, recharge to the syenite aquifer is focused within the pits. The amount of backfill placed in the pits varies with the alternatives, with some (Alternatives L1, L5 and L6) creating positive drainage from the former pits, and others only partially backfilling the pits. However, the pit and shear zone areas would continue to be conduits for groundwater recharge. Consequently, the groundwater recharge pattern would generally be the same for all alternatives. There would be no significant changes from the current conditions, or significant differences among the alternatives, in the directions of groundwater flow or in the location of groundwater divide zones.

There are significant differences in the reclamation covers and backfilled slope grades over the Landusky Mine pits and other facilities under the alternatives. Total mine site estimated infiltration rates are more pronounced than at the Zortman Mine, differing by about 113 gpm, or 40%, between alternatives. In general, the alternatives with thicker reclamation covers, and those that use synthetic liners, have lower infiltration rates. For the Landusky Mine pits, the average infiltration volumes from modeling vary by about 66% between the alternatives, corresponding to an average difference of 66 gpm between the low and high infiltration rates. The present average rate of infiltration over the Landusky Mine area, exclusive of leach pads, is 524 gpm. Including leach pads, infiltration occurs at 747 gpm (Table 4.3-1). Water levels beneath the pits at the Landusky Mine are controlled by flow from well WS-3. Reclamation covers used on the pit floors to lower infiltration rates (Alternatives L1, L5 and L6) could also result in slightly decreasing water levels beneath the pit.

As discussed in Section 3.3.3, the majority of surface water and groundwater within the drainages are collected at the capture systems. Minor amounts of groundwater bypass the capture systems, as shown

in Table 4.3-4. Uncaptured flows are relatively small and for purposes of impact analysis are assumed to remain the same in each drainage regardless of the reclamation alternative. This is a conservative approach, since decreases in infiltration would likely result in decreases to the amount of water both entering and bypassing the capture systems.

The opening of well WS-3 shifts the Landusky Mine groundwater divide zone north to the Swift Gulch drainage basin. All reclamation alternatives include covering the Suprise pit floor with a HDPE liner to reduce the impacts of seepage through the pit floor into the shear zone aquifer and subsequent discharge to the north. This reclamation measure would continue functioning for the life of the synthetic liner (approximately 100 years). Discharge from well WS-3 influences the shear zone flow, but has little or no impact on the shallow perched groundwater flowpaths in King Creek and Swift Gulch. Discharge to this shallow system is more influenced by surface topography and mine surfaces conducive to infiltration. Evaluations of groundwater flowpaths (Spectrum 2001b) show that 40 to 60% of the predicted infiltration reaches the northern drainages via shallow perched groundwater discharge, and the rest via shear zone discharge from the regional water table.

Despite the differences in total sulfate and metals loads, downgradient water quality predictions showed a wide range of possible concentrations that vary little between alternatives. Since modeling cannot accurately predict if the water quality standards would be exceeded, continued monitoring and provisions for supplemental capture and treatment would be used to prevent significant impacts to water quality.

The following sections describe the water resource impacts of each reclamation alternative. These sections describe the relative ranks of the alternatives with respect to reductions in infiltration, and total sulfate and metals loads. Surface water and groundwater discussions are separate, but it is important to note that surface and groundwater conditions and impacts are closely related.

Alternative L1

Alternative L1 would reduce impacts to water resources by the placement of water barrier and water balance reclamation covers over the backfilled or regraded pits and leach pads, and by creating a free-draining surface to route runoff out of the mine pits. The reduction in infiltration over the mine area is estimated at 514 gpm, or 69% from the existing conditions.

Infiltration under Alternative L1 would be among the lowest of all alternatives and similar to under Alternative L6. Infiltration to the pit areas ranks intermediate among the alternatives, similar to Alternative L5. This decrease in infiltration is due to the use of GCL in the reclamation covers and over the pit floor for the Queen Rose and Gold Bug pits, in addition to the synthetic liner placed in the Suprise pit during interim reclamation. As noted for Alternative Z1, GCL is not as long-lasting as HDPE or PVC. Therefore, the positive effects of the reclamation covers would be short-lived (30 years vs. 100 years for HDPE), after which the covers would function more like water balance covers. The total sulfate and metals loads predicted to be released to all drainages would be the lowest under Alternative L1.

Water Quality and Quantity

Swift Gulch

Surface Water: Surface water in Swift Gulch represents groundwater discharge from the shallow groundwater and the shear zone. The mine facilities that potentially impact Swift Gulch include portions of the Queen Rose and Suprise pits and the reclaimed Big Horn ramp. The pits have been partially backfilled and the material in them is a highly acid generating source of contaminants. Rainwater that falls on these pits infiltrates through the pit floor impacting the shear zone groundwater quality, or flows to the south as surface runoff. A small amount of water also discharges to Swift Gulch along a shallow groundwater flowpath, separate from the shear zone system. The impact to surface water quality in Swift Gulch is relatively small, but would increase as pit backfill progresses toward geochemical maturity. The reclamation measures in Alternative L1 would slightly improve current water quality conditions.

Predictions of groundwater discharge from the disturbed area to Swift Gulch surface water are 5 to 13 gpm (Table 4.3-4). This discharge would decrease with placement of the synthetic liner over the pit floor under interim reclamation, and would be further reduced by water barrier reclamation covers that would be placed over most of the Suprise and Queen Rose pit backfill and benches. All surface runoff would continue to be routed to the south, so there would be no change in water quantity.

Groundwater: Infiltration of precipitation through the pit floor and backfill presently results in poor water quality. Pit floor liners and water barrier covers would reduce this infiltration through the pit floor, which would reduce impacts to water quality in Swift Gulch. The liners and barriers would also decrease the amount of groundwater entering Swift Gulch. In the short term, the total sulfate and metals loads would be slightly reduced. However, as noted previously, the quality of infiltration water would also decrease as the pit backfill reaches geochemical maturity.

King Creek

Surface Water: Removal of the east lobe of the August #2 waste rock dump would eliminates a significant portion of the contaminant source in King Creek and would reduce the total sulfate and metals loads, improving the surface water quality. There would be no change in the quantity of water flowing into King Creek. All runoff from precipitation that falls in the King Creek basin would continue to flow to the north. Removal of the east lobe of the August #2 waste rock dump would not change water quantity.

Groundwater: The groundwater divide between King Creek and the August pit acts as a barrier to groundwater flow toward the north. An estimated 5 to 15 gpm of mine-impacted water derived from the August #2 waste rock dump discharges to surface water in the King Creek basin. Removing the east lobe of this waste dump would have a positive impact on groundwater quality and would not change the groundwater quantity.

Sullivan Gulch

Surface Water and Groundwater: The Sullivan Gulch drainage system is somewhat analogous to the Alder Spur drainage at the Zortman Mine in that as long as the liner remains intact, the leach pad at the headwaters acts like an umbrella over the drainage. The only potential source of contaminants is the L91 leach pad dike. In Sullivan Gulch, this dike, the leach pad foundation, and underdrain were constructed of rock that is acid generating. The dike surface has been covered with soil and revegetated; however, poor quality water is seeping from the toe and collecting in the capture system. Although it is estimated that only a small amount of water is potentially bypassing this capture system (0.15 to 0.55 gpm), this water would contain elevated concentrations of contaminants. Alternative LI is the only alternative which includes building a buttress onto the dike face, allowing the surface to be covered with an improved reclamation cover in order to reduce infiltration through the acid generating dike material. This would result in a slight improvement to surface water and groundwater quality by reducing total sulfate and metals loads (Table 3.3-3). The buttress would need to be constructed with non-acid generating materials in order to achieve this reduction in the existing impacts.

The impact to water quantity in this drainage is currently significant due to the fact that a great deal of precipitation that falls on the headwaters ends up collecting in the leach pad and being routed to the LAD at Goslin Flats. None of the alternatives would change the amount of water entering this drainage in the near term. Although unlikely, at some point in the future, should the precipitation entering the leach pad water not require treatment it would be discharged into Sullivan Gulch downstream of the leach pad, increasing the water quantity in this drainage.

Groundwater: Groundwater is included in the surface water discussion.

Mill Gulch

Surface Water: The L87 leach pad and dike, and the Mill Gulch waste rock dump, are located at the head of Mill Gulch. The leach pad would not impact the water quality or quantity in the drainage because the water that falls on the leach pad is routed to the LAD area at Goslin Flats and does not enter the Mill Gulch drainage or capture system. The Mill Gulch capture system is collecting ARD impacted water at the toe of the waste rock dump. An estimated 6 to 18 gpm may be bypassing this capture system (Table 4.3-4). The Mill Gulch waste rock dump was reclaimed with relatively high quality reclamation covers. Stormwater runoff from the reclaimed dump slope is routed around the capture system. No changes in the impacts to surface water quality in this drainage would occur from reclamation.

The impact to surface water quantity is similar to that described for Sullivan Gulch, with the leach pad at the head of the drainage. No reclamation measures would be conducted that would change the quantity of water in Mill Gulch.

Groundwater: Downstream of the Mill Gulch capture system the monitoring data indicates that ARD has has been neutralized and the metals attenuated along the flowpath. This is due to the availability of limestone or other similar rock types in the drainage. The impact to groundwater quality in this drainage would not change, and no changes in groundwater quantity would occur from the reclamation.

Montana Gulch

Surface Water: Of the several capture systems in the Montana Gulch drainage, including an upper capture system at the toe of the Montana Gulch waste rock dump and a lower capture system below the L85/86 leach pad, an estimated total of 22.5 to 52.5 gpm of water may be bypassing the current capture systems and entering the Montana Gulch drainage (Table 4.3-4). The Gold Bug adit, the frog pond, and artesian well WS-3 also serve as groundwater capture systems.

Excavating a drainage channel along the western edge of the L85/86 leach pad would allow that tributary to be free draining, rather than draining through the French drain underneath the leach pad. This would improve the surface water quality within the drainage by adding clean water which would dilute any contaminants. In the case of the pit area, excavation of a drainage notch through the south end of the August/Little Ben pit would expose more sulfide bearing rock and possibly expose underground workings, which would create negative impacts to water quality. Overall, the existing total sulfate and metals loads would be reduced by approximately 50%. The load reduction would be significantly better than other alternatives (Table 4.3-3).

The treated water from the Landusky Mine water treatment plant is currently discharged into Montana Gulch. This includes water originating in Montana Gulch, as well as water collected in the Mill Gulch and Sullivan Gulch capture systems. The discharge from the water treatment plant would continue to raise the amount of surface water in Montana Gulch. However, since the reclamation would decrease by two-thirds the water reporting to the treatment plant, the discharge to Montana Gulch would also decrease.

Groundwater: There would be no overall change in groundwater quality. The positive impacts to groundwater quality from the reclamation covers would be offset by the negative impacts of excavating the drainage notch through the pit wall and exposing the sulfide material.

Alternative L2

The impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads. The reduction in infiltration over the mine area is estimated at 448 gpm, or 60% of the existing conditions. Alternative L2 ranks among the poorest with respect to reducing total mine site and pit area infiltration (Table 4.3-1).

Water Quality and Quantity

Swift Gulch

Surface Water: There would be a slight improvement in surface water quality and quantity, similar to those described for Alternative L1. While the pit floor reclamation covers used in Alternative L2 would not be quite as protective as those in Alternative L1, estimates of the total sulfate and metals loads do not show an appreciable difference in the contaminant loads to Swift Gulch between Alternatives L1, L2, or L3. Improvements in pit reclamation and revegetation of the Big Horn ramp and pit rim would continue to improve the quality of the shallow groundwater discharge to surface water in upper Swift Gulch.

Groundwater: The impact to groundwater quality would be slightly reduced relative to the existing conditions as a result of placing the water balance covers over the Queen Rose pit floors and benches, and the synthetic liner on the Suprise pit floor. Although the improvement in water quality would not be as great as in Alternative L1, there would be a positive impact relative to existing conditions. As noted for surface water, the predicted sulfate and metals loads would be slightly better than existing conditions and similar to those that would occur under Alternatives L1 and L3. The amount of groundwater discharge in Swift Gulch would decrease under this alternative due to the reclamation covers on most of the pit backfill and pit benches. The decline in seepage entering Swift Gulch would not be as great as that achieved under Alternative L1, which uses the water barrier covers.

King Creek

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

Sullivan Gulch

Surface Water: There would be no change in the surface water quality or quantity in Sullivan Gulch. This is because the existing reclamation on the L91 dike would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Groundwater: There would be no change in the groundwater quality or quantity in Sullivan Gulch. This is because the existing reclamation on the L91 dike would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Mill Gulch

Surface Water: There would be no change in surface water quality or quantity of water in Mill Gulch. This is because existing reclamation on the Mill Gulch waste rock dump would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Groundwater: There would be no change in groundwater quality or quantity of water in Mill Gulch. This is because existing reclamation on the Mill Gulch waste rock dump would not be modified, and the water infiltrating through the leach pad would be captured in the process circuit and routed to the LAD area at Goslin Flats.

Montana Gulch

Surface Water: Alternative L2 would result in the least amount of improvement from the existing conditions. Regrading of the L85/86 leach pad and placement of reclamation covers would not change the amount or quality of surface water entering the capture system in Montana Gulch. The estimated sulfate and metals loads would decrease slightly due to overall reclamation, but not significantly from existing conditions. The amount of water in Montana Gulch downstream of the mine would continue to be elevated due to the discharge from the water treatment plant.

Groundwater: Alternative L2 would result in the least amount of improvement from existing groundwater conditions. Since the capture systems are already functioning, the impacts to groundwater quality in the Montana Gulch drainage would not improve significantly. The estimated sulfate and metals loads would decrease slightly due to reclamation (Table 4.3-3).

Alternative L3

The impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads. The reduction in infiltration over the mine area is estimated at 446 gpm, or 60% of the existing conditions. Alternative L3 ranks among the poorest with respect to reducing total mine site and pit area infiltration (Table 4.3-1). The directional borehole would provide backup pit drainage if well WS-3 were to fail. This would increase protection of water resources by preventing the accumulation of water in acid forming areas of the pits.

Water Quality and Quantity

Swift Gulch

Surface Water: Impacts to surface water quality and quantity in Swift Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Swift Gulch would be similar to those described for Alternative L2.

King Creek

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

Sullivan Gulch

Surface Water: Impacts to surface water quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Mill Gulch

Surface Water: Impacts to surface water quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Montana Gulch

Surface Water: Impacts to surface water quality and quantity in Montana Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Montana Gulch would be similar to those described for Alternative L2.

Alternative L4 (Preferred)

Impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads, and by the removal of the L85/86 leach pad from Montana Gulch. The reduction in infiltration over the mine area is estimated at 453 gpm, or 61% of the existing conditions. Blasting and filling on the pit highwalls would cover over 80% of the sulfidic highwall, reducing the potential for effects to

water quality. Pit floor cover would be improved over Alternatives L2 and L3 by increasing the thickness of NAG and soil used in reclamation. The directional borehole would provide backup pit drainage if well WS-3 were to fail. This would increase protection of water resources by preventing the accumulation of water in acid forming areas of the pits.

Alternative L4 is among the lowest of the alternatives in reducing total infiltration and infiltration in the pit area, similar to Alternatives L2 and L3 (Table 4.3-1). The total sulfate and metals loads are estimated to be similar or slightly less than the existing conditions (Table 4.3-3).

Water Quality and Quantity

Swift Gulch

Surface Water: The surface runoff pattern would not change. Runoff from the pit area would still be routed to the south with no change in surface drainage to Swift Gulch. Groundwater discharge to surface water in Swift Gulch would be similar to that described in Alternative L2. Therefore, surface water quality and quantity would not change significantly from the existing conditions.

Groundwater: Groundwater quality and quantity would be similar to that described under Alternative L2.

King Creek

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

Sullivan Gulch

Surface Water: Impacts to surface water quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Mill Gulch

Surface Water: Impacts to surface water quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Montana Gulch

Surface Water: The removal of the L85/86 leach pad and dike from the drainage channel and restoration of drainage patterns would have a positive impact on the surface water. Although testing shows that the L85/86 leach pad and dike are not acid generating, their removal would restore the drainage pattern and remove a potential source of dissolved solids and sediment from the drainage. No change in surface water quality would occur. The amount of water entering the Montana Gulch drainage would continue to be high due to the discharge from the water treatment plant.

Groundwater: Since the L85/86 leach pad and dike are not degrading groundwater quality, no improvement in groundwater quality would occur with their removal. However, removing a lined facility would increase infiltration over the footprint area, increasing groundwater amounts. The additional backfill and coverage of pit highwalls under Alternative L4 would slightly reduce the impacts to water quality from acid drainage. The total sulfate and metals loads are estimated to slightly improve over existing conditions, and would be similar to Alternatives L2, L3, L5, and L6 (Table 4.3-3).

Alternative L5

Impacts to water resources would be reduced by the placement of reclamation covers over the mine pits and leach pads, by the removal of the L85/86 leach pad from Montana Gulch, and by covering the pit highwalls with waste rock. The backfilled pit floor would be shaped to create a trough from the end of the southwest corner of the August/Little Ben pit to the northeast corner of the Suprise pit. This configuration would route runoff away from the pit highwalls and to the south in order to reduce the impacts to water quality, particularly in the northern drainages. The reduction in total infiltration over the mine area is estimated at 460 gpm, or 62% of the existing conditions (Table 4.3-1).

Despite the use of pit floor liners and groundwater recovery wells constructed in the backfill between the pits and the northern drainages, seepage through the backfill would increase the potential for impacts to the Swift Gulch and King Creek drainages. This is due to the poor quality of the backfill material and the difficulty in capturing all the infiltration that may pass through the backfill and enter northern-flowing drainages.

Water Quality and Quantity

Swift Gulch

Surface Water: As with the previous alternatives, surface runoff would continue to be routed to the south. The backfill used to create free-draining surfaces in the Suprise and Queen Rose pits would be of poor

quality. Therefore, any infiltration through the pit reclamation covers to groundwater that discharges to surface water in Swift Gulch would have a negative impact to surface water quality in Swift Gulch. The amount of water in Swift Gulch would not significantly change as a result of surface reclamation.

Groundwater: The only ready source of backfill material available to achieve the pit backfill configuration for this alternative is material from the L87 leach pad. This material is acid generating and contains a significant amount of stored oxidation products. The backfill would be a significant source of contaminants that would negatively impact the surface water and groundwater quality in Swift Gulch. A series of recovery wells and the HDPE liner on the pit floors would be used to direct and capture undesirable leachate from the backfill. However, even with these measures, there would probably be an overall negative impact to water resources in Swift Gulch. The quantity of groundwater would be reduced due to the use of pit floor barrier covers and collection wells which would route groundwater to the Landusky Mine water treatment plant.

King Creek

Surface Water: Impacts to surface water quality and quantity in King Creek would be similar to those described for Alternative L1.

Groundwater: Impacts to groundwater quality and quantity in King Creek would be similar to those described for Alternative L1.

Sullivan Gulch

Surface Water: Impacts to surface water quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Mill Gulch

Surface Water: Impacts to surface water quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Mill Gulch would be similar to those described for Alternative L2.

Montana Gulch

Surface Water: Removal of the L85/86 leach pad and dike would have impacts similar to those described for Alternative L4. In order to protect water quality, the surface runoff from the pit area would be captured in the existing ponds and routed to the water treatment plant, if treatment was needed, or discharged directly to the drainage. The amount of surface water in Montana Gulch would increase with surface runoff from the entire Landusky Mine pit area discharging as surface water to this drainage.

Groundwater: Impacts to groundwater from the removal of the L85/86 leach pad and dike would be similar to those described for Alternative L4. The placement of potentially acid generating backfill into the pit complex at the headwaters of Montana Gulch would have a negative impact to groundwater quality. Overall, the total sulfate and metals loads entering Montana Gulch groundwater are predicted to remain similar to existing conditions, and to be relatively constant across all the alternatives (Table 4.3-3).

Alternative L6

Alternative L6 would restore the drainage pattern in the pit areas to approximate the pre-mining topography. The impacts to water quality in the southern drainages would be reduced by placement of the reclamation covers over the pits and leach pads. The reduction in total infiltration over the mine area is estimated at 559 gpm, or 75% of the existing conditions. Water quality impacts in the northern drainages would increase due to the acid generating nature of the material placed as pit backfill in the headwaters of these drainages.

Estimated infiltration rates for Alternative L6 are the lowest of all alternatives for the total mine area and the pit area. This is due to the more expansive backfill that provides for covering the highwalls, the steeper slopes which promote runoff, the use of water barrier covers, and the thicker water balance covers.

Water Quality and Quantity

Swift Gulch

Surface Water: The significant amount of backfilling needed to restore the pre-mining topography would include the use of large amounts of acid generating material from the L87 leach pad. While the surface water runoff would generally be of good quality the steeper backfill slopes would be subject to erosion. Where erosion cuts through the reclamation cover, the acidic backfill would be exposed. Runoff from this exposed material could then impact surface water quality and revegetation. In the Swift Gulch drainage the shallow and deeper groundwater discharges to surface water would also be of poor quality, similar to that described under Alternative L5.

Because the surface grading and backfill placement would restore the original topography, including the surface drainage divide, runoff toward northern drainages would increase. This would increase the amount of surface water in Swift Gulch.

Groundwater: The reclamation covers that would be placed over the backfill material and the liners on the pit floor would significantly decrease the potential for infiltration. However, water infiltrating through the backfilled material would still be of poor quality. Some seepage would bypass the liner and recovery wells, degrading the groundwater quality in Swift Gulch. The estimates of total sulfate and metals loads show that the groundwater quality in Swift Gulch would be significantly worse than existing conditions, similar to Alternative L5 (Table 4.3-3).

King Creek

Surface Water: Surface water quality would improve with the removal of both the east and west lobes of the August #2 waste rock dump. However, backfilling the entire mine pit complex to the pre-mining topography with the large amounts acid generating material from the L87/91 leach pad, would place a significant contaminant source in the upper reaches of the King Creek drainage. The overall impact to surface water quality would be negative. Restoring the topography in the headwaters of King Creek would increase the amount of surface water in the drainage.

Groundwater: Removing the east and west lobe of the August #2 waste rock dump would also positively impact groundwater quality. The backfill material used to restore surface topography would also have a negative impact to the groundwater quality in this drainage. Although there is not a large amount of groundwater flow to King Creek from the restored pit area, the total sulfate and metals loads are estimated to increase. This would cause a decline in water quality similar to Alternative L5 and significantly worse than the existing conditions.

Sullivan Gulch

Surface Water: While a large portion of the L91 leach pad material would be removed for use as pit backfill, the dike would be left in its current configuration and the leach pad area would continue to collect precipitation. Therefore, impacts to surface water quality and quantity in Sullivan Gulch would remain similar to those described for Alternative L2.

Groundwater: Impacts to groundwater quality and quantity in Sullivan Gulch would be similar to those described for Alternative L2.

Mill Gulch

Surface Water: Construction of water balance and water barrier covers on the Mill Gulch soil stockpile and the L87 leach pad, and additional vegetation on the waste rock dump, would have positive impacts

on the downstream surface water quality. The amount of surface water entering Mill Gulch would not change relative to existing conditions.

Groundwater: The total sulfate and metals loads to Mill Gulch groundwater are predicted to decrease from existing conditions, and in comparison to all other alternatives, except Alternative L1 (Table 4.3-3). The amount of infiltration through the leach pad that would be available to enter the groundwater would be less under Alternative L5 with the use of the water barrier covers, which significantly reduce infiltration. This would only affect streamflow if, at some point in the future, the leach pad water quality met standards and heap drainage was allowed to be discharged through the liner system.

Montana Gulch

Surface Water: Restoration of surface drainage patterns and removal of the L85/86 leach pad and dike, and placement of water barrier covers over flat upstream areas would have a positive impact on surface water quality. However, as a result of the restoration of pre-mining topography and additional drainage of surface water to the northern drainages, surface water quantity would be reduced relative to existing conditions. This would be a minor change in flow compared to the amount of water discharging from the water treatment plant.

Groundwater: Groundwater quality would be negatively impacted by the placement of potentially acid generating material in the headwaters of the Montana Gulch drainage. Removal of the L85/86 leach pad and dike would have impacts similar to those described for Alternative L4. The estimated total sulfate and metals loads show that water quality would slightly improve, similar to the other alternatives (Table 4.3-3).

4.3.5 Goslin Flats LAD Area

The Goslin Flats Land Application Disposal (LAD) area is described in Chapter 3, Section 3.3. The location of the LAD facility is shown in Figure 3.3-22.

The initial LAD operation was not designed as a zero discharge system. From 1998 to 2000, local groundwater flows in Goslin Gulch and lower Ruby Creek were impacted by elevated selenium, nitrate, TDS, and low levels of total cyanide. The expansion of the LAD area in 2000 allowed for much lower application rates per acre, which led to a reduction in the contaminants entering the Goslin Gulch surface and groundwater (HSI and Spectrum 2000). This downward trend in contaminants would continue regardless of the reclamation alternatives selected. Over the next several years, moderate amounts of water would be applied to the original 96-acre LAD area to enhance vegetation growth and consume the residual nitrate levels in the soil.

As presented in Chapter 2, a successful pilot project for biological treatment of nitrate, selenium and cyanide was completed in November 2000. The biological treatment system would be used to reduce the selenium and nitrate levels which are presently limiting the amount of process water that can be land applied

without impacting adjacent surface and groundwaters. Use of the biological treatment system would occur under all alternatives and would result in significant positive impacts to water resources. Full-scale biological treatment of leach pad waters in late 2001 would provide new options for disposing of leach pad solutions. Pad waters would continue to go to the LAD, or may be routed through the water treatment plants for metals removal and discharged at existing outfall points in Ruby Creek and Montana Gulch. The choice of treatment for specific leach pad waters would depend on a number of factors, including biological treatment efficacy, MPDES permit limits, operational cost considerations, and LAD management needs.

Reclamation of the leach pads would reduce the amount of precipitation infiltrating the surface and accumulating in the leach pads. Any of the reclamation alternatives would significantly reduce the average annual accumulation of leach pad water. With the various soil reclamation covers, infiltration rates would be reduced from about 70% currently, to 15 to 42%. The alternatives that include barrier reclamation covers on the leach pads would provide for the most reduction in accumulated pad water, at least in the short term. Alternatives that remove leach pads for backfill also reduce the total amount of leach pad water that accumulates by removing the lined catchment area. For the Zortman Mine, the alternatives have the following relative ranking for reduction in accumulation of leach pad water: Alternatives Z1, Z4, Z5, Z6, Z3, and Z2. Alternatives Z4, Z5, and Z6 are all within 3 gpm of the same result. For the Landusky Mine, the relative ranking of the alternatives for reducing accumulation of leach pad water is as follows: Alternatives L1, L6, L2 and L3 tied, L4, and L5. Alternative L4 is essentially the same as Alternatives L2 and L3, since they are within 1 gpm of the same result. The use of GCL covers over the leach pads in Alternatives Z1 and L1 leads to short-term benefits, but the limited life of these liners gives then a lower long-term rank.

The effects of the reclamation alternatives on the leach pad solution quality are more difficult to assess. For residual contaminants already stored within the pads such as nitrate and sodium, alternatives that most reduce the infiltration rate would likely prolong the period required for flushing these from the leach pads. The timeframe for ARD maturation may be extended by the alternatives with thicker soil covers or with barrier-type covers. None of the alternatives would eliminate or significantly reduce the eventual development of ARD conditions. Alternatives that slow the ARD generation process would prolong the time for which elements like selenium and arsenic, mobilized in non-acidic solutions, require treatment. In short, there are many tradeoffs among the alternatives, and no alternative is clearly preferential or detrimental with respect to leach pad water quality.

In summary, under any of the reclamation alternatives, the potential impacts to the Goslin Flats LAD area from leach pad water disposal would be greatly reduced over current conditions. Continued use of the LAD at its current disposal rate is dependent upon successful implementation of the biological treatment system for selenium and nitrate reduction. The next limiting factor for continued land application is salinity and sodium buildup in the soils. Metals concentrations are relatively low in most leach pad waters, since most are still non-acidic. The impacts from land application on soils and water quality are currently in decline, and would continue to decline under all alternatives as the planned zero-infiltration/discharge operating plan for the LAD is implemented.

4.3.6 Zortman and Landusky Town Water Supplies

Zortman

There would be no impacts to the water supply for the town of Zortman under any of the alternatives. This is 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.

Landusky

As discussed in Chapter 3, there have been varying degrees of mine-related impacts to the four shallow wells used by Landusky residents, TP-1, TP-2, TP-3 and TP-4. Wells TP-1 and TP-2 were impacted 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 occurs in all these wells, but not other ARD indicator metals, it may be due to natural conditions (WMCI p. 536).

The capture systems in Sullivan Gulch, Mill Gulch and Montana Gulch are the primary reclamation component responsible for maintaining acceptable water quality at the Landusky townsite wells. Since all the Landusky Mine reclamation alternatives include maintaining the capture systems, the variations of reclamation activities among the alternatives would not likely have any differential effect on the water quality or quantity of the Landusky Town wells. The concentrations and frequency of contamination in the drainages would continue to decline and the water in these domestic wells would remain suitable for domestic use.

4.3.7 Madison Group Aquifer

Impacts to the Madison Group aquifer would occur only by seepage of poor quality surface water into the Madison subcrop which is located downstream of the mine areas. Since the subcrop is located below the capture systems, most of the poor quality water would be from the uncaptured groundwater bypassing the system. Poor quality water could only infiltrate where the limestone was not discharging to the drainage (i.e. the vertical gradient in the Madison Aquifer was downward). Water treatment plant discharges in Ruby Gulch and Montana Gulch would also be a component of recharge to the Madison Group aquifer.

Zortman Mine

The quantity of water bypassing the capture systems in drainages from the Zortman Mine area is quite small, ranging from less than 0.05 gpm in Alder Gulch to 7-17 gpm in Ruby Gulch (Table 4.3.4). The total sulfate and metals loads would not vary significantly from the existing conditions in Ruby Gulch, Alder Spur,

and Carter Spur; or would improve under several alternatives (Table 4.3-2). Therefore, no appreciable change in impacts to the Madison Group aquifer would occur in those drainages. The Lodgepole Creek drainage in the Madison Group subcrop is 3 to 4 miles downstream of the Zortman Mine. Due to the small amount of seepage that discharges to Lodgepole Creek and the large amount of dilution, there would be no impacts to the Madison Group aquifer from infiltration in Lodgepole Creek.

Landusky Mine

The amount of water bypassing the capture systems at the Landusky Mine site ranges from a low of 0.15 to 0.55 gpm in Sullivan Gulch, a tributary of Rock Creek, to a high of 22 to 52 gpm in Montana Gulch. Recent studies (WMCI 1998) have shown there are upward vertical gradients in the Madison Group aquifer in Rock Creek. Upward vertical gradients are also considered present in Mill Gulch. No impacts to the Madison Group aquifer have been identified in these drainages. Because of upward gradients and the small amount of capture system bypass, it is unlikely the Madison Group aquifer would be impacted by infiltration in Mill and Sullivan Gulches.

No monitoring wells have been completed in the Madison Group in the Montana Gulch area. Preliminary information (WMCI 1998) indicates there is also an upward vertical gradient in Montana Gulch. Since these data are not conclusive, additional monitoring above and below the Madison subcrop would be used to determine whether the stream loses water in the Madison Group stream reach. However, even if there were downward gradients in the Madison Group and surface water entered the aquifer, impacts would probably not be significant because this a relatively isolated block of Madison which appears to discharge at Mud Creek Springs. Local recharge from the Montana Gulch area is a minor component of flow at Mud Springs Creek which, based on water temperature and chemistry, has a high percentage of regional discharge. Surface water contributed from the Landusky Mine site to Montana Gulch is treated, which would also reduce impacts to the Madison aquifer.

4.3.8 Reasonably Foreseeable Significant Adverse Impacts

Reasonably foreseeable significant adverse impacts include impacts beyond those predicted for reclamation activities under each alternative. These include impacts from events such as seismic activity or facility failures which, while less than likely to occur, would result in significant adverse impacts.

Power Failure

Power failures occur at the Zortman and Landusky Mines about a half dozen times per year. Some outages from snow or ice storms have lasted three to four days. Pollution prevention systems that require electricity such as the water treatment plant and the seepage capture system pumps continue to function during power outages with the support of backup generators. Should the backup generators not function, or be unavailable, poor quality water would be released, significantly impacting downstream water quality, aquatic resources, and domestic water supplies.

The Zortman and Landusky Mine water treatment plants can only be without power for about two days before overtopping of the storage ponds would occur. Without backup power to run the treatment plants, untreated water would have to be released.

Of even more critical importance than keeping power to the treatment plants are the capture systems, some of which can only contain contaminated seepage for a couple of hours before overtopping. At the Zortman Mine, the Alder Spur capture system has overtopped and the Ruby Gulch system has come close to overtopping due to power failures. At the Landusky Mine, Mill Gulch has overtopped within 24 hours. Since power outages are often due to extreme storm events, the capture systems could overtop even sooner without backup power.

Water Treatment Plant Failure

Potential impacts due to power failures are described above. If the water treatment plant failed to operate due to major mechanical breakdown, a timeframe of approximately two days would exist to complete repairs. After that, overtopping of the storage ponds may occur. This would result in significant short-term impacts to downgradient surface water quality, primarily elevated metals concentrations.

Capture System Failure

Potential impacts due to power failures are addressed above. All capture systems have been constructed according to standard hydrologic and engineering design criteria. However, in the event of a mechanical failure or catastrophic event such as an earthquake, the capture systems would cease to function. While unlikely, failure of any of the capture systems would result in significant impacts to downgradient water quality until such time the systems could be repaired or replaced. Non-catastrophic failures, such as that due to plugging by sediment, would probably occur over a time period sufficient to allow the problem to be noticed and repaired prior to creating significant impacts.

Facility Failure

Failure of earthen structures such as a dike is unlikely based on recent geotechnical analyses (Womack 2000a and 2000b). However unlikely, if a structural failure occurred it would have varying impacts. With the exception of the Z85/86 and the L87/91 leach pad dikes, all other dikes are constructed of NAG material, which would limit downgradient water quality impacts. Failure of the Z85/86 leach pad would not result in overtopping of the Ruby Gulch pond. Most sediment and spent ore would be retained above the capture system. Failure of the L87/91 leach pad would overwhelm the capture ponds and result in a surge of leach pad solutions and spent ore down the drainage. This would have significant impacts on downgradient water quality.

The location of the water treatment plants and seepage capture systems require a significant amount of uphill pumping. Failure of pumps and pipelines associated with the capture systems and treatment plants

would release contaminated seepage. This would cause short-term impacts to downstream water quality.

High Precipitation Event

The 100-year, 24-hour precipitation event of 6.33 inches was calculated in 1995. Precipitation data reviewed through the year 2000 show there is no need to increase the magnitude of this storm event. Stormwater structures built by ZMI after 1995 were based on the 6.33 inch event. However, the 100-year event is a probabilistic event that could be exceeded. Over a period of 20 years there is an 18% probability of a 100-year storm event occurring. If this happens, capacities of stormwater ditches and retention structures could be exceeded, resulting in overtopping and release of runoff. The impacts would probably include water and debris flows from the mine sites to the surrounding principal drainages with release of metals and other mine contaminants. However concentrations would be low due to very high dilution. There would be significant damage to mine reclamation covers, capture systems and other structures that would require major expenditures to repair or replace.

Subsidence and Collapse

Settlement of the pit backfill and subsidence of underground workings may result in significant impacts to reclamation covers and pit floor liners, including ruptures of the materials or covers. This would create areas of increased infiltration, allowing runoff to infiltrate the poor quality backfill materials. Seepage would then enter the shear zones and affect water quality. Seepage capture and treatment systems would reduce, not not eliminate impacts to water quality.

Liner Degradation

Over time the HDPE, PVC and GCL liners in the pits, leach pad containment systems, and water barrier covers would degrade, losing their ability to prevent infiltration or contain leach solutions. The GCL layers in the reclamation covers would begin deteriorating after about 30 years. Geosynthetic liners would have a functional life of about 100 years. It should be noted that the liners would not fail completely when reaching their life expectancy, but may develop holes or other areas allowing increased infiltration. As this occurs the water barrier covers would begin to act more like water balance covers and have slightly increased infiltration.

Geochemical Maturity

Data collected over the years show that there are different stages of ARD evolution at the mines, and that contaminant concentrations would continue to increase until the final or "mature" state is achieved. As the sulfides oxidize, sulfuric acid is produced and the concentration of sulfate increases. The sulfate concentration would change over time, being at its highest concentration at full ARD "maturity."

The ARD conditions at the Zortman Mine are more mature than those at the Landusky Mine. There is a big spread in the actual conditions at each site, with some isolated zones 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 (alkalinity) 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 Landusky Mine (for example in the Bighorn dolomite and the Emerson shale).

It is anticipated that the full cycle from oxidation initiation to finally reaching the "oxide" state would take tens to hundreds of years. Water quality would continue to worsen from facilities that are not now fully mature. This reasonably foreseeable adverse impact would be mitigated by provisions for long-term water treatment.

4.4 SOILS and RECLAMATION

4.4.1 Impacts Common to All Alternatives

The most impact to the soil resource at the mines has been from the mining activity itself. The natural soil profiles have been disrupted and the topsoil has been mixed with the subsoil material and stockpiled. The stockpiled soil is different than the premined soils due to the loss of distinct soil horizons with characteristic organic matter, fertility, soil microbe populations, zones of clay and calcium accumulation, base saturation, structure, and coarse fragment content. All alternatives would improve existing conditions by replacing the soil over the disturbed areas. However, the alternatives differ in respect to the amount of surface that would be revegetated and the suitability of the reconstructed soil profile to plant growth.

The alternatives differ mainly in the areas that are revegetated, the average slope of those areas, and the designs of the reclamation covers. Figures 2.4-1 and 2.4-2 provide information on the various reclamation covers that would be used in each alternative. For a given reclamation cover, the differences in slope and revegetation success largely determine the erosion potential, which increases with slope steepness and length. The type and thickness of the cover material and organic content largely determine the water and nutrient holding capacity, which are important for plant growth. The aspect of the regraded slopes (north vs. south) determines soil temperature and length of growing season, as well as optimal type of vegetation. South facing slopes are warmer and have higher evapotranspiration rates, but at the same time the growing season is longer than on cool aspects.

Acidification of cover soils in past reclamation generally has not limited revegetation success. At a few sites where shallow soils (usually between 0.5 and 1.0 foot thick) have been placed directly over strongly acidic mine waste, the result was stunted trees and scant plant cover. In future reclamation the soil would not be placed in direct contact with materials having a pH of less than 5.5 in order to avoid this effect. One of the purposes of the NAG layer is to separate the soils from underlying potentially acid-forming rock.

The two most important soil factors relating to revegetation success are compaction of the soil for trees, and soil fertility for grasses. In the past soil compaction during placement, and as the result of dozer tracking, has limited tree root penetration, resulting in small unhealthy trees. Soil compaction is the single most limiting factor for tree growth (Bighorn Environmental 2000). Moreover, the stockpiled soils have a coarse fragment content of 50% or greater. When the clay content is greater than 20% and the soils are compacted, the plant roots are unable to penetrate the soil and obtain nutrients, water, and physical support.

Fertility is also a limiting factor common to all alternatives, as the soil material available for reclamation is low in organic matter content. Stockpiled soil material has an organic matter content of less than 1.5%. Productive native grass soils in the area have up to 15% organic matter. Native soils supporting lodgepole pine stands have organic matter contents up to 5%. In Montana Gulch, soils supporting productive stands of trees have an organic matter content of 2.1%. Soil stockpiles at Montana and Mill Gulches have organic

matter contents of 0.6% and 1.0%, respectively (Bighorn Environmental 2000). The impact of this low organic content is that soil fertility would be limited for revegetation without the addition of inorganic fertilization and establishment of nitrogen fixing vegetation.

Another limitation in soils without much organic matter is the lack of soil bacteria and fungi populations necessary for nutrient cycling. Nitrate levels in past reclamation soils at the mines have been below detection limit (0.1 ppm), but with an average of 8 ppm ammonium (Bighorn Environmental 2000). This indicates a bottleneck in the conversion of ammonia to nitrogen. The stockpiled soils have an imbalance between bacteria and fungi populations. A good wood-based compost or clean wood product would help correct this balance.

A good organic amendment is prohibitively expensive. Wood waste is less expensive, but the probability of introducing weed seed into soils outweighs the benefits of the amendment. Since large-scale organic amendment is not feasible, the soils would be amended with a bioactivator that, instead of providing organic matter, would promote bacteria and fungi populations. This would improve nitrogen cycling and reclamation success.

In order to provide the necessary nutrients to support reclamation, fertilizer would be added to achieve 20 ppm nitrate concentration, and 250 ppm phosphorous and plant-available potassium. Based on incorporation into the upper six inches of soil and a rock content of 50%, fertilization prescriptions for reclamation soils have been calculated to be 45 pounds/acre of urea, 19 pounds/acre of phosphorus, and 120 pounds/acre of potassium. These prescriptions would result in adequate nutrients available in the soil profile to support revegetation.

The water barrier and water balance reclamation covers used in some of the alternatives would isolate potentially acid forming mine rock from precipitation infiltrating through the cover soil and prevent the soil material from becoming acidic over time. The water holding capacity of the two reclamation covers would be similar and adequate to support plant growth. Because the liners used in the water barrier reclamation cover would be impermeable, they would create a barrier to downward root growth. As the liners degrade over time, this barrier would be removed. The water balance reclamation covers contain a filter fabric which is permeable to water but would be somewhat of a barrier to plant roots.

Consequently, it is the soil material above the filter fabric and liners in the reclamation covers that supports plant growth. The thickness of the soil above these materials affects the growth of plant species used in reclamation. Deeper rooting plant species such as trees may be at a slight disadvantage on these reclamation covers. Lodgepole pine can survive in a minimum of four feet of soil material. However, ponderosa pine prefer six feet minimum soil depth and perform best in soils greater than eight feet deep (Bighorn Environmental 2000). Grasses and forbs would generally better perform than trees in areas with the water barrier or water balance reclamation covers.

4.4.2 Zortman Mine

Alternative Z1

The water barrier reclamation cover that would be used on flat and slightly sloping surfaces would provide 48 inches of material suitable for plant growth. This cover would be less prone to erosion because it would be used on relatively flat surfaces. The water balance cover would be more susceptible to erosion because it would be used on the sloped areas were there would be more runoff and detachment of soil particles. In addition, the effective rooting depth is less for the water balance cover than the water barrier cover, 36 inches as opposed to 48 inches. The geotextile at a depth of 36 inches might tend to increase the potential for erosion by reducing soil cohesion along its contact.

Deeper rooting plants such as trees may be at a slight disadvantage on the water balance cover as the geotextile would be a rooting barrier for a certain time. Therefore, the areas where these reclamation covers are used would be planted with grass and forb species which would be better suited. The 48-inch rooting depth in the flatter areas would support limited stands of trees.

The water holding capacity of the water barrier and the water balance covers would be similar, provided the textural difference and the rock fragment content are similar in the soil and the NAG material. However, if there is a significant textural difference and/or rock fragment content between the soil and the NAG material, a discontinuity could exist that would affect water movement and storage. Under this circumstance, the water barrier cover may hold less water for use by plants than the water balance cover. The water balance cover would provide 36 inches of soil material of a very similar texture and coarse fragment content. Water movement and storage would be more consistent through the material resulting in better water-holding capacity. The water-holding capacity of any soil material is dependent on the texture and the coarse fragment content. The higher the percentage of clay in the texture, the more water-holding capacity available. However, the opposite occurs with relation to coarse fragment content, the higher the coarse fragment content, the lower the water-holding capacity.

Reclamation of the Alder Gulch and South Ruby waste rock dumps includes a cover of 12 inches of NAG and 12 inches soil over native ground. Provided that the native soil material has little to no metal contamination and is not compacted, this cover would adequately support plant growth. Placement of these materials would resemble the soil horizons that were disturbed during mining.

Cover for the O.K. waste rock dump, haul roads, facilities and the limestone quarry includes placing 12 inches of soil over native ground. Provided the native material has little to no metal contamination or is not compacted, this cover would perform quite well as a medium for plant growth.

Alternative Z2

The reclamation cover on the O.K./Ruby pit would provide 36 inches of rooting depth over an 8-inch clay barrier. This cover material would perform very similar to the water balance cover that would be used in Alternative Z1, provided there were no huge textural or rock fragment content differences between the soil material and the NAG. The rooting depth would not support tress but would be adequate for grass and forb species. The clay liner would prevent infiltration of water into the medium below and would prevent acidification of the soil material above.

The reclamation cover for the Mint pit and the Z85/86 leach pad would perform well provided that compaction and discontinuities are not present. The 12 inches of soil over 24 inches of NAG would provide more than a 36-inch rooting depth. Tree species would have limited rooting depth for proper growth, so they would be planted in only two relatively small areas.

The reclamation cover for the Ross pit would provide 24 inches of material, which is adequate for rooting depth. This cover is very similar to the one over the Z82 leach pad footprint, and provides 24 inches of material available for rooting depth.

The reclamation cover that would be used for the South Alabama pit and its associated haul roads and borrow area is 12 inches of soil over 24 inches of NAG. This cover would provide more than a 36-inch rooting depth, which is more than adequate for the plant species that would be used in revegetation of this area. The floor of the North Alabama pit and the regraded mine facility areas would be covered with 12 inches of soil over the existing native materials. Adequate rooting depth and water-holding capacity would be quite similar to the soil material that existed prior to disturbance, provided it was not compacted during placement.

Alternative Z3

The reclamation covers that would be used in Alternatives Z3 are the same as used in Alternative Z2, except for 7-inch layer of Ruby Gulch tailings that would be placed between the soil and NAG layer. Although the Ruby Gulch tailings are erosive and have little water-holding capacity due to their sandy texture and coarse fragment content (~70%), cover modeling has shown that this cover would perform better than placing the soil directly over the coarse NAG material and the tailings would increase the soil volume available for root growth.

Alternative Z4

The water barrier reclamation cover used in this alternative would provide 36 inches of rooting depth over a geosynthetic liner. While the liner used in the barrier cover in Alternative Z4 would be different than the GCL used in Alternative Z1, the impact to the soil resource would be the same. The rooting depth would be sufficient for grasses and forbs but not suitable for trees.

The geotextile filter fabric placed between the 12 inches of soil and 36 inches of NAG in the water balance reclamation cover would prevent the soil from plugging the capillary break. The fabric would create somewhat of a barrier to root penetration. Water would tend to perch in the upper 12 inches of soil during the wet season but there would be limited water-holding capacity to support plants in the dry season due to the shallow soil. On steep slopes, the filter fabric could also increase the chances for erosion if the upper 12 inches became saturated and unable to hold additional water. Otherwise the 12-inch layer of soil would be adequate to establish grass cover, as less than 15 inches of soil is adequate for grass establishment provided compaction does not occur (Bighorn Environmental 2000).

Alternative Z5

The soil depth is shallower in the reclamaton covers that would be used in this alternative than for the other alternatives. This may limit seed establishment and plant growth to some degree as there is less material available for holding water and supplying nutrients.

The water barrier and water balance reclamation covers would only be used on the O.K./Ruby pit backfill. The water barrier reclamation cover would provide 42 inches of rooting depth in areas with less than a 25% slope. The NAG used in this cover would be the coarse tailings from Ruby Gulch, while the 10-inch layer of tailings placed below the soil layer would be finer grained tailings. The tailings would provide additional soil material for root penetration but only little water-holding capacity or nutrient availability.

The water balance reclamation cover would provide 30 inches of rooting depth over the geotextile filter fabric. The 8 inches of soil and 24 inches of tailings would create a drier condition for plant growth. The tailings have marginal water holding capacity; therefore, the water necessary to support plant growth would have to be stored in the 8-inch soil layer. This thickness of soil would limit water storage. The surface would be susceptible to erosion on steep slopes because water infiltrating through the soil may move rapidly downslope through the tailings instead of passing through the filter fabric. This could result in erosion at the point where water discharges.

Establishing acceptable plant growth on the Ross pit backfill may be difficult. The use of 8 inches of soil over 10 inches of tailings would result in a very low water-holding capacity. A rooting depth of 18 inches would support grasses and forbs, but not trees. If the material beneath the tailings was acidic, it would further limit plant growth.

The use of 8 inches of soil over 10 inches of tailings on the graded footprints of the Z85/86 leach pad and the Alder Gulch waste rock dump would also result in a reclaimed surface with a very low water-holding capacity. Because the exposed native ground might have better water-holding capacity than the tailings, the use of the tailings over these footprint areas might not provide much benefit other than for rooting depth. The rooting depth of 18 inches would support grasses and forbs, but not trees.

Alternative Z6 (Preferred Alternative)

The water barrier reclamation cover would provide four feet of rooting depth over the O.K./Ruby pit backfill, the North Alabama pit backfill and on the top of the Alder Gulch waste rock dump. The tailings would provide soil material for root penetration, but offer little water holding capacity or nutrient availability. The water barrier reclamation cover would be adequate for grasses and forbs, but may be limiting for some tree species.

The water balance reclamation cover would also provide two feet of rooting depth above the geotextile, which would be adequate for grasses and forbs, but limiting for trees. This cover would have a higher susceptibility to erosion than the water barrier cover since it would be used on slopes, although its use would be limited to small areas.

4.4.3 Landusky Mine

Alternative L1

The impacts of the water barrier and water balance reclamation covers would be the same as those described for Alternative Z1. The placement of 36 inches of soil material would not restrict rooting depth for grasses and forbs. The water-holding capacity would be limited to the upper 36 inches in the water balance covers and the upper 48 inches in the water barrier covers. Lodgepole and ponderosa pine probably would be able to establish on these surfaces.

Alternative L2

The thickest reclamation cover would be 48 inches, with equal depths of soil and NAG. Therefore, rooting depth would not be limited. Soil material may become acidic in areas where it is placed over acid generating material. However, the potential for this to occur would be minimized with lime treatment prior to soil placement. The water-holding capacity would be similar to other reclamation covers of equal depth.

The reclamation covers that would be used on the L87/91 leach pad complex and the Montana Gulch waste rock dump would be 39 inches thick with 24 inches of soil over 15 inches of NAG. This would be adequate to establish grasses, forbs, and most tree species.

The Queen Rose and August/Little Ben/Suprise pit complex would be covered with 18 inches of soil over 6 inches of NAG. The rooting depth would be limited to 24 inches if acid generating material is located below the cover. Grasses and forbs would be suited as vegetation but tree success would be limited by the cover thickness.

Alternative L3

The reclamation covers that would be used in Alternative L3 are similar to those that would be used under Alternative L2. The impacts would be the same as those described above for Alternative L2.

Alternative L4 (Preferred Alternative)

The majority of the reclamation covers are 48 inches thick with equal depths of soil and NAG. This would not limit rooting depth for grasses, forbs, and trees. Soil material may become acidic in areas where it is placed over acid generating material. However, the potential for this to occur would be minimized with lime treatment prior to soil placement.

After removal of the L85/86 leach pad and dike, the footprint would be covered with 24 inches of soil over the native ground. There would be no limitation to rooting depth provided the underlying material is not acidic. In the unlikely event the native ground is acid producing, it would be neutralized with lime to a depth of 24 inches prior to soil placement. This would limit the rooting depth to 24 inches, which would not be suitable for tree establishment.

Alternative L5

The majority of the reclamation covers are 46 inches thick with 21 inches of NAG covered with 25 inches soil. This reclamation cover material would perform the same as the 48 inch thick reclamation covers discussed under Alternatives L2, L3 and L4. The 2 inch difference in cover material would have a very minimal effect on the performance of these reclamation covers in supporting vegetation.

After removal of the L85/86 leach pad and dike, the footprint would be covered by 12 inches of soil over the native ground. This cover would not provide as much water-holding capacity and rooting depth as the 24 inch soil cover in Alternative L4, but would be adequate to establish grasses and forbs.

The 24 inches of soil that would be placed over the August #1 waste rock dump area, and the 12 inches of soil on the Montana Gulch soil stockpile site would provide adequate water-holding capacity and rooting depth to support revegetation. These surfaces are not composed of acid forming material and the soil thicknesses would support grasses and forbs.

Alternative L6

The water barrier cover would provide 46 inches of rooting depth and water holding capacity over a synthetic liner. This cover would not perform significantly different than the water barrier cover that would be used in Alternative L1. The liners are of different material but both are a barrier to water infiltration and root penetration. The 2-inch difference in cover material thickness would have a very minimal effect on the reclamation cover performance.

The water balance reclamation cover would limit rooting thickness to 27 inches. A geotextile fabric would be placed over the NAG material and covered with 27 inches of soil. This reclamation cover would be adequate to support grasses and forbs, but would be limiting for some tree species. Erosion potential may increase on steep side slopes. There is a potential for water to infiltrate the soil, migrate laterally through the NAG layer, and discharge downslope causing erosion where it surfaces.

4.5 VEGETATION and REVEGETATION

4.5.1 Impacts Common to All Alternatives

Revegetation success at the Zortman and Landusky Mines is based upon achievement of the following objectives given the soil composition and availability:

- Maximizing evapotranspiration;
- Minimizing soil erosion;
- Creating wildlife (ungulate) habitat;
- Establishing persistent, diverse plant communities;
- Growing species of special interest to Fort Belknap; and
- Creating revegetation that is visually pleasing and suitable for recreational activities.

It is not possible to maximize each revegetation objective on each acre of revegetated surface. However, by using a mosaic of the three seed mixes described below, the objectives would be achieved at a landscape scale. This would result in revegetation success to varying degrees for all alternatives, though the specific vegetation patterns would vary among alternatives.

Maximum evapotranspiration would result from high productivity and a variety of rooting depths among revegetation species. A forest would have the highest evapotranspiration, but this conflicts with other objectives, requires deep soils (including NAG), takes decades to develop, and is expensive to establish. The revegetation effort would establish very productive herbaceous plant communities using species of varying seasonalities with a variety of both fibrous-rooted and taprooted species to maximize evapotranspiration.

The revegetation would also achieve the objective of limiting soil erosion by creating lots of foliage and plant litter to intercept falling raindrops and dissipate their energy, and by establishing rhizomatous species. The seedmix would achieve this by consisting largely of bunchgrasses and forbs, and by including rhizomatous species where they are likely to persist.

In the forest habitat that surrounds the reclamation area, the wildlife diversity and ungulate abundance would be improved by the planting of the grass-forb community in a mosaic pattern. The species composition would also benefit wildlife by including protein-rich, nitrogen-fixing legumes such as clover and alfalfa. These plants benefit ungulates (deer, elk, sheep), particularly from winter through early spring. The use of nitrogen-fixing legumes would assist in the establishment of other vegetation species.

The first three objectives are best served by planting introduced species, which establish easily, excel in productivity, and include the best-known legumes. The fourth objective, persistence and diversity, is at odds in some respects with the first three and must be achieved over time. The introduced species would not persist forever, although they would play a crucial role in soil-building and nutrient supply during the first

few decades. To promote longer-term persistence and diversity in the revegetation, two other seed mixes would be planted in an interspersed pattern with the primary grass-forb mix. One is a native mix that would provide a native seed source to colonize the nearby empty habitats, if and when the introduced species fail to reproduce. The other seed mix would be mostly native species which would be relatively noncompetitive. This seed mix would allow invasion of native vegetation from adjacent undisturbed areas, including pine trees, and would be used along the edges of the mine disturbances to allow natural invasion to occur with minimum competition. In large mine disturbance areas, pine seedlings would be planted in specific groupings along with the noncompetitive mix. This would establish a future seed source for long-term propagation into the disturbance areas.

The three seed mixes are described below. All legumes would be inoculated. The comparative acreage of where these mixes would be used provides a basis for comparing the alternatives.

General Grass-Forb Mix		Pounds PLS*/acre, Broadcast
Nitrogen Fixation		
Alfalfa	Spreador III	1.50
Red Clover	Kenland	0.75
White Clover	Ladino	0.75
Short-Term Erosion Control		
Slender Wheatgrass	Prior	1.50
Big Bluegrass	Sherman	1.00
Enduring Grasses		
Intermediate Wheatgrass	Chief	2.50
Meadow Brome	Regar	1.50
Hard Fescue	Durar	1.50
Canada Bluegrass	Reubens	2.00
Additional Forbs and Shrubs		
Yarrow		0.50
Blue Flax		0.50
Short-Term Cover Only		
Wheat or Barley		2.50
	Total	16.00 lbs/acre

* pure live seed

Grass-Forb Mix for Natural Tree Revegetation		Pounds PLS*/acre, Broadcast
Nitrogen Fixation		
Sainfoin	Eski	1.50
Black Medic Clover	Kenland	1.00
Short-Term Erosion Control		
Slender Wheatgrass	Prior	1.50
Canada Wild Rye		1.00
Big Bluegrass	Sherman	0.50
Enduring Grasses		
Bluebunch Wheatgrass	Goldar	2.00
Bluebunch Wheatgrass	Whitmar	1.00
Bluebunch Wheatgrass	Secar	1.00
Additional Forbs & Shrubs		
Arrowleaf Balsamroot		0.50
Rubber Rabbitbrush		0.50
American Vetch		0.25
Cudweed Sagewort (*Artemisia ludoviciana*)		0.25
	Total	11.00 lbs/acre

* pure live seed

For healthy, growing trees, soil and NAG would be ripped and left uncompacted.

Native Seed Mix		Pounds PLS/acre, Broadcast
Short-Term Erosion Control		
Slender Wheatgrass	Prior	1.50
Big Bluegrass	Sherman	0.75
Enduring Grasses		
Bluebunch Wheatgrass	Goldar	2.00
Bluebunch Wheatgrass	Whitmar	2.00
Bluebunch Wheatgrass	Secar	1.00
Thickspike Wheatgrass	Critana	1.00
Forbs		
Alfalfa*	Ladak, Rambler	0.50
Aster ascendens		0.25
Vicia americana		0.25
Yarrow		0.25
Black Medic*		0.50
Lupinus argenteus		0.25
Arrowleaf Balsamroot		0.50
	Total	10.75 lbs/acre

*Introduced species, for nitrogen fixation

Several species identified by Fort Belknap are included in the seed mixes. The Natural Resources Conservation Service would provide some sweetgrass transplants for use in revegetation, and some chokecherry seedlings would be planted in moist habitats.

Visually pleasing landscapes take many forms, but the pattern of vegetation types usually plays an important role based upon the structure or appearance of vegetation independent of the vegetation species. Revegetation would take the form of mosaics of grass-forb communities and smaller acreage where trees are encouraged to regenerate naturally (noncompetitive mix) or seedlings are transplanted. Shrubs would be used to establish a diverse vegetation appearance. Although shrub establishment is incompatible with the strong-establishing, competitive species of the general grass-forb seed mix, rubber rabbitbrush has been included in the noncompetitive seed mix. Recreation would be enhanced by wildlife sightings, which are sure to increase if nitrogen-fixing species become abundant as planned.

The alternatives differ chiefly in additional disturbance, the produced topography, and the acreage put into each of the three revegetation types. The main negative impact associated with some alternatives is the amount of additional acreage that would be disturbed by excavation of borrow materials for use in reclamation and in moving the water treatment plant to Goslin Flats. The acreage of total disturbance

(existing plus any additional created during reclamation) for each alternative is shown in Table 4.5-1 for the Zortman Mine, and Table 4.5-2 for the Landusky Mine. The impact of revegetation would be very positive under all alternatives.

Use of the three seed mixes, plus various plantings, have been mapped for each alternative. The acreage planted corresponds with the acreage that would receive the various reclamation covers. In general, the native seed mix would be placed on gentle slopes because it would not prevent erosion as well as the general grass-forb mix. The noncompetitive mix would be planted along borders with the existing coniferous forest where seedlings are likely to volunteer, and also where conifer seedlings would be planted. Under all alternatives, most areas would be seeded with the general grass-forb mix and would establish a grass and forb revegetation pattern.

4.5.2 Zortman Mine

Impacts to vegetation, and the revegetation types by acreage for the six alternatives are included in Table 4.5-1. The existing condition includes 303 acres of disturbance and 103 acres of existing revegetation of which 77% is grass-forb vegetation with introduced species dominating.

Table 4.5-1. Vegetation Acreage for Zortman Mine Alternatives

Reclamation Alternative	Total Disturbed	Previous and Planned Revegetation Acres				% Revegetated
		Grass-Forb	Native Grass	Conifer/Non-Invasive Grass	Total	
Z1	428.4	281.7	14.9	58.1	354.7	82.8
Z2	417.3	255.2	14.9	47.0	317.1	76.0
Z3	409.3	247.9	14.9	47.7	310.5	75.9
Z4	430.2	278.8	15.9	65.0	359.7	83.6
Z5	417.3	278.3	14.8	68.7	361.8	86.7
Z6	409.3	249.1	14.9	47.7	311.7	76.2

Alternative Z1

Alternative Z1 would disturb about 11 acres of forested vegetation to establish the limestone quarry and another 3.2 acres to construct the pit drainage diversion. An 8-acre soil borrow area on Goslin Flats grasslands would be disturbed and then replanted. About 74 acres of the mine disturbance would not be revegetated since it would be left as pit highwalls, access roads, or for the water treatment plant operation. New revegetation would cover 252 acres, including almost 24 acres of Ruby Gulch tailings. This additional

revegetation would bring the overall site revegetation percentage up to about 83% (Table 4.5-1). The revegetation quality would be good.

Alternative Z2

Alternative Z2 would revegetate about 76% of the mine disturbance. About 100 acres of disturbance would not be revegetated since it would be left as highwalls or access roads. Because the water treatment plant would be moved to Goslin Flats, 8 acres of grassland would be disturbed for these facilities. An additional 3.2 acres of forest would be disturbed to construct the pit drainage diversion. Fewer grass-forb acres would be re-established, mainly because there would be no limestone quarry to reclaim and most of the Ruby Gulch tailings would remain unvegetated.

Alternative Z3

Alternative Z3 has the lowest disturbance acreage (Table 4.5-1). It would involve only 3.2 acres of disturbance to construct the pit drainage diversion. Vegetation in the mine area would not be disturbed as no limestone quarry, soil borrow area, or new facilities would be constructed. Revegetated acreage would be an additional 207 acres. This is less than Alternative Z2 because the water treatment plant would be left in place, along with some associated roads. About 99 acres of disturbance would not be revegetated since it would be left as highwall or access road. The additional revegetation under Alternative Z3 would bring the overall site revegetation percentage up to about 76%.

Alternative Z4

Alternative Z4 would disturb an additional 13 acres of vegetation during construction of the limestone quarry and 3.2 acres for construction of the pit drainage diversion. The movement of the water treatment plant to Goslin Flats would also create 8 acres of new disturbance. This would eventually be reclaimed, although with a less mature stand of vegetation.

About 70 acres of disturbance would be not be revegetated since it would be left as highwall, access roads, or for support facilities such as the new water treatment plant location. The amount of new revegetation acreage would be 273 acres, including almost 24 acres of Ruby Gulch tailings. Some of this increase (about 16 acres) is accounted for by replacing the existing revegetation on the Z79/81 leach pad. The revegetation would bring the overall site revegetation percentage up to about 84%. Most of the increase is in the forest vegetation type which would occur over the backfilled mine pit areas.

Alternative Z5

Alternative Z5 would result in the same disturbance as Alternative Z2, but would result in about 14% more acres revegetated due to the backfill placement over the pit highwalls (Table 4.5-1). There would be 214 acres of new grass-forb revegetation and 45 acres of new forest revegetation. The 259 acres of area

revegetated would be slightly less than the Alternative Z4 acreage because the new disturbance for the limestone quarry would not be required and the Z79/81 leach pad would not be redisturbed.

Alternative Z6 (Preferred Alternative)

Alternative Z6 has the lowest disturbed acreage (Table 4.5-1). There would be 249 acres of grass-forb type vegetation, 15 acres of native grass vegetation, and 48 acres of forest-type vegetation. Vegetation would cover 76% of the 409-acre disturbance area. The remaining 96 acres would be left as pit highwalls, access roads, and support facility locations for the water treatment plant.

4.5.3 Landusky Mine

A summary of the impacts to vegetation, and the revegetation acreage for the six alternatives, are presented in Table 4.5-2. Except for Alternative L1, the amount of disturbance to vegetation is virtually identical across the alternatives. The acreage revegetated is similar for Alternatives L1 and L4. Alternatives L2 and L3 also have similar revegetation acreage, though significantly lower that Alternatives L1 and L4. Alternative L5 would incrementally increase the revegetated acreage. Alternative L6 would achieve the most revegetation at 92% of the disturbed area, about 10% more revegetation area than Alternative L1.

Table 4.5-2. Vegetation Acreage for Landusky Mine Alternatives

Reclamation Alternative	Total Disturbed	Previous and Planned Revegetation Acres				% Revegetated
		Grass-Forb	Native Grass	Conifer/Non-Invasive Grass	Total	
L1	873.5*	603.0	41.1	60.9	705.0	80.7
L2	852.1	547.9	42.1	71.6	661.6	77.6
L3	854.0	548.4	42.1	72.2	662.7	77.6
L4	853.3	593.2	40.8	60.9	694.9	81.4
L5	852.4	594.6	52.5	81.1	728.2	85.4
L6	851.0	661.7	35.3	84.8	781.8	91.9

* Reclamation Alternative L1 disturbs additional acreage to provide limestone borrow from two sources.

Alternative L1

Alternative L1 would disturb about 21 additional acres of forest and grassland than the other alternatives, mostly from excavation of the limestone quarry. All the alternatives would increase the disturbance amount by about 4 acres for highwall reduction, but Alternative Z1 includes added disturbance for excavation of

the limestone quarry, construction of the L85/86 pad drainage notch, and buildout of the L91 leach pad dike. About 490 acres of additional revegetation would occur, bringing the overall site revegetation percentage up to about 81%.

Alternatives L2 and L3

Alternatives L2 and L3 are similar in their impacts to vegetation and revegetation (Table 4.5-2). The total revegetation area would be about 662 acres under either alternative, or 78% of the disturbance. In both cases, 83% of this revegetation would be predominantly introduced grass-forb type. Compared to Alternative L1, there would be less revegetation in the area around the pit complex.

Alternative L4 (Preferred Alternative)

Alternative L4 increases the amount of revegetation in the area around the August/Little Ben/Suprise/Queen Rose pit complex and the Montana Gulch waste rock dump by more than 40 acres compared to Alternatives L2 and L3. The amount of mine disturbance revegetated would be 695 acres, or 81% of the disturbance (Figure 4.5-2). Most of the additional revegetation would be of the general grass-forb type. The overall revegetation quality would be adequate. The area backfilled would be configured about the same as in Alternative L1, except where the backfill was dumped as steep rock scree slopes and not seeded.

Alternative L5

Alternative L5 would increase the revegetation acreage to about 728 acres, or about 85% of the mine disturbance (Table 4.5-2). This would be accomplished by extending the backfilling and revegetation up the pit highwall areas. There would be a greater amount of trees used in revegetation, and the existing forest revegetation on the Montana Gulch waste rock dump would also be increased. Overall the revegetation area would be greater for Alternatives L5 and L6 than for the other alternatives.

Alternative L6

Alternative L6 would increase revegetation acreage at the Landusky Mine pit complex by backfilling to eliminate the highwalls. Compared to Alternative L5, about 54 more acres would be revegetated, with a proportional increase in forest revegetation. This would constitute 782 acres of total revegetation, or 92% of the mine disturbance (Table 4.5-2). The remaining area would not be vegetated and would serve as access road and support facilities such as the seepage capture and treatment systems.

4.6 WILDLIFE and AQUATICS

4.6.1 Impacts Common to All Alternatives

During the operating life of the Zortman and Landusky Mines, several roads were closed to public access for safety and security reasons. Reopening these roads to public use once reclamation activities have been completed would likely have a long-term negative impact on game animals due to increased hunting pressure in the presently closed area.

While vehicle collisions with wildlife species are discussed in the individual alternative analysis sections below, they would not have a significant impact on wildlife. During the life of the Zortman and Landusky Mines, only one vehicle/wildlife collision was reported, which resulted in the death of a deer. All alternatives involve increased vehicle activity associated with reclamation. This would raise the probability of vehicle/wildlife collisions. These collisions could result in the deaths of individual animals but would not affect overall wildlife populations.

The temporary increase in activities at the Goslin Flats area for land application would probably cause a small increase in the noise heard at Azure Cave. The 1996 FEIS examined the effects mine expansion and the development of a conveyor belt to haul material to the Goslin Flats area would have on bats. It was determined that noise impacts at Azure Cave would have been approximate to the level of older urban residential areas. (FEIS 1996). Bats are commonly found in urban residential areas and the increased noise level at Azure Cave would not have a negative impact on Townsend's big-eared bat or any other bat species using Azure Cave, since noise levels would be short-term and lower than those examined in 1996 for the proposed mine expansion.

All of the alternatives would improve the existing quality of the wildlife habitat in the disturbance areas. Replacing the original pine forest habitat with large areas of grasses and forbs would improve the forage value for wildlife. None of the reclamation activities or alternatives would damage any habitat for threatened or endangered species.

4.6.2 Zortman Mine

Alternative Z1

The potential negative impacts to wildlife include:

- Wildlife mortality from reclamation traffic;
- Water catchment facilities containing high metals concentrations and acid rock drainage that could attract and potentially contaminate wildlife;

- Use of Goslin Flats as a soil borrow area, resulting in the temporary loss of 8 acres of wildlife habitat;

- New disturbance associated with the 11-acre limestone quarry; and

- The approximately 17% of the mine disturbance area that would not be revegetated.

The potential positive impacts include:

- Use of the water balance reclamation cover which would inhibit acidic materials from contacting the cover soil, impacting vegetative growth, and damaging wildlife forage and habitat;

- Improved potential for the establishment of vegetation and wildlife forage on reduced slopes; and

- Removal of the tailings in Ruby Gulch which would prevent future degradation of wildlife habitat due to erosion.

Wildlife Mortality

Vehicle/wildlife collisions are the only identifiable factor that might affect wildlife mortality. As the number of reclamation personnel increases, so would the probability of vehicle/wildlife collisions. Alternative Z1 would have higher mortality rates than Alternatives Z2, Z3, and Z6, but somewhat lower mortality rates than Alternatives Z4 and Z5. Once reclamation activities are completed, it is expected that mortality rates would return to pre-mine levels. Wildlife mortality from vehicle collisions would be a minor short-term negative impact.

Wildlife Habitat

Alternative Z1 would result in a loss of vegetated wildlife habitat of 17% of the total disturbance area at the Zortman Mine (~80 acres), a negative long-term impact for wildlife. Total new disturbance of wildlife habitat would be 8 acres from a soil borrow area at Goslin Flats, a short-term negative impact, and an 11-acre limestone quarry, a negative long-term impact for wildlife.

The 8 acres of disturbance for the soil borrow area at Goslin Flats would be reclaimed by grading and seeding. The 11-acre limestone quarry would be reclaimed by regrading, replacing all topsoil salvaged from the quarry area, and seeding. In the mine area, the footprints left after removal of the waste rock dumps would be restored to their original contours, covered with soil, and revegetated. Backfilled areas and leach pad areas would be graded and revegetated. The pit highwall areas would be left as rock cliffs or scree slopes. The overall reclamation plans would establish a diverse topography with improved vegetation cover providing a higher quality habitat for grassland species.

The removal of the Alder Gulch waste rock dump and the capture system would increase water quantity in Carter Gulch. This would have a long-term positive impact on aquatic organisms.

Compatibility of reclamation for wildlife habitat is ranked as intermediate. Long-term impacts to wildlife and aquatic resources would be negligible. Removal of the tailings in Ruby Gulch would prevent future degradation of wildlife habitat from erosion.

Approximately 19 acres of disturbance would be created. The water treatment plant would be operated on a long-term basis requiring continued disturbance for facilities and access. Cumulative impacts include the loss of habitat from not revegetating 17% of the disturbed land.

Potential impacts to wildlife and aquatic macroinvertebrates from acid rock drainage and contaminated water would continue to be reduced at the source and by water treatment. The reclamation would significantly increase wildlife forage and habitat re-establishment at the mine. Water capture and treatment facilities serve to improve water-related resources in both the short term and the long term.

Non-vegetated areas would have a lower habitat value because fewer species would prefer to use these areas. The 8-acre soil borrow area in Goslin Flats and the 11-acre limestone quarry that are excavated and reclaimed would create a minor change in topography.

Alternative Z2

The potential negative impacts to wildlife include:

- Only 76% of the mine disturbance would be revegetated; and
- The 8 acres of new disturbance in Goslin Flats for the water treatment plant.

The potential positive impacts to wildlife include:

- Relatively low impacts to aquatic species;
- Wildlife mortality relatively lower than other alternatives due to lower haul traffic; and
- Many of the pit highwalls may provide suitable habitat for peregrine falcon nesting sites.

Wildlife Mortality

Haul traffic would be somewhat lower than with the other alternatives. There would not be a large potential for wildlife vehicle collisions. The processing pond for the water treatment plant in Goslin Flats would be netted and fenced to prevent wildlife from using the pond as a watering site. Existing stock ponds in the

Goslin Flats area would remain operational providing sufficient resources to meet the needs of wildlife populations.

Wildlife Habitat

The 8 acres of new disturbance in the Goslin Flats area to relocate the water treatment plant would result in a short-term negative impact to wildlife using this area. Twenty-four percent of the disturbed area would not be revegetated. Without adequate vegetative cover the mine would have lower habitat value than prior to mining, a long-term negative impact.

Revegetation density, diversity and stability are not as high as the other alternatives. Most of the pit highwalls would be left as cliffs or scree slopes and may provide suitable habitat for peregrine falcon nesting sites, a possible long-term positive impact for peregrine falcons.

Relocating the water treatment plant to the Goslin Flats area would create a new long-term disturbance which would be offset to some degree by reclaiming the old water treatment plant area. The placement of the water treatment plant in Goslin Flats would lower the water quantity in Ruby Gulch. This may have a negative impact on aquatic organisms in the drainage. This would be somewhat offset by improvements in water quality. Alternative Z2 would improve aquatic habitat slightly in Alder Spur and Carter Gulch by improving water quality. Aquatic resources in Lodgepole Creek and Beaver Creek would be maintained at current levels.

Long-term productivity for wildlife would be lower because fewer acres would be revegetated than under most other alternatives. The relocation of the water treatment plant would result in loss of habitat in the Goslin Flats area where the treatment plant is located.

Alternative Z3

The potential negative impacts to wildlife include:

- The percentage of disturbance that would be reclaimed with vegetation is slightly lower than Alternative Z2 with 76% of the disturbed area being revegetated.

The potential positive impacts to wildlife include:

- Revegetation density, diversity and sustainability improve with 18 inches of growth medium cover soil that would be used to reclaimed disturbed areas; and

- No new surface disturbance.

Wildlife Mortality

Haul traffic would be somewhat lower than Alternatives Z1, Z4, Z5, and Z6. There would not be a large potential for wildlife/vehicle collisions.

Wildlife Habitat

Alternative Z3 has a lower percentage of disturbed area revegetated with only 76% of the disturbed area being revegetated, a long-term negative impact on wildlife species.

Alternative Z3 has the lowest percentage of disturbed area with vegetative cover at only 76%. The remaining 24% would be left as cliffs and scree slopes and is not likely to have high wildlife habitat value, a long-term negative impact for wildlife. Alternative Z3 is not likely to improve aquatic habitat in Alder Spur, Carter Gulch, Ruby Gulch and Lodgepole Creek.

Areas that are reclaimed with vegetation have a fairly good probability of producing adequate habitat for a variety of wildlife species. The estimated 24% of the disturbed area that would not be revegetated has little potential to provide habitat for a wide variety of wildlife. Disturbed areas not adequately revegetated are likely to result in an irretrievable loss of wildlife habitat.

Alternative Z4

The potential negative impacts to wildlife include:

- New 8-acre disturbance in Goslin Flats for relocation of water treatment plant;
- New disturbance with 13-acre limestone quarry; and
- The potential for wildlife mortality would be higher than under Alternatives Z1, Z2, Z3, and Z6 due to increased reclamation traffic, but lower than with Alternative Z5.

The potential positive impacts to wildlife include:

- Tailings in Ruby Gulch would be removed, preventing the possibility of future damage to wildlife habitat due to erosion of tailings; and
- Larger percentage of disturbed area would be reclaimed with vegetation with a high potential to provide valuable wildlife habitat.

Wildlife Mortality

With a larger number of reclamation personnel, the potential for wildlife mortality might increase as a result of vehicle/wildlife collisions. This mortality would be a short-term negative impact lasting through the reclamation process. Long-term wildlife mortality would return to pre-mine, negligible levels once mine reclamation activity is completed. The processing pond for the water treatment plant in Goslin Flats would be netted and fenced off to discourage wildlife from using the pond as a foraging/watering site. Existing stock ponds in the Goslin Flats area would remain operational, providing sufficient resources to meet the needs of wildlife populations.

Wildlife Habitat

The 8 acres of new disturbance in the Goslin Flats area for the relocation of the water treatment plant would be a short-term negative impact. The 13-acre disturbance resulting from the limestone quarry would be a long-term negative impact.

Alternative Z4 would reclaim 84% of the disturbed area with vegetation. The resulting revegetation would have high vegetation density, diversity and sustainability, providing for high value wildlife habitat.

Backfilling the Ross pit may increase water quantity into Lodgepole Creek but positive impacts to aquatic species are offset somewhat with a slight decrease in water quality. Alternative Z4 improves aquatic habitat in Alder Spur, Carter Gulch and Ruby Gulch by improving water quality.

Some wildlife species would likely avoid the Goslin Flats area once the water treatment plant is relocated there. Townsend's big-eared bat is the only sensitive status species likely to use the area. It would not be negatively affected because stock ponds in the area would not be affected by the development of the water treatment plant. Wildlife mortality would be higher than under Alternatives Z1, Z2, Z3, and Z6. This is likely to be a short-term negative impact affecting individual animals with no overall impact to wildlife populations.

The high percentage of revegetation would produce high quality wildlife habitat resulting in high productivity and species richness. The 13-acre limestone quarry and the relocation of the water treatment plant commit resources, but benefits from either of these actions outweigh possible adverse impacts.

Alternative Z5

The potential negative impacts to wildlife include:

- New 8-acre disturbance at Goslin Flats for relocation of the water treatment plant; and
- Backfilling to original contour would eliminate artificial nesting habitat for peregrine falcons.

The potential positive impacts to wildlife include:

- Ruby Gulch tailings removal would prevent damage to wildlife habitat from erosion;
- Highest percentage (87%) of disturbed area being reclaimed to vegetation providing valuable wildlife habitat; and
- Extensive highwall reclamation increases acreage that can be revegetated.

Wildlife Mortality

Alternative Z5 has the greatest potential for wildlife mortality as a result of vehicle collisions during hauling of reclamation materials. Once reclamation is completed, wildlife mortality is expected to pre-mine negligible rates. The processing pond for the water treatment plant in Goslin Flats would be netted and fenced off to discourage wildlife from using the pond as a foraging/watering site. Existing stock ponds in the Goslin Flats area would remain operational, providing sufficient resources to meet the needs of wildlife populations.

Wildlife Habitat

Relocation of the water treatment plant to the Goslin Flats area would create 8 acres of new disturbance that would likely result in some wildlife species avoiding the area until they become accustomed to its presence, a short-term negative impact to wildlife. Backfilling the pits to original contour would eliminate artificial nesting habitat for the peregrine falcon by removing the highwalls. This action is not likely to have a negative impact on peregrine falcons because there is natural nesting habitat for the peregrine falcon within the Little Rocky Mountains. The natural nesting habitat is higher quality habitat than the artificial habitat provided by the pit highwalls. Peregrine falcons are not known to use any of these sites in recent history.

Alternative Z5 would result in 87% of the disturbance being revegetated. The resulting revegetation would have high vegetation density, diversity and sustainability providing for high value wildlife habitat.

Backfilling the Ross pit may increase water quantity into Lodgepole Creek, but positive impacts to aquatic species are offset somewhat with a slight decrease in water quality. Alternative Z5 improves aquatic habitat in Alder Spur, Carter Gulch and Ruby Gulch by improving water quality.

Cumulative impacts of Alternative Z5 would be low because reclamation would restore high value wildlife habitat. Some wildlife species would likely avoid the area of Goslin Flats once the water treatment plant is relocated there. Townsend's big-eared bat is the only sensitive status species likely to use the area. It would not be negatively affected because stock ponds in the area would not be changed by the development of the water treatment plant.

Establishment of the vegetation and its increased stability would probably result in higher productivity rates for a variety of wildlife species. The high level of reclamation success would result in the least amount of irreversible and irretrievable habitat loss. The relocation of the water treatment plant would result in a long-term use in the Goslin Flats area and a disturbance of wildlife habitat, but benefits from these actions would outweigh possible adverse impacts either might have.

Alternative Z6 (Preferred Alternative)

The potential negative impacts to wildlife include:

- Percentage of disturbance that would be reclaimed with vegetation is about the same as Alternatives Z2 and Z3, with 76% of disturbed area being revegetated.

The potential positive impacts to wildlife include:

- Revegetation density, diversity and sustainability would improve with 24 inches of growth medium cover soil that would be used to reclaimed disturbed areas; and

- No new surface disturbance.

Wildlife Mortality

Haul traffic would be somewhat lower than with Alternatives Z1, Z4 and Z5. There would not be a large potential for wildlife/vehicle collisions.

Wildlife Habitat

Alternative Z6 has a lower percentage of disturbed area revegetated with 76% of the disturbed area being revegetated, a long-term negative impact on wildlife species.

The remaining 24% would be left as cliffs and scree slopes and is not likely to have high wildlife habitat value, a long-term negative impact for wildlife. Alternative Z6 is not likely to improve aquatic habitat in Alder Spur, Carter Gulch, Ruby Gulch and Lodgepole Creek.

Areas that are reclaimed with vegetation have a fairly good probability of producing adequate habitat for a variety of wildlife species. The estimated 24% of the disturbed area that would not be revegetated has little potential to provide habitat for a wide variety of wildlife. Disturbed areas not revegetated would probably result in an irretrievable loss of wildlife habitat.

4.6.3 Landusky Mine

Alternative L1

The potential negative impacts to wildlife include:

- Development of two new limestone quarries that would result in new disturbance;
- Drainage notch in August/Little Ben pit would expose sulfides which could lower water quality in Montana Gulch; and
- Drainage channel on the west side of L85/86 leach pad would create 2 acres of new disturbance.

The potential positive impacts to wildlife include:

- 81% of disturbance area would be revegetated resulting in high value wildlife habitat.

Wildlife Mortality

The primary cause of wildlife mortality would be wildlife/vehicle collisions. Hauling a large amount of fill material for reclamation work increases haul traffic and increases the probability of wildlife mortality. Once reclamation is completed and traffic declines, wildlife mortality as a result of vehicle collisions is expected to return to pre-mine rates.

Wildlife Habitat

The two new limestone quarries would create 18 acres of new disturbances resulting in a modification of wildlife habitat that is currently intact, a short-term negative impact. Nineteen percent of the disturbed area would not be reclaimed to vegetation and would have restricted habitat values, a long-term negative impact.

The drainage notch cut in the August/Little Ben pit would expose sulfides which may decrease water quality in Montana Gulch. However, this small incremental increase in the area of sulfides exposed in highwalls would be offset, in part, by the pit floors being covered with thick layers of non-sulfide fill. The high percentage of disturbed land that would be revegetated would help offset the temporary loss of habitat from the development of the two limestone quarries. Aquatic resources in Rock Creek downstream of Montana Gulch would be maintained at current levels.

Nineteen percent of the disturbed lands would not be reclaimed to vegetation, resulting in a long-term loss of wildlife habitat. Short-term use of the project area would be limited to reclamation activities and water treatment. This would increase wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species.

The two new limestone quarries would result in altering of the topography and a change in wildlife habitat. It would not be possible to reclaim this area to pre-disturbance configuration resulting in a loss of habitat.

Alternative L2

The potential negative impacts to wildlife include:

- Only 78% of disturbance would be reclaimed to vegetation; and
- The steeper slopes on the L87/91 leach pad would make vegetation re-establishment more difficult than the 3H:1V slopes that would be used in Alternative L1.

The potential positive impacts to wildlife include:

- There would be no new disturbances for limestone quarries; and
- The highwalls would provide possible nesting habitat for peregrine falcons.

Wildlife Mortality

Reclamation haul traffic would not be as high as under Alternative L1. Wildlife mortality as a result of vehicle collisions would be considerably lower throughout the reclamation process.

Wildlife Habitat

Twenty-two percent of the disturbed area would not be reclaimed with vegetation, limiting its value as wildlife habitat. This would be a long-term negative impact.

The use of artesian well WS-3 to drain the August/Little Ben pit would eliminate the need to cut a notch in the wall to allow pit drainage. Hence additional sulfides would not be broken or exposed and water quality in Montana Gulch would be maintained. Aquatic resources in Rock Creek would be maintained with a fair chance of improvement. Heaps associated with the L87/91 leach pad would be regraded with a 2.5H:1V slope. These slopes are steeper than the average slopes in Alternatives L1, L5 and L6, making it more difficult to establish vegetative cover for wildlife habitat. Alternative L2 has the second lowest percentage of disturbed area that would be reclaimed to vegetation at 78%. The remaining 22% of the area would have a habitat value for most wildlife species below the pre-mine value.

Short-term use of the project area would be limited to reclamation activities and water treatment. The reclamation activity would result in an increase in wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species. The long-term productivity would probably not reach pre-mine levels.

Alternative L3

The potential negative impacts to wildlife include:

- The heaps on the L87/91 leach pad would be regraded to 2.5H:1V slopes making vegetation re-establishment difficult; and
- 2 additional acres would be disturbed for the Montana Gulch drainage.

The potential positive impacts to wildlife include:

- August/Little Ben pit would be drained primarily through use of artesian well WS3. The directional bore hole would ensure the pit is free draining;
- 78% of disturbed area would be revegetated; and
- Lower haul traffic than with Alternative L1 would decrease the probability of wildlife/vehicle collisions.

Wildlife Mortality

Haul traffic would not be as high as Alternative L1. Wildlife mortality as a result of vehicle collisions would be somewhat lower throughout the reclamation process which is expected to be completed in 2003.

Wildlife Habitat

Twenty-two percent of the disturbed area would not be reclaimed with vegetation. This limits the habitat value of the non-vegetated area, a long-term negative impact.

Surface water quality in Montana Gulch would be maintained and aquatic resources are likely to be maintained. The 87/91 leach pad would be regraded with a 2.5H:1V slope. These slopes are steeper than the 3H:1V slopes in Alternatives L1, L5 and L6, making it more difficult to establish vegetative cover for wildlife habitat. Alternative L3 has the lowest percentage of disturbed area that would be reclaimed to vegetation at 78%. The remaining 22% of the area would have a habitat value for most wildlife species below the pre-mine value, an unavoidable adverse impact.

Short-term use of the project area would be limited to reclamation activities and water treatment. The reclamation activity would result in an increase in wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species. Long-term productivity may not reach pre-mine levels.

Alternative L4 (Preferred)

The potential negative impacts to wildlife include:

- 19% of the disturbed area would not be revegetated;
- The heaps on the L87/91 leach pads would be regraded to 2.5H:1V slopes, making vegetation re-establishment more difficult than on 3H:1V slopes; and
- Existing reclamation on the August #2 waste rock dump would be redisturbed for backfill.

The potential positive impacts to wildlife include:

- 81% of the disturbed area would be revegetated;
- Removal of spent ore in Montana Gulch would result in an improvement in water quality which would benefit biological resources; and
- The pit floor would be backfilled and revegetated, adding useful habitat areas.

Wildlife Mortality

Haul traffic would be similar to Alternative L1. Wildlife mortality as a result of vehicle collisions would be similar to Alternative L1, but slightly higher than Alternatives L2 and L3. After reclamation activities are completed, wildlife mortalities would return to pre-mine levels.

Wildlife Habitat

The removal of the L85/86 leach pad from Montana Gulch would restore the drainage system and provide for the re-establishment of aquatic organisms in this reach of the stream. Alternative L4 has a fairly high percentage of disturbed area being reclaimed with vegetation.

Nineteen percent of the disturbed area would not be reclaimed with vegetation. This would limit the habitat value for many wildlife species to below the pre-mine value. Short-term use of the project area would be limited to reclamation activities and water treatment. The reclamation activity would result in an increase in wildlife productivity by providing increased quantity and quality of habitat available to a variety of wildlife species. Long-term productivity may not reach pre-mine levels.

Alternative L5

The potential negative impacts to wildlife include:

- 15% of the disturbance would not be reclaimed with vegetation;
- Wildlife mortality would increase due to collisions with vehicles hauling reclamation materials; and
- Existing reclamation on the August #2 waste rock dump would be redisturbed.

The potential positive impacts to wildlife include:

- Removal of spent ore in Montana Gulch would result in an improvement in water quality which would benefit biological resources;
- The August/Little Ben pit would be backfilled to be free draining and sulfide highwalls would be covered with 2H:1V slopes or flatter, resulting in additional revegetation area and improved water quality in Montana Gulch;
- The disturbed areas that are reclaimed with vegetation would provide high quality wildlife habitat with increased density, diversity and sustainability of vegetation; and
- Regrading the L87 leach pad with flatter slopes would provide a base for establishing revegetation more valuable to wildlife.

Wildlife Mortality

Haul traffic would be considerably higher with this alternative than it would be with Alternatives L2 and L3 but only slightly higher than Alternatives L1 and L4. The increase in haul traffic would increase the probability of wildlife mortality due to vehicle/wildlife collisions. Once reclamation activities are completed, wildlife mortalities should return to pre-mine rates.

Wildlife Habitat

Fifteen percent of the disturbed area would not be reclaimed with vegetation. This limits the habitat value of the non-vegetated area, a long-term negative impact.

Approximately 85% of the disturbance area would be revegetated, providing wildlife habitat. Backfilling the August/Little Ben pit to be free draining and covering sulfide highwalls could improve the surface water quality in Montana Gulch. The condition of aquatic resources in Rock Creek downstream of Montana Gulch may improve slightly with increased water quantity and improved water quality in Montana Gulch. There would also be a greater potential for increased groundwater contamination due to the acid generating character of the backfill. This leachate could migrate into southern drainages, decreasing water quality and impacting aquatic resources.

Fifteen percent of the disturbed area would not be revegetated resulting in a long-term loss of wildlife habitat. Reclamation activities and water treatment would increase wildlife productivity by providing increased quantity and quality of habitat available to wildlife species.

Alternative L6

The potential negative impacts to wildlife include:

- A decrease in surface water quality due to leaching of backfill in upper Swift Gulch, King Creek, and Montana Gulch; and
- Wildlife mortality due to vehicle collisions associated with hauling of reclamation materials would be the highest with this alternative.

The potential positive impacts to wildlife include:

- 92% of the disturbed area would be revegetated, providing high quality wildlife habitat to a variety of species;
- Removal of spent ore in Montana Gulch would result in an improvement of water quantity and quality which would benefit biological resources;
- Backfill of the August/Little Ben pit to original topography allowing it to be free draining restores surface drainage patterns and improves habitat for aquatic species; and
- L87/91 leach pad regrade would provide a stable, diverse topography suitable for revegetation to high quality wildlife habitat.

Wildlife Mortality

Potential wildlife mortality as a result of vehicle/wildlife collisions would be highest with this alternative due to the high level of haul traffic. Once reclamation is completed, and traffic declines, wildlife mortality as a result of vehicle collisions would return to pre-mine levels.

Wildlife Habitat

This alternative would result in the lowest loss of wildlife habitat. Some 92% of the mine disturbance would be revegetated. Water quality in King Creek, upper Swift Gulch, and Montana Gulch may be impacted by leaching of the backfill which would locally impact aquatic resources. Complete backfilling and contouring to pre-mine topography would result in the loss of a small amount of artificial nesting habitat for the peregrine falcon. This would not affect peregrine falcons because the Little Rocky Mountains contain

a significant amount of natural nesting habitat for the peregrine falcon and peregrine falcons have not been observed nesting in the Little Rockies in recent history.

Alternative L6 is designed to obtain "full restoration" by complete backfilling and contouring to pre-mine topography. Removal of spent ore in Montana Gulch would improve surface water quality. Possible leaching from backfills may degrade surface water quality in King Creek, Montana Gulch and upper Swift Gulch, resulting in decreased habitat for aquatic species. Still, Alternative L6 offers the greatest protection of wildlife resources. Ninety-two percent of the disturbed area would be revegetated, providing the greatest amount of high value wildlife habitat for a wide variety of species.

The high level of restoration would result in the least amount of impacts to wildlife habitat. Aquatic habitat may remain at the intermediate level in King Creek, Montana Gulch and upper Swift Gulch due to the possibility of leaching of the backfills. Reclamation activities and water treatment would result in the greatest amount of wildlife productivity by providing increased quantity and quality of habitat available to wildlife species.

4.7 AIR QUALITY

4.7.1 Methodology

Air quality impacts were assessed for each alternative by comparing estimated levels of air pollutants from the reclamation activities with the National Ambient Air Quality Standards (NAAQS). NAAQS were selected as the criteria because they represent enforceable standards under State of Montana and Federal regulations and because this was the standard used in the 1996 FEIS. The impacts are compared to the average 24-hour (150 mg/m^3) and the average annual (50 mg/m^3) standards for respirable particulate matter less than 10 microns in size (known as "PM_{10}"), which is the pollutant of most concern due to the dust generated by truck traffic and other reclamation activities.

Information from nine years of air quality monitoring in and around the Zortman and Landusky Mines, plus the assessments of the various reclamation alternatives provided in Section 4.6 of the FEIS, have been used to predict the impacts that would occur under each alternative. At the Zortman Mine the historical air quality data provides only a partial year of data during active mining. However, air quality data from the Landusky Mine provides six years of information while mining at various production rates and three years of post-mining data. The monitoring stations used to collect this information were located inside the towns of Zortman and Landusky. Because dust is generated by truck traffic, blasting, and grading under past mining or future reclamation scenarios, the impacts are comparable for similar production rates.

Projected impacts under Alternative 3 in the FEIS were used as reference values in this analysis because Alternative 3 is representative of SEIS Alternatives Z1 and L1. Much of the impact anticipated under FEIS Alternative 3 was the result of hauling quantities of soil, subsoil, gravels, and other non-acid generating rock up to the mine through the town of Zortman. Most of the SEIS alternatives do not have this requirement, so it represents a conservative analysis. Air quality impacts are projected for the reclamation work remaining under each alternative and do not include emissions from the interim reclamation work that has already occurred.

Sensitive Receptors

As in the 1996 FEIS, the towns of Zortman and Landusky were selected as the sensitive receptor locations for the analyses. They were chosen because of their proximity to the reclamation activities, population potentially affected, and location on routes used to deliver reclamation materials.

Impact Significance

Section 4.6.5.1 of the FEIS (Alternative 3) projected that the concentrations of PM_{10} dust impacting the towns of Zortman and Landusky would be below the applicable federal and state ambient air quality standards. The impacts were rated as having a low magnitude and were not considered significant. Because the major impacts of hauling thousands of truck loads of reclamation material though the towns

of Zortman and Landusky were eliminated under most of the alternatives in the SEIS, none of the Zortman Mine reclamation alternatives would approach even this level of impact. Only the Landusky Mine reclamation Alternative L6, which projects a modest 4 mg/m^3 increase over the highest 24-hour levels in Alternative 3 of the FEIS, would have a greater projected impact. Consequently, none of the alternatives for reclamation of either the Zortman or Landusky Mines would have a significant impact on sensitive receptors.

The analysis assumed that reclamation activities under all alternatives would occur 220 days per year. This would result in higher daily production rates than a year-around operation. Consequently, more equipment would need to be operated on scheduled work days to accomplish the reclamation tasks within the time limits defined under the alternatives. It should be noted that in 1996, ZMI had received an air quality permit for the Zortman Mine, to mine at the rate of 28 million tons per year with a 350-day-per-year operation. This was an approved increase from the previous permitted production level of 4,686,500 tons per year.

Historical Air Quality Records

Table 4.7-1 presents PM_{10} air quality data on a yearly basis from 1990 through 1998. The table also provides mine production data covering this period. The Zortman Mine ended active mining in 1990 while the Landusky Mine continued to operate into 1996. The Landusky Mine was mined at a rate of 20 to 25 million tons per year.

4.7.2 Zortman Mine

Projected impacts to PM_{10} air quality are presented by alternative in Table 4.7-2 . The projected 24-hour values and annual values are accompanied by production rate and duration in years. The impacts under all alternatives are of low magnitude and are not significant. Alternative Z1 would have a marginally higher impact than Alternatives Z2, Z3, Z4, or Z6. Although Alternative Z5 has greater overall production requirements, the reclamation would be spread over a longer period, resulting in similar air quality impacts that would affect the town of Zortman over a longer period.

Table 4.7-1. Historical Air Quality Data

Landusky Mine - Historical Air Quality as Monitored at Landusky Townsite									
	1990	1991	1992	1993	1994	1995	1996	1997	1998
PM-10 Suspended Particulates ug/m^3									
Highest 24-Hour	31	35	96	30	75	50	29	34	82
Second Highest 24-Hour	25	32	37	27	55	40	27	31	37
Annual (Average)	13	10	10	10	15	10	8	9	8
Landusky Mine Ore + Waste Production									
Tons x 1000 Per Year	17,453	20,281	18,826	20,834	25,808	17,721	347		
Tons Per Day at 350 Days/Year	49,866	57,946	53,789	59,526	73,737	50,631			

Zortman Mine - Historical Air Quality as Monitored at Zortman Townsite									
	1990	1991	1992	1993	1994	1995	1996	1997	1998
PM-10 Suspended Particulates ug/m^3									
Highest 24-Hour	42	35	102	28	35	23	33	26	55
Second Highest 24-Hour	34	31	29	21	34	21	30	24	49
Annual (Average)	15	9	9	9	11	8	8	8	11
Zortman Mine Ore + Waste Production									
Tons x 1000 Per Year	Periodic								
Tons Per Day at 350 Days/Year	Periodic								

Table 4.7-2. Zortman Mine - Projected Air Quality at Zortman Townsite

	Avg. Mining 1980-1989	FEIS Alt. 3 Projected	Alt. Z1	Alt. Z2	Alt. Z3	Alt. Z4	Alt. Z5	Alt. Z6
Zortman Mine Ore + Waste Production								
Total Tons x 1000 Handled	33,395	15,885	6,395	915	1,166	6,167	13,647	5,615
Years	10	4	3	1	1	4	6	3
Tons Per Day	15,180	18,051	9,690	4,158	5,298	7,008	10,338	3,962
Assume 220 days per year								
PM-10 Suspended Particulates ug/m^3								
Highest 24-Hour		130	90	75	75	80	90	75
Annual (Average)		13	14	12	12	14	14	12
Background								
Highest 24-Hour	42	30	42	42	42	42	42	42
Annual (Average)	10	9	10	10	10	10	10	10
Impact								
Highest 24-Hour		100	48	33	33	38	48	33
Annual (Average)		4	4	2	2	4	4	2
Standard								
Highest 24-Hour	150	150	150	150	150	150	150	150
Annual (Average)	50	50	50	50	50	50	50	50

4.7.3 Landusky Mine

Projected impacts to PM_{10} air quality are presented by alternative in Table 4.7-3. The projected 24-hour values and annual values are accompanied by production rate and duration in years. The impacts under all alternatives are of low magnitude and are not significant. Alternative L1 would have a marginally higher impact than Alternatives L2, L3, or L4. Alternatives L5 and L6 have somewhat greater air quality impacts that would affect the community of Landusky over a longer period. Reclamation requirements under Alternative L6 are much greater than any of the other alternatives. Hence, the air quality impacts and duration are correspondingly greater. Because the Alternative L6 material handling requirements are similar to the average production in the last six years of mining at the Landusky Mine, the PM_{10} levels would also be similar.

Table 4.7-3. Landusky Mine - Projected Air Quality at Landusky Townsite

	Avg. Mining 1990-1995	FEIS Alt. 3 Projected	Alt. L1	Alt. L2	Alt. L3	Alt. L4	Alt. L5	Alt. L6
Landusky Mine Ore + Waste Production								
Total Tons x 1000 Handled	120,922	19,410	17,142	6,710	7,398	11,328	29,375	88,339
Years	6	4	4	3	3	4	5	8
Tons Per Day	57,582	22,057	19,480	10,167	11,209	12,873	26,705	50,192
Assume 220 days per year								
PM-10 Suspended Particulates ug/m^3								
Highest 24-Hour	96	61	50	45	45	45	55	65
Avg. High All Years	45							
Annual (Average)	12	17	13	12	12	12	14	15
Background								
Highest 24-Hour	30	30	30	30	30	30	30	30
Annual (Average)	8	9	8	8	8	8	8	8
Impact								
Highest 24-Hour	66	31	20	15	15	15	25	35
Annual (Average)	4	8	5	4	4	4	6	7
Standard								
Highest 24-Hour	150	150	150	150	150	150	150	150
Annual (Average)	50	50	50	50	50	50	50	50

4.8 LAND USE

Impacts Common to All Alternatives

Public Land Order 7464 (PLO) created a locatable mineral withdrawal on 3,530.62 acres of public lands in the Little Rocky Mountains. The purpose of the withdrawal is to facilitate reclamation activities being conducted by the State of Montana and the BLM at the Zortman and Landusky mines. The withdrawal is for a period of 5 years beginning October 5, 2000 and ending on October 4, 2005. The beneficial impact of the withdrawal is the protection of the reclamation activity from conflicts with potential mineral operators who may have tried to proceed with development activity simultaneously with the reclamation work. The negative impact of the withdrawal is that it removes high potential mineral lands from future development for five years. Both of these impacts are short term.

The 14 communication rights-of-way on the Antoine Butte communication site adjacent to the mining area would not be impacted in the long term by any of the alternatives, provided that an access road is left to the Antoine Butte communication site. Short-term disruption in the power supply to the communication systems may occur during blasting for highwall reduction or road construction.

No grazing leases have been issued by BLM in the Little Rocky Mountains or near the Zortman and Landusky Mines. None of the alternatives would affect livestock grazing on public lands. The disposal of leach pad solutions at the Goslin Flats land application area would both positively and negatively impact private livestock grazing on these lands. The positive impact would be the increased amount of forage available to livestock as a result of spray irrigation during what would normally be dry summer range conditions. The potential negative impact would be the accumulation of constituents in plant tissue such as selenium that would be harmful to livestock. The pending addition of the biological treatment circuit for selenium removal and the implementation of the land application monitoring and management program would reduce the negative impacts to a negligible level.

Upon completion of reclamation, the area would be open to hiking, hunting, vegetation gathering and other public land uses with certain restrictions which are common to all recreational activities (see also Section 4.9, Recreation and Visual Resources). This would be a positive impact to land use which previously was dedicated to mining. Also, upon completion of the reclamation and expiration of the locatable mineral withdrawal, the area would be available for location under the Mining Law, which would be consistent with the BLM Resource Management Plan (BLM 1992).

4.9 RECREATION and VISUAL RESOURCES

4.9.1 Impacts Common to All Alternatives

Recreation Resources

The benefits to recreation include the benefits of tourism and outdoor recreation, tourism trends, and adding value to tourism sites. The scars left from the open pit mining operations would remain visible to varying degrees, depending upon the amount of reclamation used to rebuild the mountains and fix the visual impacts. While these open pits and their associated visual impacts would reduce the types of recreation experiences that depend upon unblemished scenery, at the same time they present an opportunity for other recreation experiences. Adding value to tourism consists of providing authentic experiences to visitors, which in this case can mean providing interpretive opportunities to provoke, relate, and reveal the whole story that may be told about mining in this area. People are curious and want to see and learn about how a mine works, and they want to see gold ore, understand the process of extracting gold from rock, and observe the results of the reclamation efforts. In this sense, the impacts on recreation would be more of a change in the type of recreation opportunities and visitors than a loss or addition to overall recreation use.

The overall public safety concern is represented by the amount of areas with pit highwalls, the height of those highwalls, and their stability or tendency for rockfall. Potential risks to visitor safety would be reduced by erecting physical barriers such as berms to prevent access to highwall areas by vehicles. Signs and road closures would minimize public access to safety hazards in the pit areas. The future use of roads and off-highway vehicle use in the area would be subject to determinations made through the BLM planning process under the interim guidance described in the Off-Highway Vehicle EIS/Plan Amendment (BLM 2001).

Visual Resources

The assessment of visual impacts is based upon the impact significance criteria and methodology developed in the BLM's visual contrast rating system. The degree to which project facilities would impact the scenic qualities of the landscape depends on the amount of visible contrast created by project facilities in relation to the existing landscape character. The amount of contrast between reclamation efforts and project facilities, and the existing landscape features is defined by an analysis of each of the basic visual elements present in the landscape (line, form, color and texture).

Two key issues determine the level of visual contrast. These include the type and extent of actual physical contrast brought about by the mining project, and the visibility of the proposed reclamation project activities to sensitive viewpoints within the study area. The type of physical contrast is determined by evaluating the following criteria: scale differential, spatial dominance, landforms, soil color, landscape diversity, structural compatibility, and vegetation patterns. Scale differential refers to the proportionate size of project components relative to the surroundings in which they are placed. Spatial dominance is related to scale and

refers to the prominence of project components within the landscape. Variables considered in evaluating visibility of facilities included viewer orientation, view distance, duration of view, lighting conditions, topographic and/or vegetation screening, and viewer sensitivity.

The significance of impacts are evaluated by examining the visual contrasts brought about by existing facilities and reclamation proposals, and how those contrasts affect the following: the quality of any scenic resource; scenic resources of rare or unique value; views from (or the visual setting of) parks, wilderness areas, natural areas, or other sensitive land use; views from (or the visual setting of) travel routes, including roads and trails; and views from (or the visual setting of) established or planned recreational, educational, scientific or preservational facility or use areas.

Sensitive viewpoints within the study area, termed Key Observation Points (KOPs), were selected as representative views from travel routes, recreational areas, residential areas, and views from several sites of significance to American Indians. A total of 21 KOPs were mapped within the study area (see Figure 4.8, FEIS). The adjoining Table 4.8-1 (FEIS) describes significant visibility characteristics of the KOPs and results of the visibility analysis from each KOP. Visibility of various proposed reclamation efforts and facilities from the KOPs were analyzed through the examination of aerial photographs, 7.5 min. topographic maps, site visits, photographs taken from the KOPs, and computer visibility models.

In addition to the visibility analysis, photographic simulations of reclaimed facilities were prepared from selected viewpoints. Simulations are from viewpoints with representative views from recreation areas, travel routes and areas traditionally used by American Indians, and display the existing view and views with the proposed reclamation activities. These simulations were presented in Appendix D of the Draft EIS (BLM 1995).

Modern mining began at the Zortman and Landusky mines in 1979. At that time, surface disturbance associated with historic mining activity was visible in Alder and Ruby Gulches near Zortman, and in the area surrounding Gold Bug Butte near Landusky. Visual contrasts were evident in the landscape, caused by road building, surface mining, adits, waste rock and tailings. However, these disturbances were on a relatively small scale and the area could still be characterized as being generally natural appearing, except in a few localized areas. Historic mining had disturbed approximately 54 acres in the vicinity of the Zortman and Landusky Mines. Views of the disturbed areas were generally confined to a small local viewshed, and were not noticeable from the main roads surrounding the Little Rocky Mountains.

In 1979 the visual resources of the Little Rocky Mountains were evaluated by the BLM using the Visual Resource Management (VRM) methodology. The scenic quality of the area was classified as A scenery (the highest rating), and was given a VRM Class II rating. Objectives for Class II landscapes call for the retention of the existing character of the land. Changes in the landscape should be low and not attract attention.

Currently, there are approximately 400 acres of disturbance at the Zortman Mine and over 800 acres of disturbance at the Landusky Mine. This includes disturbance from open mine pits, heap leach pads, waste rock storage, roads, topsoil stockpiles, processing areas and other ancillary facilities/disturbance areas. Impacts to the scenic quality of the area have been significant.

Open pit mining has caused major changes in landforms, creating sharp contrasts in the line, form, color and textures visible in the landscape. Areas where rock and soil have been exposed contrast with color and texture of the surrounding natural vegetation. Unnatural looking landforms have been created by the excavation of the mine pits, and by the large heap leach pads and waste rock dumps. Roads, especially the downhill sidecast along the roads, create color and line contrasts visible for miles from the mine sites. Benches along the highwall create strong geometric lines and forms that contrast with the characteristic lines and shapes naturally occurring mountain landscapes. The scale of the disturbance dominates the viewers attention.

The visual contrasts created by the Zortman Mine are visible from many of the surrounding peaks and buttes, including Old Scraggy Peak and Saddle Butte, both of which are used by recreationists for hiking, picnicking and wildlife viewing, and by American Indians for cultural purposes. Although portions of the disturbed areas at the Zortman Mine can be seen from several high viewpoints surrounding the mine, much of the disturbance is topographically enclosed and not visible from lower vantage points. The Landusky Mine has twice the amount of disturbed acres as the Zortman Mine, and is visible not only to high points surrounding the mine, but to viewpoints as far away as the Missouri Breaks Back Country Byway, located over 20 miles south of the mine. Closer to the project area, mine facilities can be seen by travelers along U.S. Highway 191 and State Highway 66. The current disturbance at both the Zortman and Landusky Mines is not compatible with the scenery management objectives of VRM Class II landscapes.

Impacts to the visual resource values have been analyzed in the FEIS (March 1996) for reclamation without further mine expansion under Alternatives 1,2 and 3 in that document. Potential impacts to the visual resources from the alternatives considered in this SEIS are similar to those previously addressed in the FEIS with the exception of the full restoration and backfill proposals. Thus, Alternatives Z1, Z2, Z3 and Z6, and L1, L2 and L3 would have impacts to visual resources similar to those described for Alternatives 1, 2 and 3 in the 1996 FEIS.

SEIS Alternatives Z4, Z5 and Z6, and L4, L5 and L6 provide additional backfill that would reduce the mines' visual impact on the landscape by providing a greater surface area for revegetation. A slight negative impact would be the additional time needed to complete the reclamation work.

Appendix E contains topographic simulations of the mining areas under existing conditions and upon completion of the reclamation alternatives. While these simulations do not show color contrast, they do reveal differences in overall topography form and line.

4.9.2 Zortman Mine

Alternative Z1

Recreation

The highwalls would present a safety hazard to visitors despite the barriers erected to alert visitors to the danger. Removal of the tailings and restoration of Ruby Gulch would improve tourism potential in and around the Zortman area. Moving the county road back to original roadbed would restore original access and connect the towns of Landusky and Zortman. Revegetation would enhance hunting opportunities after final reclamation.

Visual Resources

This alternative is the same as Alternative 3 in the 1996 FEIS. It is important to note that the scenic resources of the area have already been degraded by past mine development and would only be improved by reclamation.

Revegetation of mine facilities would mitigate much of the color contrasts caused by the exposed rock and soil. In areas where revegetation is not successful, bare soil would be exposed and the landscape would continue with the visual contrasts that currently exist.

Visual contrasts would be reduced with the placement of the reclamation covers. This would produce revegetation on all mine disturbances except inaccessible pit walls and benches. Some mine benches that are reclaimed could be reacidified by pitwall runoff, thereby reducing the color contrasts caused by exposed soil. The alteration of topography caused by mine pits and the large man-made landforms caused by the heap leach and waste rock facilities would be apparent, even after reclamation. Visual contrasts resulting from the failure of reclamation to establish ground cover in some areas, the contrasts in landforms, and the visual scar left by the pit highwalls would attract attention from several sensitive viewpoints, causing long-term significant negative impacts to the visual resources of the southern Little Rocky Mountains. These impacts would be very noticeable to travelers along US Highway 191 and the Seven Mile county road south of Zortman. Pit highwalls, landform contrasts, and contrasts in vegetation pattern and textures would still be evident in the landscape after reclamation, and would cause significant long-term impacts to close-in viewpoints. VRM Class II objectives would be met from the more long-distance viewpoints, but would not be met from close-in viewpoints, mostly due to the result of the color and form contrasts of pit highwalls, engineered benches used for drainage on waste rock dumps and heap leach pads, and other topographic variations produced by manmade structures. A topographic simulation of the landscape after reclamation is shown in Figure E-2. Working toward a natural landscape appearance with the contouring and revegetation efforts over the next two years would be a positive impact compared to existing conditions.

Alternative Z2

Recreation

This alternative would revegetate the least percentage of the disturbed area. This is the best alternative upon which to develop an interpretive program on the area mining; its culture, history, social aspects, and environmental factors. Hunting opportunities would be dependent on the minimal vegetation. Tailings in Ruby Gulch remain a concern for tourism potential in and around the Zortman area. The highwalls would pose a safety hazard to visitors.

Visual Resources

With reclamation efforts to be completed in 2001, the existing negative impacts would be shorter in duration than in Alternative Z1, while the positive reclamation impacts would be similar.

The water treatment plant and ancillary facilities in Goslin Flats would be located in what is now pasture land. Visual impacts from the facilities would include moderate form and color contrasts created by the introduction of a geometric shape which would be incongruous with any natural features found in the surrounding landscape along Goslin Flats. Structures associated with the water treatment plant would introduce additional line and form contrasts. This would be a negative impact.

A topographic simulation of the landscape after reclamation is shown in Figure E-3.

Alternative Z3

Recreation

Impacts on recreation resources would be similar to Alternative Z2.

Visual Resources

Reclamation impacts would be similar to those described for Alternative Z2, except that the visual contrasts associated with the water treatment plant and ancillary facilities on Goslin Flats would not occur. A topographic simulation of the landscape after reclamation is shown in Figure E-4.

Alternative Z4

Recreation

This alternative would reduce the highwall safety hazard for visitors significantly and enhance the tourism potential of the area.

Visual Resources

Reclamation would reduce the visual impacts at the Zortman Mine by partially backfilling the pits, leaving some highwalls partially exposed. This would partially restore the visual landscape to its pre-1979 condition. A topographic simulation of the landscape after reclamation is shown in Figure E-5. The revegetation of this area would be a positive impact for the visual zones. The additional earthwork would lengthen the reclamation period, but only until 2004, a slight short-term negative impact.

Alternative Z5

Recreation

Impacts would be similar to Alternative Z4. The complete backfilling of the pits and high quality revegetation would provide for high value wildlife habitat. This would greatly enhance hunting opportunities. This alternative would be the most aesthetically pleasing to tourists who seek naturalness as a value in recreation opportunities. It would also present the least risk from a safety perspective by covering the pit highwalls.

Visual Resources

Reclamation would reduce the visual impacts at the Zortman Mine by backfilling the pits and eliminating the highwalls as a source of visual impact. This would restore the visual landscape to its pre-1979 condition, although there would still be color and line contrasts. The revegetation of a larger area would also be a positive impact for the visual zones. The additional earthwork would lengthen the reclamation period, but only until 2006, a short-term negative impact. This alternative would result in the greatest reduction of the visual impacts created by the Zortman Mine. A topographic simulation of the landscape after reclamation is shown in Figure E-6.

Alternative Z6 (Preferred Alternative)

Recreation

Impacts on recreation would be slightly more positive than those described for Alternative Z3. The additional backfill would reduce the amount of highwall that could present a safety concern, although enough would remain that a risk would still be present. If visitors ignored the barriers and warning signs, injury could result. Revegetation would provide additional wildlife habitat and hunting opportunities. The removal of some tailings from Ruby Gulch for use in reclamation would improve the conditions in this drainage and may have a slight positive impact on the tourism potential of the area.

Visual Resources

Reclamation would reduce the visual impacts at the Zortman Mine by backfilling the lower portions of the pit highwalls in the Alabama and Ross pits. This would partially restore the visual landscape to its pre-1979 condition. A topographic simulation of the landscape after reclamation is shown in Figure E-7. The revegetation of a larger area would be a positive impact for the visual zones. The additional earthwork would lengthen the reclamation period, but only until 2003, a slight short-term negative impact. Alternative Z6 would reduce the visual impacts from the Zortman Mine better than Alternative Z3, but not as well as Alternatives Z4 and Z5.

4.9.3 Landusky Mine

Alternative L1

Recreation

Revegetation would result in fairly high value wildlife habitat which would enhance hunting opportunities. The highwalls would still pose a hazard for visitors that ignored the warning signs and obstructions. The naturalness of this area would improve slightly.

Visual Resources

This alternative is the same as Alternative 3 in the 1996 FEIS. It is important to note that the scenic resources of the area have already been degraded by past mine development and would only be improved by reclamation.

Revegetation of mine facilities would mitigate much of the color contrasts caused by the exposed rock and soil. In areas where revegetation was not successful, bare soil would be exposed and the landscape would continue with the visual contrasts that currently exist.

Visual contrasts would be reduced by placement of the reclamation covers. This would produce revegetation on all mine disturbances except mine highwalls. The alteration of topography caused by mine pits and the large manmade landforms caused by the heap leach and waste rock facilities would be apparent, even after reclamation. Visual contrasts resulting from the failure of reclamation to establish ground cover in some areas, the contrasts in landforms, and the visual scar left by the pit highwalls would attract attention from several sensitive viewpoints, causing long-term significant negative impacts to the visual resources from the south and west of the Little Rocky Mountains. These impacts would be very noticeable to travelers along US Highway 191 and State Highway 66. They would also be noticeable from the Fort Belknap community of Hays, and from the Pow Wow grounds in Mission Canyon. Pit highwalls, landform contrasts, and contrasts in vegetation pattern and textures would still be evident in the landscape after reclamation, and would cause significant long-term impacts to close-in viewpoints at the Landusky

Mine. VRM Class II objectives would be met from the more long-distance viewpoints, but would not be met from close-in viewpoints, mostly due to the result of the color and form contrasts of pit highwalls, engineered benches used for drainage on waste rock dumps and heap leach pads, and other topographic variations produced by manmade structures. A topographic simulation of the landscape after reclamation is shown in Figure E-9. Working toward a natural landscape appearance with the contouring and revegetation efforts over the next four years would be a positive impact compared to existing conditions.

Alternative L2

Recreation

Approximately one-fourth of the disturbed area would not be revegetated. This area would not be as conducive for wildlife as other alternatives and would have slightly lower hunting opportunities than adjacent lands. The pit highwalls would present a hazard for visitors. If they ignored the warning signs and obstructions, injury could result.

Visual Resources

Reclamation at the Landusky Mine would result in a reduction in visual impacts similar to that described for Alternative L1. A topographic simulation of the landscape after reclamation is shown in Figure E-10.

Alternative L3

Recreation

Impacts from Alternative L3 would be similar to those described for Alternative L2.

Visual Resources

Reclamation at the Landusky Mine would result in a reduction in visual impacts similar to that described for Alternative L1. A topographic simulation of the landscape after reclamation is shown in Figure E-11. The highwall reduction through blasting would improve the appearance of the pit highwalls from the more distant viewpoints.

Alternative L4 (Preferred Alternative)

Recreation

There would be fewer pit highwalls than in Alternatives L1, L2 and L3. The remaining highwall would still present a hazard for visitors. Removal of the L85/86 leach pad would remove a contaminant source that

could impact the water in Montana Gulch, which flows through the BLM campground. This would be a slight positive impact to recreation use in the campground.

Visual Resources

Impacts to visual resources would be reduced over that achieved under Alternatives L1 through L3. The additional backfill of the pit area and the covering of about 85% of the sulfides exposed in the pit highwalls would reduce the visual contrast considerably over present conditions. Removal of the L85/86 leach pad from Montana Gulch would re-create the more natural drainage pattern and reduce the existing visual contrast considerably, although this would be evident only to local observers. The highwall blasting would improve the appearance of the pit highwalls from the more distant viewpoints. A topographic simulation of the landscape after reclamation is shown in Figure E-12.

Alternative L5

Recreation

The amount of highwall would be reduced by the backfilling, although what highwall remained would present a hazard for visitors. There would be more vegetative cover in the pit areas adjacent the highwalls. The increased vegetative cover would further restore and enhance wildlife habitat, thereby enhancing hunting opportunities. One negative impact from the amount of reclamation work is the noise, dust, and vehicle use in the area. This would impinge upon visitors' perceptions of naturalness and solitude during the approximately five years reclamation work would be active. This would be a short-term impact.

Visual Resources

The backfill would provide more area for vegetative cover which, in turn, would decrease the existing visual contrasts of form and color. Covering the highwalls would reduce the strong visual contrasts as viewed from great distances. These would be positive impacts and Alternative L5 would result in greater reduction in impacts than Alternatives L1 through L4. Removal of the L85/86 leach pad from Montana Gulch would re-create the more natural drainage pattern and reduce the existing visual contrast considerably, although this would be evident only to local observers. A topographic simulation of the landscape after reclamation is shown in Figure E-13. A minor negative short-term impact is that the reclamation work would require five years to complete.

Alternative L6

Recreation

Backfilling to the approximate pre-mining topography would eliminate the highwalls as a hazard to area visitors. The backfill would provide a surface for maximum vegetative cover, and forage and habitat for

wildlife. This would enhance hunting opportunities in the area. This alternative best restores the naturalness of the area and would be a positive impact for visitors seeking solitude-oriented recreation. It would also erase most of the evidence of mining activity and the opportunity for development of interpretive programs on this activity. One negative impact from the amount of reclamation work is the noise, dust, and vehicle use in the area. This would impinge upon visitors' perceptions of naturalness and solitude during the approximately eight years reclamation work would be active. This would be a short-term impact.

Visual Resources

This alternative would result in the greatest reduction of the visual impacts created by the Landusky Mine. It is also the only alternative that would remove the visual impact of the upper highwalls as seen from State Highway 66, and from near the community of Hays and the Pow Wow grounds on the Fort Belknap Reservation. Complete backfilling of the pits would eliminate the visual contrast of the pit highwalls. The backfill would also provide additional surface for revegetation which would reduce the color contrasts. A topographic simulation of the landscape after reclamation is shown in Figure E-14. A negative short-term impact is that the reclamation work would take eight years to complete, three years longer than Alternative L5 and twice as long as Alternative L4.

4.10 CULTURAL RESOURCES

4.10.1 Impacts Common to All Alternatives

Impacts to cultural resources from reclamation without further mine expansion were analyzed in the 1996 FEIS. None of the alternatives in this SEIS involve additional ground disturbance beyond what was considered in the FEIS. Consequently, potential impacts to cultural resources from the alternatives considered here are very similar to the reclamation-only alternatives previously analyzed in the FEIS. Specifically, Alternatives Z1 through Z3, and L1 through L3 are variations of Alternatives 1through 3 in the 1996 FEIS, while Alternatives Z4, Z5, Z6, L4, L5 and L6 involve additional pit backfill.

All of the reclamation alternatives would aid in restoration of the area to pre-1979 conditions to varying degrees. It is assumed that restoration to pre-1979 conditions would facilitate restoration of pre-1979 uses of the area, including traditional American Indian practices. All of the alternatives would, therefore, be a significant improvement over the existing conditions. However, all of the alternatives still involve the creation of a post-mining landscape. The mountains could not be restored to their pre-1979 condition under any alternative, though the additional backfill alternatives would bring it closest to that condition.

The additional backfill alternatives would better obscure the open pit mine and create a more "natural" appearing landscape. Additional backfilling would also provide more surface for revegetation, although the increased acreages are not great. It is assumed that a revegetated, more natural appearing landscape would better provide for restoration of traditional American Indian uses of the area. However, it is also recognized that the distinction between a natural and reclaimed landscape may be important to some individuals, limiting the full restoration of pre-mining uses of the area.

The additional backfill alternatives would require more time to complete. The additional time to complete reclamation is considered a minor negative impact which is generally offset by the increased acreage suitable for revegetation and the decreased visual impact.

4.10.2 Zortman Mine

Alternative Z1

This is the same as Alternative 3 in the FEIS. Reclamation of the disturbance caused by large-scale modern mining may restore some areas to pre-1979 uses, including traditional American Indian spiritual practices. This would be especially true for areas adjacent to, but not disturbed by past mining.

The natural setting and general solitude that existed prior to large-scale modern mining would begin to return with the cessation of mining. These characteristics are necessary for fasting (McConnell 1990). Hastening the progression back to a natural landscape with contouring and revegetation would be a positive impact compared to no reclamation. This positive impact of facilitating the return to a more natural

landscape relates to its return to pre-1979 traditional uses. This alternative would result in revegetation of 83% of the mine disturbance.

There would, however, be a short-term impact to solitude resulting from the heavy equipment and general increased activity associated with reclamation. Reclamation would be complete in 2003. This short-term impact would be minor.

Alternative Z2

Alternative Z2 is similar to Alternative Z1, except most reclamation would be completed in 2001 and only 76% of the mine disturbance would be revegetated. Negative impacts associated with reclamation would, therefore, be shorter in duration than under Alternative Z1 with comparable positive impacts.

Alternative Z3

Impacts from Alternative Z3 would be similar to Alternative Z2, except there would be no additional disturbance on Goslin Flats related to relocation of the water treatment plant.

Alternative Z4

This alternative includes more of both the positive and negative impacts of Alternatives Z1, Z2 and Z3. Additional backfilling and contouring would better restore the area visually to pre-1979 conditions. Revegetation of a larger area would be an added positive impact of this alternative. Gathering of certain plants is a traditional use, and more area to support these plants could be a beneficial impact. This alternative would revegetate 84% of the mine disturbance.

Additional earthwork would take longer to complete than under Alternatives Z1, Z2 and Z3, so short-term impacts to solitude would be of greater duration. This short-term impact would still be minor since reclamation would be complete by 2004.

Alternative Z5

Alternative Z5 is similar to Alternative Z4. This alternative would be the closest to returning the mine area to pre-1979 conditions. Mine disturbance would be 87% revegetated. However, the mountains would still be a reclaimed, rather than a natural landscape. This distinction may be important to some individuals. Additionally, reclamation would not be complete until 2006. So, the minor negative impact of reclamation would be two years longer than under Alternative Z4, three years longer than under Alternative Z1, and five years longer than under Alternatives Z2 and Z3. Even so, this alternative would be most conducive to restoring pre-1979 conditions and uses in the area.

Alternative Z6 (Preferred Alternative)

This alternative combines features of both Z3 and Z4. As such, its impacts are similar to Alternatives Z3 and Z4. There would be a significant improvement in the existing situation, but slightly less beneficial than Alternative Z4.

4.10.3 Landusky Mine

Alternative L1

This is the same as Alternative 3 in the FEIS. Reclamation of the disturbance caused by large-scale modern mining may restore some areas to pre-1979 uses, including traditional American Indian spiritual practices. This would be especially true for areas adjacent to, but not disturbed by past mining. Reclamation would be complete by 2004, with 81% of mine disturbance revegetated.

Alternative L2

Alternative L2 is similar to Alternative L1, but reclamation would be complete in 2003 with 78% of mine disturbance revegetated. Consequently, negative impacts associated with reclamation (noise, dust and increased human activity) would be one year shorter in duration than for Alternative L1, but at the cost of slightly less revegetation.

Alternative L3

Impacts from Alternative L3 would be similar to Alternative L2. There would be slightly more highwall reduction in Alternative L3 which would reduce the visual impacts.

Alternative L4 (Preferred Alternative)

Alternative L4 would revegetate 84% of the mine disturbance. Blasting and backfilling would reduce the visual impacts of the pit highwalls. Suitability for traditional practices in the mine area would remain somewhat low due to the visual impact of the remaining pit highwalls.

Alternative L5

This alternative would revegetate 81% of the mine disturbance, more than Alternatives L1 to L4. It would cover most of the pit highwalls, although the upper portions would still be visible. Covering the highwalls would more closely restore the landscape to its pre-mining "natural" appearance. Since the natural landscape is an important component of traditional uses, this would be an additional positive impact over Alternatives L1 through L4.

A minor negative impact would be the additional time required for heavy equipment and personnel to complete reclamation as compared to Alternatives L1, L2, L3 and L4. Reclamation would not be complete until 2005, during which time the solitude of the area would be impacted.

Alternative L6

This alternative would provide the closest to restoring pre-1979 conditions and vegetation. However, it would still be a reclaimed, rather than a natural landscape, which may be an important distinction to some individuals. The highwalls would be eliminated by the pit backfill, and vegetation would cover over 92% of the disturbance area.

A minor negative impact of this alternative would be the increased time required for reclamation. The solitude of the area would be impacted until 2008 with reclamation traffic, three years longer that Alternative L5. This time period impact may be more relevant on the Landusky Mine than at the Zortman Mine, since the activities are closer to traditional event areas on the Fort Belknap Reservation such as the Pow Wow grounds in Mission Canyon. The impact of the longer time period for reclamation would be a minor impact. This alternative is most conducive to restoring pre-1979 conditions and uses.

4.11 SOCIAL and ECONOMIC CONDITIONS

4.11.1 Impacts to Social Conditions

The reclamation alternatives would create impacts to the social well-being of affected groups and individuals. These alternatives can affect social well-being in a variety of ways, including changes in the amount and quality of resources such as recreation opportunities, and resolution of problems related to resource use such as access problems. The agencies' decisions could affect employment in an area, which could in turn affect the standard of living and, therefore, social well-being. Beliefs that could affect social well-being include individuals feeling they have a sense of control over the decisions that affect their future, and the feeling that the government strives to act in ways that benefit everyone equitably. The following factors have the ability to affect social well-being: effects to recreation opportunities, effects to the visual environment, effects to American Indian religious and cultural practices and effects on local employment.

Zortman Mine

Alternative Z1

Social well-being would improve for recreationists who use the area, people who obtain employment related to the reclamation project, people concerned with the visual environment, and those involved with traditional American Indian cultural practices.

For recreationists and those concerned with the visual environment, this alternative would produce good vegetation density and diversity which would enhance hunting opportunities and improve the visual environment. However, safety hazards would continue to exist for recreationists and other visitors. See the Recreation and Visual Resources section for a more detailed discussion of these effects.

Between 27 and 40 people would obtain employment related to the reclamation project through 2003. This does not include long-term employment associated with the water treatment plant operation. See Section 4.11.2 for a more detailed discussion of these effects.

Social well-being would improve for those involved with traditional American Indian cultural practices because the return to a more natural landscape may restore some areas to pre 1979 uses, including these traditional practices. See Section 4.10 for a more detailed discussion of these effects.

Alternative Z2

The effects to social well-being would be similar to Alternative Z1. The lower percentage of vegetation restored would result in slightly less improvement in the visual environment, opportunities for hunting, and for those involved in traditional cultural practices. The reclamation employment would only be available for two years.

Alternative Z3

The effects to social well-being from Alternative Z3 would be similar to those described for Alternative Z2.

Alternative Z4

Effects would be similar to Alternative Z1, but the positive benefits would be greater for all groups. Safety hazards for recreationists and other visitors would be significantly reduced and there would be greater improvement for those involved in traditional cultural practices.

Alternative Z5

Total restoration of the pre-mining topography would benefit all groups by providing the greatest improvement to recreational resources, the largest reduction in visual impacts, the minimization of effects on traditional practices, and the largest employment opportunity.

Alternative Z6 (Preferred Alternative)

The effects to social well-being would be a significant improvement from the existing condition for all affected groups. The partial pit backfilling would somewhat restore the visual environment and partially eliminate safety hazards for recreationists and other visitors. This would also be a positive impact for groups using the area for traditional cultural practices. Reclamation employment would be available for three years. For more information, see the discussions in Sections 4.9, 4.10 and 4.11.2.

Landusky Mine

Alternative L1

Social well-being would improve for recreationists who use the area, people who obtain employment related to the reclamation project, people concerned with the visual environment, and those involved in traditional American Indian cultural practices.

For recreationists and those concerned with the visual environment, this alternative would produce good vegetation density and diversity which would enhance hunting opportunities and improve the visual environment. However, safety hazards would continue to exist for recreationists and other visitors. See Section 4.9 for a more detailed discussion of these effects.

Between 35 and 48 people would obtain employment related to the reclamation project through 2004. This does not include employment associated with operation of the water treatment plants. See Section 4.11.2 for a more detailed discussion of these effects.

Social well-being would improve for those involved with traditional American Indian cultural practices because the return to a more natural landscape may restore some areas to pre-1979 conditions, improving the suitability for traditional practices.

Alternative L2

The effects would be similar to Alternative L1, except the visual environment and recreational opportunities for hunting would be slightly less improved, reclamation-related employment would be available through 2003, and there would be less improvement in environmental conditions for those involved in traditional cultural practices.

Alternative L3

The effects would be similar to Alternative L2. However, there would be an additional reduction in visual impacts and a safer environment for recreationists and others with the highwall reduction. The reduction in visual impacts would also slightly improve the suitability of the area for those involved in traditional cultural practices.

Alternative L4 (Preferred Alternative)

The effects would be similar to Alternative L3 except reclamation-related employment would be available for a longer period of time and the visual impacts and safety concerns would be reduced even further with the leach pad backfilling. The reduction in visual impacts would also improve the suitability of the area for those involved in traditional cultural practices. For more information, see the discussions in Sections 4.9, 4.10 and 4.11.2.

Alternative L5

The effects would be similar to Alternative L4, but the benefits would be greater for all groups. The alternative would significantly reduce the safety hazards and visual impacts associated with the mine pits. There would be an improvement in the suitability of the area for traditional cultural practices.

Alternative L6

The effects would be similar to Alternative L5 but the positive benefits would be greater for all groups. The total restoration of the pre-mining topography would benefit all groups by providing the greatest improvement to recreational resources, the largest reduction in visual impacts, the minimization of effects on traditional cultural practices, and the largest employment opportunity.

4.11.2 Impacts to Economic Conditions

Introduction

The primary economic impacts to the local study area from any of the reclamation alternatives would come from wages earned by local reclamation workers at the mine sites and local spending by the contractor for goods and services such as fuel, office supplies, and the repair and maintenance of vehicles and equipment. These direct expenditures on wages, goods, and services would create additional rounds of spending in the study area, known as the multiplier effect, which represent an additional economic benefit. Total economic activity associated with local expenditures by the contractor and local spending of wages by workers is estimated through the use of the IMPLAN Input-Output Model which calculates the multiplier effect of spending in the study area. As mentioned in Chapter 3, these local expenditures for wages, goods, and services currently total about $1.2 million annually, generating $1.5 million in total output and 60 full-time and part-time jobs, including the jobs at the mines and in the local economy.

Additionally, each alternative has a "nonlocal" spending component. These expenditures would be primarily for materials such as synthetic liners, heavy equipment, replacement parts for heavy equipment, and other costs for supplying heavy earthmoving equipment and other industrial purchases. For analysis purposes it is assumed these costs would occur outside the study area because the reclamation contractor would most likely be from outside the area and many of the materials and equipment are not available locally. Consequently, the benefits associated with these expenditures, such as increased employment and income that comes from increased spending by the contractor, would not accrue to the local economy. Thus, this category of costs is not included in the analysis of employment and income impacts to the study area, although they are included in the analysis of total costs for each alternative. It should be noted that once the reclamation contract is issued, the actual distribution of local vs. non-local expenditures may differ from the analyses presented here. Each of the alternatives contains other assumptions that may not hold once a contract has been awarded and final reclamation begins. These assumptions include: the number of years reclamation would occur, the number of workers hired from within the study area (i.e. Blaine and Phillips Counties), and the number of American Indian workers.

The assumptions regarding years of reclamation for each alternative were developed with the idea that relatively smaller, in-state contractors could do the work. If the reclamation work is bid with a short construction timeframe (between 1-2 years) and greater than an $8 million (amount under any of the alternatives), there is a greater likelihood the contractor would be from outside Montana, making it more likely the contractor would supply his or her own workforce from outside the area. These analyses use the year 2000 as a starting point and include the money spent on the interim reclamation.

The assumptions regarding the number of workers hired from within the study area and the number of workers who are American Indian is related to the makeup of the current workforce. It is assumed that the number of workers hired locally and the number of American Indian workers would occur in the same proportion as the current workforce. About 90% of the current workforce is from the study area and

about one-third is American Indian. It isn't clear whether there would be preference hiring of American Indians if additional funding for reclamation were to become available (i.e. funding beyond the remaining bond amount). This would depend on the source of additional funding and what conditions may be placed on that funding.

Tables 3 and 5 in the Economics Appendix (Appendix D) show the estimated annual expenditures and employment for each of the reclamation alternatives. The amounts in these tables represent *direct* expenditures and employment by the contractor.

Impacts Common to All Alternatives.

The existing water treatment plants would continue operating regardless of which reclamation alternatives are selected. The current annual costs for operating the facility are about $850,000 and include 13 jobs. About $425,000 of this total impacts the local study area. Table 4.11-1 below shows the annual costs of operating this facility.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would be about 19, including the 13 jobs directly associated with water treatment plant. Total employee compensation in the study area would be $77,000, and total industry output would be $522,000. It should be noted that the total "employee compensation" does *not* include the wages paid to workers at the treatment plant. Those wages are included under "final demand."

The total annual costs of operating the Zortman Mine water treatment plant may decrease under Alternatives Z2, Z4, and Z5. Moving the water treatment plant to Goslin Flats may reduce some of the operating costs. However, the amount of cost savings is unknown at this time.

Table 4.11-1. Impacts from Employment/Expenditures for Water Treatment Plant (current $)

	Annual	Local Portion*
Employment at Treatment Plant	13	13
Expenditures:		
Labor**	$367,000	$275,300
Supplies (local)	$47,000	$47,000
Supplies (nonlocal)	$334,000	$0
Power/Fuel	$103,000	$103,000
Total Annual Expenditures	$851,000	$425,250
Economic Impact in Study Area from Local Expenditures		
Final Demand		$425,300
Total Industry Output		$522,100
Value Added:		
Employee Compensation		$76,600
Total Value Added		$189,600
Employment		19

* Local Portion: The portion of all annual expenditures for the water treatment plant that are anticipated to be spent in the study area (Blaine and Phillips Counties).
** Labor expenses were reduced by 25% to estimate the portion of all labor expenses spent locally. This 25% accounts for that part of wages (e.g. taxes, medical benefits, etc.) that would generally not be available as disposable income.
Source: Spectrum (2000e) for estimated total annual expenditures; IMPLAN Input-Output Modelling System, 1996 (for impacts)

The Range of Spending Across All Alternatives. Of all the alternatives presented (six for the Landusky Mine and six for the Zortman Mine), there are 36 possible ways the reclamation alternatives could be combined to assess overall economic impacts in the study area. Combining the two lowest-cost alternatives and the two highest-cost alternatives is done to show the maximum range of employment and expenditure impacts that could occur since it is not known which two alternatives would actually be selected. It should be noted these estimates do not include jobs and expenditures associated with the permanent water treatment plant.

Least-Cost Combination. Table 1 in the Economics Appendix (Appendix D) shows the direct employment and expenditures of the two *least-cost* alternatives, Alternative Z2 for the Zortman Mine and Alternative L2 for the Landusky Mine. For Alternatives Z2 and L2 combined, total reclamation and

maintenance costs for the life of the projects would be $29.6 million. Reclamation work would extend through 2003. Employment would peak at 44 jobs in year 2001 and decline to 10 jobs in years 2002 and 2003.

Total annual direct expenditures would peak in year 2001 at about $7 million and decline to about $4.3 million annually for years 2002 and 2003. Expenditures include labor and supplies obtained locally and from outside the study area. It is estimated that about two-thirds of these peak expenditures (e.g. capital expenditures, expenditures for synthetic liners, purchase of heavy equipment, etc.) would occur outside the local study area, so the total economic activity associated with these expenditures would also occur outside the study area.

Table 1 in the Economics Appendix also shows estimated total economic activity, which includes the multiplier effect of additional rounds of spending in the local area due to direct spending by the contractor and wage earners. For the peak year of 2001, it is estimated that the total number of jobs generated by reclamation spending would be 96, including workers at the site. Total income (employee compensation) generated is estimated to be $609,000 and total output is estimated to be $1.8 million in the study area. Impacts decline in years 2002 and 2003 as reclamation activities are completed. It should be noted that total jobs estimated to occur under Alternatives Z2-L2 combined (96 jobs in the peak year of 2001) does not guarantee that these jobs would be generated through additional rounds of spending in the study area. To the extent that many of these jobs already exist in such businesses as retail outlets, additional spending by wages earners and the contractor may not result in more hiring by local businesses.

Highest-Cost Combination. Table 2 in the Economics Appendix shows the direct employment and expenditures of the two *highest-cost* alternatives, Alternative Z5 for the Zortman Mine and Alternative L6 for the Landusky Mine. For Alternatives Z5 and L6 combined, total reclamation and maintenance costs would be $203.4 million. Reclamation work would extend through 2008. Reclamation employment would peak at 48 jobs in the years 2002 through 2004, then decline to about 25 jobs annually through 2008.

Total annual direct expenditures would peak in years 2002-2004 at $29.8 million to $31.7 million and decline to about $20.5 million annually for years 2005 through 2008. About 90% of these expenditures (e.g. capital expenditures, expenditures for synthetic liners, purchase of heavy equipment, etc.) would occur outside the local study area so the total economic benefit associated with these expenditures would also occur outside the study area.

Table 2 in the Economics Appendix also shows estimated total economic activity, which includes the multiplier effect of additional rounds of spending in the local area due to direct spending by the contractor and wage earners. For the peak years of 2002-2004, the total number of jobs generated by reclamation spending would be 102, including workers at the site. Total income (employee compensation) generated is estimated to be $704,000 and total output is estimated to be $1.5 million in the study area. Impacts decline for years 2005 through 2008 as reclamation activities are completed. It should be noted that the total jobs estimated to occur under Alternatives Z5-L6 combined (102 jobs) does not guarantee that the

jobs would be generated through additional rounds of spending in the study area. To the extent that many of these jobs already exist in such businesses as retail outlets, additional spending by wages earners and the contractor may not result in more hiring by local businesses.

Multiple Accounts Analysis. The Multiple Accounts Analysis (MAA) (see Appendix A) considered what impacts the reclamation alternatives would have on various social and economic components in the study area. The impacts were measured qualitatively from low to high. In the short term, while reclamation activities are underway, the more reclamation done the greater the risk would be to worker health and safety from accidents. Likewise, the longer reclamation takes just in terms of *completion time*, the greater the possibility other negative factors may come into play such as financial difficulties or political instabilities that could affect the progress of reclamation. From an *employment* standpoint, the more reclamation done and the longer it takes, the more positive the impact on employment opportunities. In terms of the *future burden on society*, all alternatives are considered to have a "somewhat high" impact since they all involve some level of long-term management, post reclamation. Finally, *mineral development potential* in the long term is lower the more reclamation is done (i.e. the more backfilling is done) simply because economic reserves would be harder to reach.

Zortman Mine

Alternative Z1

The total cost of Alternative Z1 would be $26.3 million through 2003. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to remain fairly stable from 2001 through 2003, ranging from $1 million to $1.4 million.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 40 jobs in 2001 and drop to 27 jobs in 2002 and 2003, including the number of workers at the mine site. Total employee compensation would peak at $233,000 and drop to $190,000. Total output in the study area would peak at $1,081,000 and drop to $830,000. Table 4.11-2 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative Z1 ($26.3 million) exceeds the $10 million bond available for reclamation by $16.3 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-2. Alternative Z1 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,080,800	$1,245,500	$233,400	$486,400	40
2002	$830,300	$965,600	$189,700	$406,900	27
2003	$830,300	$965,600	$189,700	$406,900	27

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z2

The total cost of Alternative Z2 would be $10 million over a three-year period, ending in 2001. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local spending for 2001 is estimated to be $1.7 million.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 46 jobs in 2001. Total income (employee compensation) would peak at $270,000 and total output in the study area would peak at $1.5 million. Table 4.11-3 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Moving the water treatment plant to Goslin Flats may reduce some of the plant's operating costs. However, it is unknown at this time how much cost savings may be possible.

Table 4.11-3. Alternative Z2 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,305,800	$1,505,900	$270,300	$588,300	46

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z3

The total cost of Alternative Z3 would be $10 million over a three-year period, ending in 2001. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local spending for 2001 is estimated to be $2.4 million.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 54 jobs in 2001. Total income (employee compensation) would peak at $365,000 and total output in the study area would peak at $2.2 million. Table 4.11-4 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Table 4.11-4. Alternative Z3 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,878,900	$2,156,200	$365,300	$803,200	54

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z4

The total cost of Alternative Z4 would be $43 million over a six-year period, ending in 2004. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to remain fairly stable from 2001 through 2004, ranging from $1.4 million to $1.5 million.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 48 jobs from 2002-2004. Total income (employee compensation) would peak at $318,700. Total output in the study area would peak at $1.5 million. Table 4.11-5 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Moving the water treatment plant to Goslin Flats may reduce some of the plant's operating costs. However, it is unknown at this time how much cost savings would be possible.

The total cost for Alternative Z4 ($43 million) exceeds the $10 million bond available for reclamation by $33 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-5. Alternative Z4 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,089,500	$1,254,500	$221,200	$482,900	41
2002	$1,249,800	$1,468,200	$318,700	$673,500	48
2003	$1,249,800	$1,468,200	$318,700	$673,500	48
2004	$1,249,800	$1,468,200	$318,700	$673,500	48

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modeling System (1996)

Alternative Z5

The total cost of Alternative Z5 would be $46.2 million over an eight-year period, ending in 2006. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to remain fairly constant from 2001 through 2006 at $1.4 million.

Including the multiplier effect of additional rounds of spending, estimated total annual employment in the study area would be about 47 jobs through 2006. Total income (employee compensation) would be about $311,000 annually and total output in the study area would be about $1.4 million. Table 4.11-6 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine sites. Those wages are included under "final demand."

Moving the water treatment plant to Goslin Flats may reduce some of the plant's operating costs. However, it is unknown at this time how much cost savings may be possible.

The total cost for Alternative Z5 ($46.2 million) exceeds the $10 million bond available for reclamation by $36.2 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-6. Alternative Z5 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$966,400	$1,117,000	$205,500	$445,400	38
2002	$1,178,300	$1,388,800	$310,600	$653,500	47
2003	$1,178,300	$1,388,800	$310,600	$653,500	47
2004	$1,178,300	$1,388,800	$310,600	$653,500	47
2005	$1,178,300	$1,388,800	$310,600	$653,500	47
2006	$1,178,300	$1,388,800	$310,600	$653,500	47

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative Z6 (Preferred Alternative)

The total cost of Alternative Z6 would be $15.1 million over a four-year period ending in 2002. Table 3 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 4 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local spending for 2001 is estimated to be $2.4 million and $1.4 million in 2002.

Including the multiplier effect of additional rounds of spending in the study area, it is estimated that total employment in the study area would peak at about 54 jobs in 2001 and decrease to 47 jobs in 2002. Total income (employee compensation) would peak at $365,000 in 2001 and decrease to $245,600 in 2002. Total output in the study area would peak at $2.2 million in 2001 and decrease to $1.3 million in 2002. Table 4.11-7 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative Z6 ($15.1 million) exceeds the existing $10 million bond available for reclamation by $5.1 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-7. Alternative Z6 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,878,900	$2,156,200	$365,300	$803,200	54
2002	$1,109,400	$1,286,700	$245,700	$529,500	47

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Landusky Mine

Alternative L1

The total cost of Alternative L1 would be $46.2 million over a five-year period, ending in 2004. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.8 million in 2001 to $1.5 million in 2002-2004.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 48 jobs in 2001 and drop to 35 jobs in 2002 to 2004, including the number of workers at the mine site. Total employee compensation would peak at $316,000 and drop to $231,000. Total output in the study area would peak at $1,642,000 and drop to $1,326,000. Table 4.11-8 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L1 ($46.2 million) exceeds the $19.6 million bond available for reclamation by $26.6 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-8. Alternative L1 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,415,500	$1,642,900	$316,200	$680,500	48
2002	$1,153,200	$1,326,600	$231,200	$505,800	35
2003	$1,153,200	$1,326,600	$231,200	$505,800	35
2004	$1,153,200	$1,326,600	$231,200	$505,800	35

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L2

The total cost of Alternative L2 would be $ 19.6 million over a four-year period, ending in 2003. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.9 million in 2001 to $1.4 million in 2002-2003.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 50 jobs in 2001 and drop to 31 jobs in 2002 to 2003, including the number of workers at the mine site. Total employee compensation would peak at $338,000 and drop to $329,000. Total output in the study area would peak at $1,765,000 and drop to $1,296,000. Table 4.11-9 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

Table 4.11-9. Alternative L2 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,521,700	$1,765,600	$338,800	$729,500	50
2002	$1,120,800	$1,295,700	$329,100	$518,100	31
2003	$1,120,800	$1,295,700	$329,100	$518,100	31

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L3

The total cost of Alternative L3 would be $22.2 million over a four-year period, ending in 2003. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.9 million in 2001 to $1.4 million in 2002-2003.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 50 jobs in 2001 and drop to 30 jobs in 2002 to

2003, including the number of workers at the mine site. Total employee compensation would peak at $340,000 and drop to $234,000. Total output in the study area would peak at $1,769,000 and drop to $1,283,000. Table 4.11-10 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L3 ($22.2 million) exceeds the bond amount available for reclamation by $2.6 million. If this alternative is chosen and the existing funding could not cover these costs, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-10. Alternative L3 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,524,800	$1,769,100	$339,500	$730,900	50
2002	$1,111,400	$1,283,400	$233,600	$507,400	30
2003	$1,111,400	$1,283,400	$233,600	$507,400	30

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L4 (Preferred Alternative)

The total cost of Alternative L4 would be $36.6 million over a five-year period, ending in 2004. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.9 million in 2001 to $1.5 million in 2002-2004.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 49 jobs in 2001 and drop to 36 jobs in 2002 to 2004, including the number of workers at the mine site. Total employee compensation would peak at $331,000 and drop to $242,000. Total output in the study area would peak at $1,723,000 and drop to $1,397,000. Table 4.11-11 shows these annual impacts. It should be noted that total "employee

compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L4 ($36.6 million) exceeds the $19.6 million bond available for reclamation by $17 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-11. Alternative L4 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,485,300	$1,723,600	$331,100	$712,700	49
2002	$1,215,000	$1,397,000	$242,100	$530,100	36
2003	$1,215,000	$1,397,000	$242,100	$530,100	36
2004	$1,215,000	$1,397,000	$242,100	$530,100	36

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L5

It is estimated that the total cost of Alternative L5 would be $67.9 million over a six-year period, ending in 2005. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.8 million in 2001 to $1.5 million in 2002-2005.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would peak at about 48 jobs in 2001 and drop to 35 jobs in 2002 to 2005, including the number of workers at the mine site. Total employee compensation would peak at $319,000 and drop to $232,000. Total output in the study area would peak at $1,662,000 and drop to $1,339,000. Table 4.11-12 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L5 ($67.9 million) exceeds the $19.6 million bond available for reclamation by $48.3 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-12. Alternative L5 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,432,000	$1,662,300	$319,800	$688,300	48
2002	$1,164,700	$1,339,100	$232,100	$508,300	35
2003	$1,164,700	$1,339,100	$232,100	$508,300	35
2004	$1,164,700	$1,339,100	$232,100	$508,300	35
2005	$1,164,700	$1,339,100	$232,100	$508,300	35

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

Alternative L6

The total cost of Alternative L6 would be $157.3 million over a nine-year period, ending in 2008. Table 5 in the Economics Appendix shows estimated total employment and reclamation costs for each year of reclamation activity. Table 6 in the Economics Appendix shows the same total annual costs broken out by local vs. non-local spending. It is the local spending that would affect the two-county study area. Local expenditures are estimated to range from $1.5 million in 2001 to $1.8 million annually thereafter through 2008.

Including the multiplier effect of additional rounds of local spending in the study area, it is estimated that total employment in the study area would be about 43 jobs in 2001 and increase to 54 jobs annually thereafter through 2008, including the number of workers at the mine site. Total employee compensation would peak at $385,000 for years 2002-2008. Total annual output in the study area would be about $1,759,000 from 2002-2008. Table 4.11-13 shows these annual impacts. It should be noted that total "employee compensation" does *not* include the wages paid to reclamation workers at the mine site. Those wages are included under "final demand."

The total cost for Alternative L6 ($157.3 million) exceeds the existing $19.6 million bond available for reclamation by $137.7 million. If this alternative is chosen, additional funding would have to be obtained in order to complete reclamation activities. If these funds come from state and/or federal appropriations, the additional cost represents a financial burden that would be borne by the taxpayers of Montana (if funding comes from the State of Montana) or by taxpayers nationwide (if funding comes from the Federal Government).

Table 4.11-13. Alternative L6 Estimated Total Economic Impact to Study Area (current $)

Year	Final Demand	Total Industry Output	Value Added		Employment
			Employee Compensation	Total Value Added	
2000	$622,300	$729,400	$155,400	$329,200	31
2001	$1,183,800	$1,375,000	$266,900	$573,600	43
2002	$1,495,400	$1,758,600	$385,500	$813,300	54
2003	$1,495,400	$1,758,600	$385,500	$813,300	54
2004	$1,495,400	$1,758,600	$385,500	$813,300	54
2005	$1,495,400	$1,758,600	$385,500	$813,300	54
2006	$1,495,400	$1,758,600	$385,500	$813,300	54
2007	$1,495,400	$1,758,600	$385,500	$813,300	54
2008	$1,495,400	$1,758,600	$385,500	$813,300	54

Note: "Final Demand" includes wages paid to reclamation workers at the mine sites and direct expenditures by the contractor on goods and services in the local study area. Wages paid to workers were reduced by 25% to estimate "disposable income" to account for taxes, savings, and employee benefits that are not part of workers' local spending. "Employee Compensation" includes wages paid for jobs generated in the study area as a result of spending by the contractor and reclamation employees. Source: IMPLAN Input-Output Modelling System (1996)

4.12 RECLAMATION and WATER TREATMENT BONDS

Many of the alternatives cannot be fully implemented with the money available under the existing bonds. Reclamation at the Zortman and Landusky Mines is composed of two principal activities, surface reclamation and water treatment. It is recognized that a certain level of water treatment is necessary under all alternatives, but the degree and the cost associated with water treatment is influenced by both the type and amount of surface reclamation. Some of the alternatives would maximize surface reclamation by using thick soil covers or impermeable barriers to reduce water infiltration, thereby reducing the cost of water treatment; other alternatives instead focus on maximizing the dollar value of water treatment. This section addresses the effects of the reclamation alternatives on the availability and use of the various bonds.

At the completion of the currently approved interim reclamation there would be approximately $5.1 million available for Zortman Mine reclamation, and approximately $14.7 million available for Landusky Mine reclamation. Summaries of the total estimated cost for each alternative (including interim reclamation) are presented in Table 4.12-1 for the Zortman Mine and in Table 4.12-2 for the Landusky Mine. These tables do not include costs associated with running the seepage capture systems or water treatment plants, which are covered under separate bonds and discussed later. The following is a brief description of the estimated costs associated with implementing the various reclamation alternatives.

Consequences of Alternative Selection on the Reclamation Bonds

For the Zortman Mine, Alternatives Z2 and Z3 could accomplish reclamation within bond limits. At the Landusky Mine, only the cost of implementing Alternative L2 is estimated to be within bond limits. However, the estimated cost for Alternative L3 is $22.2 million, which is only about $2.6 million over the available bond. Because the reclamation cost estimates are based on average contractor prices for the work specified, in a competitive bidding process, the low bid for the Alternative L3 reclamation might be very close to the amount available from the reclamation bond. Therefore, the choice of either Alternatives L2 or L3 perhaps could accomplish reclamation within the available bond.

If an alternative is chosen whose implementation cost exceeds the available bond, there is a risk that the effectiveness identified for that alternative could be less than predicted if the funding is not first assured and reclamation items are left partially complete awaiting funding. Associated water treatment costs could also increase during that period. In order to achieve the anticipated performance of alternatives other than Alternatives Z2, Z3, L2 or L3, additional sources of funding would need to first be obtained to ensure their full implementation.

Table 4.12-1. Zortman Mine Reclamation Cost by Alternative

Mine Feature	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	(Preferred) Alternative Z6
Mine Pits:						
O.K./Ruby Pit	$1,876,000	$1,044,000	$1,246,000	$1,644,000	$2,051,000	$1,805,000
Mint Pit	$378,000	$59,000	$59,000	$1,343,000	$144,000	$102,000
Ross Pit	$223,000	$223,000	$217,000	$1,074,000	$1,821,000	$383,000
North Alabama Pit	$222,000	$55,000	$40,000	$448,000	$550,000	$84,000
South Alabama Pit	$562,000	$222,000	$214,000	$776,000	$858,000	$667,000
Extensive Regrade for Barrier Covers	$0	$0	$0	$3,000,000	$0	$0
Leach Pads:						
Z79-81 Pad (Reclaimed in 1991)	$15,000	$15,000	$15,000	$621,000	$15,000	$15,000
Z82 Pad (Reclaimed in 2000-2001) & Z82 Pad North Slope	$1,519,000	$1,519,000	$1,519,000	$1,519,000	$1,519,000	$1,519,000
Z83, Z84, Z89 Pads (Reclaimed in 2000-2001)	$1,513,000	$585,000	$585,000	$2,144,000	$585,000	$585,000
Z85/86 Pad	$1,720,000	$1,074,000	$1,116,000	$2,605,000	$13,752,000	$1,116,000
Leach Pad Dikes:						
Z83 Pad Dike (Reclaimed in 1992)	$6,000	$6,000	$6,000	$6,000	$6,000	$6,000
Z84 Pad Dike (Reclaimed in 1992)	$7,000	$7,000	$7,000	$7,000	$7,000	$7,000
Z85/86 Pad Dike	$340,000	$0	$217,000	$366,000	Part of 85/86 pad removal	Part of 85/86 pad removal
Z89 Pad Dike (Reclaimed in 1989)	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000
Rock Dumps & Stockpiles:						
Alder Gulch Waste Rock Dump	$5,920,000	$0	$0	$8,264,000	$8,205,000	$1,873,000
O.K. Waste Rock Dump	$1,029,000	$0	$0	$531,000	$215,000	$295,000
Z82 Sulfide Stockpile, South Ruby Dump	$511,000	$511,000	$511,000	$831,000	$511,000	$511,000
North Ruby Soil Stockpile	$8,000	$8,000	$8,000	$8,000	$8,000	$8,000

Mine Feature	Alternative Z1	Alternative Z2	Alternative Z3	Alternative Z4	Alternative Z5	(Preferred) Alternative Z6
Ruby Gulch Tailings Removal	$522,000	$0	$51,000	$522,000	$537,000	$1,551,000
New Disturbance:						
Proposed Limestone Quarry (LS-2)	$1,510,000	$0	$0	$2,587,000	$0	$0
Ruby Gulch Drain Notch (By Z85/86 Pad)	$140,000	$140,000	$140,000	$140,000	$140,000	$140,000
Haul Roads, Support Facilities & Other:						
Surface Water Controls	$650,000	$136,000	$250,000	$650,000	$650,000	$250,000
Mine Facilities	$512,000	$29,000	$29,000	$495,000	$477,000	$29,000
Relocate Water Treatment Plant	$0	$1,888,000	$0	$1,888,000	$1,888,000	$0
Reclaim Water Treatment Plant Ponds	$0	$184,000	$0	$251,000	$290,000	$133,000
Process Water Management	$2,745,000	$1,128,000	$2,626,000	$2,926,000	$2,739,000	$2,626,000
Reclamation Maintenance	$515,000	$252,000	$232,000	$773,000	$773,000	$232,000
Reclamation Overhead	$3,824,000	$924,000	$924,000	$7,553,000	$8,421,000	$1,129,000
Totals:						
Total Reclamation Costs	**$26,275,000**	**$10,017,000**	**$10,020,000**	**$42,980,000**	**$46,170,000**	**$15,074,000**
Excess Cost Over Bond Amount	$16,251,000	$0	$0	$32,956,000	$36,146,000	$5,050,000

Table 4.12-2. Landusky Mine Reclamation Cost by Alternative

Mine Feature	Alternative L1	Alternative L2	Alternative L3	(Preferred) Alternative L4	Alternative L5	Alternative L6
Mine Pits:						
August/Little Ben & Suprise Pit Complex	$1,967,000	$580,000	$1,041,000	$1,809,000	$16,205,000	$72,467,000
August/Little Ben Drainage Control (Notch/Drill Hole)	$4,899,000	$0	$676,000	$1,055,500	$462,000	$0
Queen Rose Pit	$688,000	$133,000	$133,000	$123,000	$7,984,000	Part of August/ Little Ben
Gold Bug & South Gold Bug Pits	$1,488,000	$1,077,000	$1,191,000	$2,076,000	$2,486,000	$27,766,000
Leach Pads:						
L79 Pad (Reclaimed in 1991) Additional Revegetation	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000
L80-82, L83, & L84 Pad Complex (Reclaimed in 2000-2001)	$1,695,000	$1,695,000	$1,695,000	$1,695,000	$1,695,000	$1,695,000
L85/86 Pad	$1,152,000	$853,000	$1,083,000	$8,274,000	$10,777,000	$10,486,000
L87/91 Pad Complex	$10,929,000	$6,090,000	$6,090,000	$7,249,000	$6,650,000	$8,911,000
Leach Pad Dikes:						
L83 Pad Dike (Reclaimed in 1988)	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000
L84 Pad Dike (Reclaimed in 2001)	$0	$0	$0	$0	$0	$0
L85/86 Pad Dike	$116,000	$70,000	$66,000	Part of L85/86 Pad Removal	Part of L85/86 Pad Removal	Part of L85/86 Pad Removal
L91 Pad Dike (Buildout under Alt. L1, Revegetation on L2-L6)	$3,523,000	$13,000	$13,000	$13,000	$13,000	$13,000
Rock Dumps and Stockpiles:						
Mill Gulch Waste Rock Dump	$583,000	$83,000	$83,000	$83,000	$166,000	$559,000
Montana Gulch Waste Rock Dump	$570,000	$59,000	$80,000	$525,000	$105,000	$247,000
August #1 Waste Rock Dump	$57,000	$283,000	$283,000	$283,000	$282,000	$508,000
August #2 Waste Dump (East & West Lobes)	$79,000	$0	$58,000	$57,000	$68,000	$92,000

Mine Feature	Alternative L1	Alternative L2	Alternative L3	(Preferred) Alternative L4	Alternative L5	Alternative L6
Gold Bug Yellow Waste Rock Dump	$465,000	$197,000	$201,000	$203,000	$649,000	Part of Gold Bug Complex
Upper and Lower Gold Bug Blue Waste & South Gold Bug Limestone Stockpiles	$343,000	$178,000	$205,000	$186,000	$384,000	$536,000
Gold Bug Soil Stockpile	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
New Disturbance:						
Proposed Limestone Quarries	$698,000	$0	$0	$0	$0	$0
West MT Gulch Drain (By L85/86 Pad)	$970,000	$0	$768,000	$0	$0	$0
Haul Roads, Support Facilities & Other:						
Surface Water Controls	$487,000	$342,000	$342,000	$527,000	$532,000	$557,000
Mine Facilities	$194,000	$174,000	$174,000	$181,000	$192,000	$140,000
Process Water Management	$6,446,000	$5,036,000	$5,036,000	$6,098,000	$6,098,000	$5,792,000
Suprise Pit Recovery Wells	$0	$0	$0	$0	$1,408,000	$1,411,000
Big Horn Ramp Revegetation	$32,000	$32,000	$32,000	$32,000	$32,000	$32,000
Reclamation Cover Repair	$486,000	$423,000	$444,000	$506,000	$532,000	$1,160,000
Reclamation Overhead	$8,308,000	$2,267,000	$2,531,000	$5,609,000	$11,205,000	$24,883,000
Totals:						
Total Reclamation Costs	**$46,190,000**	**$19,600,000**	**$22,240,000**	**$36,600,000**	**$67,940,000**	**$157,270,000**
Excess Cost Over Bond Amount	$26,590,000	$0	$2,640,000	$17,000,000	$48,340,000	$137,670,000

4.12.1 Zortman Mine

Alternative Z1

Major cost items associated with Alternative Z1 include: the use of barrier and balance covers employing geosynthetic materials; the placement of four feet of cover material; and the removal and placement of the Alder Gulch waste rock dump into the mine pits. The total cost to implement this alternative is approximately $26.3 million, which is $16.3 million more than is available under the reclamation bond.

Alternative Z2

This alternative would keep reclamation costs within the available bond and would focus on optimizing water treatment. Reclamation bond money would be spent to relocate the Zortman Mine water treatment plant to Goslin Flats where plant operating costs would be minimized by having water gravity fed to the plant instead of incurring electrical costs for pumping. The total cost for this alternative is estimated at $10 million.

Alternative Z3

Alternative Z3 would focus on minimizing surface water infiltration within the available reclamation bond amount. Measures such as increased cover soil thickness over and above what is described in Alternative Z2 would be used in place of the geosynthetic materials described in Alternative Z1. Extensive use of Ruby Gulch tailings as part of the reclamation covers is included for pit floor reclamation and on selected waste dumps and leach pads. The objective in this alternative is to minimize water contamination and hence the need for water treatment. The thickened reclamation covers would hold more water and make it available for plant uptake, while at the same time reducing infiltration into underlying zones where it can become contaminated, requiring expenditure for collection and treatment. The cost for Alternative Z3 is also estimated at $10 million.

Alternative Z4

The additional backfill in the North and South Alabama, and Ross pits, used to reduce the amount of north-facing vertical highwalls increases the cost of this alternative. In addition, barrier covers using geosynthetics for most flat areas over the backfilled pits and on selected leach pad and waste rock dump tops would increase costs. Other high cost items include the development of a limestone quarry to serve as a NAG source and the removal of the Alder Gulch waste rock dump. The cost for this alternative is estimated at $43 million, which is approximately $33 million more than the existing reclamation bond.

Alternative Z5

Alternative Z5 would include extensive backfilling of mine pits with waste rock and spent ore in order to match pre-mine contours. Most reclamation covers would be a combination of soil and NAG, and the geosynthetics would only be used over the O.K./Ruby pit backfill and on the floor of the Ross pit. The backfilling cost is the major reclamation expense for this alternative. The cost to implement Alternative Z5 is estimated at $46.2 million. This would be approximately $36 million over the existing reclamation bond.

Alternative Z6 (Preferred Alternative)

Alternative Z6 incorporates aspects of Alternatives Z3 and Z4 and includes additional backfill in the North Alabama pit with material removed from the Alder Gulch waste rock dump. The additional backfill would cover sulfide bearing rock currently exposed in the pit highwalls, which would reduce the amount of water requiring active water treatment. Similarly, the thick soil covers and water barrier covers would reduce the need for water treatment. Alternative Z6 is estimated to cost $15.1 million, or $5.1 million above what is currently available in the reclamation bond.

4.12.2 Landusky Mine

Alternative L1

Major cost items associated with Alternative L1 include: the use of barrier and balance covers and the associated geosynthetic materials, the placement of four feet of cover material, the construction of a drainage notch between the August/Little Ben pit complex and the Montana Gulch drainage, the construction of a Montana Gulch surface drain bypass around the L85/86 leach pad, the buttressing of L91 dike, and the development of a limestone quarry for capping material. The cost of these items represent approximately 40% of the cost of this alternative. The implementation of Alternative L1 is estimated to cost approximately $46.2 million, which would be $26.6 million more than is available under the Landusky Mine reclamation bond.

Alternative L2

Alternative L2 would reclaim the Landusky Mine within the existing reclamation bond amount. Major differences between Alternative L1 and L2 that reduce reclamation costs include: using an existing artesian well to drain the August/Little Ben pit complex instead of cutting the drainage notch, reducing reclamation cover thickness and eliminating most geosynthetic material use, modifying the drain around the L85/86 leach pad, leaving the L91 dike in its present configuration, and using lime to create NAG thereby eliminating the need for a limestone quarry. This alternative would accomplish surface reclamation within the available bond and is estimated to cost approximately $19.6 million.

Alternative L3

Alternative L3 is similar to Alternative L2, but includes a backup constructed drill hole drain for the August/Little Ben pit complex and more backfill and highwall reduction in the pit area. This alternative is estimated to cost approximately $22.2 million, or $2.6 million more than what is currently available in the reclamation bond.

Alternative L4 (Preferred Alternative)

Major cost sensitive reclamation features of Alternative L4 include: more backfill of the August/Little Ben pit complex, complete removal of the L85/86 leach pad and dike, additional highwall reduction, and thick soil reclamation covers without the use of geosynthetics. The cost of these major items represents approximately 35% of the total cost of this alternative. Total cost to implement Alternative L4 is estimated at approximately $36.6 million, which would be $17 million more than is available under the existing reclamation bond.

Alternative L5

Most of the increased costs associated with Alternative L5 are due to pit backfilling. The cost of backfilling the August/Little Ben, Suprise, Queen Rose and Gold Bug pit complexes to cover the exposed sulfides in the pit highwalls accounts for approximately 60% of the reclamation cost. The total estimated cost to implement Alternative L5 is approximately $67.9 million, or $48.3 million over the existing reclamation bond amount.

Alternative L6

In order to re-establish the pre-mine topography an extensive amount of pit backfilling would be conducted. Hauling backfill from the L85/86 and L87/91 leach pads would represent the majority of the costs for this alternative. Additional costs would be associated with the use of geosynthetics in the reclamation covers. Total estimated cost for this alternative is approximately $157 million, or $137.7 million over the existing reclamation bond amount.

4.12.3 Water Treatment Bonds and Options

The agencies hold three bonds for water treatment: (1) an operations and maintenance bond of $731,321 per year until 2017; (2) a long-term trust fund with a face value of $12.3 million in 2017; and (3) a construction assurance bond for seepage and capture system construction that currently stands at $2.9 million as of January 1, 2001.

Near-Term Water Treatment (2000 to 2017)

Water treatment plant expenses would average approximately $840,000 per year if the mines are left in their current condition and no more reclamation is performed. Even a modest reclamation cover would decrease the amount of water needing treatment, resulting in a reduction in treatment costs. However, the total gallons treated is not the only, nor the most significant variable in the cost of water treatment. Other parameters such as seepage water chemistry, flow surges that occur during severe storm events, chemical requirements, and electrical costs contribute to fluctuating water treatment costs. The present water treatment bond provides $731,231 per year until year 2017. The shortfall between the average annual estimated cost of $840,000 and the annual amount from the bond would continue to be covered by supplemental funding from the agencies' programs or by using monies from the surface reclamation bonds.

While expenditures for operation and maintenance are tied to specific cost categories within these bonds, it is possible to operate the capture systems and water treatment plants within bond limits. This belief is based on two years of operating experience at the treatment plants. In order for this to occur, the bond terms would have to provide flexibility in "how" and "for what" the total annual operation and maintenance funds can be spent.

Surface reclamation would reduce water treatment costs by reducing the amount of infiltration and by promoting more surface runoff of uncontaminated water, further reducing the volume of water needing treatment. Acid rock drainage would continue at the mines for the foreseeable future as the chemical reactions underlying acid formation have not fully gone to completion. Given this, some nominal level of water treatment would be required regardless of any other circumstances, and regardless of the surface reclamation alternative implemented.

There are several measures that could be implemented to immediately reduce water treatment costs. Labor represents approximately 40% of the yearly costs. With minor modifications, the seepage capture systems and the water treatment plants can be semi-automated to run without continuous monitoring, yet without a reduction in safety or environmental compliance. Other measures to reduce yearly operating costs could include blending low pH water with high pH water prior to treatment in order to reduce reagent requirements, and to provide storage for storm events so that a measured and regulated flow could be sent through the treatment plants. Principal unknown costs that would have a direct bearing on annual operation include electrical costs, water chemistry and reagent requirements, volume of water to be treated, and peaks in volume throughput.

Long-Term Water Treatment (Trust Fund)

The amount needed in a trust fund in order to generate annual income sufficient to operate the seepage capture systems and the water treatment plants until 2080[1] is estimated at $24.8 million. This assumes a yearly operating cost of $840,000, inflated yearly by 2.5%, and discounted at 6% (assumes the fund earns 6%). The funding for water treatment, inclusive of the $731,321 per year until 2017 and the funds presently invested in the trust, have a current value of approximately $13.8 million, representing a short-fall of $11 million. If the yearly treatment cost of $840,000 is maintained from now until 2080 ***and*** this yearly cost is subject to a yearly inflation increase of approximately 2.5% (beginning in year 2000) ***and*** the available funding is invested at 6%, this money would last until 2028.

Long-range forecasting of capital requirements for the operation and maintenance of the water treatment systems is subject to numerous assumptions and variables. The analysis is especially sensitive to the assumed inflation rate and the discount rate. The discounted cash flow analysis assumes a constant net inflation rate of 2.5% and a discount rate of 6%. Even slight deviations from these values alter the length of time monies would be available to operate the capture and treatment systems. A 0.5% increase in the rate of return earned on the trust fund would decrease the shortfall from $11 million to $9.5 million over the next 80 years. If the trust fund earns 10% (historic return on US stocks) over the life of the trust, the shortfall would be approximately $3.6 million. Conversely, an inflation increase of 0.5% over the course of the trust fund would generate a shortfall of approximately $13.3 million compared to the current projected shortfall of $11 million. If inflation were to approach 5% over the life of the fund and the fund were earning 6% on the corpus, the shortfall would be close to $27 million and the fund would be exhausted by 2024.

Options available to erase projected trust fund shortfalls include reducing yearly operating costs, realizing a greater rate of return on invested funds above the current 6%, and securing additional sources of capital for the trust fund. The yearly operating costs could be reduced below the current $840,000, especially once reclamation covers are in place. Water infiltration would be reduced and water management techniques refined, all of which can contribute to lower annual operating costs. Certain fixed costs such as electricity and chemicals are subject to inflationary pressures and must be offset with cost savings elsewhere. The trust fund is currently invested in zero-coupon bonds with a fixed rate of return. Other investments may be found that yield a greater annual return without encumbering additional risk. As a comparison, the State of Montana Public Employees' Retirement System (State employees' pension fund), has earned 12.60%, 19.63%, 16.67%, 12.11%, and 7.97% for the fiscal years 1996 through 2000, respectively. Alternative sources of funding are unknown at this time. Failure to decrease operating costs and/or increase the size of the trust fund would result in a shortfall of money to operate the water treatment systems as needed to meet water quality limits over the long term.

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[1]Discounted cash flow terminated at 2080 due to variability in long-term projections and 99% of projected discounted costs occurring in the first 80 years.

Consequences of Alternative Selection on Water Treatment Bond

Near-term (2000 through 2017) water treatment costs are projected to exceed the available bond by approximately $100,000 per year if the current conditions are maintained and no reclamation takes place. It is anticipated that with modest reclamation cover and better water management techniques, the bond would nearly cover the cost for water treatment under all alternatives.

The combined cost for providing long-term treatment at both treatment plants, under any combination of alternatives, is estimated to vary by approximately $2 million between alternatives. Considering that these values are discounted costs forecasted 80 years into the future, the long-term water treatment costs can be considered the same for all combinations of alternatives. The rationale behind this assumption is that the determination of final treatment costs over tens of years is highly sensitive to certain variables such as inflation and the rate of return on invested money. Minor deviations from the assumed values, even for short periods of time, can significantly alter the final cost, masking any difference due to the reclamation alternatives. As the difference in projected water treatment costs for any combination of alternatives is slightly over $2 million, this amount could easily be absorbed over time by fluctuations in inflation and interest rates. Conversely, changes in inflation and interest rates can also erode the buying power of what monies are set aside for long-term treatment. An increase in inflation can easily increase the shortfall in long-term funding. This would result in the trust fund being consumed prematurely and there being no money available to collect and treat water.

Currently the long-term trust fund is $11 million short of the projected capital necessary to run the water treatment systems (under present conditions) for the next 80 years. As these numbers represent present values, or the amount of money <u>needed today</u> in order to meet future obligations, an additional $11 million is necessary today to meet the ongoing long-term treatment costs. If the agencies are unable to secure $11 million immediately, either treatment costs over time would need to be reduced and/or the trust fund would need to grow faster than projected in order to meet treatment costs in the future. There is the potential to make up fund shortfalls through annual treatment cost savings and through alternative investments.

4.13 COMPARISON of the ALTERNATIVES

4.13.1 Alternative Comparison Methods

The EIS process and the Multiple Accounts Analysis (MAA) provide two complimentary methods for evaluating the performance of the reclamation alternatives. The first approach uses an 'arguments-based' evaluation whereby the positive and negative impacts of the various alternatives are described mostly in qualitative terms as discussed throughout most of this chapter. The second, more detailed approach, is to take the qualitative evaluation and assign it a specific number or score. These numbers can then be "weighted" according to the relative importance of the indicator (e.g., water protection is more important than cost) and scored mathematically for each alternative. The alternative with the highest score is the alternative with the greatest overall benefit, although within that single score there may be wide variation in specific impacts which can offset each other. This numerical evaluation has been completed for the reclamation alternatives at each mine through the MAA scoring process (See also Appendix A). It should be noted that the results of the MAA do not necessarily determine which alternative would be selected or even identified as preferred. The MAA scoring is a performance evaluation tool and does not include factors such as legal requirements or management constraints that may affect the agencies' ultimate decision.

4.13.2 Zortman Mine Alternatives Comparison

The detailed evaluations for the Zortman Mine MAA are provided in Appendix A. A summary is given in this section. Figure 4.13-1 summarizes the results of the various MAA analyses. This figures shows the overall MAA score for each of the three types of numeric evaluations. Included on this plot are the scores for both the existing conditions and the interim conditions on site. The scale on the left-hand side of the plot represents the MAA score on a scale of 1 to 9, where 9 would be the best performance and 1 the worst. The first two evaluations, i.e. the technical working group consensus evaluation and the same evaluation taking into consideration only the discriminatory values, plot very close to one another. The relative ranking of the alternatives' overall performance from best to worst in these evaluations is Z6, Z5, Z4, Z3 = Z2 = Z1. The third evaluation focuses on environmental indicators only (all economic indicators were excluded) and the resulting MAA scores change the relative ranking of the alternatives slightly to Z5, Z4, Z6, Z1, Z3, and Z2.

Within each evaluation, the account scores do not always result in the same ranking as the overall MAA score. Figure 4.13-2 provides the individual account scores as well as the MAA score for the technical working group's consensus evaluation. This figure shows that if considering only the socioeconomic account, for instance, the relative ranking from highest scoring to lowest scoring alternative would be Alternatives Z5, Z6, Z4, Z2, Z3, and Z1. If considering only the project economic account score, the highest scoring alternative would be Z2 followed by Z3, Z6, Z1, Z4 and Z5 in descending order. If considering only environmental performance accounts, the scoring results in a relative ranking of Z6, Z5, Z4, Z1, Z3 and Z2, in descending order.

Figure 4.13-3 shows a type of cost-benefit analysis. This plot shows the reclamation cost for each Zortman Mine reclamation alternative against the MAA score for the evaluation that only considers environmental performance. A best-fit logarithmic trendline has been shown on this graph to illustrate the comparison between the alternatives' overall environmental performance and their cost. In general, the higher cost alternatives at the Zortman Mine have a higher environmental score (greater environmental benefit); however, the environmental benefit per dollar value tends to decrease as the cost increases, and the curve flattens out. Ideally, an alternative that plotted near the top left corner (i.e. all the environmental benefit for the existing bond amount) would be the best option from a cost-benefit perspective.

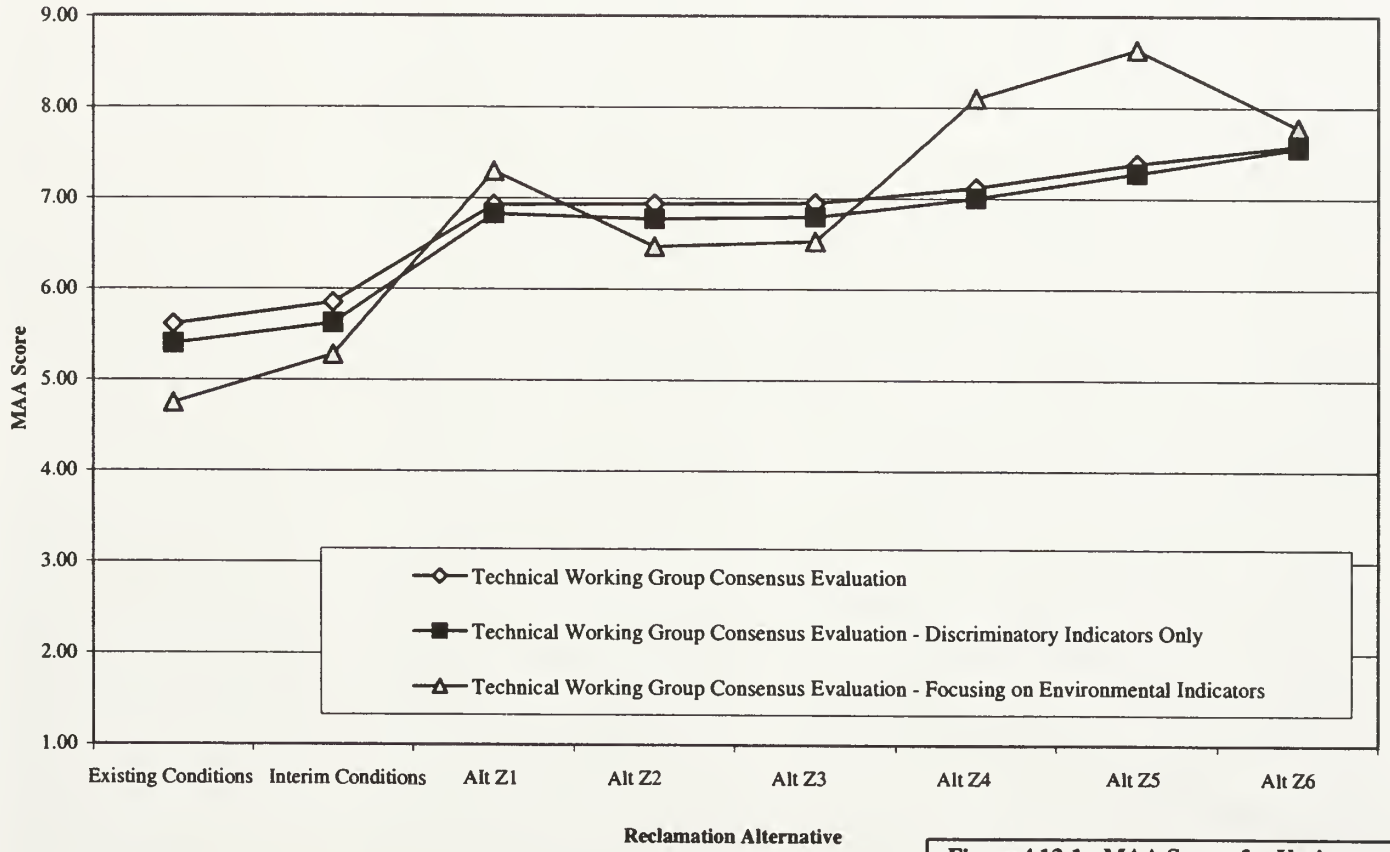


Figure 4.13-1 - MAA Scores for Various Analyses for the Zortman Mine

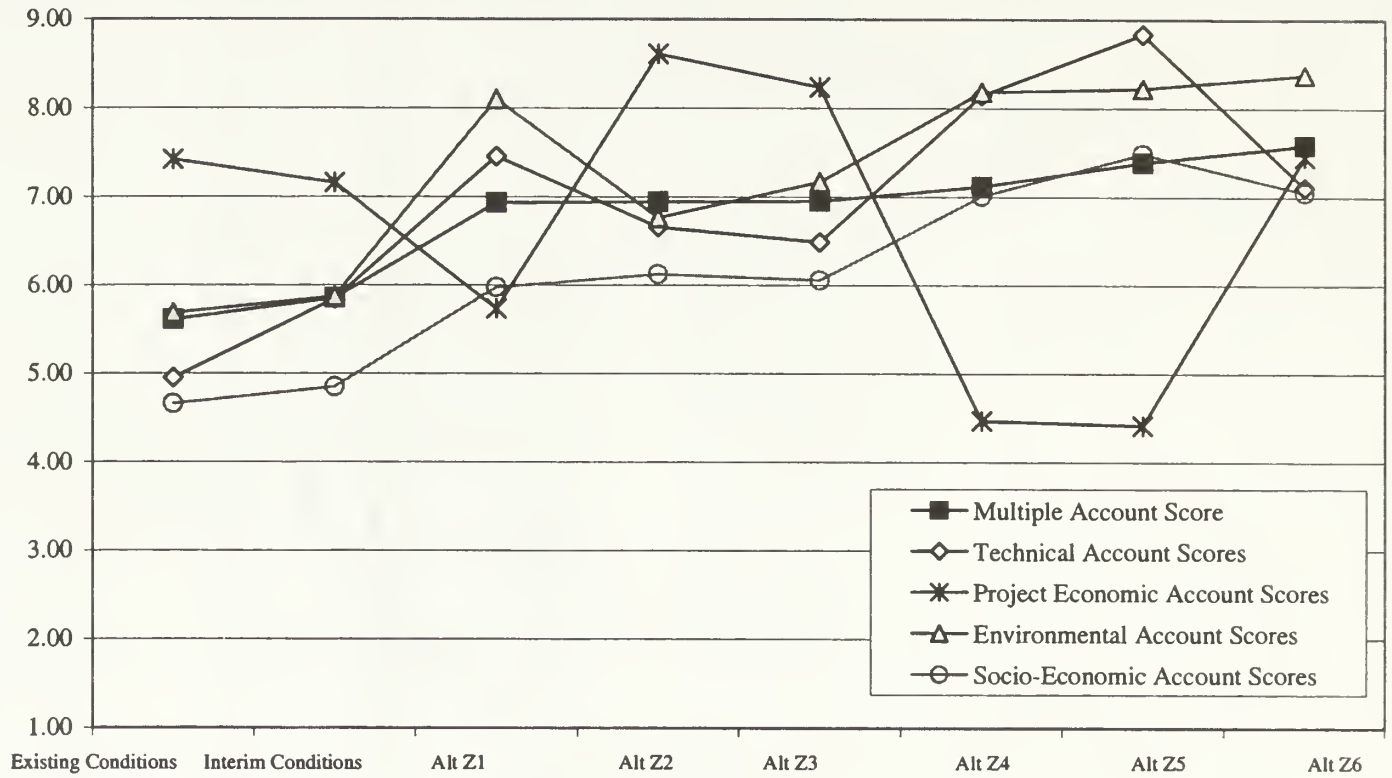
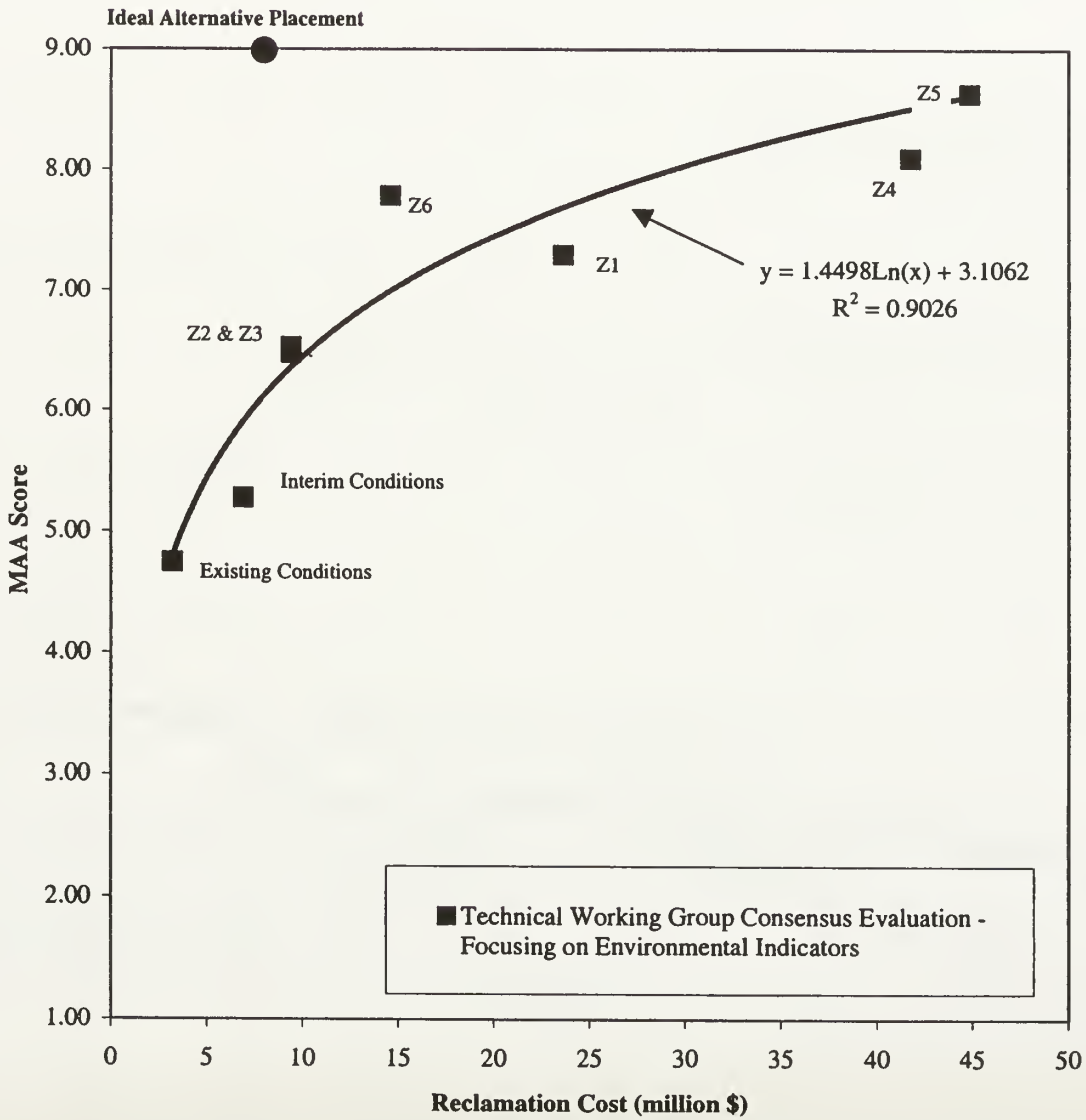


Figure 4.13-2 - Four Main Account Scores for the Technical Working Group Consensus Analyses for the Zortman Mine



Interim conditions and Alt Z1 not included in logarithmic curve fitting

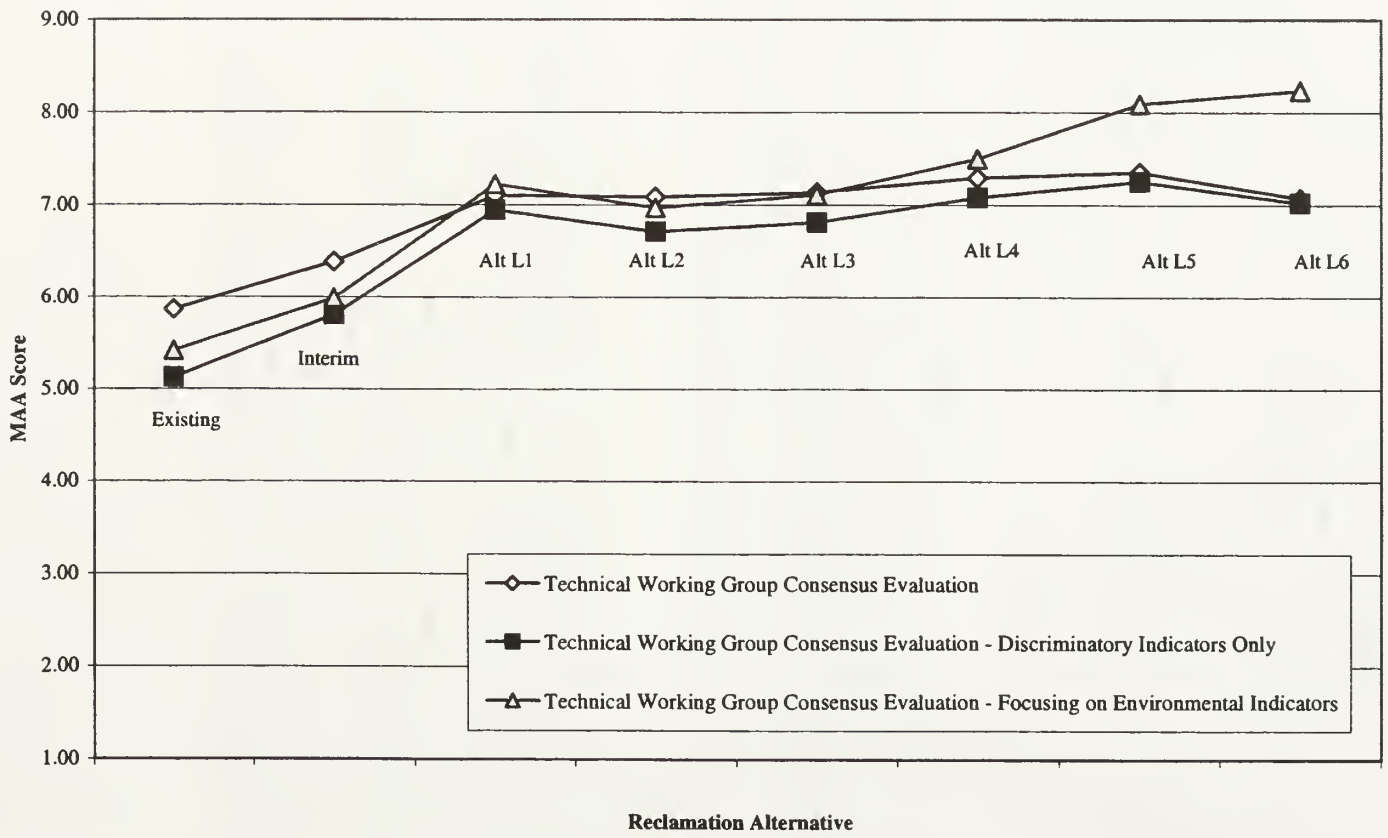
FIGURE 4.13-3 MAA SCORES VERSUS RECLAMATION COST FOR THE ZORTMAN RECLAMATION ALTERNATIVES

4.13.3 Landusky Mine Alternatives Comparison

The detailed Landusky Mine MAA evaluations are provided in Appendix A. Figure 4.13-4 shows the Landusky Mine MAA scores for the three evaluations completed on the reclamation alternatives. The ranking by the technical working group shows an overall MAA score, from best to worst, of L4, L5, L3, L2, L6, and L1, respectively. Note that this line is nearly flat, indicating that there is not a large difference between any of the alternatives. The second evaluation, the one that looks only at discriminatory indicators, is also flat and roughly parallels the line from the first analysis. The overall ranking in this evaluation, however, is from highest to lowest score L5, L6, L4, L1, L3, and L2. This is a different ranking than provided by the first evaluation, again showing how close the scores for the alternatives are. Because the scores are so close to one another, and elimination of the non-discriminatory indicators changes the overall ranking, the alternatives should be considered equal. If cost is removed as a scoring factor and only the environmental performance is considered, the evaluation produces more of a difference between alternatives, with an overall ranking of L6, L5, L4, L1, L3 and L2 (Figure 4.13-4).

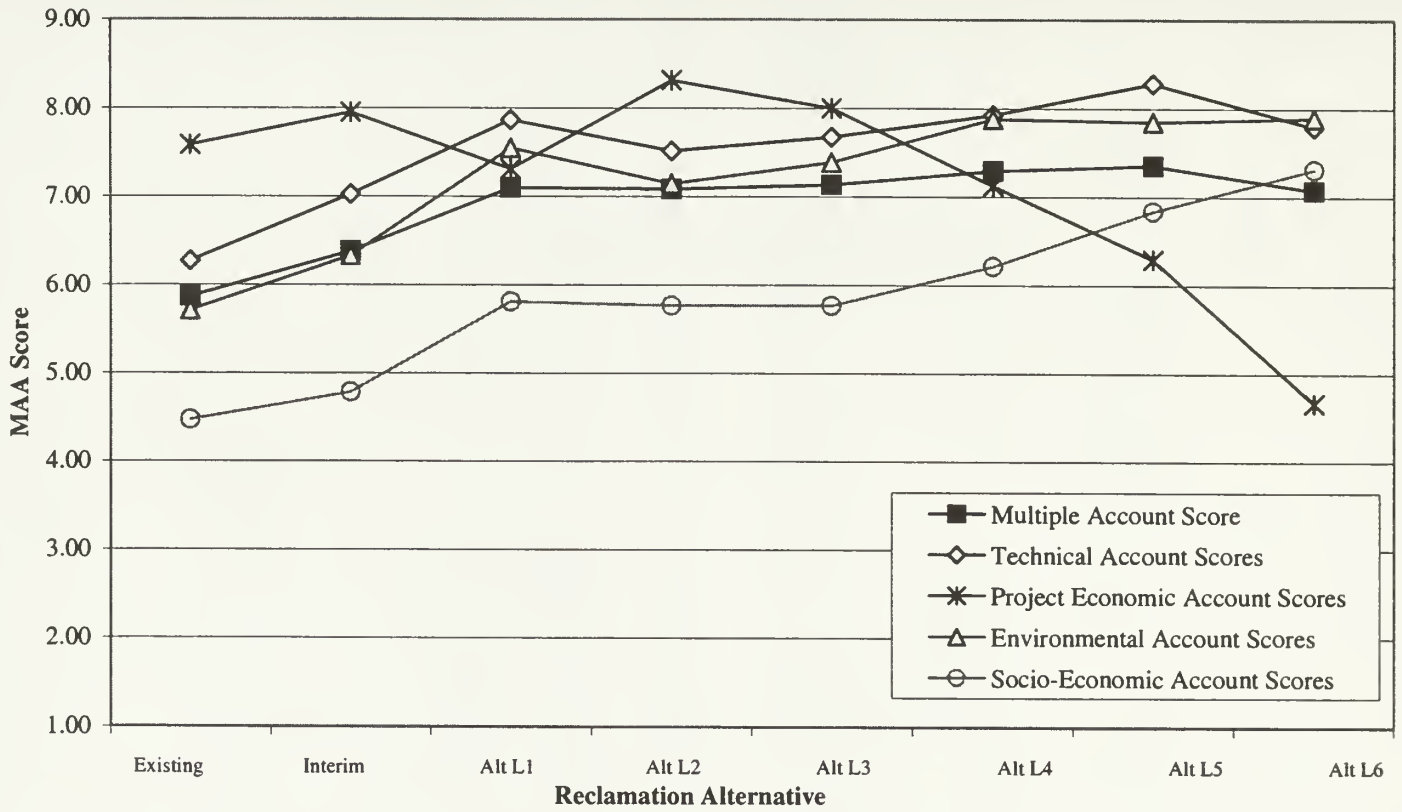
Figure 4.13-5 breaks down the MAA to show the individual account scores arrived at in the technical working group consensus evaluation. This figure shows the variability in relative ranking of alternatives between the four main accounts. Both the environmental and socioeconomic accounts show a flattening in the curves between alternatives L1, L2, and L3, indicating that these alternatives are more or less equal in these categories, whereas L4, L5 and L6 are ranked higher. The project economics on the other hand provides lower scores for L5 and L6. This is reflective of the high cost associated with Alternatives L5 and L6 that involve large amounts of backfill requiring increased employment, yet yielding only slightly greater environmental benefits.

Figure 4.13-6 shows the same type of cost-benefit analysis for the Landusky Mine reclamation alternatives as was prepared for the Zortman Mine (Figure 4.13-3). This plot shows the reclamation cost for each alternative against the MAA evaluation that only scored environmental performance. A best-fit logarithmic trendline has been shown on this graph to illustrate the comparison between the alternatives' overall environmental performance and their cost. In general, the higher cost alternatives at the Landusky Mine have a higher MAA score (greater environmental benefit); however, the environmental benefit per dollar value tends to decrease as the overall cost increases and the curve flattens out. This illustrates the high cost associated with the large amounts of pit backfill in Alternatives L5 and L6, compared to the only slight environmental benefit. Ideally, an alternative that plotted near the top left corner (i.e. all the environmental benefit for the existing bond amount) would be the best option from a cost-benefit perspective.



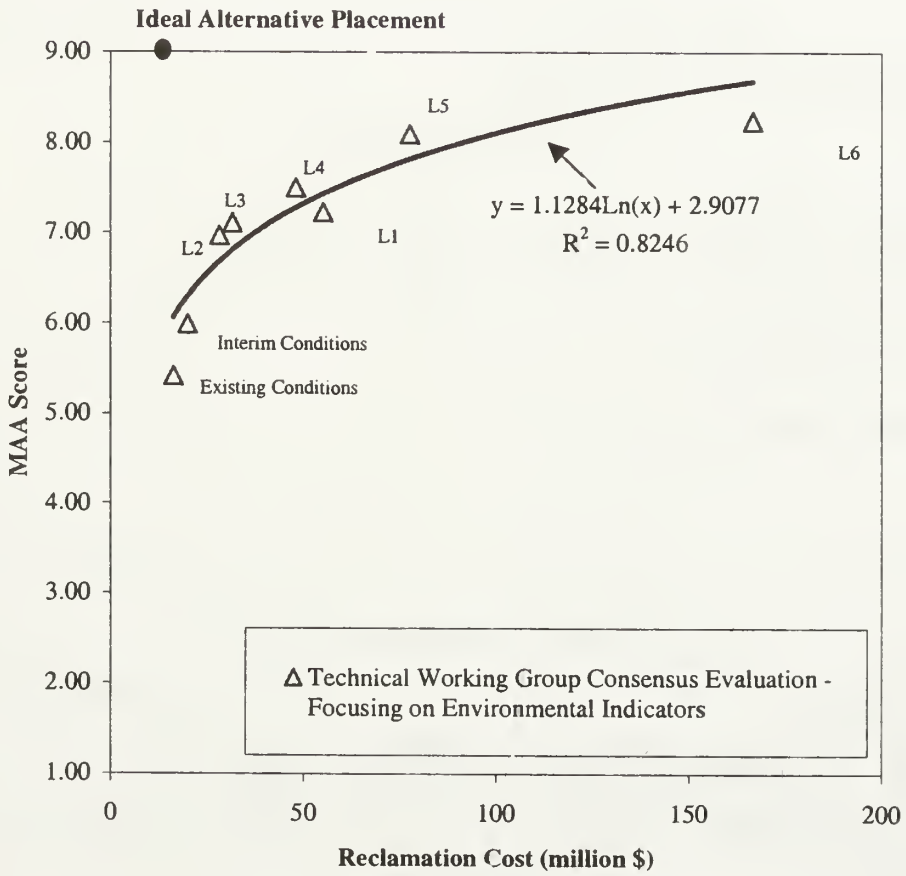
NOTE: Figure provided by Robertson GeoConsultants Inc.
(File Name: Landusky MAA_Figs 4.13-4 to 4.13-6.xls)

Figure 4.13-4 - MAA Scores for Various Analyses for the Landusky Mine



NOTE: Figure provided by Robertson GeoConsultants Inc. (File Name: Landusky MAA_Figs 4.13-4 to 4.13-6.xls)

Figure 4.13-5 - Four Main Account Scores for the Technical Working Group Consensus Analyses for the Landusky Mine



Interim & Alt L1 not included in logarithmic curve fitting

Figure 4.13-6 - MAA Scores Versus Reclamation Cost for the Landusky Mine Reclamation Alternatives

CHAPTER 5
CONSULTATION AND COORDINATION

This chapter describes public involvement, interagency coordination, and the government-to-government consultation that occurred during preparation of the SEIS. Also included is a list of the SEIS authors and a brief description of their responsibility.

5.1 PUBLIC INVOLVEMENT

A notice announcing the preparation of the SEIS was published in the Federal Register on August 3, 2000. A public scoping notice that described the SEIS process, requested public comments and announced the public scoping meetings was sent to a mailing list of over 100.

During September of 2000, public scoping meetings were held in the communities of Lodgepole, Hays, and Landusky. Attendance numbered approximately 16, 19, and 16 people, respectively. Oral comments were taken and written comments were received through October 2000.

As part of the scoping process, the agencies made a presentation to the Malta Chamber of Commerce on September 18 regarding the reclamation project, SEIS analysis, and the alternatives developed by the technical working group. Approximately 13 people attended this meeting.

5.2 CONSULTATION with the FORT BELKNAP GOVERNMENT

In a decision dated May 29, 1998, the Interior Board of Land Appeals (IBLA) directed the BLM to consult with the Fort Belknap government over measures needed to protect Tribal water resources and to report back on its efforts in its decision. As part of the government-to-government consultation process BLM, Fort Belknap, EPA and the Montana DEQ formed a technical working group to discuss and analyze the technical issues associated with mine reclamation. The purpose of the technical working group was to resolve what technical issues they could and identify others that required further discussion and possible resolution by the parties' respective managers.

While consultation is not complete until a decision has been made, the following is a chronology of key events and meetings that have been part of BLM's consultation process with the Fort Belknap government on reclamation of the Zortman and Landusky Mines. More detailed documentation of the meetings or events listed below is available from BLM files.

Consultation Chronology

06/01/98 The DEQ and BLM issue a Record of Decision selecting reclamation under Alternative 3 of the 1996 Final EIS, *Zortman and Landusky Mines Reclamation Plan Modifications and Mine Life Extensions.*

11/20/98 The IBLA issues an Order that sets aside the BLM Record of Decision of June 1, 1998 and directs that, "...BLM must separately analyze, and consult with the Tribes about, potential effects on Tribal water resources and report on its actions in its decision."

02/01/99 The BLM Field Manager Rick Hotaling sends a letter to Joseph McConnell, President, Fort Belknap Indian Community Council, requesting initiation of consultation discussions in reference to the IBLA Order.

02/05/99 A meeting is held in Billings with BLM, DEQ, BIA, Fort Belknap, CSP^2, and EPA to discuss adequacy of the Groundwater Investigation conducted under the Consent Decree and its applicability to final reclamation.

03/09/99 The Fort Belknap government responds to Mr. Hotaling's letter of February 1, 1999. Fort Belknap requests consultation begin immediately, and provides Fort Belknap's alternative reclamation plan prepared by Jim Kuipers of CSP^2 for the BLM to consider.

03/17/99 The BLM provides all parties a draft report prepared by BLM consulting hydrogeologist Kathy Gallagher that compares and evaluates the groundwater information from the Final Zortman-Landusky EIS, the Groundwater Investigation, and the Public Health Assessment.

03/24/99 A meeting is held in Helena. Attendance includes the Fort Belknap government, BLM, DEQ, and EPA technical staff, management, and legal counsel. Concludes to arrange for meeting of the technical staffs at the mine site to develop reclamation issues.

04/14/99 A meeting of the various parties' technical specialists is held at the mine site from 4/14/ to 4/16. Issues covered range from water monitoring to agency support for supplemental funding from Congress. The group agrees to continue discussions on possible immediate reclamation needs.

05/11/99 The BLM provides a technical completeness review of the Fort Belknap government's alternative reclamation plan and requests additional information on a variety of components.

05/22/99	Interior Secretary Babbitt and BLM State Director Larry Hamilton visit Fort Belknap and hear concerns regarding the mines and reclamation.
05/24/99	The EPA Regional Administrator, Bill Yellowtail, meets with the Fort Belknap government to discuss the situation with the mines.
05/25/99	A meeting is held in Billings with Bill Yellowtail and Larry Hamilton (plus staffs) to discuss Mr. Yellowtail's recent trip to Fort Belknap. It is agreed to conduct a 30-day working period for the technical people to address the reclamation problem and identify reclamation work that can go forward without conflict while other reclamation aspects are discussed.
06/02/99	The BLM management and staff, plus DEQ staff, meet with the Fort Belknap government on reclamation options and how to best achieve consultation. Council President Joseph McConnell asks that the technical people be allowed to develop this as much as possible.
06/23/99	The technical working group holds a brief meeting at the mine site. Spectrum Engineering personnel, hired by the agencies to develop the reclamation plans, are introduced to the working group members.
07/20/99	A technical working group meeting occurs at the mine site from 7/20 to 7/21. The group discusses use of the Multiple Accounts Analysis (MAA) and various processes for getting some reclamation work done this year.
08/24/99	A technical working group meeting occurs at the mine site from 8/24 to 8/25. The group discusses with EPA the King Creek tailing removal project and integration with Landusky Mine reclamation. A tour of the mines and, specifically, the 1999 reclamation work areas, is held for Fort Belknap Indian Community Council members and others.
09/01/99	A letter is sent from the BLM Field Manager Rick Hotaling to the Fort Belknap government requesting concurrence on phase 1 interim reclamation for 1999.
09/10/99	The final comparison report on groundwater conditions by Kathy Gallagher is distributed to the technical working group. The comparison report generally confirms the FEIS description of groundwater conditions.
09/14/99	A letter is received from the Fort Belknap government in general agreement with phase 1 interim reclamation efforts for 1999.
09/20/99	The technical working group holds a conference call. The group discusses the Montana Consensus Council contract, work plans, and conduct of the MAA.

10/18/99	The technical working group meets at the mine site from 10/18 to 10/19. Facilitation is provided by the Montana Consensus Council. The group discusses MAA development.
12/08/99	The technical working group meets in Billings from 12/8 to 12/10. The group discusses the mass balance reports and MAA format, and overall schedule for 2000 reclamation work. The Montana Consensus Council facilitates the meeting on 12/10.
01/06/00	A conference call is held among the decisionmakers and their staffs. Included in the call are Joseph McConnell, Larry Hamilton, Bill Yellowtail, and DEQ Director Mark Simonich. The main issue discussed is the Fort Belknap government's demand that the agencies prepare a Supplemental EIS on reclamation of the mines.
01/21/00	Bill Yellowtail meets with the Fort Belknap government to discuss mine reclamation and the possible need for a Supplemental EIS.
01/24/00	A subgroup of the technical working group, which includes DEQ, BLM, EPA, and Fort Belknap representatives, meets at Zortman to discuss the regulatory triggers that might require preparation of a Supplemental EIS.
01/25/00	The technical working group meets in Zortman. Development starts on the MAA for the Zortman Mine reclamation.
02/09/00	A major meeting of the technical working group is held in Billings from 2/9 to 2/11 to score the MAA on Zortman Mine reclamation alternatives. The agency decisionmakers also hold a meeting on 2/9 that includes Bill Yellowtail, Larry Hamilton, Joseph McConnell and Mark Simonich. EPA announces it is stepping back from the consultation process and only responding to specific requests for technical assistance. The technical working group holds an expanded meeting on 2/11 that includes individuals and traditionalists from Fort Belknap to provide input for the MAA on cultural and social issues and their relative importance.
02/17/00	A letter is sent from the BLM State Director and the DEQ Director to the EPA Regional Administrator confirming that EPA is pulling out of the consultation process and only responding to requests for technical assistance. The BLM and DEQ letter requests assistance in several key technical areas from EPA specialists.
02/25/00	The Fort Belknap government and their attorneys meet with Interior Secretary Babbitt in Washington D.C. and visit Congressional offices. The Secretary discusses trust issues and the Grinnell lands issue with the Fort Belknap government.

03/08/00 The Fort Belknap government holds a public meeting at Hays to explain the MAA process to residents and receive their input. The BLM and DEQ attend.

03/09/00 The Fort Belknap government holds a public meeting at Lodgepole to explain the MAA process to residents and receive their input. The BLM and DEQ attend.

03/10/00 Stanley Jaynes (Acting BLM Field Manager), Scott Haight (BLM) and Wayne Jepson (DEQ) meet with the Fort Belknap Indian Community Council to discuss the MAA results and the success of the technical working group. They confirm with the Council an agenda for the 3/24 decisionmakers' meeting.

03/20/00 The EPA responds to the BLM-DEQ letter of 2/17/00 requesting technical assistance by saying staff may not be available due to other work priorities and EPA will advise if the situation changes.

03/23/00 The technical working group meets in Zortman to discuss MAA development, monitoring, and land application disposal issues.

03/24/00 Larry Hamilton and Mark Simonich (plus staffs) meet with the Fort Belknap Indian Community Council. A review of the MAA progress is presented. The BLM and DEQ announce they have decided to prepare a SEIS on the final reclamation plan. The agencies ask Fort Belknap if they want to be a cooperating agency on the SEIS. The Fort Belknap government endorses the agency decision to prepare the SEIS and expresses the desire to continue working with the agencies, even during the lawsuit they intend to file in Federal Court on trust issues. The technical working group presents a plan for interim reclamation in 2000 and 2001.

03/28/00 The Fort Belknap government requests EPA to provide technical assistance on both the MAA and the SEIS process.

03/29/00 A conference call is held between Bill Yellowtail, Mark Simonich and Larry Hamilton (plus staffs). The callers discuss the recent decisions to prepare the SEIS and EPA providing funding assistance.

04/07/00 A phone conversation is held between Scott Haight (BLM) and Jim Kuipers (CSP^2-Fort Belknap). Mr. Kuipers states that the Fort Belknap government is not interested in being a cooperating agency on the SEIS, but will be providing input through the consultation process instead.

04/12/00 The Fort Belknap government makes a public announcement that they are suing the BLM, BIA and Public Health Service over trust responsibility issues associated with the mines.

04/17/00 The agencies receive written concurrence from the Fort Belknap government on interim reclamation plans for the years 2000 and 2001.

04/18/00 The technical working group meets in Polson, MT on 4/18 and 4/19. The meeting focuses on the development of the Landusky Mine reclamation MAA and revegetation study needs.

04/25/00 The Fort Belknap government files a complaint against the United States in Federal District Court alleging that the BLM, BIA and IHS have violated trust responsibilities by allowing operation of the Zortman and Landusky Mines. The complaint seeks a court order to implement the Fort Belknap reclamation plan.

04/26/00 A letter is received from EPA by DEQ and BLM which says EPA will provide the technical input requested by the agencies. The letter lists people assigned to a team to assist the agencies and says it is awaiting clarification on the role DEQ and BLM want EPA to play in the SEIS.

07/25/00 The technical working group meets in Zortman from 7/25 to 7/26. The group works on a consensus scoring for the Landusky Mine MAA and on other items. A tour of the mine site is provided for several Fort Belknap Indian Community Council members.

08/02/00 A management meeting is held in Billings. Participants include the BLM Deputy State Director, DEQ Director, EPA Acting Regional Administrator, Fort Belknap Indian Community Council President, and respective staffs. The main topic of discussion is funding sources and status of the SEIS.

08/03/00 The EPA Acting Regional Administrator Rebecca Hamner tours the mines with Fort Belknap Indian Community Council members and some Congressional staff.

08/28/00 The technical working group meets in Bozeman. The meeting includes management and legal staff. Two simultaneous group meetings are held, one to discuss SEIS preparation and one to discuss MPDES permit development and the water resources monitoring program.

09/07/00 A management meeting is held at Fort Belknap. Participants include the BLM Deputy State Director, DEQ Director, EPA Acting Regional Administrator, Fort Belknap Indian Community Council, and respective staffs. The agenda covers the MAA process, interim reclamation and concurrence on its continuance, funding sources, jobs training and development of an interagency memorandum of understanding (MOU) on preparation of the SEIS.

09/19/00 The technical working group meets in Zortman from 9/19 to 9/20. The group reviews the MAA scores on both the Zortman and Landusky Mines. A SEIS team meeting is held on 9/21 with all parties in attendance to discuss SEIS preparation and assignments.

10/01/00 The BLM amends its Fort Belknap Technical Assistance Agreement to provide another $15,000 to fund the Fort Belknap government's participation in the technical working group and SEIS efforts. The cumulative award to Fort Belknap from the BLM is at $30,000.

10/17/00 A SEIS team meeting is held in Billings. Attendance at the meeting includes members of the technical working group from all the parties.

11/02/00 The technical working group meets in Billings to discuss finalizing the MAA and the continued role of the working group in the SEIS preparation.

11/03/00 A management meeting is held in Billings. Attendees include the BLM Deputy State Director, DEQ Director, EPA Deputy Regional Administrator, Fort Belknap Indian Community Council President, and respective staffs. The group discusses the status and schedule of the SEIS, funding, function of the technical working group, and the preferred alternative identification process.

11/07/00 The MOU between the BLM, DEQ, EPA, and the Fort Belknap government on preparation of the SEIS is signed by all parties.

11/08/00 A meeting is held in Helena between the BLM, DEQ, EPA staff and Jim Kuipers, representing the Fort Belknap government, to discuss the SEIS content regarding analysis of compliance with applicable laws and regulations.

11/27/00 The technical working group meets in Billings to make final revisions to the MAA. The group reviews the loading calculations prepared by Robertson GeoConsultants and discusses the need to provide for the upgrade of water capture facilities across all alternatives.

11/30/00 Working drafts of the SEIS text are provided to all MOU parties for their review and comment.

12/14/00 A SEIS team meeting is held in Billings. Attendance includes legal and technical representatives from the Fort Belknap government. Fort Belknap's comments on the working drafts of the SEIS are discussed. A revision and review schedule for completion of the Draft SEIS is established.

01/04/01 A management meeting is held in Helena to discuss the preferred alternative identification. The Fort Belknap Indian Community Council President is unable to attend, so the preferred alternative discussion is postponed. Remaining managers, staff and legal counsel discuss the range of alternatives in the SEIS. The range is considered adequate, but development by the technical working group of a mid-range reclamation alternative for the Zortman Mine is recommended.

01/10/01 The technical working group meets in Bozeman. Alternative Z6 is developed and scored using the MAA process. The group also discusses the SEIS analysis, scheduling and funding.

01/22/01 A management meeting is held in Helena to discuss the preferred alternative identification. The technical working group presents the results of the MAA, including new Zortman Mine Alternative Z6. The agencies identify Alternative Z6 as their preferred alternative for the Draft SEIS. Fort Belknap feels they can concur with the identification of Z6. The group then discusses the Landusky Mine reclamation alternatives. The agencies identify Alternative L4 as their preferred alternative. Fort Belknap expresses interest in Alternative L5. The technical working group is directed to look at possible changes to Alternatives L4 and L5 which might either improve L4 performance or address concerns with L5 impacts.

01/25/01 A meeting of some technical working group members is held in Helena to discuss Landusky Mine alternative adjustments. No major changes are identified for Alternatives L4 or L5.

01/30/01 A meeting of some technical working group members is held in Billings to hear the results of the pilot test on biological treatment of nitrates and selenium in the leach pad waters.

02/06/01 The technical working group meets in Bozeman to discuss some changes to Alternative L4, rescore the Landusky Mine MAA, and discuss additional interim reclamation measures.

02/12/01 A management meeting is held in Helena to discuss the preferred alternative identification, additional interim reclamation, and comments on the SEIS working drafts. It is agreed that the preferred alternatives identified in the Draft SEIS will be Alternatives Z6 and L4.

02/22/01 The second round of working draft SEIS chapters is provided to all parties for their review and comment.

03/12/01 A management meeting is held in Helena to discuss final concerns prior to publication of the Draft SEIS.

03/16/01 Members of the Fort Belknap Indian Community Council meet with BLM State Director Mat Millenbach to discuss the reclamation status, Grinnell lands transfer, and contacts in the Washington offices of the Department of the Interior and BLM.

5.3 DISTRIBUTION LIST

The following is a list of organizations, businesses, agencies and individuals to whom this Draft SEIS has been distributed.

Organizations
American Wildlands
Buffalo Chasers Society
Center for Science in Public Participation
First Nations
Indian Law Clinic
Indian Law Resource Center
Land and Water Fund
Mineral Policy Center
Montana Bowhunters Association
Montana Environmental Information Center
Montana Wilderness Association
National Wildlife Federation
Northern Plains Resource Council
Phillco Economic Growth Council
Square Butte Grazing Association
Western Environmental Law Center
Wild Rockies Field Institute
Wilderness Society
Zortman Water Users Association

Businesses
Big Flat Electric
Billings Gazette
Chinook Opinion
Ezzie's Wholesale, Inc.
Great Falls Tribune
Helena Independent Record
Hop Brook Farm
HydroSolutions, Inc.
KEMC Radio
KMMR Radio
KOJM-KPQX Radio
Parsons Behle & Latimer
Phelps Dodge Corporation
Phillips County News
Robertson GeoConsultants, Inc.
Spectrum Engineering, Inc.
Zortman Mining, Inc.

Congressional Offices
Congressman Dennis Rehberg
Senator Max Baucus
Senator Conrad Burns

Tribal Government
Fort Belknap Fish & Wildlife
Fort Belknap Indian Community Council
Fort Belknap Planning Department

Federal Offices
Bureau of Indian Affairs
Bureau of Land Management
Environmental Protection Agency
Field Solicitor's Office
Fish and Wildlife Service
Fort Belknap Agency/BIA
Interior Board of Land Appeals

State of Montana
Bureau of Mines and Geology
Department of Environmental Quality

Department of Health and Environmental Sciences
Department of Natural Resources and Conservation
Environmental Quality Council
Montana Fish, Wildlife & Parks
Montana Hardrock Impact Board
Office of the Governor
State Historic Preservation Office

County Commissions
Phillips County Commission

Individuals
Charles Alcott
Sheila Askins
Don Bachman
Irene Bailey
Allen Beck
Delmar Bigby
Gary Boos
Elaine Broadhead
Michael J. Carney
Russell and Julia Cebulski
Ed Chandler Sr.
Dean Dirksen
Ace and Arv Duvall
Dale Enerson
John Erdman
Byron Ereaux
Stan Frasier
Mert Freyholtz
Vicki Freyholtz
Kathy Gallagher
Joe Ginalias
Thomas Gregory
Catherine and Bill Halver
Ken Gus Helgeson
Daylight Horse Capture
Gary Howell
Mitchell King
Tracy King
J.R. Kirkaldie
Louis Kirkaldie
Don Kraftenberg
Kenneth B. Lewis Sr.
Lonnie Link
Mike Long
Ken Maine
Rose Main
Vernie Main
Don Marble
Ally Marshall
Frank McConnell
Virgil McConnell
Glenn Miller
Winston Mitchell
Joan Montagne
Grace Nesbit
Ina Nez Perce
Don Nevrivy
Mark Newby
Leann Pankratz
Alex Parker
William Patric
Fritz Prellwitz
Paul Robinson
John Ross
Darryl Seeley
Sam Shimko, Jr.
Ross Simser
Arlo Skari
Brad Smith
Rhonda Snell
Richard Thieltges
Robert Toombs
Ilene LK Wing
Gerry Williams
Lorri Williams
Christy Wilson
Kim Wilson
Paul Zogg

Libraries
Harlem Public Library
Havre City Library
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5.4 LIST of PREPARERS

The Draft Supplemental EIS was prepared by an interdisciplinary team from the Bureau of Land Management (BLM), Montana Department of Environmental Quality (DEQ), and Spectrum Engineering, Inc., a third-party consulting firm working under the direction of the two agencies. The BLM, DEQ, and Spectrum Engineering personnel involved in the production of the Draft Supplemental EIS, their responsibilities and qualifications are listed below.

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GLOSSARY OF TERMS

ADIT: A near horizontal passage, driven from the surface, by which a mine may be entered, ventilated, and dewatered.

AFFECTED ENVIRONMENT: The biological and physical environment that will or may be changed by actions proposed and the relationship of people to that environment.

ALLUVIAL: Pertaining to material or processes associated with transportation or deposition by running water.

ALTERNATIVE: A combination of actions or management prescriptions applied in specific amounts and locations to achieve a desired management emphasis as expressed in goals and objectives. One of the several policies, plans, or projects proposed for decision making. An alternative need not substitute for another in all respects.

ATTENUATION: The reduction in concentration of a contaminant primarily through chemical interaction with other materials along its flowpath.

BANK CUBIC YARDS: The volume measure of earthen material before it is excavated.

BIOASSAY: An analysis of the concentration of a specific substance in a biological organism.

BIOLOGICAL ASSESSMENT: An evaluation conducted on federal actions in accordance with the Endangered Species Act. The purpose of the assessment is to determine whether the proposed action is likely to affect an endangered, threatened, or candidate species.

CAPILLARY BREAK: An abrupt change in the relative grain size of a soil profile designed to prevent the vertical upward migration of fluid by capillary action, or to slow the downward flow of fluid by causing it to accumulate above the capillary break. Usually composed of coarse material compared to the overlying soil.

CATION EXCHANGE CAPACITY: The sum of exchangeable cations absorbed by a soil, expressed in milliequivalent per 100 grams of oven dry soil.

CHEMICAL MASS BALANCE: The assignment of the measured chemical load, or mass of contaminants to the various source areas, such as surface water or groundwater basins.

COLLUVIUM: Fragments of rock carried and deposited by gravity. Usually coarser than alluvium and only transported a short distance or formed in place with little lateral movement.

CONNECTIVITY: The amount of connection between the pore spaces. Important because it indicates how readily fluid might move through the rock. The greater the connectivity the easier the movement between pore spaces.

CONSENT DECREE: Refers to the agreement between Zortman Mining, Inc., Pegasus Gold Corporation, the State of Montana, the U.S. Environmental Protection Agency, the Fort Belknap Tribal Government, and the Island Mountain Protectors that was signed as part of the settlement of complaints filed under the federal Clean Water Act and the Montana Water Quality Act. The Consent Decree required the mine operator to, among other things, construct seepage capture and treatment systems, develop a water quality improvement plan, conduct the Groundwater Study (WMCI 1998), and implement supplemental environmental projects to offset environmental impacts.

CUBIC-YARDS: A volume measure commonly applied to rock or soil material. One cubic yard is a cube of material that measures one yard in length, width, and height. One cubic-yard equals 27 cubic-feet.

CULTURAL RESOURCES: Remains of human activity, occupation, or endeavor as reflected in sites, buildings, artifacts, ruins, etc.

DIRECTIONAL BORE HOLE: A hole drilled at a specific angle other than vertical. As used in the SEIS, it describes a hole that would be drilled from outside the pit area to intercept groundwater beneath the pit.

ENDANGERED SPECIES: Any plant or animal species which is in danger of extinction throughout all or a significant portion of its range (Endangered Species Act of 1973).

ENVIRONMENTAL IMPACT STATEMENT (EIS): A detailed, written statement as required by Section 102(2)(c) of the National Environmental Policy Act of 1969.

EROSION: The processes whereby earthen or rocky material is worn away by natural forces such as wind, water, or ice and removed from any part of the earth's surface.

FOOTPRINT: The surface expression of the area of disturbance caused by a mine pit, waste rock dump, leach pad, or stockpile. As used, it generally refers to the area where a mine facility was located prior to removal. Reclamation of footprints generally only require placement of soil and revegetation.

FORAGE: Vegetation used for food by wildlife, particularly big game wildlife and livestock.

FORB: Any herbaceous plant other than a grass, especially one growing in a field or meadow.

GAINING STREAM: A stream that gains water as flow proceeds downstream. Water is gained from groundwater inflow and/or tributary streams.

GALLONS PER MINUTE (GPM): A measurement flow per minute. Seepage volumes are sometimes annualized to show what the steady flow in gpm would be if spread out over the entire year.

HEAP LEACH PAD: A lined area upon which ore is placed and leached with cyanide. Leachate accumulates at the base of the ore heap, on top of the leach pad liner, and is processed to remove precious metals from the cyanide solution. The term is also used generically to refer to both the pad liner and the ore stacked upon it.

HYDRAULIC CONDUCTIVITY: A measure of the ease with which water moves through soil or rock; permeability.

HYDROGRAPHS: A graph with measure flow volumes over time. Usually applied to the long term measurement of surface water flow in a river or stream.

HYDROSTRATIGRAPHIC UNITS: A unit rock which functions as an aquifer. Defined more by its groundwater character than by the character of the rock formation.

IN-SITU: Means "in place." In its original location.

LAND APPLICATION DISPOSAL (LAD): The disposal of excess solution by spray irrigation over a large area where evaporation and plant uptake utilize the water. LAD is also a treatment method for some contaminants such as residual amounts of cyanide, which breaks down when exposed to oxygen and sunlight; or nitrates which are used in plant growth.

LOSING STREAM: A stream that loses water as flow proceeds downstream. Typically, water loss is via infiltration into the ground and evaporation.

MACROINVERTEBRATES: Animals without backbones that are visible without a microscope; insects.

MERRILL-CROWE PLANT: A type of processing plant used to recover gold and silver from cyanide solutions after the leaching process.

MINE WASTE UNIT: A distinct accumulation of rock that is either waste rock or spent ore. Upon reclamation a mine waste unit may be a waste rock dump or leach pad.

MINERALIZATION: The process by which a valuable mineral or minerals are introduced into a rock resulting in a potential or actual ore deposit.

MPDES PERMIT: The Montana Pollution Discharge Elimination System permit. The MPDES permit sets the limits of contaminants that may discharged to state waters in order to comply with the Montana

Water Quality Act.

NAG: Non-Acid Generating material. Material that has been identified through testing as not likely to result in generation of acidic effluent. A layer, or base, composed of NAG material is used in most of the reclamation covers. NAG may be obtained from mined waste or ore with low sulfide content, historic mine tailings, subsoil material, or created, in the case of a base, by mixing agricultural lime with the substrate material.

OSMOTIC STRESS: Stress on plants as evidenced by wilting or browning due to elevated salt content in the soil.

PEAK FLOW: The greatest flow attained during the melting of the winter snowpack or from a storm event. Also known as "Peak Runoff."

PERMEABILITY: The capacity for transmitting a fluid; depends on the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter. It is measured by the rate at which a fluid of standard viscosity can move a given distance through a given interval of time.

PIEZOMETER: A well, generally of small diameter, that is used to measure the elevation of the water table.

PORE SPACE: The area, or void, between grains or clasts which can contain fluid or liquid. Measured by porosity as a percent of the rock that is void space.

POTENTIOMETRIC SURFACE: The surface or level to which water will rise in a well. The water table is a particular potentiometric surface for an unconfined aquifer.

READY-LINE: As used in the SEIS, the parking area on top of the Montana Gulch Waste Rock Dump where the haul trucks used to park during down times. It is a large flat area with a line of power outlets.

RECLAMATION COVER: The various layers, or combination of layers, of rock material, synthetics (such as GCL, PVC or HDPE), subsoil, soil and vegetation that is placed over the mining area as part of reclamation. May be a simple as a single layer of soil with revegetation, or as complex as multiple layers of rock soil, and synthetics. Depends upon the availability of construction materials and the nature of the mine waste that is being reclaimed.

RECORD OF DECISION (ROD): A document separate from but associated with an environmental impact statement that publicly and officially discloses the responsible official's decision. This is the document that actually selects the alternative to be implemented.

RIPARIAN: Situated on or pertaining to the bank of a river, stream, or other body of water. Normally used to refer to the plants of all types that grow along and around springs.

RUBY GULCH TAILINGS - Second grade or waste material derived when raw material is screened or processed that have been placed or washed into Ruby Gulch[?].

SCOPING: A term used to identify the process for determining the scope of issues related to a proposed action and for identifying significant issues to be addressed in an environmental analysis.

SEDIMENTARY: Rock formed of sediment, especially: (1) Clastic rocks, as, conglomerate, sandstone, and shales, formed of fragments of other rock transported from their sources and deposited in water. (2) Rocks formed by precipitation from solution, as rock salt and gypsum, or from secretions of organisms, as most limestone.

SEISMIC: Of, or produced by, earthquakes

SHEAR ZONE: A zone in which shearing has occurred on a large scale so that rock is crushed and brecciated. The shear zones in the mining areas have greatly increased porosity and permeability, allowing rapid water movement.

SULFIDE ZONE: That part of the rock not yet oxidized by air or surface water and containing sulfide minerals. As used at the mines it means the sulfide zones in the pit walls which contain enough sulfides to generate contaminated leachate when in contact with precipitation.

SULFIDE: A mineral composed of sulfur and one other metallic element. The most common sulfide mineral at the mines is iron pyrite (FeS_2).

SYENITE PORPHYRY: The dominant type of igneous rock in the mining areas.

TAILING: Rock that has been mined, crushed and leached. Mine tailings are present in the Ruby Gulch, Alder Gulch and King Creek drainages. These materials range in size from sand sized particles to gravel size.

TECHNICAL WORKING GROUP: The interagency, intergovernmental group of technical specialists from DEQ, BLM, EPA, Fort Belknap, and their consultants, that worked on development of the reclamation alternatives and Multiple Accounts Analysis.

THREATENED SPECIES: Any species of plant or animal which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

THRESHOLD LIMIT VALUE: The acceptable limit for exposure by workers to a potential contaminant.

WASTE ROCK DUMP: Area which waste rock us end-dumped from the top downward, typically without any selective handling criteria being used to sort the more reactive waste rock component.

WASTE ROCK REPOSITORY: An area where waste rock is placed, usually in lifts engineered for isolation of the reactive waste rock component. Typically constructed from the lower portions upward allowing for concurrent surface reclamation and built-in water management structures.

WASTE ROCK: Rock that has to be mined to access precious metal-bearing ore, but does not contain enough mineral to be mined and processed at a profit.

WATER BARRIER RECLAMATION COVER: A cover system designed, constructed, and maintained to prevent moisture infiltration to the waste below.

WATER BALANCE RECLAMATION COVER: A cover system designed to maintain a moisture balance that results in the rapid physical, chemical, and biological stabilization of the waste. A water balance cover contains enough soil in the upper part of the profile to "hold" the precipitation within the soil pore spaces until it can evaporate or be utilized by vegetation.

WATERSHED: The area from which runoff water drains to a specific stream or drainage. Surface water watersheds correspond to the topography unless the drainage is diverted. Groundwater watersheds may not correspond to the topography but follow geologic structures or underground mine workings.

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APPENDIX A

MULTIPLE ACCOUNTS ANALYSIS SPREADSHEETS

Multiple Accounts Analysis Process

The Multiple Accounts Analysis (MAA) for both mines is based on four fundamental accounts, namely technical, project economics, environmental and socio-economics. These main accounts are broken down into a list of sub-accounts and indicators on which the assessments are made. Sub-accounts can be defined as any material issue resulting in an impact (benefit or loss) by any of the alternatives being evaluated. An example is the water quality protection values described in Chapter 4, Section 4.3. Each sub-account may have one or more indicators that measure, either qualitatively or quantitatively, the impact of each alternative. An indicator value is provided for each indicator and for each alternative. An example of this is the values of *high* to *low* used to describe the water quality protection value. The descriptive value, or work description, in the account ledgers form the basis for the ranking, scaling and weighting of each alternative in a numerical analysis.

To do this, the alternatives are first **ranked** in order from best to worst with respect to each indicator for each sub-account. Ranking is a simple ordered list and makes no attempt to distinguish how great the difference of the impact is between the alternatives on the list. In practice, there may be very little difference in the impact from the best to the worst.

Since the separation of the best alternative from the worst may be either very slight or very significant, a **scaled** value (S) is assigned to each alternative for each of the sub-accounts using a nine point scale. In practice, the nine point scale provides a significant degree of differentiation between alternatives. The "best" alternative in the ranking is always given a value of 9. If the "worst" alternative is considered half as good as the best, it is given a value of 5 and the other alternatives distributed between these values.

An example could be "acidity load reporting to the water treatment plant." If all the potential alternatives are predicted to have a similar acid load then the scaled effort of the "worst" alternative may not be very different from the "best" alternative, and may be made in proportion to the predicted acid load. An example is provide in Figure A-1 and Figure A-2.

For certain indicators, the impacts may be similar for the various alternatives. For example, the indicators for the heap leach pad liner impacts do not change from one alternative to the other. These are termed "non-discriminatory" indicators.

Each indicator sub-account and account is then assigned a weighting factor (W) according to its relevant importance with respect to the other accounts, sub-accounts or indicators within the same level. Weighting is the factor most likely to reflect the analysts' bias or value basis. A weight of 5 indicates a "high value" indicator in the MAA.

MAA Scoring and Evaluation

The "score" an alternative has in a sub-account is the product of the scaled values times the indicator weighting. The cumulative "score" of one alternative in any one sub-account is obtained by adding the products of the scalar value and weight for each indicator in a sub-account and normalizing by dividing the sum of the weights for all indicators of that sub-account (equation (1)). The higher the sub-

Scale Factor	
9	**BEST**
8	*VERY GOOD*
7	GOOD
6	*GOOD 'ISH*
5	**INTERMEDIATE**
4	*POOR 'ISH*
3	POOR
2	*VERY POOR*
1	**WORST**

Figure A-1 Subdivisions of a Scaling System

Scale Factor	
9	**Alternative A** (e.g. 500 tons per year)
8	
7	
6	**Alternative C** (e.g. 850 tons per year)
5	**Alternative B** (e.g. 1000 tons per year)
4	
3	
2	
1	

Figure A-2 Example of scaling and positioning of "ranked" alternatives.

account score, the more favorable the alternative in that category.

$$= \frac{\text{Sum of Scalar Values x Weights (for each indicator in the Sub-Account)}}{\text{Sum of Weights for the indicators in the Sub-Account}} \quad (1)$$

Similarly, account scores are calculated for each alternative by summing the products of the sub-account scores and their weights and normalizing by dividing by the sum of the sub-account weights within that account. The multiple account scores are calculated the same way using the account scores and weights.

Tables A-1a and A-2a in this appendix provide the multiple accounts analysis ledgers for the Zortman and Landusky mines respectively. The 'numerical based' analysis for these ledgers are provided in Tables A-1b and A-2b. These numerical evaluations are representative of the technical working group's consensus evaluation. There are three levels of scoring, the first is the 'sub-account score' where, for example, the alternatives are scored for only a specific sub-account such as the surface water quality protection value. The second level of scoring is termed the 'account score' which provides the relative score within a specific account such as the environmental account. The third level of scoring is the 'multiple account score' which takes into consideration all the issues on the list. Sensitivity runs of these evaluations have also been performed and are described below.

Comparison Discussion

For each mine, a set of 3 evaluations were completed. The first, as mentioned above was a technical working group consensus analysis (Tables A-1b and A-2b). This evaluation includes all the issues deemed important for consideration by the members of the technical working group with input from the public at various public meetings.

The second evaluation takes into account only those indicators that are discriminatory between alternatives. A discrimination value, or DV, is calculated for each indicator. This value represents the difference in the score between the highest ranked alternative and the lowest ranked alternative and can be seen on the right hand side of the tables. If the difference is small, in this case less than 20% difference, then the indicator is termed non-discriminatory and dropped from the list. If the difference is greater than 20% then the indicator is left in the list and used in the calculations. The second set of scores therefore represents the evaluation of only those indicators that discriminate between alternatives. Tables A-1c and A-2c provide these evaluations for Zortman Mine and Landusky Mine respectively.

The third evaluation excludes the economic-related accounts and sub-accounts. Therefore, the project economics account and thos economic-related subaccounts in the socio-economics account are given 'weights' of zero and are excluded from the calculations. The resulting score is one in which money does not play a role in the alternative scoring. Tables A-1d and A-2d provide the 'cost excluded' evaluations for Zortman and Landusky mines.

Zortman Mine MAA Tables

Table A-1a. Multiple Accounts Analysis Ledger for the Zortman Mine Reclamation.

Table A-1b. Technical Working Group Consensus Evaluation for the Zortman Mine MAA.

Table A-1c. Discriminatory Values Only from the Technical Working Group Consensus Evaluation for the Zortman Mine MAA.

Table A-1d. Technical Working Group Consensus Evaluation of the Zortman Mine MAA Focusing on Environmental Issues Only.

Table A-1e. Summary of the Technical Working Group MAA Evaluation for the Zortman Mine.

Table A-1f. Summary of the Technical Working Group MAA Evaluation for the Zortman Mine Focusing on Environmental Issues.

TABLE A-1a. MULTIPLE ACCOUNTS ANALYSIS LEDGER FOR THE ZORTMAN MINE SITE RECLAMATION.
Updated March 19th, 2001

ACCOUNTS	SUB ACCOUNTS (issues)	INDICATORS	MEASURES	HIGH VALUE INDICATORS*	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT-3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)
TECHNICAL	79/81, 83, 84, 89 LEACH PAD											
	Dikes	Stability/Erodability/Maintainability	value (good-poor)	*	somewhat poor	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	Heaps	Stability/Erodability/Maintainability	value (good-poor)		intermediate	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	Liners	Durability/Maintainability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	82 LEACH PAD											
	Heap, Dike & Liner	Stability/Erodability/Maintainability	value (good-poor)		intermediate	good	good	good	good	good	good	good
	85/86 LEACH PAD											
	Dike	Stability/Erodability/Maintainability	value (good-poor)		somewhat poor	somewhat poor	somewhat good	somewhat poor	somewhat good	somewhat good	good	somewhat good
	Heap	Stability/Erodability/Maintainability	value (good-poor)		poor	somewhat poor	intermediate	intermediate	intermediate	somewhat good	good	somewhat good
	Liner	Durability/Maintainability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	good	intermediate
	WASTE ROCK DUMPS (Alder Gulch)	Stability/Erodability/Maintainability	value (good-poor)		somewhat poor	somewhat poor	somewhat good	somewhat poor	somewhat poor	somewhat good	somewhat good	intermediate
	WASTE ROCK DUMPS (OK)	Stability/Erodability/Maintainability	value (good-poor)		intermediate	intermediate	good	intermediate	intermediate	somewhat good	somewhat good	somewhat good
	WASTE ROCK DUMPS (South Ruby)	Stability/Erodability/Maintainability	value (good-poor)		intermediate	good	good	good	good	good	good	good
	OPEN PITS (N. Alabama)	Stability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	good	good	somewhat good
	OPEN PITS (S. Alabama)	Stability	value (good-poor)		intermediate	somewhat good	somewhat good	somewhat good	somewhat good	good	good	somewhat good
	OPEN PITS (OK/Ruby & Mint Pits)	Stability	value (good-poor)		somewhat poor	intermediate	intermediate	intermediate	intermediate	intermediate	good	intermediate
	OPEN PITS (Ross Pit)	Stability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	good	good	somewhat good
	UNDERGROUND WORKINGS	Stability	value (good-poor)		poor	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	TAILINGS (in Ruby Gulch)	Erodability	value (low-high)		high	high	low	high	high	low	low	intermediate
	STORM WATER CONTROL (ditches)	Stability/Erodability/Maintainability	value (low-high)	*	intermediate	intermediate	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low
	COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	Operating Requirements	value (low-high)		high	high	somewhat high	intermediate	high	somewhat low	somewhat low	high
		Maintenance Requirements	value (low-high)		intermediate	intermediate	intermediate	somewhat low	intermediate	somewhat low	somewhat low	intermediate
	WTP/LAD TREATMENT & RELEASE	Operating Requirements	value (low-high)	*	high	high	somewhat low	intermediate	intermediate	somewhat low	somewhat low	intermediate
		Sludge Disposal	value (difficult-easy)		somewhat easy	somewhat easy	somewhat easy	somewhat difficult	somewhat easy	somewhat difficult	somewhat difficult	somewhat easy
	ALTERNATIVE TECHNOLOGIES	Potential Application	value (difficult-easy)		somewhat difficult	somewhat difficult	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	RECLAMATION COVERS	Long-term Durability	value (good-poor)		somewhat good	somewhat good	somewhat poor	somewhat good	somewhat good	somewhat poor	somewhat good	intermediate
PROJECT ECONOMICS	RECLAMATION COST											
	Short Term Reclamation & LAD	Cost	$ (million)	*	3.2	6.9	25.8	9.8	9.8	42.2	45.4	14.8
	Long Term Monitoring/Maintenance	NPV of Annual Costs	NPV $ (million)		1	1	0.52	0.25	0.23	0.77	0.77	0.23
	% Attainable	% Attainable Within Bond	%	*	100%	100%	40%	100%	100%	23%	21%	66%
	LONG TERM WATER COLLECTION/TREATMENT COST (WTP, MPDES Monitoring)											
	Costs	NPV of Total Costs	NPV $ (million)	*	9.85	9.85	9.3	8.3	9.8	8.1	8.1	9.3
ENVIRONMENT	SURFACE WATER QUALITY PROTECTION VALUE	Alder Spur	value (high-low)		intermediate	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high
		Carter Spur	value (high-low)		intermediate	intermediate	high	somewhat high	intermediate	high	high	somewhat high
		Ruby Gulch	value (high-low)		somewhat low	somewhat low	somewhat high	intermediate	somewhat low	somewhat high	somewhat high	intermediate
		Lodgepole Creek	value (high-low)	*	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	intermediate	intermediate	high

TABLE A-1a. MULTIPLE ACCOUNTS ANALYSIS LEDGER FOR THE ZORTMAN MINE SITE RECLAMATION.
Updated March 19th, 2001

ACCOUNTS	SUB ACCOUNTS (Issues)	INDICATORS	MEASURES	HIGH VALUE INDICATORS*	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)
	SURFACE WATER QUANTITY PROTECTION VALUE	Alder Spur	value (high-low)		low	low	low	low	low	low	low	low
		Carter Spur	value (high-low)		somewhat high	somewhat high	high	somewhat high	somewhat high	high	high	somewhat high
		Ruby Gulch	value (high-low)		somewhat high	somewhat high	somewhat high	somewhat low	somewhat high	intermediate	intermediate	somewhat high
		Lodgepole Creek	value (high-low)	*	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	high	high	somewhat high
	GROUNDWATER PROTECTION VALUE	Alder Spur	value (high-low)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
		Carter Spur	value (high-low)		intermediate	intermediate	high	intermediate	intermediate	high	high	somewhat high
		Ruby Gulch	value (high-low)		somewhat low	somewhat low	somewhat high	intermediate	intermediate	somewhat high	somewhat high	somewhat high
		Lodgepole Creek	value (high-low)	*	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	intermediate	intermediate	high
	WTP WATER QUANTITY & QUALITY	Acidity Load	value (high-low)		high	high	intermediate	somewhat high	somewhat high	intermediate	intermediate	intermediate
	LAD WATER QUALITY	NO3/NO2 Load	value (high-low)		high	high	high	high	high	high	high	high
	LAD WATER QUANTITY	Volume	value (high-low)		high	somewhat high	somewhat low	somewhat high	intermediate	somewhat low	somewhat low	intermediate
	RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	Density of Revegetated Areas	value (poor-good)		somewhat poor	somewhat poor	somewhat good	intermediate	somewhat good	good	good	good
		Ecosystem Diversity/Sustainability	value (poor-good)	*	somewhat poor	somewhat poor	somewhat good	intermediate	somewhat good	good	good	good
		% of Area Revegetated	%		35.7	35.7	84.3	78.7	79	85	88.2	79.3
		Compatability for Wildlife Habitat	value (low-high)		somewhat low	somewhat low	intermediate	intermediate	intermediate	high	high	somewhat high
SOCIO-ECONOMICS	AESTHETICS	Appearance (Pleasing)	value (low-high)	*	low	somewhat low	intermediate	somewhat low	intermediate	somewhat high	high	somewhat high
	HUNTING & RECREATION	Suitability	value (low-high)		somewhat low	somewhat low	intermediate	intermediate	intermediate	somewhat high	somewhat high	somewhat high
	TOURISM	Suitability	value (low-high)		low	low	intermediate	somewhat high	intermediate	somewhat high	somewhat high	intermediate
	HEALTH AND SAFETY	Protection During Reclamation (Workers)	value (low-high)	*	high	somewhat high	somewhat low	somewhat high	somewhat high	somewhat low	somewhat low	intermediate
		Protection Post Reclamation (Public)	value (low-high)	*	somewhat low	intermediate	intermediate	intermediate	intermediate	somewhat high	high	somewhat high
	TRADITIONAL/CULTURAL	Usability	value (high-low)	*	low	low	somewhat low	somewhat low	somewhat low	intermediate	somewhat high	intermediate
	COMMUNITY INFRASTRUCTURE	Condition of Utilities (Water System)	value (low-high)		low	low	intermediate	low	low	intermediate	intermediate	somewhat low
	COMPLETION PERIOD	Time	years		0	1	4	2	2	5	7	3
	MINERAL DEVELOPMENT POTENTIAL	Mineral Development Potential	value (low-high)		somewhat high	intermediate	somewhat low	intermediate	intermediate	low	low	somewhat low
	FUTURE EFFORT BURDEN ON SOCIETY	Long Term Management Requirements	value (high-low)	*	high	high	somewhat high	intermediate	somewhat high	intermediate	intermediate	somewhat high
	EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	Short Term Local Employment Value	value (low-high)		low	somewhat low	somewhat high	intermediate	intermediate	high	high	somewhat high
		Long Term Local Employment Value	value (low-high)		somewhat high	somewhat high	intermediate	somewhat low	intermediate	somewhat low	somewhat low	intermediate

NOTE:
The short term reclamation costs for Alternatives Z1 through Z6 include the cost for measures completed during interim reclamation

TABLE A-1b. TECHNICAL WORKING GROUP CONSENSUS EVALUATION FOR THE ZORTMAN MAA
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT-3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)	Discriminating Value (based on 20%)	
TECHNICAL	3	79/81, 83, 84, 89 LEACH PAD	2												
		Dikes		Stability/Erodability/Maintainability	5	7	9	9	9	9	9	9	9	10	D
		Heaps		Stability/Erodability/Maintainability	3	7	9	9	9	9	9	9	9	6	ND
		Liners		Durability/Maintainability	1	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		7.22	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		82 LEACH PAD	2												
		Heap, Dike & Liner		Stability/Erodability/Maintainability	4	5	9	9	9	9	9	9	9	16	D
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		85/86 LEACH PAD	4												
		Dike		Stability/Erodability/Maintainability	3	3	3	7	3	7	7	9	7	18	D
		Heap		Stability/Erodability/Maintainability	4	1	3	5	5	5	7	9	7	32	D
		Liner		Durability/Maintainability	1	5	5	5	5	5	5	9	5	4	ND
				SUB ACCOUNT SCORE		2.25	3.25	5.75	4.25	5.75	6.75	9.00	6.75		
		WASTE ROCK DUMPS (Alder Gulch)	3	Stability/Erodability/Maintainability	3	5	5	9	5	5	9	9	7	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	9.00	9.00	7.00		
		WASTE ROCK DUMPS (OK)	2	Stability/Erodability/Maintainability	2	5	5	9	5	5	7	7	7	8	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	7.00	7.00	7.00		
		WASTE ROCK DUMPS (South Ruby)	2	Stability/Erodability/Maintainability	2	5	9	9	9	9	9	9	9	8	D
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		OPEN PITS (N. Alabama)	1	Stability	1	5	5	5	5	5	9	9	7	4	ND
				SUB ACCOUNT SCORE		5.00	5.00	5.00	5.00	5.00	9.00	9.00	7.00		
		OPEN PITS (S. Alabama)	2	Stability	2	5	7	7	7	7	9	9	7	8	D
				SUB ACCOUNT SCORE		5.00	7.00	7.00	7.00	7.00	9.00	9.00	7.00		
		OPEN PITS (OK/Ruby & Mint)	2	Stability	2	3	5	5	5	5	5	9	5	12	D
				SUB ACCOUNT SCORE		3.00	5.00	5.00	5.00	5.00	5.00	9.00	5.00		
		OPEN PITS (Ross Pit)	2	Stability	2	5	5	5	5	5	9	9	7	8	D
				SUB ACCOUNT SCORE		5.00	5.00	5.00	5.00	5.00	9.00	9.00	7.00		
		UNDERGROUND WORKINGS	1	Stability	1	3	9	9	9	9	9	9	9	6	ND
				SUB ACCOUNT SCORE		3.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		TAILINGS (in Ruby Gulch)	3	Erodability	3	1	1	9	1	1	9	9	5	24	D
				SUB ACCOUNT SCORE		1.00	1.00	9.00	1.00	1.00	9.00	9.00	5.00		
		STORM WATER CONTROL (Ditches)	5	Stability/Erodability/Maintainability	5	7	7	9	9	9	9	9	9	10	D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00		
		COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	5	Operating Requirements	3	3	3	5	7	3	9	9	3	18	D
				Maintenance Requirements	2	7	7	7	9	7	9	9	7	4	ND
				SUB ACCOUNT SCORE		4.60	4.60	5.80	7.80	4.60	9.00	9.00	4.60		
		WTP/LAD TREATMENT & RELEASE	2	Operating Requirements	5	3	3	9	7	7	9	9	7	30	D
				Sludge Disposal	3	9	9	9	5	9	5	5	9	12	D
				SUB ACCOUNT SCORE		5.25	5.25	9.00	6.25	7.75	7.50	7.50	7.75		
		ALTERNATIVE TECHNOLOGIES	1	Potential Application	1	7	7	9	9	9	9	9	9	2	ND
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00		
		RECLAMATION COVERS	3	Long-term Durability	3	9	9	5	9	9	5	9	7	12	D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	9.00	9.00	5.00	9.00	7.00		
				ACCOUNT SCORE		4.95	5.85	7.45	6.65	6.49	8.14	8.83	7.11		
PROJECT ECONOMICS	3	RECLAMATION COST	5												
		Short Term Reclamation & LAD (~ 5yrs)		Cost	5	9	8	4.5	7.5	7.5	1	1	6.5	40	D
		Long Term Monitoring/Maintenance		NPV of Annual Costs	2	1	1	5	9	9	3	2.5	9	16	D
		% Attainable		% Attainable Within Bond	5	9	9	4	9	9	2	2	7	35	D
				SUB ACCOUNT SCORE		7.67	7.25	4.38	8.38	8.38	1.75	1.67	7.13		
		LONG TERM WATER TREATMENT COST	3												
		Costs		NPV of Annual Costs	5	7	7	8	9	8	9	9	8	10	D
				SUB ACCOUNT SCORE		7.00	7.00	8.00	9.00	8.00	9.00	9.00	8.00		
				ACCOUNT SCORE		7.42	7.16	5.73	8.61	8.23	4.47	4.42	7.45		

TABLE A-1b. TECHNICAL WORKING GROUP CONSENSUS EVALUATION FOR THE ZORTMAN MAA
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)	Discriminating Value (based on 20%)	
ENVIRONMENT	5	SURFACE WATER QUALITY PROTECTION VALUE	4	Alder Spur	1	7	9	9	9	9	9	9	9	2	ND
				Carter Spur	1	5	5	9	7	5	9	9	7	4	ND
				Ruby Gulch	4	5	5	9	7	5	9	9	7	16	D
				Lodgepole Creek	5	7	7	7	7	7	5	5	9	20	D
				SUB ACCOUNT SCORE		6.09	6.27	8.09	7.18	6.27	7.18	7.18	8.09		
		SURFACE WATER QUANTITY PROTECTION VALUE	3	Alder Spur	1	9	9	9	9	9	9	9	9	0	ND
				Carter Spur	1	7	7	9	7	7	9	9	7	2	ND
				Ruby Gulch	4	9	9	9	5	9	7	7	9	16	D
				Lodgepole Creek	5	7	7	7	7	7	9	9	7	10	D
				SUB ACCOUNT SCORE		7.91	7.91	8.09	6.45	7.91	8.27	8.27	7.91		
		GROUNDWATER PROTECTION VALUE	5	Alder Spur	1	9	9	9	9	9	9	9	9	0	ND
				Carter Spur	1	5	5	9	5	5	9	9	7	4	ND
				Ruby Gulch	3	5	5	9	7	7	9	9	9	12	D
				Lodgepole Creek	5	7	7	7	7	7	5	5	9	20	D
				SUB ACCOUNT SCORE		6.40	6.40	8.00	7.00	7.00	7.00	7.00	8.80		
		WTP WATER QUANTITY & QUALITY (INFLOW)	3	Acidity Load	3	5	5	9	7	7	9	9	9	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	7.00	7.00	9.00	9.00	9.00		
		LAD WATER QUALITY	3	NO3/NO2 Load	2	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		LAD WATER QUANTITY	2	Volume	2	3	5	9	5	7	9	9	7	12	D
				SUB ACCOUNT SCORE		3.00	5.00	9.00	5.00	7.00	9.00	9.00	7.00		
		RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	5	Density of Revegetated Areas	3	3	3	7	5	7	9	9	9	18	D
				Ecosystem Diversity/Sustainability	5	3	3	7	5	7	9	9	9	30	D
				% of Area with Regrowth	3	2	2	8.5	8	8	8	9	8	21	D
				Compatability for Wildlife Habitat	4	3	3	5	5	5	9	9	7	24	D
				SUB ACCOUNT SCORE		2.80	2.80	6.77	5.60	6.67	8.80	9.00	8.27		
				ACCOUNT SCORE		5.68	5.87	8.10	6.76	7.17	8.18	8.22	8.38		
SOCIO-ECONOMICS	4	AESTHETICS	5	Appearance (Pleasing)	5	1	3	5	3	5	7	9	7	40	D
				SUB ACCOUNT SCORE		1.00	3.00	5.00	3.00	5.00	7.00	9.00	7.00		
		HUNTING & RECREATION	3	Suitability	3	5	5	7	7	7	9	9	9	12	D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	9.00	9.00	9.00		
		TOURISM	3	Suitability	3	3	3	7	9	7	9	9	7	18	D
				SUB ACCOUNT SCORE		3.00	3.00	7.00	9.00	7.00	9.00	9.00	7.00		
		HEALTH AND SAFETY	5	Protection During Reclamation (Workers)	5	9	7	3	7	7	3	3	5	30	D
				Protection Post Reclamation (Public)	5	3	5	5	5	5	7	9	7	30	D
				SUB ACCOUNT SCORE		6.00	6.00	4.00	6.00	6.00	5.00	6.00	6.00		
		TRADITIONAL/CULTURAL	5	Usability	5	3	3	5	5	5	7	9	7	30	D
				SUB ACCOUNT SCORE		3.00	3.00	5.00	5.00	5.00	7.00	9.00	7.00		
		COMMUNITY INFRASTRUCTURE	3	Condition of Utilities (Water System)	3	5	5	9	5	5	9	9	7	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	9.00	9.00	7.00		
		COMPLETION PERIOD	3	Time to Complete Reclamation	3	9	8	5	7	7	4	2	6	21	D
				SUB ACCOUNT SCORE		9.00	8.00	5.00	7.00	7.00	4.00	2.00	6.00		
		MINERAL DEVELOPMENT POTENTIAL	3	Mineral Development Potential	3	9	7	5	7	7	3	3	5	18	D
				SUB ACCOUNT SCORE		9.00	7.00	5.00	7.00	7.00	3.00	3.00	5.00		
		FUTURE BURDEN ON SOCIETY	5	Long Term Management Requirements	5	5	5	7	9	7	9	9	9	20	D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	9.00	7.00	9.00	9.00	9.00		
		EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	5	Short Term Local Employment Value	4	1	3	7	5	5	9	9	7	32	D
				Long Term Local Employment Value	2	9	9	7	5	7	5	5	7	8	D
				SUB ACCOUNT SCORE		3.67	5.00	7.00	5.00	5.67	7.67	7.67	7.00		
				ACCOUNT SCORE		4.66	4.85	5.98	6.13	6.06	7.01	7.48	7.05		
				MULTIPLE ACCOUNT SCORE		5.61	5.85	6.93	6.94	6.95	7.12	7.39	7.58		

TABLE A-1c. DISCRIMINATORY VALUES ONLY FROM TECHNICAL WORKING GROUP CONSENSUS EVALUATION FOR THE ZORTMAN MAA.
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)	Discriminating Value (based on 20 %)	
TECHNICAL	3	79/81, 83, 84, 89 LEACH PAD	2												
		Dikes		Stability/Erodability/Maintainability	5	7	9	9	9	9	9	9	9	10	D
		Heaps		Stability/Erodability/Maintainability	0	7	9	9	9	9	9	9	9	0.0000002	ND
		Liners		Durability/Maintainability	0	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		82 LEACH PAD	2												
		Heap, Dike & Liner		Stability/Erodability/Maintainability	4	5	9	9	9	9	9	9	9	16	D
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		85/86 LEACH PAD	4												
		Dike		Stability/Erodability/Maintainability	3	3	3	7	3	7	7	9	7	18	D
		Heap		Stability/Erodability/Maintainability	4	1	3	5	5	5	7	9	7	32	D
		Liner		Durability/Maintainability	0	5	5	5	5	5	5	9	5	0.0000004	ND
				SUB ACCOUNT SCORE		1.86	3.00	5.86	4.14	5.86	7.00	9.00	7.00		
		WASTE ROCK DUMPS (Alder Gulch)	3	Stability/Erodability/Maintainability	3	5	5	9	5	5	9	9	7	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	9.00	9.00	7.00		
		WASTE ROCK DUMPS (OK)	2	Stability/Erodability/Maintainability	2	5	5	9	5	5	7	7	7	8	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	7.00	7.00	7.00		
		WASTE ROCK DUMPS (South Ruby)	2	Stability/Erodability/Maintainability	2	5	9	9	9	9	9	9	9	8	D
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		OPEN PITS (N Alabama)	0	Stability	0	5	5	5	5	5	9	9	7	0.0000004	ND
				SUB ACCOUNT SCORE		5.00	5.00	5.00	5.00	5.00	9.00	9.00	7.00		
		OPEN PITS (S. Alabama)	2	Stability	2	5	7	7	7	7	9	9	7	8	D
				SUB ACCOUNT SCORE		5.00	7.00	7.00	7.00	7.00	9.00	9.00	7.00		
		OPEN PITS (OK/Ruby & Mint)	2	Stability	2	3	5	5	5	5	5	9	5	12	D
				SUB ACCOUNT SCORE		3.00	5.00	5.00	5.00	5.00	5.00	9.00	5.00		
		OPEN PITS (Ross Pit)	2	Stability	2	5	5	5	5	5	9	9	7	8	D
				SUB ACCOUNT SCORE		5.00	5.00	5.00	5.00	5.00	9.00	9.00	7.00		
		UNDERGROUND WORKINGS	0	Stability	0	3	9	9	9	9	9	9	9	0.0000006	ND
				SUB ACCOUNT SCORE		3.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		TAILINGS (in Ruby Gulch)	3	Erodability	3	1	1	9	1	1	9	9	5	24	D
				SUB ACCOUNT SCORE		1.00	1.00	9.00	1.00	1.00	9.00	9.00	5.00		
		STORM WATER CONTROL (Ditches)	5	Stability/Erodability/Maintainability	5	7	7	9	9	9	9	9	9	10	D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00		
		COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	5	Operating Requirements	3	3	3	5	7	3	9	9	3	18	D
				Maintenance Requirements	0	7	7	7	9	7	9	9	7	0.0000002	ND
				SUB ACCOUNT SCORE		3.00	3.00	5.00	7.00	3.00	9.00	9.00	3.00		
		WTP/LAD TREATMENT & RELEASE	2	Operating Requirements	5	3	3	9	7	7	9	9	7	30	D
				Sludge Disposal	3	9	9	9	5	9	5	5	9	12	D
				SUB ACCOUNT SCORE		5.25	5.25	9.00	6.25	7.75	7.50	7.50	7.75		
		ALTERNATIVE TECHNOLOGIES	0	Potential Application	0	7	7	9	9	9	9	9	9	0.0000002	ND
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00		
		RECLAMATION COVERS	3	Long-term Durability	3	9	9	5	9	9	5	9	7	12	D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	9.00	9.00	5.00	9.00	7.00		
				ACCOUNT SCORE		4.69	5.53	7.34	6.46	6.20	8.10	8.82	6.83		
PROJECT ECONOMICS	3	RECLAMATION COST	5												
		Short Term Reclamation & LAD (~ 5yrs)		Cost	5	9	8	4.5	7.5	7.5	1	1	6.5	40	D
		Long Term Monitoring/Maintenance		NPV of Annual Costs	2	1	1	5	9	9	3	2.5	9	16	D
		% Attainable		% Attainable Within Bond	5	9	9	4	9	9	2	2	7	35	D
				SUB ACCOUNT SCORE		7.67	7.25	4.38	8.38	8.38	1.75	1.67	7.13		
		LONG TERM WATER TREATMENT COST	3												
		Costs		NPV of Annual Costs	5	7	7	8	9	8	9	9	8	10	D
				SUB ACCOUNT SCORE		7.00	7.00	8.00	9.00	8.00	9.00	9.00	8.00		
				ACCOUNT SCORE		7.42	7.16	5.73	8.61	8.23	4.47	4.42	7.45		

TABLE A-1c. DISCRIMINATORY VALUES ONLY FROM TECHNICAL WORKING GROUP CONSENSUS EVALUATION FOR THE ZORTMAN MAA.
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)	Discriminating Value (based on 20%)	
ENVIRONMENT	5	SURFACE WATER QUALITY PROTECTION VALUE	4	Alder Spur	0	7	9	9	9	9	9	9	9	0.0000002	ND
				Carter Spur	0	5	5	9	7	5	9	9	7	0.0000004	ND
				Ruby Gulch	4	5	5	9	7	5	9	9	7	16	D
				Lodgepole Creek	5	7	7	7	7	7	5	5	9	20	D
				SUB ACCOUNT SCORE		6.11	6.11	7.89	7.00	6.11	6.78	6.78	8.11		
		SURFACE WATER QUANTITY PROTECTION VALUE	3	Alder Spur	0	9	9	9	9	9	9	9	9	0	ND
				Carter Spur	0	7	7	9	7	7	9	9	7	0.0000002	ND
				Ruby Gulch	4	9	9	9	5	9	7	7	9	16	D
				Lodgepole Creek	5	7	7	7	7	7	9	9	7	10	D
				SUB ACCOUNT SCORE		7.89	7.89	7.89	6.11	7.89	8.11	8.11	7.89		
		GROUNDWATER PROTECTION VALUE	5	Alder Spur	0	9	9	9	9	9	9	9	9	0	ND
				Carter Spur	0	5	5	9	5	5	9	9	7	0.0000004	ND
				Ruby Gulch	3	5	5	9	7	7	9	9	9	12	D
				Lodgepole Creek	5	7	7	7	7	7	5	5	9	20	D
				SUB ACCOUNT SCORE		6.25	6.25	7.75	7.00	7.00	6.50	6.50	9.00		
		WTP WATER QUANTITY & QUALITY (INFLOW)	3	Acidity Load	3	5	5	9	7	7	9	9	9	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	7.00	7.00	9.00	9.00	9.00		
		LAD WATER QUALITY	0	NO3/NO2 Load	0	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		LAD WATER QUANTITY	2	Volume	2	3	5	9	5	7	9	9	7	12	D
				SUB ACCOUNT SCORE		3.00	5.00	9.00	5.00	7.00	9.00	9.00	7.00		
		RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	5	Density of Revegetated Areas	3	3	3	7	5	7	9	9	9	18	D
				Ecosystem Diversity/Sustainability	5	3	3	7	5	7	9	9	9	30	D
				% of Area with Regrowth	3	2	2	8.5	8	8	8	9	8	21	D
				Compatability for Wildlife Habitat	4	3	3	5	5	5	9	9	7	24	D
				SUB ACCOUNT SCORE		2.80	2.80	6.77	5.60	6.67	8.80	9.00	8.27		
				ACCOUNT SCORE		5.20	5.38	7.85	6.38	6.88	7.86	7.91	8.34		
SOCIO-ECONOMICS	4	AESTHETICS	5	Appearance (Pleasing)	5	1	3	5	3	5	7	9	7	40	D
				SUB ACCOUNT SCORE		1.00	3.00	5.00	3.00	5.00	7.00	9.00	7.00		
		HUNTING & RECREATION	3	Suitability	3	5	5	7	7	7	9	9	9	12	D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	9.00	9.00	9.00		
		TOURISM	3	Suitability	3	3	3	7	9	7	9	9	7	18	D
				SUB ACCOUNT SCORE		3.00	3.00	7.00	9.00	7.00	9.00	9.00	7.00		
		HEALTH AND SAFETY	5	Protection During Reclamation (Workers)	5	9	7	3	7	7	3	3	5	30	D
				Protection Post Reclamation (Public)	5	3	5	5	5	5	7	9	7	30	D
				SUB ACCOUNT SCORE		6.00	6.00	4.00	6.00	6.00	5.00	6.00	6.00		
		TRADITIONAL/CULTURAL	5	Usability	5	3	3	5	5	5	7	9	7	30	D
				SUB ACCOUNT SCORE		3.00	3.00	5.00	5.00	5.00	7.00	9.00	7.00		
		COMMUNITY INFRASTRUCTURE	3	Condition of Utilities (Water System)	3	5	5	9	5	5	9	9	7	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	9.00	9.00	7.00		
		COMPLETION PERIOD	3	Time to Complete Reclamation	3	9	8	5	7	7	4	2	6	21	D
				SUB ACCOUNT SCORE		9.00	8.00	5.00	7.00	7.00	4.00	2.00	6.00		
		MINERAL DEVELOPMENT POTENTIAL	3	Mineral Development Potential	3	9	7	5	7	7	3	3	7	18	D
				SUB ACCOUNT SCORE		9.00	7.00	5.00	7.00	7.00	3.00	3.00	7.00		
		FUTURE BURDEN ON SOCIETY	5	Long Term Management Requirements	5	5	5	7	9	7	9	9	9	20	D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	9.00	7.00	9.00	9.00	9.00		
		EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	5	Short Term Local Employment Value	4	1	3	7	5	5	9	9	7	32	D
				Long Term Local Employment Value	2	9	9	7	5	7	5	5	7	8	D
				SUB ACCOUNT SCORE		3.67	5.00	7.00	5.00	5.67	7.67	7.67	7.00		
				ACCOUNT SCORE		4.66	4.85	5.98	6.13	6.06	7.01	7.48	7.20		
				MULTIPLE ACCOUNT SCORE		5.40	5.62	6.83	6.77	6.80	7.00	7.28	7.56		

TABLE A-1d. TECHNICAL WORKING GROUP CONSENSUS EVALUATION OF THE ZORTMAN MAA FOCUSING ON ENVIRONMENTAL ISSUES ONLY

Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERNATIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)	Discriminating Value (based on 20%)	
TECHNICAL	3	79/81, 83, 84, 89 LEACH PAD	2												
		Dikes		Stability/Erodability/Maintainability	5	7	9	9	9	9	9	9	9	10	D
		Heaps		Stability/Erodability/Maintainability	3	7	9	9	9	9	9	9	9	6	ND
		Liners		Durability/Maintainability	1	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		7.22	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		82 LEACH PAD	2												
		Heap, Dike & Liner		Stability/Erodability/Maintainability	4	5	9	9	9	9	9	9	9	16	D
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		85/86 LEACH PAD	4												
		Dike		Stability/Erodability/Maintainability	3	3	3	7	3	7	7	9	7	18	D
		Heap		Stability/Erodability/Maintainability	4	1	3	5	5	5	7	9	7	32	D
		Liner		Durability/Maintainability	1	5	5	5	5	5	5	9	5	4	ND
				SUB ACCOUNT SCORE		2.25	3.25	5.75	4.25	5.75	6.75	9.00	6.75		
		WASTE ROCK DUMPS (Alder Gulch)	3	Stability/Erodability/Maintainability	3	5	5	9	5	5	9	9	7	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	9.00	9.00	7.00		
		WASTE ROCK DUMPS (OK)	2	Stability/Erodability/Maintainability	2	5	5	9	5	5	7	7	7	8	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	7.00	7.00	7.00		
		WASTE ROCK DUMPS (South Ruby)	2	Stability/Erodability/Maintainability	2	5	9	9	9	9	9	9	9	8	D
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		OPEN PITS (N. Alabama)	1	Stability	1	5	5	5	5	5	9	9	7	4	ND
				SUB ACCOUNT SCORE		5.00	5.00	5.00	5.00	5.00	9.00	9.00	7.00		
		OPEN PITS (S. Alabama)	2	Stability	2	5	7	7	7	7	9	9	7	8	D
				SUB ACCOUNT SCORE		5.00	7.00	7.00	7.00	7.00	9.00	9.00	7.00		
		OPEN PITS (OK/Ruby & Mint)	2	Stability	2	3	5	5	5	5	5	9	5	12	D
				SUB ACCOUNT SCORE		3.00	5.00	5.00	5.00	5.00	5.00	9.00	5.00		
		OPEN PITS (Ross Pit)	2	Stability	2	5	5	5	5	5	9	9	7	8	D
				SUB ACCOUNT SCORE		5.00	5.00	5.00	5.00	5.00	9.00	9.00	7.00		
		UNDERGROUND WORKINGS	1	Stability	1	3	9	9	9	9	9	9	9	6	ND
				SUB ACCOUNT SCORE		3.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		TAILINGS (in Ruby Gulch)	3	Erodability	3	1	1	9	1	1	9	9	5	24	D
				SUB ACCOUNT SCORE		1.00	1.00	9.00	1.00	1.00	9.00	9.00	5.00		
		STORM WATER CONTROL (Ditches)	5	Stability/Erodability/Maintainability	5	7	7	9	9	9	9	9	9	10	D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00		
		COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	5	Operating Requirements	3	3	3	5	7	3	9	9	3	18	D
				Maintenance Requirements	2	7	7	7	9	7	9	9	7	4	ND
				SUB ACCOUNT SCORE		4.60	4.60	5.80	7.80	4.60	9.00	9.00	4.60		
		WTP/LAD TREATMENT & RELEASE	2	Operating Requirements	5	3	3	9	7	7	9	9	7	30	D
				Sludge Disposal	3	9	9	9	5	9	5	5	9	12	D
				SUB ACCOUNT SCORE		5.25	5.25	9.00	6.25	7.75	7.50	7.50	7.75		
		ALTERNATIVE TECHNOLOGIES	1	Potential Application	1	7	7	9	9	9	9	9	9	2	ND
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00		
		RECLAMATION COVERS	3	Long-term Durability	3	9	9	5	9	9	5	9	7	12	D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	9.00	9.00	5.00	9.00	7.00		
				ACCOUNT SCORE		4.95	5.85	7.45	6.65	6.49	8.14	8.83	7.11		
PROJECT ECONOMICS	0	RECLAMATION COST	5												
		Short Term Reclamation & LAD (~ 5yrs)		Cost	5	9	8	4.5	7.5	7.5	1	1	6.5	40	D
		Long Term Monitoring/Maintenance		NPV of Annual Costs	2	1	1	5	9	9	3	2.5	9	16	D
		% Attainable		% Attainable Within Bond	5	9	9	4	9	9	2	2	7	35	D
				SUB ACCOUNT SCORE		7.67	7.25	4.38	8.38	8.38	1.75	1.67	7.13		
		LONG TERM WATER TREATMENT COST	3												
		Costs		NPV of Annual Costs	5	7	7	8	9	8	9	9	8	10	D
				SUB ACCOUNT SCORE		7.00	7.00	8.00	9.00	8.00	9.00	9.00	8.00		
				ACCOUNT SCORE		7.42	7.16	5.73	8.61	8.23	4.47	4.42	7.45		

TABLE A-1d. TECHNICAL WORKING GROUP CONSENSUS EVALUATION OF THE ZORTMAN MAA FOCUSING ON ENVIRONMENTAL ISSUES ONLY

Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERNATIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)	Discriminating Value (based on 20%)	
ENVIRONMENT	5	SURFACE WATER QUALITY PROTECTION VALUE	4	Alder Spur	1	7	9	9	9	9	9	9	9	2	ND
				Carter Spur	1	5	5	9	7	5	9	9	7	4	ND
				Ruby Gulch	4	5	5	9	7	5	9	9	7	16	D
				Lodgepole Creek	5	7	7	7	7	7	5	5	9	20	D
				SUB ACCOUNT SCORE		6.09	6.27	8.09	7.18	6.27	7.18	7.18	8.09		
		SURFACE WATER QUANTITY PROTECTION VALUE	3	Alder Spur	1	9	9	9	9	9	9	9	9	0	ND
				Carter Spur	1	7	7	9	7	7	9	9	7	2	ND
				Ruby Gulch	4	9	9	9	5	9	7	7	9	16	D
				Lodgepole Creek	5	7	7	7	7	7	9	9	7	10	D
				SUB ACCOUNT SCORE		7.91	7.91	8.09	6.45	7.91	8.27	8.27	7.91		
		GROUNDWATER PROTECTION VALUE	5	Alder Spur	1	9	9	9	9	9	9	9	9	0	ND
				Carter Spur	1	5	5	9	5	5	9	9	7	4	ND
				Ruby Gulch	3	5	5	9	7	7	9	9	9	12	D
				Lodgepole Creek	5	7	7	7	7	7	5	5	9	20	D
				SUB ACCOUNT SCORE		6.40	6.40	8.00	7.00	7.00	7.00	7.00	8.80		
		WTP WATER QUANTITY & QUALITY (INFLOW)	3	Acidity Load	3	5	5	9	7	7	9	9	9	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	7.00	7.00	9.00	9.00	9.00		
		LAD WATER QUALITY	3	NO3/NO2 Load	2	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		LAD WATER QUANTITY	2	Volume	2	3	5	9	5	7	9	9	7	12	D
				SUB ACCOUNT SCORE		3.00	5.00	9.00	5.00	7.00	9.00	9.00	7.00		
		RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	5	Density of Revegetated Areas	3	3	3	7	5	7	9	9	9	18	D
				Ecosystem Diversity/Sustainability	5	3	3	7	5	7	9	9	9	30	D
				% of Area with Regrowth	3	2	2	8.5	8	8	8	9	8	21	D
				Compatability for Wildlife Habitat	4	3	3	5	5	5	9	9	7	24	D
				SUB ACCOUNT SCORE		2.80	2.80	6.77	5.60	6.67	8.80	9.00	8.27		
				ACCOUNT SCORE		5.68	5.87	8.10	6.76	7.17	8.18	8.22	8.38		
SOCIO-ECONOMICS	4	AESTHETICS	5	Appearance (Pleasing)	5	1	3	5	3	5	7	9	7	40	D
				SUB ACCOUNT SCORE		1.00	3.00	5.00	3.00	5.00	7.00	9.00	7.00		
		HUNTING & RECREATION	3	Suitability	3	5	5	7	7	7	9	9	9	12	D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	9.00	9.00	9.00		
		TOURISM	3	Suitability	3	3	3	7	9	7	9	9	7	18	D
				SUB ACCOUNT SCORE		3.00	3.00	7.00	9.00	7.00	9.00	9.00	7.00		
		HEALTH AND SAFETY	5	Protection During Reclamation (Workers)	0	9	7	3	7	7	3	3	5	6E-07	ND
				Protection Post Reclamation (Public)	5	3	5	5	5	5	7	9	7	30	D
				SUB ACCOUNT SCORE		3.00	5.00	5.00	5.00	5.00	7.00	9.00	7.00		
		TRADITIONAL/CULTURAL	5	Usability	5	3	3	5	5	5	7	9	7	30	D
				SUB ACCOUNT SCORE		3.00	3.00	5.00	5.00	5.00	7.00	9.00	7.00		
		COMMUNITY INFRASTRUCTURE	3	Condition of Utilities (Water System)	3	5	5	9	5	5	9	9	7	12	D
				SUB ACCOUNT SCORE		5.00	5.00	9.00	5.00	5.00	9.00	9.00	7.00		
		COMPLETION PERIOD	0	Time to Complete Reclamatioo	0	9	8	5	7	7	4	2	6	7E-07	ND
				SUB ACCOUNT SCORE		9.00	8.00	5.00	7.00	7.00	4.00	2.00	6.00		
		MINERAL DEVELOPMENT POTENTIAL	0	Mineral Development Potential	0	9	7	5	7	7	3	3	7	6E-07	ND
				SUB ACCOUNT SCORE		9.00	7.00	5.00	7.00	7.00	3.00	3.00	7.00		
		FUTURE BURDEN ON SOCIETY	5	Loog Term Management Requirements	5	5	5	7	9	7	9	9	9	20	D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	9.00	7.00	9.00	9.00	9.00		
		EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	0	Short Term Local Employmeot Value	0	1	3	7	5	5	9	9	7	8E-07	ND
				Long Term Local Employment Value	0	9	9	7	5	7	5	5	7	4E-07	ND
				SUB ACCOUNT SCORE		5.00	6.00	7.00	5.00	6.00	7.00	7.00	7.00		
				ACCOUNT SCORE		3.41	4.10	6.17	5.97	5.76	7.97	9.00	7.55		
				MULTIPLE ACCOUNT SCORE		4.74	5.28	7.30	6.47	6.53	8.10	8.63	7.78		
				Relative to existing conditions:		0.00	0.53	2.55	1.73	1.78	3.36	3.89	3.04		
				Sum of cost estimates (million $)		14.05	17.75	35.62	18.35	19.83	51.07	54.27	24.33		
				Points per dollar value			3.00	7.16	9.41	8.99	6.57	7.17	12.50		

Table A-1e. SUMMARY OF THE TECHNICAL WORKING GROUP EVALUATION FOR THE ZORTMAN RECLAMATION.
Updated March 19th, 2001

ACCOUNTS		EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT-3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERNATIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERANTIVE Z6 (Optimize Source Control and Aesthetics)
TECHNICAL	RELATIVE RANKING	8	7	3	5	6	2	1	4
	ACCOUNT SCORE	4.95	5.85	7.45	6.65	6.49	8.14	8.83	7.11
PROJECT ECONOMICS	RELATIVE RANKING	3	4	5	1	2	6	8	7
	ACCOUNT SCORE	7.42	7.16	5.73	8.61	8.23	4.47	4.42	7.45
ENVIRONMENT	RELATIVE RANKING	8	7	4	6	5	3	2	1
	ACCOUNT SCORE	5.68	5.87	8.10	6.76	7.17	8.18	8.22	8.38
SOCIO-ECONOMICS	RELATIVE RANKING	8	7	6	4	5	3	1	2
	ACCOUNT SCORE	4.66	4.85	5.98	6.13	6.06	7.01	7.48	7.05
OVERALL RANKING		8	7	6	5	4	3	2	1
MULTIPLE ACCOUNT SCORE		5.61	5.85	6.93	6.94	6.95	7.12	7.39	7.58
SCORE RELATIVE TO EXISTING CONDITIONS		0.00	0.24	1.32	1.33	1.34	1.51	1.78	1.97

Table A-1f. SUMMARY OF THE TECHNICAL WORKING GROUP EVALUATION FOCUSING ON ENVIRONMENTAL ISSUES.
Updated March 19th, 2001

ACCOUNTS		EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE Z1 (Final EIS ALT.3, ROD)	ALTERNATIVE Z2 (Optimize Water Treatment within Bond)	ALTERNATIVE Z3 (Optimize Source Control within Bond)	ALTERNATIVE Z4 (Additional Pit Backfilling)	ALTERANTIVE Z5 (Total Backfill to Pre-Mine Topography)	ALTERNATIVE Z6 (Optimize Source Control and Aesthetics)
TECHNICAL	RELATIVE RANKING	8	7	3	5	6	2	1	4
	ACCOUNT SCORE	4.95	5.85	7.45	6.65	6.49	8.14	8.83	7.11
PROJECT ECONOMICS	RELATIVE RANKING	1	1	1	1	1	1	1	7
	ACCOUNT SCORE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ENVIRONMENT	RELATIVE RANKING	8	7	4	6	5	3	2	1
	ACCOUNT SCORE	5.68	5.87	8.10	6.76	7.17	8.18	8.22	8.38
SOCIO-ECONOMICS	RELATIVE RANKING	8	7	4	5	6	2	1	3
	ACCOUNT SCORE	3.41	4.10	6.17	5.97	5.76	7.97	9.00	7.55
OVERALL RANKING		8	7	4	6	5	2	1	3
MULTIPLE ACCOUNT SCORE		4.74	5.28	7.30	6.47	6.53	8.10	8.63	7.78
SCORE RELATIVE TO EXISTING CONDITIONS		0.00	0.53	2.55	1.73	1.78	3.36	3.89	3.04

SUM OF COSTS FOR EACH ALTERNATIVE		17.75	35.62	18.35	19.83	51.07	54.27	24.33
POINT SCORE PER DOLLAR REQUIRED		3.00	7.16	9.41	8.99	6.57	7.17	12.50

Landusky Mine MAA Tables

Table A-2a. Multiple Accounts Analysis Ledger for the LanduskyMine Reclamation.

Table A-2b. Technical Working Group Consensus Evaluation for the Landusky Mine MAA.

Table A-2c. Technical Working Group Consensus Analysis for the Landusky Mine MAA with the Non-Discriminatory Indicators Eliminated.

Table A-2d. Technical Working Group Consensus Evaluation of the Landusky Mine MAA Focusing on Environmental Issues Only.

Table A-2e. Summary of the Technical Working Group MAA Evaluation for the Landusky Mine.

Table A-2f. Summary of the Technical Working Group MAA Evaluation for the Landusky Mine Focusing on Environmental Issues.

TABLE A-2a. MULTIPLE ACCOUNTS ANALYSIS LEDGER FOR THE LANDUSKY MINE SITE RECLAMATION.
Updated March 19th, 2001

ACCOUNTS	SUB ACCOUNTS (Issues)	INDICATORS	MEASURES	HIGH VALUE INDICATORS	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)
TECHNICAL	LOWER LEACH PADS (80/82, 83, 84)											
	Dikes	Stability/Erodability/Maintainability	value (good-poor)		intermediate	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	Heaps	Stability/Erodability/Maintainability	value (good-poor)		somewhat poor	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	Liners	Durability/Maintainability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	85/86 LEACH PAD											
	Dikes	Stability/Erodability/Maintainability	value (good-poor)		intermediate	intermediate	somewhat good	somewhat good	somewhat good	good	good	good
	Heaps	Stability/Erodability/Maintainability	value (good-poor)		somewhat poor	intermediate	intermediate	somewhat good	somewhat good	good	good	good
	Liners	Durability/Maintainability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	good	good	good
	87/91 LEACH PAD											
	Dikes	Stability/Erodability/Maintainability	value (good-poor)	•	intermediate	intermediate	good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	Heaps	Stability/Erodability/Maintainability	value (good-poor)		somewhat poor	intermediate	somewhat good	intermediate	intermediate	intermediate	good	good
	Liners	Durability/Maintainability	value (good-poor)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	WASTE ROCK DUMPS (Mill Gulch)	Stability/Erodability/Maintainability	value (good-poor)		intermediate	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	WASTE ROCK DUMPS (Montana Gulch)	Stability/Erodability/Maintainability	value (good-poor)		intermediate	intermediate	somewhat good	intermediate	intermediate	intermediate	intermediate	intermediate
	WASTE ROCK DUMPS (Aug #1 & #2)	Stability/Erodability/Maintainability	value (good-poor)		intermediate	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good	good
	OPEN PITS	Stability	value (good-poor)		poor	somewhat poor	somewhat poor	somewhat poor	somewhat poor	intermediate	somewhat good	good
		Drainage Sustainability	value (good-poor)	•	somewhat poor	intermediate	somewhat good	somewhat poor	intermediate	intermediate	good	good
	UNDERGROUND WORKINGS	Stability	value (good-poor)		somewhat good	somewhat good	intermediate	somewhat good	somewhat good	somewhat good	somewhat good	somewhat good
	STORM WATER CONTROL (Ditches)	Maintenance Requirements	value (low-high)	•	intermediate	intermediate	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	intermediate
	COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	Operating Requirements	value (low-high)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	somewhat high	somewhat high
		Maintenance Requirements	value (low-high)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	somewhat high	somewhat high
	WTP/LAD TREATMENT & RELEASE	Operating Requirements	value (low-high)	•	high	somewhat high	somewhat low	intermediate	intermediate	intermediate	somewhat low	somewhat low
		Sludge Disposal	value (difficult-easy)		somewhat easy	somewhat easy	somewhat easy	somewhat easy	somewhat easy	somewhat easy	somewhat easy	somewhat easy
	ALTERNATIVE TECHNOLOGIES	Potential Application	value (difficult-easy)		somewhat difficult	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	RECLAMATION COVERS	Long-term Durability	value (good-poor)		somewhat good	somewhat good	somewhat poor	somewhat good	somewhat good	somewhat good	somewhat good	somewhat poor
PROJECT ECONOMICS	RECLAMATION COST											
	Short Term Reclamation & LAD	Cost	$ (million)	•	5.5	10.0	45.7	19.2	21.8	36.1	67.4	156.1
	Long Term Monitoring/Maintenance	Costs Over Next 10 Years	$ (million)		1	0.20	0.49	0.42	0.44	0.51	0.53	1.20
	% Attainable	% Attainable Within Bond	%	•	100%	100%	41%	96%	84%	51%	28%	12%
	LONG TERM WATER COLLECTION/TREATMENT COST (WTP, MPDES Monitoring)											
	Costs	NPV of Annual Cost	NPV $ (million)	•	9.85	9.85	8.9	9.5	9.4	9.4	9.4	9.3
ENVIRONMENT	SURFACE WATER QUALITY PROTECTION VALUE	Upper Swift Gulch	value (high-low)	•	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	intermediate
		King Creek	value (high-low)	•	intermediate	intermediate	somewhat high	intermediate	somewhat high	somewhat high	somewhat high	intermediate
		Sullivan Gulch	value (high-low)		intermediate	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high
		Mill Gulch	value (high-low)		intermediate	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high
		Montana Gulch	value (high-low)	•	somewhat low	somewhat low	low	intermediate	intermediate	high	somewhat high	somewhat high
	SURFACE WATER QUANTITY PROTECTION VALUE	Upper Swift Gulch	value (high-low)	•	somewhat high	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat high
		King Creek	value (high-low)	•	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	high
		Sullivan Gulch	value (high-low)		somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low
		Mill Gulch	value (high-low)		somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low	somewhat low

TABLE A-2a. MULTIPLE ACCOUNTS ANALYSIS LEDGER FOR THE LANDUSKY MINE SITE RECLAMATION.
Updated March 19th, 2001

ACCOUNTS	SUB ACCOUNTS (issues)	INDICATORS	MEASURES	HIGH VALUE INDICATORS	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)
		Montana Gulch	value (high-low)		high	high	high	high	high	high	high	intermediate
	GROUNDWATER QUALITY PROTECTION VALUE	Swift Gulch (Upper & Lower)	value (high-low)	•	low	intermediate	somewhat high	intermediate	intermediate	somewhat high	somewhat low	somewhat low
		King Creek	value (high-low)	•	intermediate	intermediate	somewhat high	intermediate	somewhat high	somewhat high	somewhat high	intermediate
		Sullivan Gulch	value (high-low)		intermediate	intermediate	somewhat high	intermediate	intermediate	intermediate	intermediate	intermediate
		Mill Gulch	value (high-low)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
		Montana Gulch	value (high-low)		intermediate	intermediate	intermediate	intermediate	intermediate	somewhat high	intermediate	intermediate
	WTP WATER QUANTITY & QUALITY (INFLOW)	Acidity Load per year	value (low-high)		high	high	intermediate	somewhat high	somewhat high	somewhat high	somewhat high	high
		Flow	value (low-high)		intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate	intermediate
	LAD WATER QUALITY	NO3/NO2 Load	value (low-high)	•	high	high	high	high	high	high	high	high
		Metals Load (Se)	value (low-high)		high	high	high	high	high	high	high	high
	LAD WATER QUANTITY	Volume	value (low-high)		high	somewhat high	intermediate	intermediate	intermediate	somewhat low	somewhat low	low
	RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	Density of Revegetated Areas	value (good-poor)		somewhat poor	somewhat poor	somewhat good	somewhat good	somewhat good	somewhat good	good	good
		Ecosystem Diversity/Sustainability	value (high-low)	•	low	intermediate	intermediate	intermediate	intermediate	intermediate	somewhat high	somewhat high
		% of Area Revegetated	%		40.1	40.1	80.7	77.6	77.6	81.4	85.4	91.9
		Compatibility for Wildlife Habitat	value (high-low)		somewhat low	intermediate	somewhat high	somewhat high	somewhat high	somewhat high	high	high
SOCIO-ECONOMIC	AESTHETICS	Appearance (Pleasing)	value (high-low)	•	low	somewhat low	somewhat low	somewhat low	somewhat low	intermediate	somewhat high	high
	HUNTING / RECREATION	Suitability	value (high-low)		somewhat low	somewhat low	intermediate	intermediate	intermediate	intermediate	somewhat high	somewhat high
	TOURISM	Suitability	value (high-low)		somewhat low	somewhat low	intermediate	intermediate	intermediate	intermediate	somewhat high	somewhat high
	HEALTH AND SAFETY	Protection During Reclamation (Workers	value (high-low)	•	high	somewhat high	intermediate	somewhat high	somewhat high	somewhat high	somewhat low	low
		Protection Post Reclamation (Public)	value (high-low)	•	intermediate	intermediate	somewhat high	somewhat high	somewhat high	somewhat high	high	high
	TRADITIONAL/CULTURAL	Usability	value (high-low)	•	low	low	somewhat low	somewhat low	somewhat low	somewhat low	intermediate	somewhat high
	COMMUNITY INFRASTRUCTURE	Protection of Water Supply	value (high-low)		somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high
	COMPLETION PERIOD	Time	years (low-high)		0	1	5	4	4	5	6	9
	MINERAL DEVELOPMENT POTENTIAL	Mineral Development Potential	value (high-low)		somewhat high	somewhat high	iotermediate	intermediate	intermediate	intermediate	somewhat low	low
	FUTURE BURDEN ON SOCIETY	Long Term Management Requirements	years (low-high)	•	high	high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high	somewhat high
	EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	Short Term Local Employment Value	value (high-low)		low	somewhat low	somewhat high	iotermediate	iotermediate	somewhat high	somewhat high	high
		Long Term Local Employment Value	value (high-low)		somewhat high	somewhat high	iotermediate	intermediate	iotermediate	intermediate	intermediate	intermediate

TABLE A2-b. TECHNICAL WORKING GROUP CONSENSUS ANALYSIS FOR THE LANDUSKY MAA
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT-3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)	Discriminating Value (based on 20%)
TECHNICAL	3	LOWER LEACH PADS	2											
		Dikes		Stability/Erodability/Maintainability	3	7	9	9	9	9	9	9	9	6 ND
		Heaps		Stability/Erodability/Maintainability	3	5	9	9	9	9	9	9	9	12 D
		Liners		Durability/Maintainability	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		6.43	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		85/86 LEACH PAD	3											
		Dikes		Stability/Erodability/Maintainability	4	5	5	7	7	7	9	9	9	16 D
		Heaps		Stability/Erodability/Maintainability	3	3	5	5	7	7	9	9	9	18 D
		Liners		Durability/Maintainability	1	5	5	5	5	5	9	9	9	4 ND
				SUB ACCOUNT SCORE		4.25	5.00	6.00	6.75	6.75	9.00	9.00	9.00	
		87/91 LEACH PAD	5											
		Dikes		Stability/Erodability/Maintainability	5	5	5	9	7	7	7	7	7	20 D
		Heaps		Stability/Erodability/Maintainability	3	3	5	7	5	5	5	9	9	18 D
		Liners		Durability/Maintainability	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		4.78	5.44	8.33	6.56	6.56	6.56	7.89	7.89	
		WASTE ROCK DUMPS (Mill Gulch)	1	Stability/Erodability/Maintainability	1	7	9	9	9	9	9	9	9	2 ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		WASTE ROCK DUMPS (Montana Gulch)	3	Stability/Erodability/Maintainability	3	7	7	9	7	7	7	7	7	6 ND
				SUB ACCOUNT SCORE		7.00	7.00	9.00	7.00	7.00	7.00	7.00	7.00	
		WASTE ROCK DUMPS (Aug #1 & #2)	1	Stability/Erodability/Maintainability	1	5	7	7	7	7	7	7	9	4 ND
				SUB ACCOUNT SCORE		5.00	7.00	7.00	7.00	7.00	7.00	7.00	9.00	
		OPEN PITS	4	Stability	2	1	3	3	3	3	5	7	9	16 D
				Drainage Sustainability	5	3	5	7	3	5	5	9	9	30 D
				SUB ACCOUNT SCORE		2.43	4.43	5.86	3.00	4.43	5.00	8.43	9.00	
		UNDERGROUND WORKINGS	1	Stability	1	9	9	7	9	9	9	9	9	2 ND
				SUB ACCOUNT SCORE		9.00	9.00	7.00	9.00	9.00	9.00	9.00	9.00	
		STORM WATER CONTROL (Ditches)	5	Maintenance Requirements	5	7	7	9	9	9	9	9	7	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	7.00	
		COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	5	Operating Requirements	3	9	9	9	9	9	9	7	7	6 ND
				Maintainability	2	9	9	9	9	9	9	7	7	4 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	7.00	7.00	
		WTP/LAD TREATMENT & RELEASE	2	Operating Requirements	5	3	5	9	7	7	7	9	9	30 D
				Sludge Disposal	3	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		5.25	6.50	9.00	7.75	7.75	7.75	9.00	9.00	
		ALTERNATIVE TECHNOLOGIES	1	Potential Application	1	7	9	9	9	9	9	9	9	2 ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		RECLAMATION COVERS	3	Long-term Durability	3	9	9	5	9	9	9	9	5	12 D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	9.00	9.00	9.00	9.00	5.00	
				ACCOUNT SCORE		6.27	7.03	7.86	7.51	7.67	7.92	8.28	7.79	
PROJECT ECONOMICS	3	RECLAMATION COST	5											
		Reclamation		Cost	5	9	8.8	6.5	8.5	8.0	7	5	1	40 D
		Sustained Monitoring/Maintenance		NPV of Annual Costs	2	4	9	7.5	8	8	7.5	7.5	3	12 D
		% Attainable		% Attainable Within Bond	5	9	9	4	9	8	5	3	1	40 D
				SUB ACCOUNT SCORE		8.17	8.90	5.63	8.63	8.00	6.25	4.58	1.33	
		LONG TERM WATER TREATMENT COST	5											
		Costs		NPV of Annual Costs	5	7	7	9	8	8	8	8	8	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	8.00	8.00	8.00	8.00	8.00	
				ACCOUNT SCORE		7.58	7.95	7.31	8.31	8.00	7.13	6.29	4.67	

TABLE A2-b. TECHNICAL WORKING GROUP CONSENSUS ANALYSIS FOR THE LANDUSKY MAA
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)	Discriminating Value (based on 20%)
ENVIRONMENT	5	SURFACE WATER QUALITY PROTECTION VALUE	4	Upper Swift Gulch	5	9	9	9	9	9	9	9	7	10 D
				King Creek	5	7	7	9	7	9	9	9	7	10 D
				Sullivan Gulch	2	7	9	9	9	9	9	9	9	4 ND
				Mill Gulch	4	7	9	9	9	9	9	9	9	8 D
				Montana Gulch	5	3	3	1	5	5	9	7	7	40 D
				SUB ACCOUNT SCORE		6.52	7.10	7.10	7.57	8.05	9.00	8.52	7.57	
		SURFACE WATER QUANTITY PROTECTION VALUE	4	Upper Swift Gulch	5	9	5	5	5	5	5	5	9	20 D
				King Creek	5	3	3	3	3	3	3	3	9	30 D
				Sullivan Gulch	1	9	9	9	9	9	9	9	9	0 ND
				Mill Gulch	3	9	9	9	9	9	9	9	9	0 ND
				Montana Gulch	4	9	9	9	9	9	9	9	5	16 D
				SUB ACCOUNT SCORE		7.33	6.22	6.22	6.22	6.22	6.22	6.22	8.11	
		GROUNDWATER QUALITY PROTECTION	5	Swift Gulch (Upper & Lower)	5	3	7	9	7	7	9	5	5	30 D
				King Creek	5	7	7	9	7	9	9	9	7	10 D
				Sullivan Gulch	2	7	7	9	7	7	7	7	7	4 ND
				Mill Gulch	4	9	9	9	9	9	9	9	9	0 ND
				Montana Gulch	4	7	7	7	7	7	9	7	7	8 D
				SUB ACCOUNT SCORE		6.40	7.40	8.60	7.40	7.90	8.80	7.40	6.90	
		WTP WATER QUANTITY & QUALITY (INFLOW)	3	Acidity Load	3	5	5	9	7	7	7	7	5	12 D
				Flow	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		6.00	6.00	9.00	7.50	7.50	7.50	7.50	6.00	
		LAD WATER QUALITY	3	NO3/NO2 Load	5	9	9	9	9	9	9	9	9	0 ND
				Metals Load	3	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		LAD WATER QUANTITY	2	Volume	2	1	3	5	5	5	7	7	9	16 D
				SUB ACCOUNT SCORE		1.00	3.00	5.00	5.00	5.00	7.00	7.00	9.00	
		RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	5	Density of Revegetated Areas	3	3	3	7	7	7	7	9	9	18 D
				Ecosystem Diversity/Sustainability	5	3	7	7	7	7	7	9	9	30 D
				% of Area Revegetated	3	3	3	7	7	7	7	7	9	18 D
				Compatibility for Wildlife Habitat	4	3	5	7	7	7	7	9	9	24 D
				SUB ACCOUNT SCORE		3.00	4.87	7.00	7.00	7.00	7.00	8.60	9.00	
				ACCOUNT SCORE		5.75	6.37	7.51	7.18	7.35	7.82	7.79	7.89	
SOCIO-ECONOMICS	4	AESTHETICS	5	Appearance (Pleasing)	5	1	3	3	3	3	5	7	9	40 D
				SUB ACCOUNT SCORE		1.00	3.00	3.00	3.00	3.00	5.00	7.00	9.00	
		HUNTING & RECREATION	3	Suitability	3	5	5	7	7	7	7	9	9	12 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		TOURISM	3	Suitability	3	5	5	7	7	7	7	9	9	12 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		HEALTH AND SAFETY	5	Suitability During Reclamation (Workers)	5	9	7	5	7	7	7	3	1	40 D
				Suitability Post Reclamation (Public)	5	5	5	7	7	7	7	9	9	20 D
				SUB ACCOUNT SCORE		7.00	6.00	6.00	7.00	7.00	7.00	6.00	5.00	
		TRADITIONAL/CULTURAL	5	Usability	5	3	3	5	5	5	5	7	9	30 D
				SUB ACCOUNT SCORE		3.00	3.00	5.00	5.00	5.00	5.00	7.00	9.00	
		COMMUNITY INFRASTRUCTURE	1	Condition of Water Supply	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		COMPLETION PERIOD	3	Time to Complete Reclamation	3	9	9	5	6	6	5	4	1	24 D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	6.00	6.00	5.00	4.00	1.00	
		MINERAL DEVELOPMENT POTENTIAL	2	Mineral Development Potential	2	9	9	7	7	7	7	5	3	12 D
				SUB ACCOUNT SCORE		9.00	9.00	7.00	7.00	7.00	7.00	5.00	3.00	
		FUTURE BURDEN ON SOCIETY	5	Long Term Management Requirements	5	7	7	9	9	9	9	9	9	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00	
		EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	5	Short Term Local Employment Value	4	1	3	7	5	5	7	7	9	32 D
				Long Term Local Employment Value	2	9	9	7	7	7	7	7	7	4 ND
				SUB ACCOUNT SCORE		3.67	5.00	7.00	5.67	5.67	7.00	7.00	8.33	
				ACCOUNT SCORE		4.47	4.78	5.81	5.77	5.77	6.22	6.84	7.32	
				MULTIPLE ACCOUNT SCORE		5.88	6.39	7.09	7.10	7.12	7.28	7.33	7.07	

TABLE A-2c. TECHNICAL WORKING GROUP CONSENSUS ANALYSIS FOR LANDUSKY WITH THE NON-DISCRIMINATORY INDICATORS ELIMINATED.
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT-3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)	Discriminating Value (based on 20%)	
TECHNICAL	3	LOWER LEACH PADS	2												
		Dikes		Stability/Erodability/Maintainability	0	7	9	9	9	9	9	9	9	0	ND
		Heaps		Stability/Erodability/Maintainability	3	5	9	9	9	9	9	9	9	12	D
		Liners		Durability/Maintainability	0	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		5.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		85/86 LEACH PAD	3												
		Dikes		Stability/Erodability/Maintainability	4	5	5	7	7	7	9	9	9	16	D
		Heaps		Stability/Erodability/Maintainability	3	3	5	5	7	7	9	9	9	18	D
		Liners		Durability/Maintainability	0	5	5	5	5	5	9	9	9	0	ND
				SUB ACCOUNT SCORE		4.14	5.00	6.14	7.00	7.00	9.00	9.00	9.00		
		87/91 LEACH PAD	5												
		Dikes		Stability/Erodability/Maintainability	5	5	5	9	7	7	7	7	7	20	D
		Heaps		Stability/Erodability/Maintainability	3	3	5	7	5	5	5	9	9	18	D
		Liners		Durability/Maintainability	0	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		4.25	5.00	8.25	6.25	6.25	6.25	7.75	7.75		
		WASTE ROCK DUMPS (Mill Gulch)	0	Stability/Erodability/Maintainability	0	7	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		WASTE ROCK DUMPS (Montana Gulch)	0	Stability/Erodability/Maintainability	0	7	7	9	7	7	7	7	7	0	ND
				SUB ACCOUNT SCORE		7.00	7.00	9.00	7.00	7.00	7.00	7.00	7.00		
		WASTE ROCK DUMPS (Aug #1 & #2)	0	Stability/Erodability/Maintainability	0	5	7	7	7	7	7	7	9	0	ND
				SUB ACCOUNT SCORE		5.00	7.00	7.00	7.00	7.00	7.00	7.00	9.00		
		OPEN PITS	4	Stability	2	1	3	3	3	3	5	7	9	16	D
				Drainage Sustainability	5	3	5	7	3	5	5	9	9	30	D
				SUB ACCOUNT SCORE		2.43	4.43	5.86	3.00	4.43	5.00	8.43	9.00		
		UNDERGROUND WORKINGS	0	Stability	0	9	9	7	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		9.00	9.00	7.00	9.00	9.00	9.00	9.00	9.00		
		STORM WATER CONTROL (Ditches)	5	Maintenance Requirements	5	7	7	9	9	9	9	9	7	10	D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	7.00		
		COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	0	Operating Requirements	0	9	9	9	9	9	9	7	7	0	ND
				Maintainability	0	9	9	9	9	9	9	7	7	0	ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	7.00	7.00		
		WTP/LAD TREATMENT & RELEASE	2	Operating Requirements	5	3	5	9	7	7	7	9	9	30	D
				Sludge Disposal	0	9	9	9	9	9	9	9	9	0	ND
				SUB ACCOUNT SCORE		3.00	5.00	9.00	7.00	7.00	7.00	9.00	9.00		
		ALTERNATIVE TECHNOLOGIES	1	Potential Application	1	7	9	9	9	9	9	9	9	2	ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00		
		RECLAMATION COVERS	0	Long-term Durability	0	9	9	5	9	9	9	9	5	0	ND
				SUB ACCOUNT SCORE		9.00	9.00	5.00	9.00	9.00	9.00	9.00	5.00		
				ACCOUNT SCORE		4.61	5.90	7.87	6.83	7.09	7.47	8.61	8.26		
PROJECT ECONOMICS	3	RECLAMATION COST	5												
		Reclamation		Cost	5	9	8.8	6.5	8.5	8.0	7	5	1	40	D
		Sustained Monitoring/Maintenance		NPV of Annual Costs	2	4	9	7.5	8	8	7.5	7.5	3	12	D
		% Attainable		% Attainable Within Bond	5	9	9	4	9	8	5	3	1	40	D
				SUB ACCOUNT SCORE		8.17	8.90	5.63	8.63	8.00	6.25	4.58	1.33		
		LONG TERM WATER TREATMENT COST	5												
		Costs		NPV of Annual Costs	5	7	7	9	8	8	8	8	8	10	D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	8.00	8.00	8.00	8.00	8.00		
				ACCOUNT SCORE		7.58	7.95	7.31	8.31	8.00	7.13	6.29	4.67		

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)	Discriminating Value (based on 20%)
ENVIRONMENT	5	SURFACE WATER QUALITY PROTECTION VALUE	4	Upper Swift Gulch	5	9	9	9	9	9	9	9	7	10 D
				King Creek	5	7	7	9	7	9	9	9	7	10 D
				Sullivan Gulch	0	7	9	9	9	9	9	9	9	0 ND
				Mill Gulch	4	7	9	9	9	9	9	9	9	8 D
				Montana Gulch	5	3	3	1	5	5	9	7	7	40 D
				SUB ACCOUNT SCORE		6.47	6.89	6.89	7.42	7.95	9.00	8.47	7.42	
		SURFACE WATER QUANTITY PROTECTION VALUE	4	Upper Swift Gulch	5	9	5	5	5	5	5	5	9	20 D
				King Creek	5	3	3	3	3	3	3	3	9	30 D
				Sullivan Gulch	0	9	9	9	9	9	9	9	9	0 ND
				Mill Gulch	0	9	9	9	9	9	9	9	9	0 ND
				Montana Gulch	4	9	9	9	9	9	9	9	5	16 D
				SUB ACCOUNT SCORE		6.86	5.43	5.43	5.43	5.43	5.43	5.43	7.86	
		GROUNDWATER QUALITY PROTECTION	5	Swift Gulch (Upper & Lower)	5	3	7	9	7	7	9	5	5	30 D
				King Creek	5	7	7	9	7	9	9	9	7	10 D
				Sullivan Gulch	0	7	7	9	7	7	7	7	7	0 ND
				Mill Gulch	0	9	9	9	9	9	9	9	9	0 ND
				Montana Gulch	4	7	7	7	7	7	9	7	7	8 D
				SUB ACCOUNT SCORE		5.57	7.00	8.43	7.00	7.71	9.00	7.00	6.29	
		WTP WATER QUANTITY & QUALITY (INFLOW)	5	Acidity Load	3	5	5	9	7	7	7	7	5	12 D
				Flow	0	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		5.00	5.00	9.00	7.00	7.00	7.00	7.00	5.00	
		LAD WATER QUALITY	5	NO3/NO2 Load	0	9	9	9	9	9	9	9	9	0 ND
				Metals Load	0	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		LAD WATER QUANTITY	5	Volume	2	1	3	5	5	5	7	7	9	16 D
				SUB ACCOUNT SCORE		1.00	3.00	5.00	5.00	5.00	7.00	7.00	9.00	
		RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	5	Density of Revegetated Areas	3	3	3	7	7	7	7	9	9	18 D
				Ecosystem Diversity/Sustainability	5	3	7	7	7	7	7	9	9	30 D
				% of Area Revegetated	3	3	3	7	7	7	7	7	9	18 D
				Compatibility for Wildlife Habitat	4	3	5	7	7	7	7	9	9	24 D
				SUB ACCOUNT SCORE		3.00	4.87	7.00	7.00	7.00	7.00	8.60	9.00	
				ACCOUNT SCORE		4.92	5.64	7.11	6.63	6.87	7.51	7.33	7.41	
SOCIO-ECONOMICS	4	AESTHETICS	5	Appearance (Pleasing)	5	1	3	3	3	3	5	7	9	40 D
				SUB ACCOUNT SCORE		1.00	3.00	3.00	3.00	3.00	5.00	7.00	9.00	
		HUNTING & RECREATION	5	Suitability	3	5	5	7	7	7	7	9	9	12 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		TOURISM	5	Suitability	3	5	5	7	7	7	7	9	9	12 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		HEALTH AND SAFETY	5	Suitability During Reclamation (Workers)	5	9	7	5	7	7	7	3	1	40 D
				Suitability Post Reclamation (Public)	5	5	5	7	7	7	7	9	9	20 D
				SUB ACCOUNT SCORE		7.00	6.00	6.00	7.00	7.00	7.00	6.00	5.00	
		TRADITIONAL/CULTURAL	5	Usability	5	3	3	5	5	5	5	7	9	30 D
				SUB ACCOUNT SCORE		3.00	3.00	5.00	5.00	5.00	5.00	7.00	9.00	
		COMMUNITY INFRASTRUCTURE	0	Condition of Water Supply	0	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		COMPLETION PERIOD	5	Time to Complete Reclamation	3	9	9	5	6	6	5	4	1	24 D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	6.00	6.00	5.00	4.00	1.00	
		MINERAL DEVELOPMENT POTENTIAL	5	Mineral Development Potential	2	9	9	7	7	7	7	5	3	12 D
				SUB ACCOUNT SCORE		9.00	9.00	7.00	7.00	7.00	7.00	5.00	3.00	
		FUTURE BURDEN ON SOCIETY	5	Long Term Management Requirements	5	7	7	9	9	9	9	9	9	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00	
		EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	5	Short Term Local Employment Value	4	1	3	7	5	5	7	7	9	32 D
				Long Term Local Employment Value	0	9	9	7	7	7	7	7	7	0 ND
				SUB ACCOUNT SCORE		1.00	3.00	7.00	5.00	5.00	7.00	7.00	9.00	
				ACCOUNT SCORE		3.97	4.39	5.72	5.58	5.58	6.14	6.78	7.36	
				MULTIPLE ACCOUNT SCORE		5.14	5.82	6.93	6.73	6.80	7.06	7.23	7.82	

TABLE A-2d. TECHNICAL WORKING GROUP ANALYSIS FOR LANDUSKY FOCUSING SOLELY ON ENVIRONMENTAL EFFECTS
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)	Discriminating Value (based on 20%)
TECHNICAL	3	LOWER LEACH PADS	2											
		Dikes		Stability/Erodability/Maintainability	3	7	9	9	9	9	9	9	9	6 ND
		Heaps		Stability/Erodability/Maintainability	3	5	9	9	9	9	9	9	9	12 D
		Liners		Durability/Maintainability	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		6.43	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		85/86 LEACH PAD	3											
		Dikes		Stability/Erodability/Maintainability	4	5	5	7	7	7	9	9	9	16 D
		Heaps		Stability/Erodability/Maintainability	3	3	5	5	7	7	9	9	9	18 D
		Liners		Durability/Maintainability	1	5	5	5	5	5	9	9	9	4 ND
				SUB ACCOUNT SCORE		4.25	5.00	6.00	6.75	6.75	9.00	9.00	9.00	
		87/91 LEACH PAD	5											
		Dikes		Stability/Erodability/Maintainability	5	5	5	9	7	7	7	7	7	20 D
		Heaps		Stability/Erodability/Maintainability	3	3	5	7	5	5	5	9	9	18 D
		Liners		Durability/Maintainability	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		4.78	5.44	8.33	6.56	6.56	6.56	7.89	7.89	
		WASTE ROCK DUMPS (Mill Gulch)	1	Stability/Erodability/Maintainability	1	7	9	9	9	9	9	9	9	2 ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		WASTE ROCK DUMPS (Montana Gulch)	3	Stability/Erodability/Maintainability	3	7	7	9	7	7	7	7	7	6 ND
				SUB ACCOUNT SCORE		7.00	7.00	9.00	7.00	7.00	7.00	7.00	7.00	
		WASTE ROCK DUMPS (Aug #1 & #2)	1	Stability/Erodability/Maintainability	1	5	7	7	7	7	7	7	9	4 ND
				SUB ACCOUNT SCORE		5.00	7.00	7.00	7.00	7.00	7.00	7.00	9.00	
		OPEN PITS	4	Stability	2	1	3	3	3	3	5	7	9	16 D
				Drainage Sustainability	5	3	5	7	3	5	5	9	9	30 D
				SUB ACCOUNT SCORE		2.43	4.43	5.86	3.00	4.43	5.00	8.43	9.00	
		UNDERGROUND WORKINGS	1	Stability	1	9	9	7	9	9	9	9	9	2 ND
				SUB ACCOUNT SCORE		9.00	9.00	7.00	9.00	9.00	9.00	9.00	9.00	
		STORM WATER CONTROL (Ditches)	5	Maintenance Requirements	5	7	7	9	9	9	9	9	7	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	7.00	
		COLLECTION & SEEPAGE CAPTURE/PUMPBACK SYSTEMS	5	Operating Requirements	3	9	9	9	9	9	9	7	7	6 ND
				Maintainability	2	9	9	9	9	9	9	7	7	4 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	7.00	7.00	
		WTP/LAD TREATMENT & RELEASE	2	Operating Requirements	5	3	5	9	7	7	7	9	9	30 D
				Sludge Disposal	3	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		5.25	6.50	9.00	7.75	7.75	7.75	9.00	9.00	
		ALTERNATIVE TECHNOLOGIES	1	Potential Application	1	7	9	9	9	9	9	9	9	2 ND
				SUB ACCOUNT SCORE		7.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		RECLAMATION COVERS	3	Long-term Durability	3	9	9	5	9	9	9	9	5	12 D
				SUB ACCOUNT SCORE		9.00	9.00	5.00	9.00	9.00	9.00	9.00	5.00	
				ACCOUNT SCORE		6.27	7.03	7.86	7.51	7.67	7.92	8.28	7.79	
PROJECT ECONOMICS	0	RECLAMATION COST	5											
		Reclamation		Cost	5	9	8 8	6 5	8 5	8.0	7	5	1	40 D
		Sustained Monitoring/Maintenance		NPV of Annual Costs	2	4	9	7.5	8	8	7.5	7.5	3	12 D
		% Attainable		% Attainable Within Bond	5	9	9	4	9	8	5	3	1	40 D
				SUB ACCOUNT SCORE		8.17	8.90	5.63	8.63	8.00	6.25	4.58	1.33	
		LONG TERM WATER TREATMENT COST	5											
		Costs		NPV of Annual Costs	5	7	7	9	8	8	8	8	8	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	8.00	8.00	8.00	8.00	8.00	
				ACCOUNT SCORE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

TABLE A-2d. TECHNICAL WORKING GROUP ANALYSIS FOR LANDUSKY FOCUSING SOLELY ON ENVIRONMENTAL EFFECTS
Updated March 19th, 2001

ACCOUNTS	ACCOUNT WEIGHT	SUB ACCOUNTS (Issues)	SUB ACCOUNT WEIGHT	INDICATORS	INDICATOR WEIGHT	EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)	Discriminating Value (based on 20%)
ENVIRONMENT	5	SURFACE WATER QUALITY PROTECTION VALUE	4	Upper Swift Gulch	5	9	9	9	9	9	9	9	7	10 D
				King Creek	5	7	7	9	7	9	9	9	7	10 D
				Sullivan Gulch	2	7	9	9	9	9	9	9	9	4 ND
				Mill Gulch	4	7	9	9	9	9	9	9	9	8 D
				Montana Gulch	5	3	3	1	5	5	9	7	7	40 D
				SUB ACCOUNT SCORE		6.52	7.10	7.10	7.57	8.05	9.00	8.52	7.57	
		SURFACE WATER QUANTITY PROTECTION VALUE	4	Upper Swift Gulch	5	9	5	5	5	5	5	5	9	20 D
				King Creek	5	3	3	3	3	3	3	3	9	30 D
				Sullivan Gulch	1	9	9	9	9	9	9	9	9	0 ND
				Mill Gulch	3	9	9	9	9	9	9	9	9	0 ND
				Montana Gulch	4	9	9	9	9	9	9	9	5	16 D
				SUB ACCOUNT SCORE		7.33	6.22	6.22	6.22	6.22	6.22	6.22	8.11	
		GROUNDWATER QUALITY PROTECTION	5	Swift Gulch (Upper & Lower)	5	3	7	9	7	7	9	5	5	30 D
				King Creek	5	7	7	9	7	9	9	9	7	10 D
				Sullivan Gulch	2	7	7	9	7	7	7	7	7	4 ND
				Mill Gulch	4	9	9	9	9	9	9	9	9	0 ND
				Montana Gulch	4	7	7	7	7	7	9	7	7	8 D
				SUB ACCOUNT SCORE		6.40	7.40	8.60	7.40	7.90	8.80	7.40	6.90	
		WTP WATER QUANTITY & QUALITY (INFLOW)	3	Acidity Load	3	5	5	9	7	7	7	7	5	12 D
				Flow	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		6.00	6.00	9.00	7.50	7.50	7.50	7.50	6.00	
		LAD WATER QUALITY	3	NO3/NO2 Load	5	9	9	9	9	9	9	9	9	0 ND
				Metals Load	3	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		LAD WATER QUANTITY	2	Volume	2	1	3	5	5	5	7	7	9	16 D
				SUB ACCOUNT SCORE		1.00	3.00	5.00	5.00	5.00	7.00	7.00	9.00	
		RE-ESTABLISHMENT OF BIOLOGICAL/VEGETATIVE POTENTIAL	5	Density of Revegetated Areas	3	3	3	7	7	7	7	9	9	18 D
				Ecosystem Diversity/Sustainability	5	3	7	7	7	7	7	9	9	30 D
				% of Area Revegetated	3	3	3	7	7	7	7	7	9	18 D
				Compatibility for Wildlife Habitat	4	3	5	7	7	7	7	9	9	24 D
				SUB ACCOUNT SCORE		3.00	4.87	7.00	7.00	7.00	7.00	8.60	9.00	
				ACCOUNT SCORE		5.75	6.37	7.51	7.18	7.35	7.82	7.79	7.89	
SOCIO-ECONOMICS	4	AESTHETICS	5	Appearance (Pleasing)	5	1	3	3	3	3	5	7	9	40 D
				SUB ACCOUNT SCORE		1.00	3.00	3.00	3.00	3.00	5.00	7.00	9.00	
		HUNTING & RECREATION	3	Suitability	3	5	5	7	7	7	7	9	9	12 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		TOURISM	3	Suitability	3	5	5	7	7	7	7	9	9	12 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		HEALTH AND SAFETY	5	Suitability During Reclamation (Workers)	0	9	7	5	7	7	7	3	1	0 ND
				Suitability Post Reclamation (Public)	5	5	5	7	7	7	7	9	9	20 D
				SUB ACCOUNT SCORE		5.00	5.00	7.00	7.00	7.00	7.00	9.00	9.00	
		TRADITIONAL/CULTURAL	5	Usability	5	3	3	5	5	5	5	7	9	30 D
				SUB ACCOUNT SCORE		3.00	3.00	5.00	5.00	5.00	5.00	7.00	9.00	
		COMMUNITY INFRASTRUCTURE	1	Condition of Water Supply	1	9	9	9	9	9	9	9	9	0 ND
				SUB ACCOUNT SCORE		9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	
		COMPLETION PERIOD	0	Time to Complete Reclamation	0	9	9	5	6	6	5	4	1	0 ND
				SUB ACCOUNT SCORE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		MINERAL DEVELOPMENT POTENTIAL	0	Mineral Development Potential	0	9	9	7	7	7	7	5	3	0 ND
				SUB ACCOUNT SCORE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
		FUTURE BURDEN ON SOCIETY	5	Long Term Management Requirements	5	7	7	9	9	9	9	9	9	10 D
				SUB ACCOUNT SCORE		7.00	7.00	9.00	9.00	9.00	9.00	9.00	9.00	
		EMPLOYMENT OPPORTUNITIES (Reclamation & WTP)	0	Short Term Local Employment Value	0	1	3	7	5	5	7	7	9	0 ND
				Long Term Local Employment Value	0	9	9	7	7	7	7	7	7	0 ND
				SUB ACCOUNT SCORE		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
				ACCOUNT SCORE		4.41	4.78	6.33	6.33	6.33	6.70	8.26	9.00	
				MULTIPLE ACCOUNT SCORE		5.43	6.00	7.21	6.98	7.09	7.48	8.07	8.24	
				Relative to existing conditions:		0.00	0.57	1.78	1.55	1.66	2.04	2.64	2.81	
				Sum of cost estimates (million $)		16.4	20.1	55.1	29.1	31.7	46.0	77.3	166.6	
				Points per dollar value			2.85	3.22	5.32	5.24	4.45	3.41	1.68	

TABLE A-2e. SUMMARY OF TECHNICAL WORKING GROUP CONSENSUS ANALYSIS FOR LANDUSKY
Updated March 19th, 2001

ACCOUNTS		EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT.3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)
TECHNICAL	RELATIVE RANKING	8	7	3	6	5	2	1	4
	ACCOUNT SCORE	6.27	7.03	7.86	7.51	7.67	7.92	8.28	7.79
PROJECT ECONOMICS	RELATIVE RANKING	4	3	5	1	2	6	7	8
	ACCOUNT SCORE	7.58	7.95	7.31	8.31	8.00	7.13	6.29	4.67
ENVIRONMENT	RELATIVE RANKING	8	7	4	6	5	2	3	1
	ACCOUNT SCORE	5.75	6.37	7.51	7.18	7.35	7.82	7.79	7.89
SOCIO-ECONOMICS	RELATIVE RANKING	8	7	4	5	5	3	2	1
	ACCOUNT SCORE	4.47	4.78	5.81	5.77	5.77	6.22	6.84	7.32
OVERALL RANKING		8	7	6	1	1	3	4	5
MULTIPLE ACCOUNT SCORE		5.88	6.39	7.09	7.10	7.12	7.28	7.33	7.07
SCORE RELATIVE TO EXISTING CONDITIONS		0.00	0.52	1.21	1.22	1.24	1.40	1.46	1.20

ABLE A-2f. SUMMARY OF TECHNICAL WORKING GROUP CONSENSUS ANALYSIS FOR LANDUSKY FOCUSING SOLELY ON ENVIRONMENTAL EFFECTS
pdated March 19th, 2001

ACCOUNTS		EXISTING CONDITIONS as of Jan 1999	CONDITIONS FOLLOWING INTERIM RECLAMATION as of Feb 2001	ALTERNATIVE L1 (Final EIS ALT-3, ROD)	ALTERNATIVE L2 (Optimize Earthwork Within Bond)	ALTERNATIVE L3 (Free Draining MT Gulch)	ALTERNATIVE L4 (Remove & Backfill 85/86 Pad but No Pit Notch)	ALTERNATIVE L5 (Backfill Pit Holes & Sulfide Highwalls)	ALTERNATIVE L6 (Total Backfill to Pre-mine Topography)
ECHNICAL	RELATIVE RANKING	8	7	3	6	5	2	1	4
	ACCOUNT SCORE	6.27	7.03	7.86	7.51	7.67	7.92	8.28	7.79
ROJECT ECONOMICS	RELATIVE RANKING	1	1	1	1	1	1	1	1
	ACCOUNT SCORE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NVIRONMENT	RELATIVE RANKING	8	7	4	6	5	2	3	1
	ACCOUNT SCORE	5.75	6.37	7.51	7.18	7.35	7.82	7.79	7.89
OCIO-ECONOMICS	RELATIVE RANKING	8	7	4	4	4	3	2	1
	ACCOUNT SCORE	4.41	4.78	6.33	6.33	6.33	6.70	8.26	9.00
OVERALL RANKING		8	7	4	6	5	3	2	1
MULTIPLE ACCOUNT SCORE		5.43	6.00	7.21	6.98	7.09	7.48	8.07	8.24
SCORE RELATIVE TO EXISTING CONDITIONS		0.00	0.57	1.78	1.55	1.66	2.04	2.64	2.81

SUM OF COSTS FOR EACH ALTERNATIVE		20.05	55.10	29.12	31.69	45.96	77.33	166.60
POINT SCORE PER DOLLAR REQUIRED		2.85	3.22	5.32	5.24	4.45	3.41	1.68

APPENDIX B

RECLAMATION COVER PERFORMANCE MODELING

APPENDIX B:
RECLAMATION COVER PERFORMANCE MODELING
ZORTMAN & LANDUSKY MINES

1.01 INTRODUCTION AND TERMS OF REFERENCE

The cover modeling for preparation of the 1996 FEIS was carried out using the HELP model (Schroeder et al., 1994). Although the HELP model is widely used and accepted by the regulatory agencies for the design of covers for land fill and other waste repository sites, it is a relatively crude model which has been replaced for modeling studies such as this one, by more sophisticated programs over the last few years. The HELP model is not well suited for simulating the performance of soil cover systems, in particular in arid or semi-arid climates, where evaporation and unsaturated flow are an important aspect of cover performance (Morris and Stormont, 1997; Meyer and Gee, 1999; RGC, 2000). Therefore, the work completed for the Multiple Accounts Analysis (MAA) process utilized the SoilCover and SEEP/W software programs.

The cover modeling completed for the technical working group during the MAA process included a brief evaluation of modifications to the ROD-specified water barrier and water balance cover designs using the HELP model (Schroeder et al., 1994); a review of the HELP modeling performed for preparation of the 1996 FEIS; and the additional modeling of the specific reclamation alternative covers using the modeling programs SoilCover and SEEP/W.

Based on the testwork completed, it became clear that the MAA alternatives should include options to those cover design(s) specified in the ROD. There are various reasons why cover options were evaluated. For one, cover layer thickness and the use of GCL liners and clay layers are cost-sensitive items and needed to be re-evaluated. There are also insufficient sources of locally available, geochemically suitable borrow materials to construct the ROD-specified cover systems (e.g. top soil, coarse sand & gravel). Technical difficulties with some aspects of the cover systems specified in the ROD also play a role. For example, geosynthethic clay layers and PVC liners have a limited lifetime. The cover systems specified in the ROD are "high-cost" covers designed to minimize the net percolation (infiltration) through the waste rock material. However, although these covers may minimize infiltration for the time period until they break down (perhaps 100 years), long term water collection and treatment will still be required. Under these conditions a lower cost cover can achieve the objectives of long term infiltration minimization, reducing the costs of long term treatment. The performance of alternative "lower-cost" covers was therefore evaluated.

The main components of the cover modeling undertaken included:

- use of the one-dimensional saturated-unsaturated coupled heat and mass transfer model SoilCover to predict net percolation through the cover. SoilCover is the state-of-the-art model for predicting the performance of mine waste cover systems, in particular for partially saturated covers in semi-arid climates where evaporation/transpiration is an important aspect of cover performance. The model algorithm calculates surface evaporation rates (based on daily climate data) and predicts water vapor flow and oxygen transfer in the waste and cover material profile.

- use of the two-dimensional saturated-unsaturated model SEEP/W to evaluate cover performance for sloped surfaces where lateral moisture movement is a significant component of the cover water balance.

- evaluation of alternative cover systems (e.g. "low-cost" water balance cover on flat surfaces; "capillary-break" cover on sloped surfaces) not considered in the ROD analysis; and

- evaluation of alternative cover materials (such as the Ruby Gulch tailings) not considered in the ROD analysis.

The work scope for cover modeling was aimed at evaluating alternative cover designs (not originally considered in the FEIS) that can be constructed with locally available material. The emphasis was on alternative cover systems which are technically feasible and emphasize long-term performance and sustainability.

A detailed physical laboratory testing program was carried out as part of this work scope to provide a basis for the design of alternative cover options and subsequent performance analyses using the numerical models. The laboratory testing program focused on the determination of geotechnical soil properties relevant to cover performance (grain size, Proctor test; Ksat and soil moisture retention). Both potential cover materials as well as mine rock samples were analyzed to provide realistic input parameters for cover performance modeling.

The results of the physical testing of potential cover materials and mine rock are summarized in Section 2. The cover performance modeling for alternative cover options on flat surfaces, carried out using SoilCover, is discussed in Section 3. Section 4 summarizes the results of the cover performance modeling for sloped surfaces using SEEP/W. The laboratory data, and more detailed interpretation of the results can be found in RGC Reports No. 075001/5 (RGC, July 2000) and 075001/7 (RGC, December 2000).

1.02 PHYSICAL CHARACTERIZATION

Field Sampling

A total of 18 samples of potential cover materials and mine rock material (from leach pads) were collected for laboratory testing during the 1999 field season. Table B-1 summarizes the sampling locations and type of material collected.

The emphasis of field sampling was on potential cover materials and included fine-grained material from the Goslin Flats area (4 samples), stockpiled topsoil (2 samples), Emerson shale from stockpile and pit (3 samples) and Ruby Gulch tailings (3 samples). Mine rock samples were taken from two leach pads at Landusky (LP 80/82 and LP 83) and one leach pad at Zortman (LP 84).

The majority of samples were taken from shallow test pits (3-6ft deep) using a backhoe. At those sampling locations where access was restricted (e.g. in-pit samples) samples were taken from the near-surface by hand. The finer-grained materials were collected as bulk grab samples (i.e. no screening in the field). In contrast, most coarse-grained material (including all mine rock from the leach pads) was screened in the field by passing it over a 1" sieve. Samples were placed in 2-3 sealed 20L plastic buckets and shipped to the soil laboratory of Daniel B. Stephens and Associates (DBSA) in Albuquerque, New Mexico for further testing. The percentage of oversized material was estimated (where required) at a later date by re-sampling the test pits and determining the weight of the oversized material relative to the weight of the material passing the 1" sieve.

Laboratory Methods

Table B-2 summarizes the laboratory tests performed on the various cover and mine rock samples. Grain size analyses were performed on all samples. Based on the results of the grain size analyses samples were selected for more detailed testing including initial bulk density, compaction tests (Standard proctor), permeability testing, and soil moisture retention. Details of the test methods are provided in RGC Report No. 075001/5 (RGC, July 2000).

TABLE B-1 - SUMMARY OF SOIL AND MINE ROCK SAMPLES SUBMITTED FOR PHYSICAL LAB TESTING

Sample ID	Sampling Location	Comments	Grain Size Curve		Soil Type
			% finer #4	% finer #200	
ZU/GF-300	Goslin Flats	grab sample	71%	48%	gravelly sandy silt/clay
ZU/GF-301	Goslin Flats	grab sample	90%	76%	clayey silt
ZU/GF-304	Goslin Flats	grab sample	94%	87%	clayey silt
Goslin	Goslin Flats	grab sample	99%	56%	sandy silt/clay
ZU/CCC-182	limestone outcrop	grab sample	62%	6%	sand & gravel
LDP/QR-567	Emerson Shale from East wall of Queen Rose pit	grab sample	48%	2%	poorly graded gravel w/ sand
LDWD/GBB-501	Goldbug Blue Stockpile	grab sample	68%	4%	well-graded sand w/ gravel
ZD/CCC-223	clay stockpile above Ruby Waste Dump	grab sample	95%	82%	silt/clay
Z1-1" minus	Ruby Gulch tailings (upstream)	sample screened in the field (>95% passing 1")	54%	9%	sand & gravel
Z2-1" minus	Ruby Gulch tailings (mid-stream)	sample screened in the field (>95% passing 1")	57%	5%	sand & gravel
Z3	Ruby Gulch tailings (downstream)	grab sample	61%	22%	silty sand & gravel
MG TS Top	Mill Gulch topsoil stockpile - near top of stockpile	sample screened in the field (~77% passing 1")	~55%	25%	silty sandy gravel
MG TS Bottom	Mill Gulch topsoil stockpile - near bottom of stockpile	sample screened in the field (~77% passing 1")	~50%	~24%	gravelly sandy silt/clay
Sediment	dolomite stockpile	grab sample	78%	44%	gravelly silt/clay
L(Z)80-82 LP	Landusky leach pad #80/82	sample screened in the field (~58% passing 1")	~28%	~2%	well-graded gravel with sand
L(Z)-83	Landusky - leach pad #83	sample screened in the field (~53% passing 1")	~18%	~1%	well-graded gravel with sand
Z-84	Zortman - leach pad #84	sample screened in the field (~59% passing 1")	~27%	~3%	well-graded gravel with sand
N. Alabama	material from Alabama pit (north wall)	grab sample	16%	3%	poorly graded gravel

Note:

1) sample ID in brackets shows label used during initial sampling and shipping

2) proportion of material passing 1" sieve was estimated during separate sampling event

TABLE B-2 - SUMMARY OF TESTS PERFORMED

Laboratory Sample Number	Initial Soil Properties[1] (θ, ρ_d, ϕ)	Saturated Hydraulic Conductivity[2]		Moisture Characteristics[3]					Unsaturated Hydraulic Conductivity	Particle Size[4]			Effective Porosity	Particle Density	Air Permeability	1/3, 15 Bar Points and Water Holding Capacity	Atterberg Limits	Proctor Compaction
		CH	FH	HC	PP	TH	WP	RH		DS	WS	H						
ZU/GF 300	X		X	X	X	X		X	X		X	X						X
ZU/GF 301			X								X	X						X
ZU/GF 304	X	X		X	X			X	X		X	X						X
ZU/CCC 182										X								
LDP/QR 567										X								
LDWD/GBB 501										X								
ZD/CCC 223											X	X						
ZU/GF 304(100% Proctor)			X															
LDWD\GBB 501(6")	X	X		X	X			X	X									X
N. ALAB										X								
Goslin			X								X	X						X
Z-1 1" minus	X	X		X	X	X		X	X		X	X						X
Z-2 1" minus		X									X	X						X
Z-3											X	X						X
Z-3-A	X	X		X	X	X		X	X									
Z-84	X	X		X	X			X	X		X	X						
L83		X								X								
MG TS Top	X	X		X	X	X		X	X		X	X						X
MG TS Bottom		X									X	X						X
L82/83		X								X								
Sediment											X	X						

1 θ = Initial moisture content, ρ_d = Dry bulk density, ϕ = Calculated porosity

2 CH = Constant head, FH = falling head

3 HC = Hanging column, PP = Pressure plate, TH = Thermocouple psychrometer, RH = Relative humidity box

4 DS = Dry sieve, WS = Wet sieve, H = Hydrometer

Results and Discussion

A summary of the physical soil properties are provided in this section and the reader is referred to RGC Report No. 075001/5 for details (RGC, July 2000).

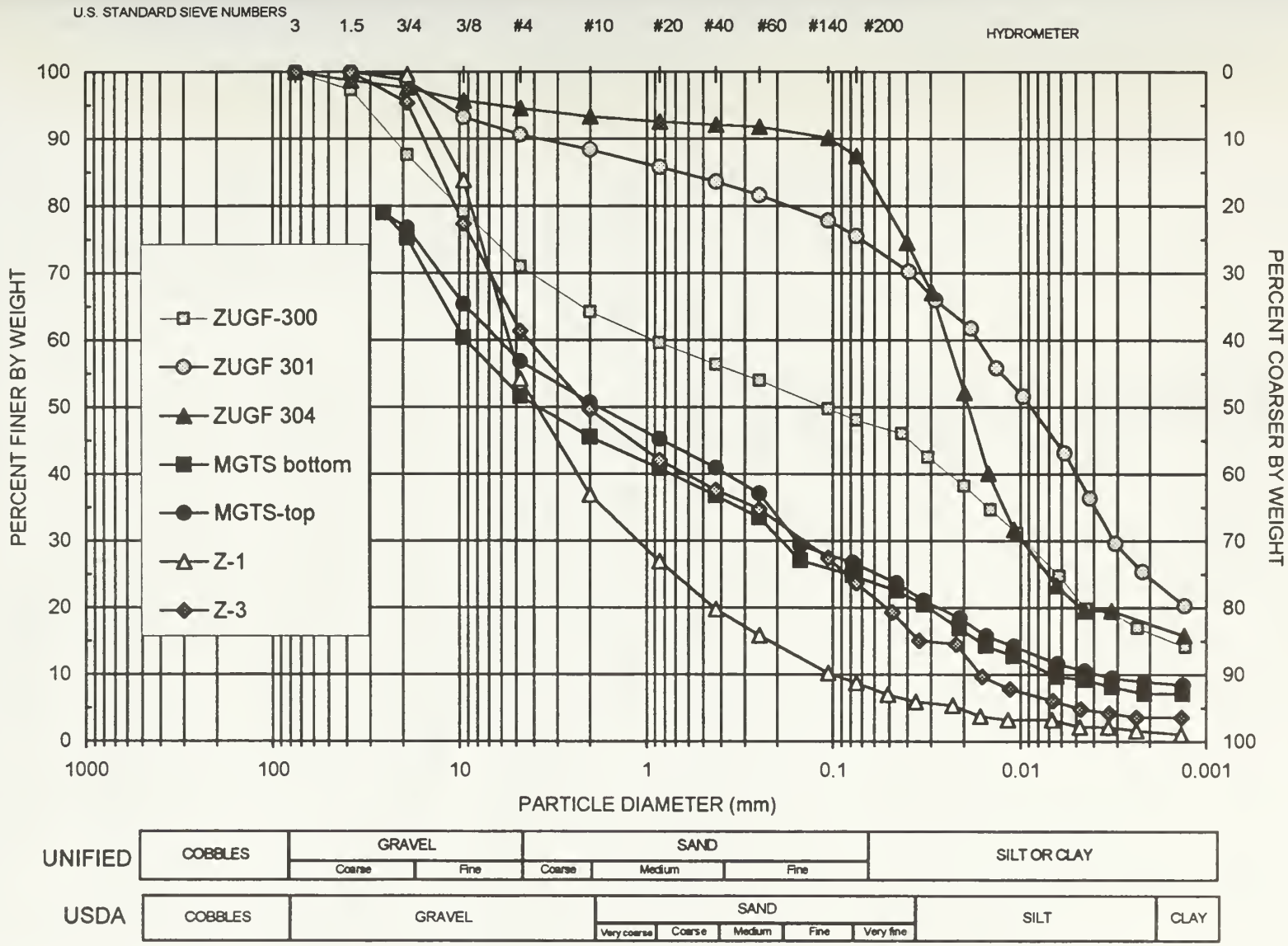
Figure B-1 shows the particle size distribution (PSD) of selected samples representing potential cover materials. The various materials showed significant variations in the fines content ranging from ~10-80%. Figure B-2 shows the PSD for the mine rock samples collected from the three leach pads at the mines. The PSD of mine rock samples from three other mine sites are shown for comparison. The mine rock samples are very coarse and consists of poorly-graded coarse gravel with some sand. The very coarse nature of the mine rock samples suggests that they have a very low moisture retention capacity and may act as a capillary barrier when covered with finer-grained soils.

The detailed results of the moisture contents, densities and porosities of selected samples are provided in Table B-3. The in-situ moisture content correlated very well with the fines content of the sample. The initial (or in-situ) moisture contents (by volume) ranged from 26.6% for the fine-grained Goslin Flats material to as low as 3% for the coarse tailings. The topsoil and the mine rock sample Z-84 showed intermediate moisture contents (13% to 16% by volume).

Table B-4 summarizes the results of the Proctor compaction tests for the finer-grained materials (Proctor testing on the coarse mine rock samples was not feasible) and Table B-5 summarizes the results of the saturated hydraulic conductivity tests.

The Goslin Flats material showed the lowest saturated hydraulic conductivity of all tested samples with Ksat values ranging from $8x10^{-7}$ to $5x10^{-6}$ cm/s (Table B-5). Upon compaction, the hydraulic conductivity was reduced by about one order-of-magnitude ($2x10^{-7}$ cm/s). The saturated hydraulic conductivity for the topsoil samples was about 2 orders-of-magnitude higher than that of the Goslin Flats material ($3x10^{-4}$ to $6x10^{-4}$ cm/s) (Table B-5). The Ruby Gulch tailings showed a significant variation in saturated hydraulic conductivity ranging from as high as $2x10^{-2}$ cm/s for the coarse tailings to as low as $3x10^{-4}$ cm/s for the fine-grained tailings. The hydraulic conductivity of the mine rock samples varied from $1x10^{-3}$ cm/s to $6x10^{-3}$ cm/s.

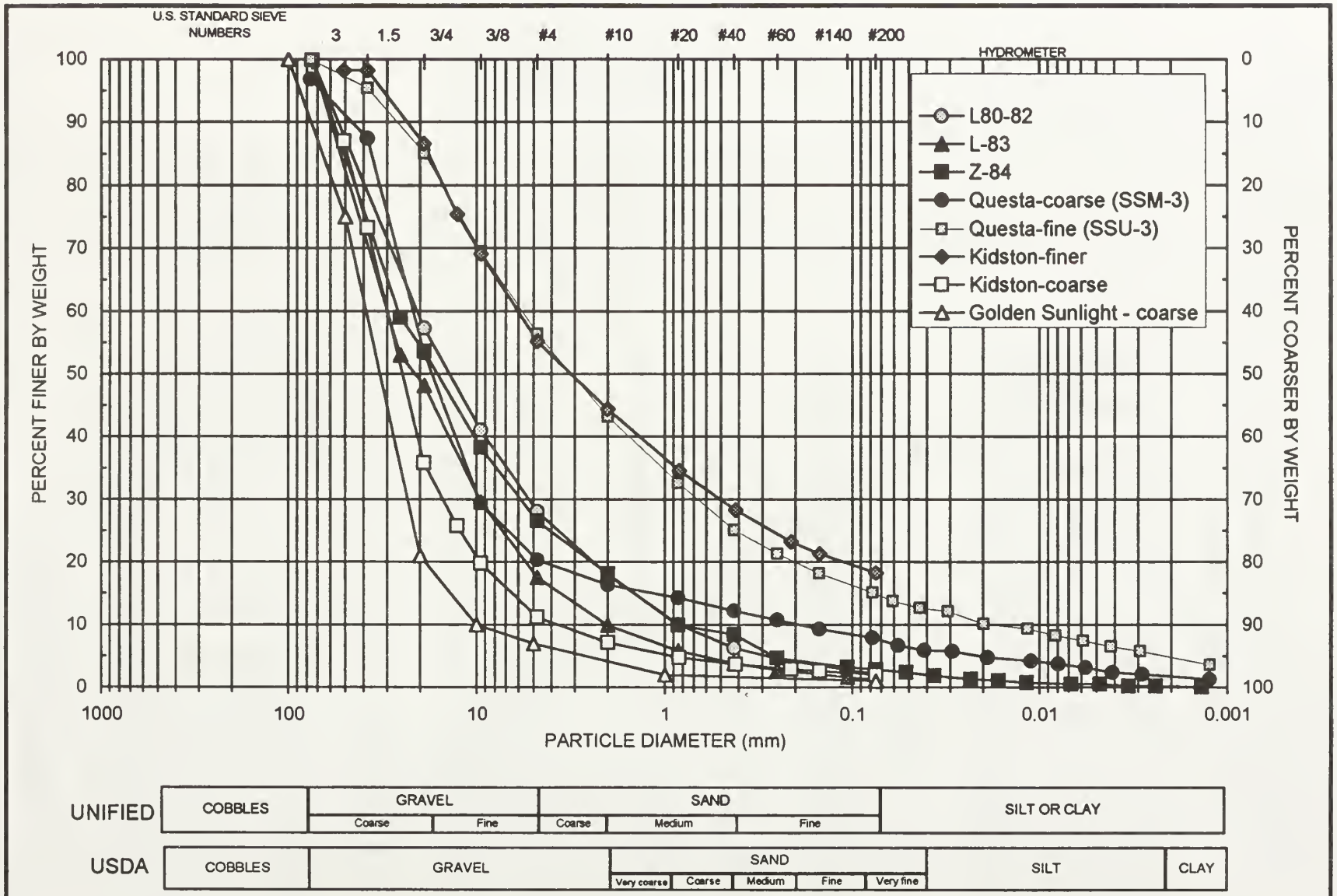
Figure B-3 shows the soil water characteristic curves (SWCC) determined in the laboratory on various potential cover materials and on one mine rock sample (Z-84). The SWCCs of mine rock samples from other sites (with similar coarse PSD as the mine rock at Zortman-Landusky) are also shown for comparison. The SWCC represents the volumetric moisture content of the material as a function of the suction (negative pressure) in the unsaturated sample. An important point on the SWCC is the air entry value (AEV), which is defined as the suction value at which the volumetric water content declines, i.e. where the soil begins to drain (AEV). The AEV is critical for cover performance as it represents the suction at which the first (largest) pores drain (i.e. the soil changes from tension-saturated to unsaturated conditions) with an associated large decline in the hydraulic conductivity of the soil.



Cover Performance Modeling

Zortman and Landusky Mine Site, Montana

FIGURE B-1 - PARTICLE SIZE DISTRIBUTIONS OF SELECTED SAMPLES.



		Cover Performance Modeling
	Zortman and Landusky Mine Site, Montana	FIGURE B-2 - COMPARISON OF PSDs OF COARSE MINE ROCK SAMPLES.

Table B-3 - Summary of Moisture Content, Densities and Calculated Porosity.

Sample Number	Initial Moisture Content		Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (%)
	Gravimetric (%, g/g)	Volumetric (%, cm^3/cm^3)			
ZU/GF 300	13.9	23.6	1.69	1.93	36.1
ZU/GF 304	16.8	26.6	1.58	1.85	40.2
LDWD\GBB 501(6")	1.8	3.1	1.76	1.79	33.6
Z-1 1" minus	3.4	5.8	1.69	1.74	36.3
Z-3-A	1.9	3.2	1.62	1.66	38.7
Z-84	8.0	13.4	1.67	1.81	36.8
MG TS Top	9.4	16.2	1.73	1.89	34.7

Table B-4 - Summary of Proctor Compaction Tests

Sample Number	Optimum Moisture Content (% g/g)	Maximum Dry Bulk Density (g/cm^3)
ZU/GF 300	12.2	1.91
ZU/GF 301	20.3	1.64
ZU/GF 304	17.1	1.74
LDWD\GBB 501(6")	8.7	1.97
Goslin	13.7	1.77
Z-1 1" minus	12.6	1.88
Z-2 1" minus	10.7	1.85
Z-3	13.3	1.82
MG TS Top	11.7	1.92
MG TS Bottom	9.5	1.93

Table B-5 - Summary of Saturated Hydraulic Conductivity Tests.

Sample Number	K_{sat} (cm/sec)	Method of Analysis	
		Constant Head	Falling Head
ZU/GF 300	5.0E-06		X
ZU/GF 301	7.6E-07		X
ZU/GF 304	4.8E-06	X	
LDWD/GBB 501	2.2E-03	X	
ZU/GF 304(100% Proctor)	2.2E-07		X
Goslin	4.7E-07		X
Z-1 1" minus	2.0E-02	X	
Z-2 1" minus	1.6E-02	X	
Z-3	2.9E-04	X	
Z-84	1.1E-03	X	
L83	5.8E-03	X	
MG TS Top	5.6E-04	X	
MG TS Bottom	3.3E-04	X	
L82/83	3.0E-03	X	

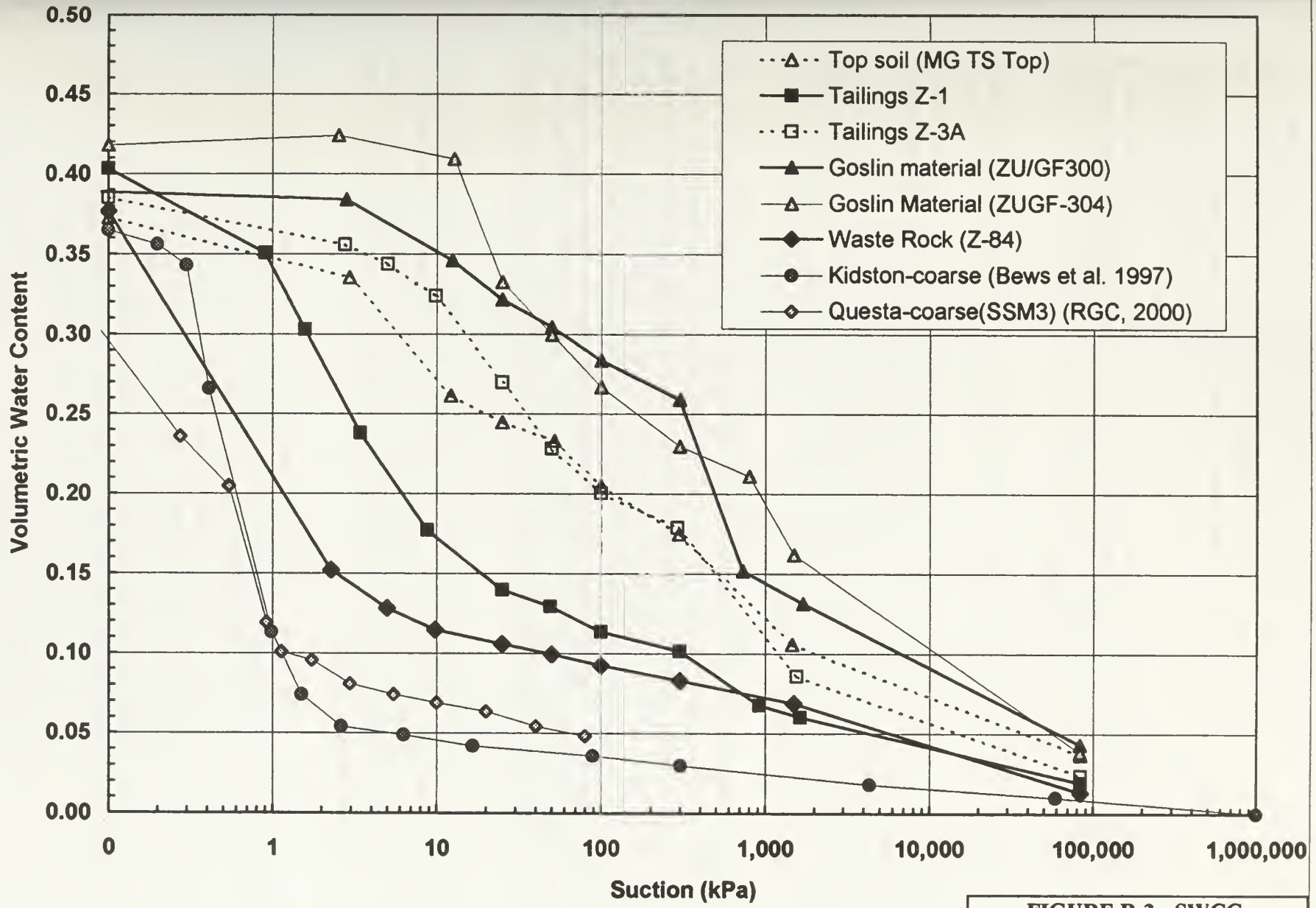


FIGURE B-3 - SWCCs DETERMINED ON LABORATORY SAMPLES

The Goslin Flats material has the highest soil moisture retention capacity of all potential cover materials with an air entry value (AEV) of about 5 to 15 kPa (50-150cm) suction. The soil (MGTS-Top) and the fine tailings (Z-3) show a fairly similar SWCC with an AEV of 2 to 5 kPa (20-50cm) suction. The fine tailings have a slightly better water holding capacity than the topsoil in the low suction range. The SWCC of the coarse tailings (Z-1) differs significantly from that of the fine tailings (Z-3) and the soil (MGTS-Top). The AEV of the coarse tailings is <1 kPa (10cm) suction and the slope of the SWCC is much steeper than that of the finer-grained materials (Figure B-3). In other words the coarse tailings are much more likely to drain under typical field conditions (suctions in the range of <1 to 100 kPa) than the fine tailings. At the same time, the ability of the soil to drain also provides more storage capacity between successive dry and wet periods.

As expected the mine rock sample (Z-84) had the lowest AEV and the steepest SWCC (Figure B-3). In fact, the water retention capacity of this sample was so low that difficulties were encountered to determine the AEV and the low suction portion of the SWCC in the laboratory. A first measurement of moisture content could only be obtained at a suction of 2.5 kPa (25 cm), at which point most of the pore water had already drained and the moisture content was close to field capacity (Figure B-3). Note that only the -#4 portion of this leach pad material could be tested due to size constraints with the laboratory apparatus (a 6" mold was used). It is likely that the bulk material present in the field (which is much coarser than the test specimen) would drain even faster, i.e. show an even steeper SWCC than was measured in the laboratory.

For comparison purposes, the SWCCs of coarse mine rock samples collected at the Questa mine site (RGC, 2000) and the Kidston mine site (Bews et al, 1997) are also shown in Figure B-3. Both of these mine rock samples are comparable to the Zortman-Landusky samples in that they represent poorly graded, coarse gravels. However, the sand and fines content of these mine rock samples differs somewhat and approximately brackets the range observed at the Zortman-Landusky site (see Figure B-2). The SWCCs for the Questa and Kidston samples show a similar steep decline in moisture content at very low suctions (0.1 to 1 kPa) with either no discernible AEV (Questa) or a very low AEV (Kidston) in the order of 0.3 kPa (3 cm) (Figure B-3). The field capacities of these coarse mine rock samples were less than 5% (at a suction of ~300 kPa).

The similarity in PSD of the Kidston sample to the coarse mine rock from Zortman-Landusky (in particular L-83, see Figure B-2) justified the use of the SWCC of the Kidston mine rock sample in this cover modeling study (representing "coarse" mine rock). The SWCC of the Z-84 sample was used in sensitivity analyses to assess the influence of the SWCC of the mine rock on cover performance (see Section 3 below).

Figure B-4 provides the hydraulic conductivity functions (calculated from the SWCCs) and illustrates that the coarse tailings show the highest hydraulic conductivity of all cover materials at very low suction (close to saturation) but show the lowest hydraulic conductivity at high suctions. The opposite trend is observed for the fine-grained Goslin Flats material (ZUGF-300). Note that the large differences in hydraulic conductivity among the various potential cover materials (a range of almost four orders of magnitude) is greatly reduced at suctions typically observed in the field (1-100 kPa). Also note that the hydraulic conductivity of all coarse mine rock samples is consistently much lower than any of the cover materials except for saturated or near-saturated conditions (<10 kPa).

1.03 COVER PERFORMANCE ON FLAT SURFACES

Modeling Approach

The modeling software SoilCover (Geo-Analysis 2000 Ltd, 2000) was used to assess alternative cover scenarios for flat (or nearly flat) surfaces. This model is a coupled heat and mass transfer, saturated-unsaturated model, which combines soil conditions with atmospheric conditions. SoilCover is capable of predicting actual evapotranspiration from the soil profile. The model input parameters include daily climate parameters (air temperature, relative humidity, pan evaporation, and precipitation) as well as soil parameters (SWCC, Ksat, hydraulic conductivity function).

The main purpose of the cover performance modeling is to predict the flux of pore water from the cover into the underlying mine rock which ultimately emerges at the base of the mine rock pile as seepage. Due to the semi-arid climate conditions at the Zortman-Landusky sites the flux of soil moisture at the cover-mine rock interface is not always downward but may also be upward (in particular during hot and dry conditions). SoilCover allows the computation of the resulting net flux of pore water (expressed as mm or inches per year) across the interface of cover and mine rock for a given time period (typically based on one calendar year or hydrologic year). This net flux is commonly referred to as the "net percolation" of the cover system.

SoilCover is a one-dimensional mode and it is implicitly assumed that the soil profile is horizontal and all soil moisture movement is vertical. Therefore, the SoilCover modeling results apply only to flat or nearly-flat surfaces. At the same time, it was assumed that the cover surface has a small slope sufficient to allow surface runoff of any excess precipitation that could not infiltrate. Surface runoff occurs when the entire cover profile is saturated and the rainfall intensity exceeds the saturated permeability of the uppermost cover layer. The modeling results indicate that this condition occurs only on a few isolated occasions during any given year. However, due to the intensity of the storm events (up to 50 mm per day) surface runoff can be significant and should be promoted by surface reshaping.

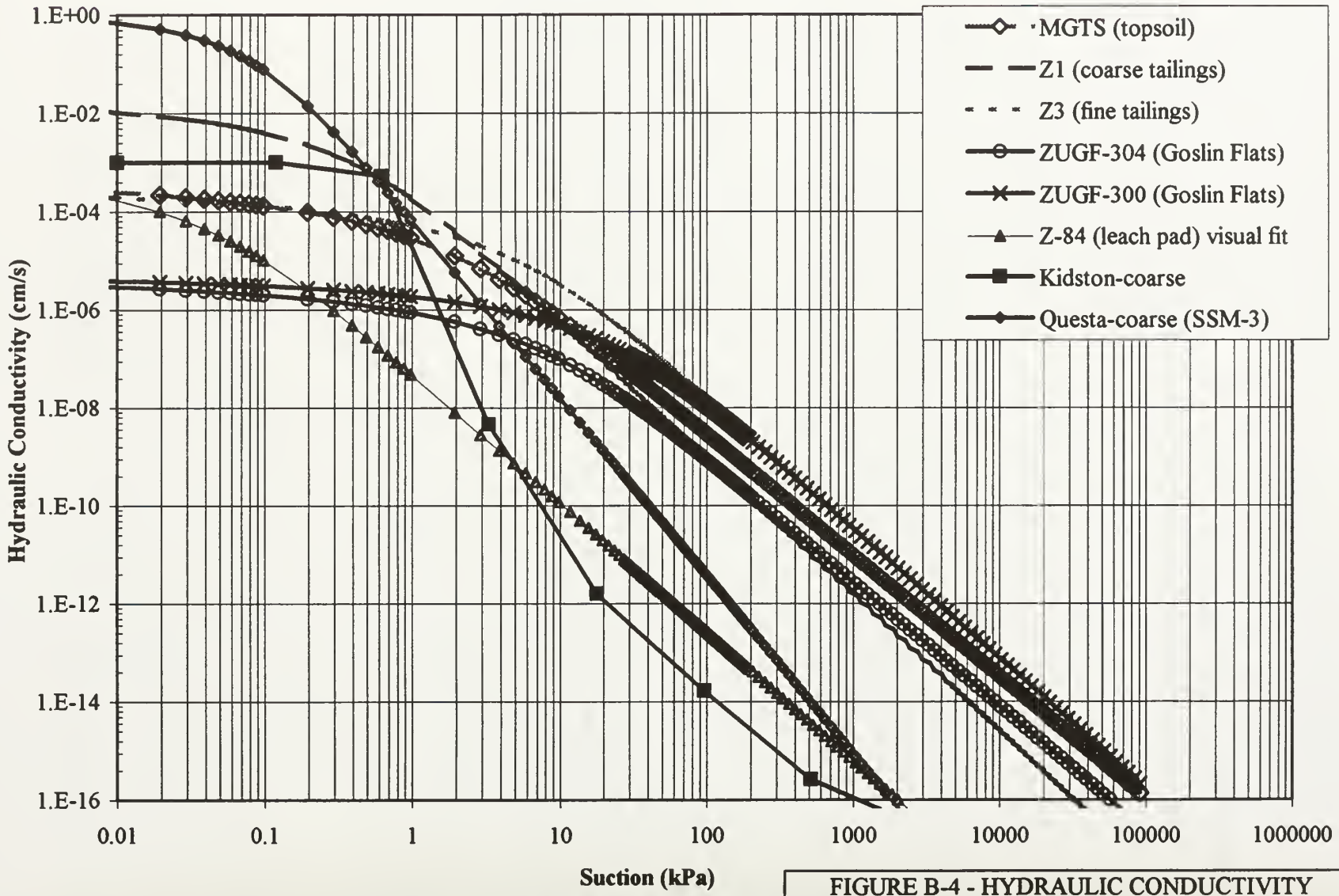


FIGURE B-4 - HYDRAULIC CONDUCTIVITY FUNCTIONS FOR LABORATORY SAMPLES DETERMINED USING VAN GENUCHTEN MODEL

Cover Alternatives

A total of seventeen different cover scenarios were evaluated and are summarized in Table B-6. The cover types vary in design and therefore effectiveness and cost. In the end, not all cover types were utilized in specific reclamation alternatives and certain covers were included in all the alternatives. Chapter 2 details the covers included in each of the reclamation alternatives.

Soil Properties

SoilCover requires the input of the SWCC and the saturated hydraulic conductivity (Ksat) for all materials in the modeled cover profile. SoilCover determines the relative hydraulic conductivity function by fitting the Fredlund and Xing (1994) model to the SWCC (Geoslope, 2000). The hydraulic conductivity at any given suction is then calculated as the product of the relative hydraulic conductivity value at that suction and the Ksat value input to the model.

Figures B-5 and B-6 show the SWCCs and the hydraulic conductivity functions for the potential cover materials and the mine rock used as input to the SoilCover model. Where available, the SWCC and saturated hydraulic conductivity values were taken directly from the laboratory test results, in some instances, professional judgement was used to estimate particular properties (for example with the mixed topsoil/tailings cover scenario).

Climate Data

The cover performance is critically dependent on the climatic conditions at the site and care was taken to obtain site-specific climate data to the extent available. SoilCover requires the input of daily values for precipitation, min/max temperature, min/max relative humidity and potential evaporation for the reduced weather data option (Geoslope, 2000).

Table B-7 lists the metereological monitoring stations and observed climate parameters in vicinity of the Zortman and Landusky mine sites. The weather stations on the Zortman site (Seven Mile Road) and on the Landusky site (Gold Bug and Sullivan Park) were maintained by Zortman Mining Inc. from 1990-1996 as part of an air monitoring program. However, these stations were of limited use for this analysis due to the short observation period and the fact that only precipitation and total monthly pan evaporation was measured. The other weather stations have been operated for much longer periods of time (in particular at Zortman and Mocassin) by various agencies. The most complete set of climate parameters is monitored at the BLM-Zortman station, which is located in close proximity to the Zortman Mine.

Table B-6 - Summary of Various Cover Scenarios Modeled

Cover Type	Topsoil	Ruby Gulch Tailings	Goslin Flats Material	NAG	Clay	Geosynthetic	Comments
1	12"			36"		GCL	ROD-specified water barrier cover
2	8"	10"		24"		HDPE	Water barrier cover
3	12"			36"		HDPE	Water barrier cover
4	11"	7"		24"	8"		Moisture storage in topsoil, capillary break layer (tailings) and a low permeability clay layer
5	12"			24"	8"		Moisture storage in topsoil with a low permeability clay layer
6	12"		12"				Compacted Goslin Flats material to provide a low permeability layer
7	12"		18"				Uncompacted Goslin Flats material to provide additional water holding capacity
8	36"			variable			ROD-type water balance cover with added water storage potential
9	24"			variable			Moisture storage layer (topsoil) - primarily a growth media cover
10	12"			variable			Moisture storage layer (topsoil) - primarily a growth media cover
11	8"			variable			Lesser water storage layer (topsoil) - primarily a growth media cover
12	18"	6"		variable			Thicker water storage layer (topsoil) with capillary break layer (tailings)
13	8"	10"		variable			Lesser water storage layer (topsoil) with greater capillary break layer (tailings)
14	11"	7"		variable			Moisture storage in the topsoil with a capillary break layer (tailings)
15	12"	7"		variable			Moisture storage in the topsoil with a capillary break layer (tailings)
16	19" (mixed)			variable			May have advantages for revegetation and water storage potential
17	29"	7"		variable			Additional water storage in thicker topsoil layer with a capillary break layer (tailings)

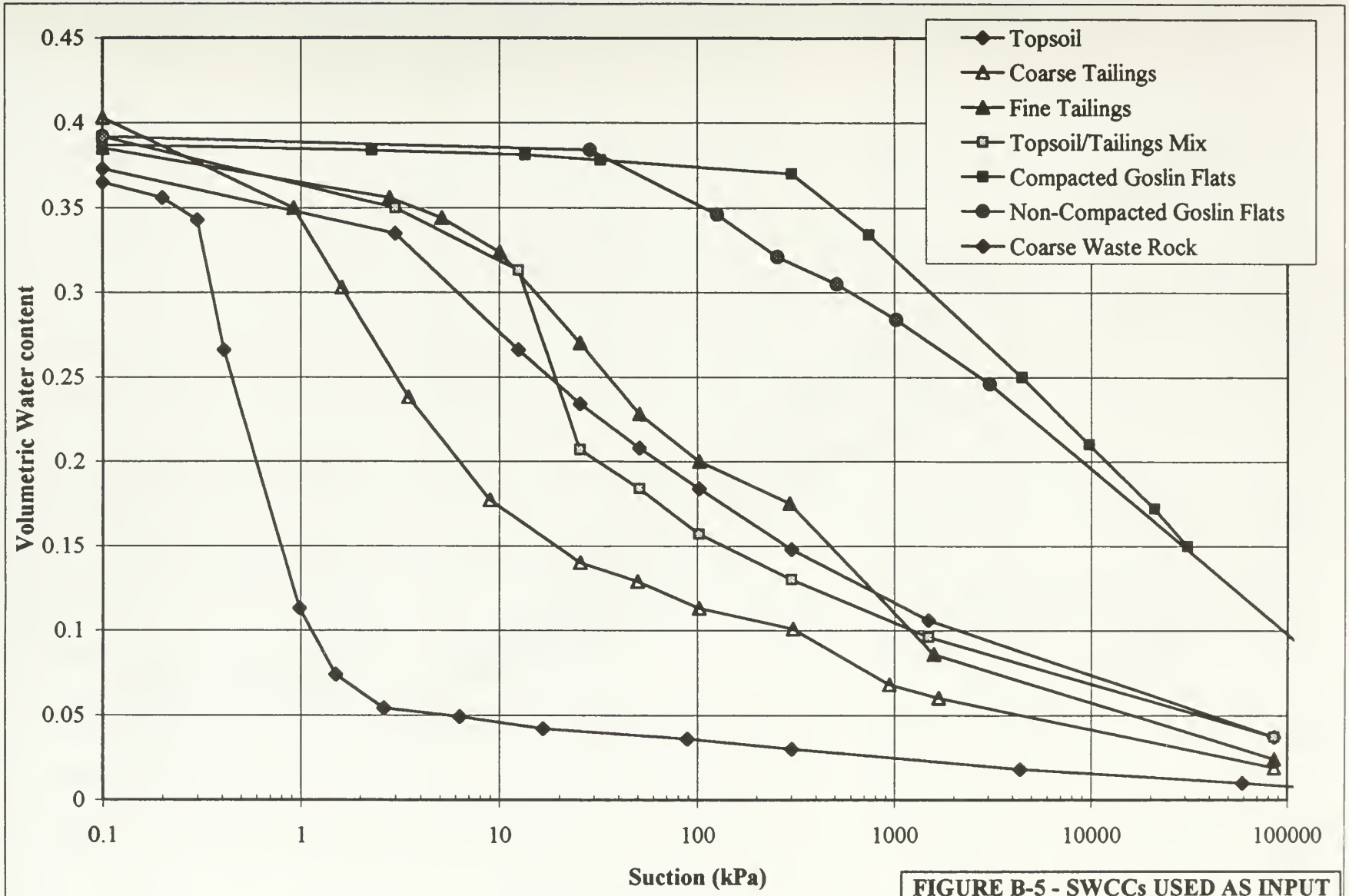


FIGURE B-5 - SWCCs USED AS INPUT TO SOIL COVER MODEL

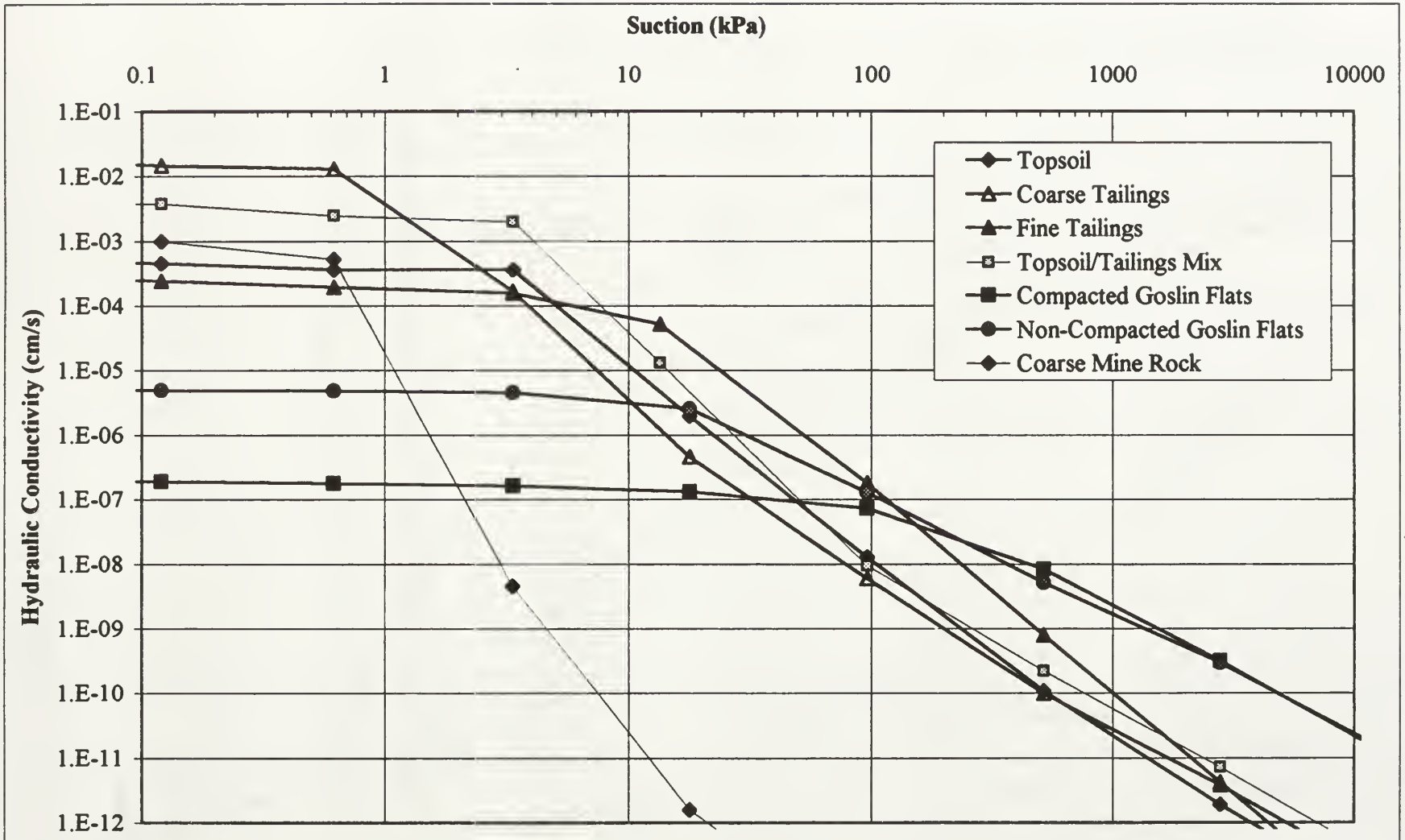


FIGURE B-6 - HYDRAULIC CONDUCTIVITY FUNCTIONS USED AS INPUT TO SOIL COVER MODEL

Table B-8 also shows the monthly total precipitation for the years 1989, 1992, 1993, 1997 and 1998 at selected met stations in vicinity of the Zortman and Landusky mine sites. The data indicate significant local variations in precipitation. The data suggest that the Landusky site receives on average more precipitation than the Zortman site. The various stations near the Zortman site also showed significant variations both from month to month and year to year. The Seven Mile Rd station received significantly less precipitation than the other three stations near Zortman, likely due to the geographic location. Elevation does not appear to be the dominant factor as the Zortman town site and the Seven Mile Rd stations are at similar elevation yet differed significantly in total annual precipitation.

The climate data also indicate that the early nineties were a relatively wet period with the year 1993 one of the wettest years on record. The year 1989 represents an above-average "wet" year whereas 1992 represents a below-average "drier" year. The slightly above-average "wet" year 1989 and a very "wet" year, 1997 were used for comparative modeling of the various cover alternatives. Years 1992 and 1993 were used for sensitivity runs using the base case cover option to assess the influence of variable climate conditions (in particular precipitation) on cover performance.

Table B-7 - Summary of Meteorological Stations near Zortman-landusky, Montana.

Name	Zortman (NCDC)	BLM - Zortman (RAWS)	Zortman Site	Landusky Site	Mocassin Exp. Station
Location	Zortman town	near Zortman mine site	Seven Mile Road	(Gold Bug/Sullivan Park)	southwest of Zortman
UTM Coordinates	684,332 E	682,825 E	687,100 E	680,200 E	579,754 E
	5,309,763 N	5,310,365 N	5,306,200 N	5,309,700 N	5,211,036 N
Elevation	3870 ft	4660 ft	3680	5160 ft	4300 ft
Measured Climate Parameters (daily)					
Precipitation	X	X	X	X	X
Temperature		X			X
RH		X			
Pan Evaporization			(monthly only)	(monthly only)	X

Note: Zortman mine (boneyard) at UTM coordinates 682,700 E and 5,310,800 N

Table B-8. Precipitation Statistics for Various Locations (in inches)

Station	Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL	
														Growing Season	Calendar Year
Zortman town	Long-term Average	0.91	0.52	0.89	1.77	3.09	3.74	2.20	1.80	1.69	0.79	0.44	0.80	15.08	**18.64**
Zortman town	1989	1.62	1.39	0.74	2.38	6.43	3.32	0.73	4.15	0.53	0.80	1.61	2.94	18.34	**26.64**
BLM - Zortman		0.09	0.29	0.47	1.85	5.94	4.10	0.66	2.67	0.50	0.76	1.29	1.09	16.48	**19.71**
Zortman town	1992	0	0.35	1.16	1.05	0.77	5.49	3.54	0.57	1.43	1.08	0.72	0.84	13.93	**17.00**
BLM - Zortman		0.01	0.16	0.19	1.28	1.05	5.03	3.8	0.91	1.53	1.79	0.55	0.13	15.39	**16.43**
Seven Mile Rd		0.00	0.14	0.09	0.73	0.16	3.43	2.76	0.50	0.45	0.74	0.55	0.35	8.77	**9.90**
Landusky (Sullivan Park)		0.92	0.26	0.91	1.26	1.43	5.96	4.09	1.77	1.45	1.66	3.78	2.15	17.62	**25.64**
Zortman town	1993	0.94	0.73	0.99	1.31	1.55	5.55	10.32	2.82	1.33	1.32	0.65	1.72	24.2	**29.23**
BLM - Zortman		0.12	0.07	0.89	1.09	1.82	4.66	9.61	3.17	1.46	0.88	0.26	0.40	22.69	**24.43**
Seven Mile Rd		0.54	0.47	0.10	1.16	1.62	2.86	5.16	1.64	0.72	1.01	0.66	0.20	14.17	**16.14**
Landusky (Gold Bug)		0.86	0.91	1.55	1.08	1.55	4.27	8.57	3.22	1.62	1.05	1.28	1.55	21.36	**27.51**
Zortman	1997	0.46	0.33	0.91	2.22	8.22	4.62	2.77	2.36	0.30	1.27	0.12	2.25	21.76	**25.83**
Landusky (Gold Bug)		0.69	0.38	0.96	1.93	5.16	3.79	2.93	1.50	0.30	1.61	0.10	0.70	17.22	**20.05**
Zortman	1998	0.80	0.43	2.52	2.82	1.22	8.20	1.25	2.11	0.11	0.93	2.00	1.56	16.64	**23.95**
Landusky (Gold Bug)		1.06	0.17	1.75	1.95	1.65	7.50	1.45	2.80	0.50	1.05	1.55	1.90	16.9	**23.33**

Table B-7 indicates that none of the weather stations in vicinity of the Zortman-Landusky mine sites monitored all climate parameters required for the SoilCover model. The most detailed set of climate data was available for the BLM-Zortman station. Hence the climate data from this station were selected for the cover modeling analysis. Precipitation observed at the BLM-Zortman station correlated fairly well with the Zortman town site. The precipitation pattern also correlated fairly well with that observed at Landusky (Sullivan Park); however, the total precipitation was significantly lower at the BLM-Zortman station (Table B-8). The precipitation data from the BLM-Zortman station were scaled upward (by 25%) in one of the sensitivity runs to assess the influence of the total amount of precipitation (with same precipitation pattern) on cover performance.

Figures B-7 and B-8 compare the average monthly minimum and maximum temperatures observed at the BLM-Zortman station (at with those observed at the Zortman site ("boneyard" at 5080 ft elev.) and the Landusky site (Sullivan Park at 5160ft elev.). The data indicate that all stations experience significant daily and seasonal variations in temperature typical for this continental climate. However, the BLM-Zortman station apparently experiences less dramatic temperature fluctuations than the mine sites, perhaps due to difference in elevation, aspect and/or wind exposure.

The only required climate parameter not measured at the BLM-Zortman station is potential evaporation (or pan evaporation). The nearest weather station with similar climate conditions and a pan evaporation record is the Experimental Mocassin station located about 150 km to the southwest of Zortman-Landusky (Table B-7). Figure B-9 compares the monthly pan evaporation rates for the period 1992 to 1997. The data indicate a generally good agreement of monthly evaporation rates for the years 1994-1996. However, in 1992 and 1993 the monthly pan evaporation rates at Mocassin were typically higher than at Zortman and in particular at Landusky.

While the overall evaporation regime appeared to be similar between Mocassin and Zortman-Landusky, adjustments were required to account for local differences (evaporation rates at Zortman-Landusky appeared to be somewhat lower) and more importantly, to account for temporal (day to day) differences in the weather pattern (relative humidity and amount of precipitation) between the two sites. In particular, precipitation and relative humidity can vary significantly in the short-term over a distance of 150 km. For the first phase of SoilCover modeling (including sensitivity analysis) the pan evaporation rates observed at Mocassin were reduced to 0 on those days when the daily minimum relative humidity at BLM Zortman was 100% and by 25% on those days where the daily maximum relative humidity was 100% (RGC Report 075001/5). For the Phase 2 cover performance modeling, carried out in support of the Supplemental EIS, the pan evaporation from Mocassin was set equal to zero for those days where precipitation was observed at BLM Zortman (RGC Report 075001/7). The latter scenario provided a better fit of simulated net percolation (i.e. infiltration through the cover) to observed seepage captured at one of the waste rock dumps for very wet conditions (1997-1998) (see below). The influence of pan evaporation on cover performance was also addressed by way of sensitivity analysis.

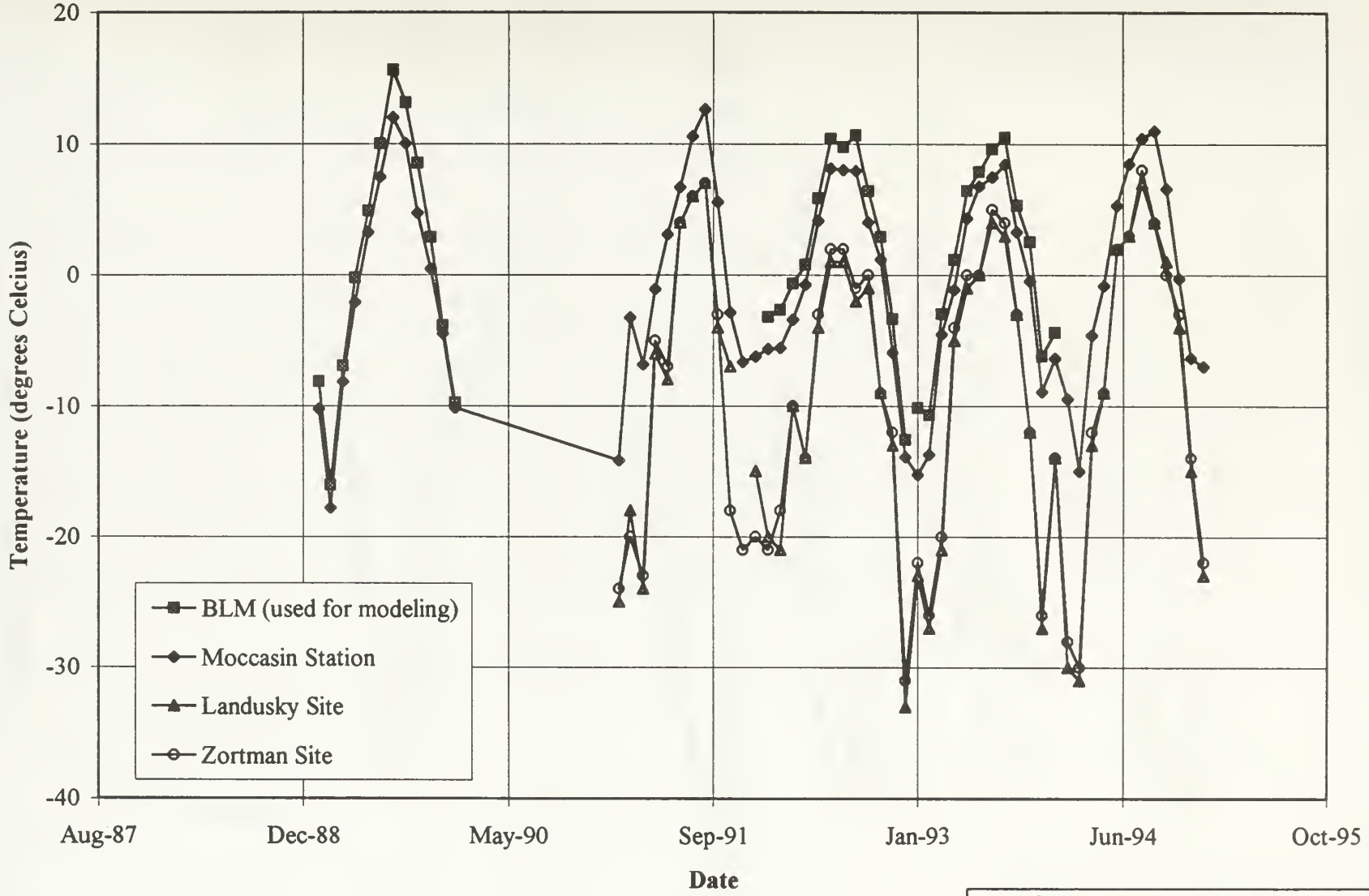


FIGURE B-7 - COMPARISON OF AVERAGE MONTHLY MINIMUM TEMPERATURES

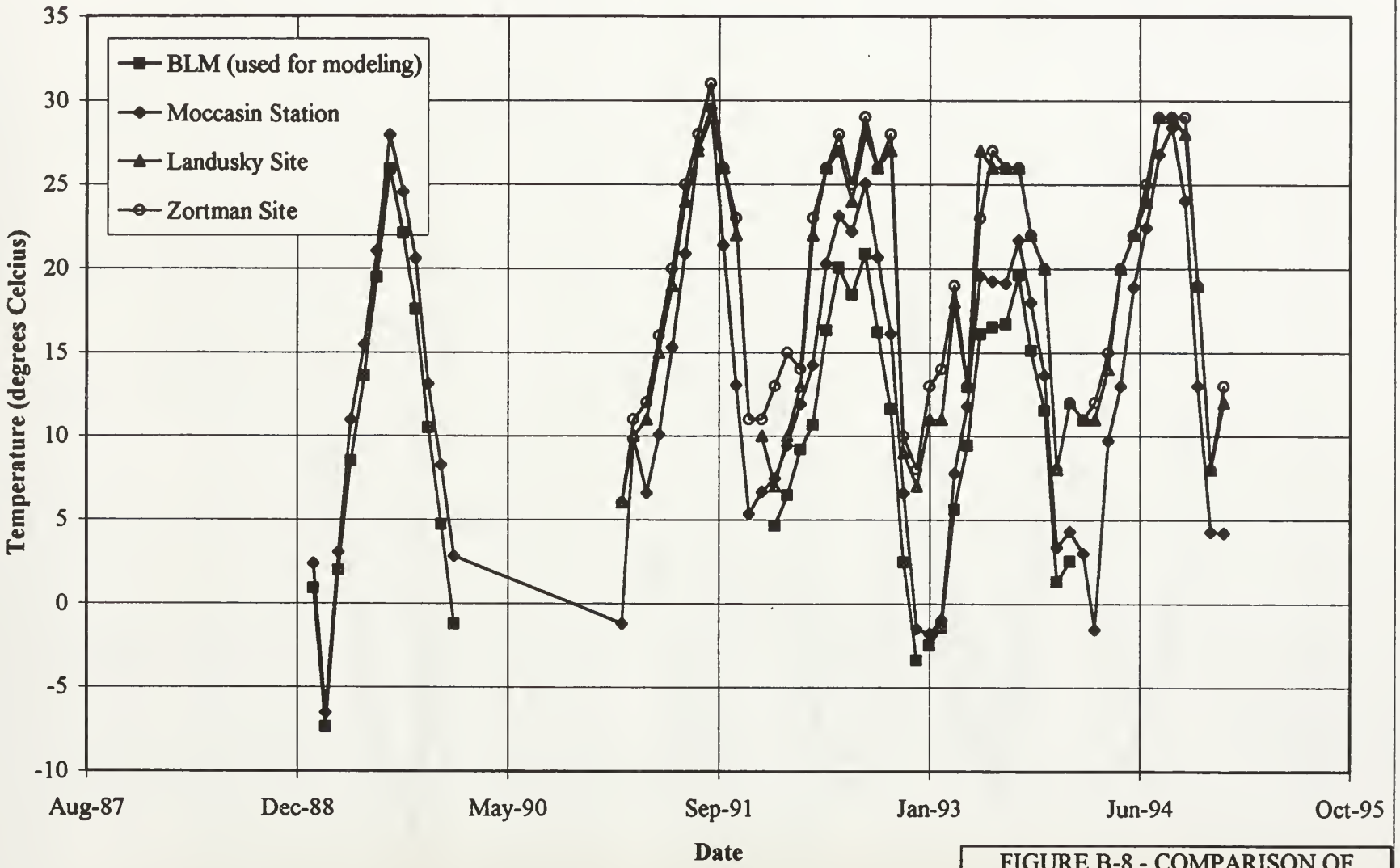


FIGURE B-8 - COMPARISON OF AVERAGE MONTHLY MAXIMUM TEMPERATURES

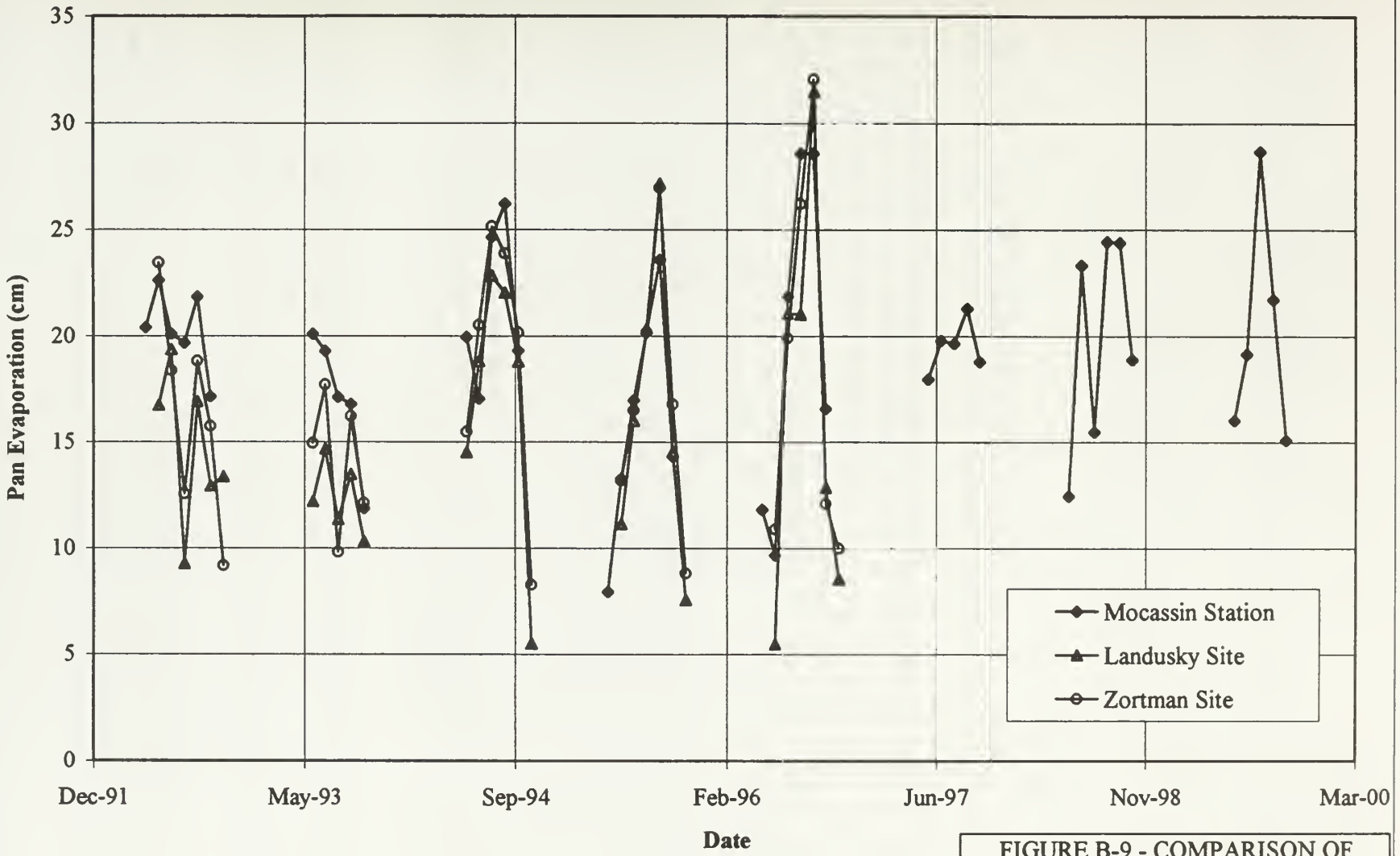


FIGURE B-9 - COMPARISON OF MONTHLY PAN EVAPORATION

Numerical Methods

The details of the numerical methods and assumptions used in the modeling analyses are described in RGC Report Nos. 075001/5 (RGC, July 2000) and 075001/7 (RGC, December 2000). In all simulations the model consisted of the cover layer(s) of variable thickness overlying a 10m thick mine rock profile. The depth of the mine rock profile was chosen sufficiently deep (10m) that this boundary condition had no effect on moisture movement in the upper profile and thus cover performance. All simulations were run for a full calendar year (from January 1st to December 31st) to capture the variable climatic conditions encountered during all four seasons.

Results & Discussion

The cover performance of various cover scenarios is provided in Table B-9. The range in net percolation represents estimates for an 'average' year and a 'very wet' year. The net percolation typically ranged between 0.1% and 1.0% for water barrier covers; 20% and 50% for a water storage type cover; and, 15% and 40% for the ROD-type water balance cover. Note that the estimates of net percolation through a water barrier cover (using HDPE or GCL) was taken from earlier modeling work carried out in support of the EIS using the HELP model (Woodward Clyde, 1995). All estimates for flat surfaces are directly or indirectly based on simulations carried out using the SoilCover model. All estimates for sloped surfaces are based on 2D cover performance calculations carried out using SEEP/W (see below).

An inspection of Table B9 shows that the net percolation into a water storage type cover and the ROD type water balance covers increases disproportionately from dry to wet years. This behavior is typical for a water storage cover with a finite storage capacity. During drier years, the vast majority of the incoming precipitation can be stored in the storage cover and can be released back to the atmosphere by evapotranspiration between subsequent events. During very wet years, the storage capacity is depleted for much of the year and a significant portion of the incoming precipitation (in particular during intense rainstorm events) can pass through the cover. In addition, wetter years typically exhibit lower potential evaporation rates (due to greater cloud cover) than do drier years thus further reducing the potential of the storage cover to release soil moisture back into the atmosphere. The modeling results of the "average" year 1989 are discussed in more detail below to illustrate the seasonal behavior of a water storage cover.

Figure B-10 shows the cumulative atmospheric fluxes (potential & actual ET, precipitation), the surface flux into the cover, and the net percolation into the mine rock profile for the cover consisting of 11" of topsoil over 7" of tailings. Positive fluxes indicate upward movement of soil moisture (out of the soil profile) and negative fluxes indicate downward movement (into the soil profile). During the early part of the year 1989 (say first 100 days) there was little precipitation and as a result infiltration into the cover was small with no significant percolation into the mine rock profile. The majority of precipitation fell during late spring/early summer (days 115 to 180). In the early part of this wet period, the precipitation was stored in the cover, as indicated by an increase in the cumulative surface flux (towards higher negative values) with no commensurate increase in the net percolation. The first significant net percolation into the mine rock profile occurred following a

period of heavy rain from day 131 to 133. During this three-day period a total of 2.44 inches (62 mm) of precipitation occurred resulting in 1.8 inches (42 mm) of net percolation. The period immediately following this event remained fairly wet allowing for very little depletion of soil moisture in the storage cover, hence additional net percolation into the mine rock profile.

Throughout the wet spring/early summer period the full potential evaporation was realized due to the very wet soil conditions providing ample moisture for evaporation. After cessation of the rain events (after day 185) evaporation quickly depleted all soil moisture available in the storage cover (as indicated by the flattening of the actual evaporative flux curve). Note that the net percolation does not decrease (move towards less negative numbers) indicating that there is no flux from the mine rock profile back into the cover layers. The lack of upward movement from the mine rock profile back into the cover layers is a result of the very coarse nature of the mine rock which causes a capillary barrier to develop between the finer cover layer and the coarse mine rock.

Subsequent isolated rainfall events that occurred throughout the late summer, fall and winter resulted in additional surface fluxes into the cover. However, all of this moisture was stored in the storage cover and did not result in additional net percolation.

Figure B-11 shows the time trends in soil suction (negative pressure) at selected depths in the soil profile. The model simulation indicates that soil suctions in the cover layers remain in the range of 1 to 10 kPa during the recharge periods. However, during the dry summer months soil suctions increase dramatically throughout the cover profile (including the tailings layer) due to the strong evaporative stresses exerted at the soil profile. The increase in suction indicates that the storage cover is drying out resulting in renewed moisture storage capacity for subsequent recharge periods. Note that the soil suctions in the mine rock profile change very little during the summer period indicating that very little moisture is removed from the mine rock back into the cover and to the surface.

Table B-9 - Modeled Cover Performance for Various Cover Scenarios

Topsoil (inches)	Tailings (inches)	Goslin Flats Material	NAG (inches)	Clay	Geosynthetic Barrier Layer		Projected Infiltration Rate (% of Annual Precipitation) (average to very wet year)
12			36		GCL	flat	0.09% - 0.12% [1]
36			variable			flat	14.0 - 42.8
						slope	7 - 21 [2]
24			variable			flat	16.4 - 43.6
						slope	12 - 33 [2]
12			variable			flat	23.8 - 50.1
						slope	21 - 45 [2]
12		18	variable			flat	21-30 [3]
8			variable			flat	28.2 - 54.1
						slope	25 - 49 [2]
18	6		variable			flat	15.0 - 42.2
						slope	13 - 36 [2]
18		12	variable			flat	5-10 [3]
8	10		variable			flat	16.6 - 43.3
						slope	14 - 37 [2]
11	7		variable			flat	17.8 - 43.8
						slope	15 - 37 [2]
8	10		24		HDPE	flat	0.09 - 1.0 [1]
12			36		HDPE	flat	
						slope	0.09 - 1.0 1
11	7		24	8		flat	8 - 15 [2]
						slope	
12			24	8		flat	10 - 15 [2]
						slope	
8	24		12			slope	13 - 21 [2]

Notes:

All infiltration rates were calculated using the Soilcover model unless otherwise indicated. The estimates for an average year were obtained by using 1989 climate data (and using relative humidity as an index for adjusting pan evaporation from Mocassin). The estimate for a "very wet" year were obtained by using 1997 climate data (and using precipitation as an index for adjusting Pan Evaporation from Mocassin). The following exceptions apply:

(1) result of HELP modeling performed by Woodward Clyde 1995

(2) estimates inferred from Soilcover (1D) and Seep/W (2D) model runs for similar cover scenarios

(3) upper limit (very wet year) represents an estimate (I.e. not simulated)

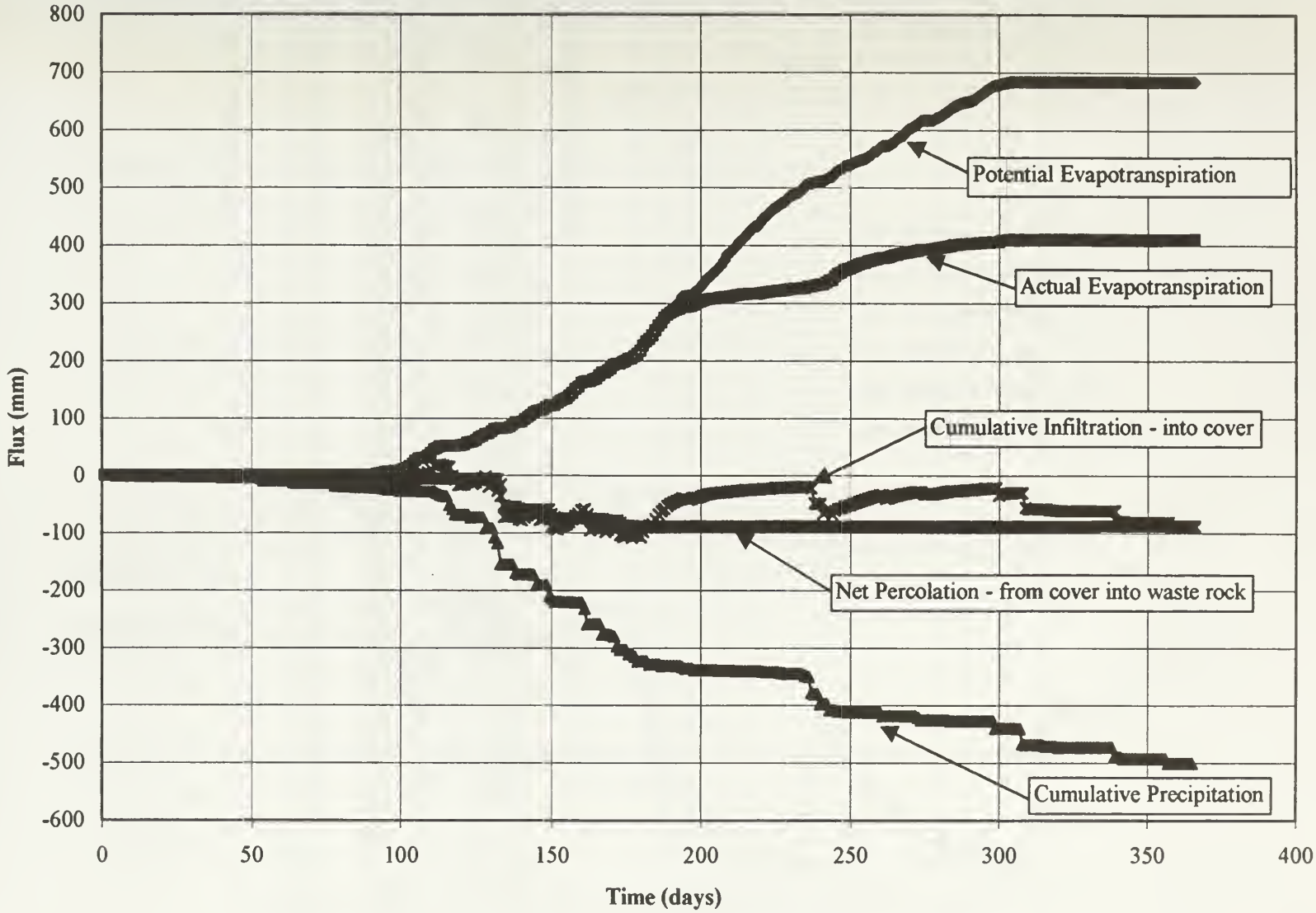


FIGURE B-10 - CUMULATIVE FLUXES AND NET PERCOLATION FOR COVER SCENARIO OF 12" TOPSOIL OVER 7" TAILINGS

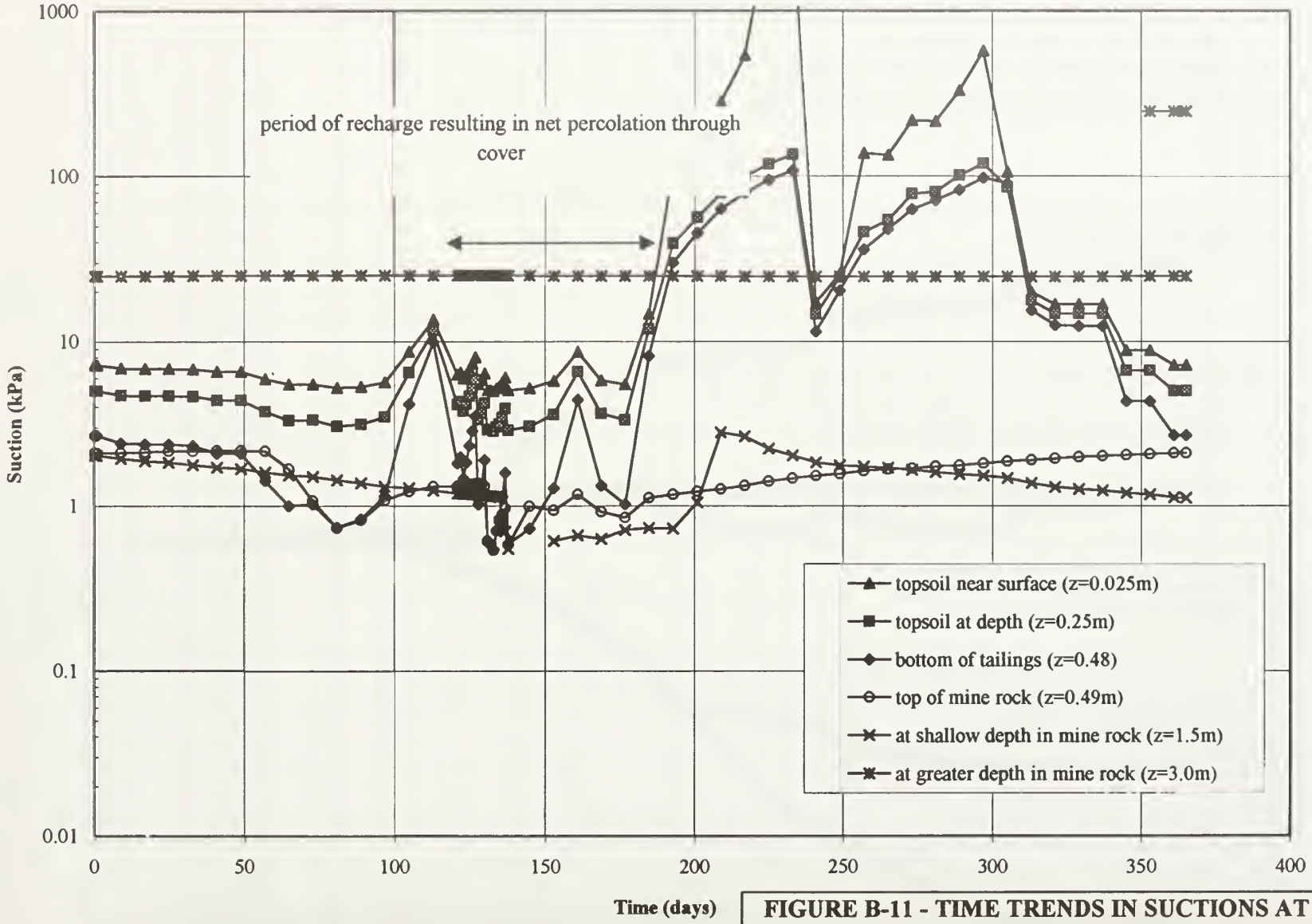


FIGURE B-11 - TIME TRENDS IN SUCTIONS AT SELECTED DATES FOR COVER SCENARIO OF 12" TOPSOIL OVER 7" TAILINGS

Figure B-12 shows the suction profiles in the upper meter of the soil profile for selected dates throughout the year. For the early part of the year (days 49, 97 and 133) the suctions decrease with depth indicating downward movement of soil moisture. Note the progressive shift of the suction profiles towards the left (lower suctions) indicating higher moisture contents and hence greater fluxes. For the following three dates strong soil suctions develop at the surface (due to evaporation and depletion of soil moisture in the storage cover) resulting in strong upward pressure gradients and upward moisture flux.

Figure B-13 shows the degree of saturation in the upper meter of the soil profile for selected dates. The degree of saturation is defined as the volume of water divided by the volume of voids (in %). At 100 % saturation the soil is completely saturated. The degree of saturation of the cover profile varies significantly throughout the year with highest values during the very wet spring/early summer period. Note that the cover profile never completely saturates even on days of intense rainfall (day 133).

In summary the simulated net percolation for the case of 11 inches of topsoil over 7 inches of tailings was 3.5 inches (88mm) over the calendar year 1989. This is equivalent to 18.0% of the total precipitation for this model year. The majority of net percolation occurred over a relatively short recharge period in late spring/early summer when very intense rain storm events resulted in depletion of all soil moisture storage in the cover layers. The large difference in PSD between the cover layers and the mine rock result in a capillary barrier developing at the boundary between the cover and the mine rock. This capillary barrier prevents upward movement of soil moisture from the mine rock back into the cover layers.

Sensitivity Analyses

Table B-10 summarizes the results of the sensitivity analysis using the cover scenario of 12" of topsoil over 7" of tailings and the "average wet" year 1989 for reference. A total of 14 sensitivity runs were carried out in which various material properties as well as climate parameters were varied within an estimated range of uncertainty. These sensitivity runs were carried out as part of the Phase 1 soil cover modeling (RGC Report 075001/5).

The results indicate that the cover performance (in terms of net percolation) is not very sensitive to the assumed material properties for the cover and mine rock profile (within the estimate range of uncertainty). In contrast, the assumed climate parameters have a strong influence on the simulated cover performance.

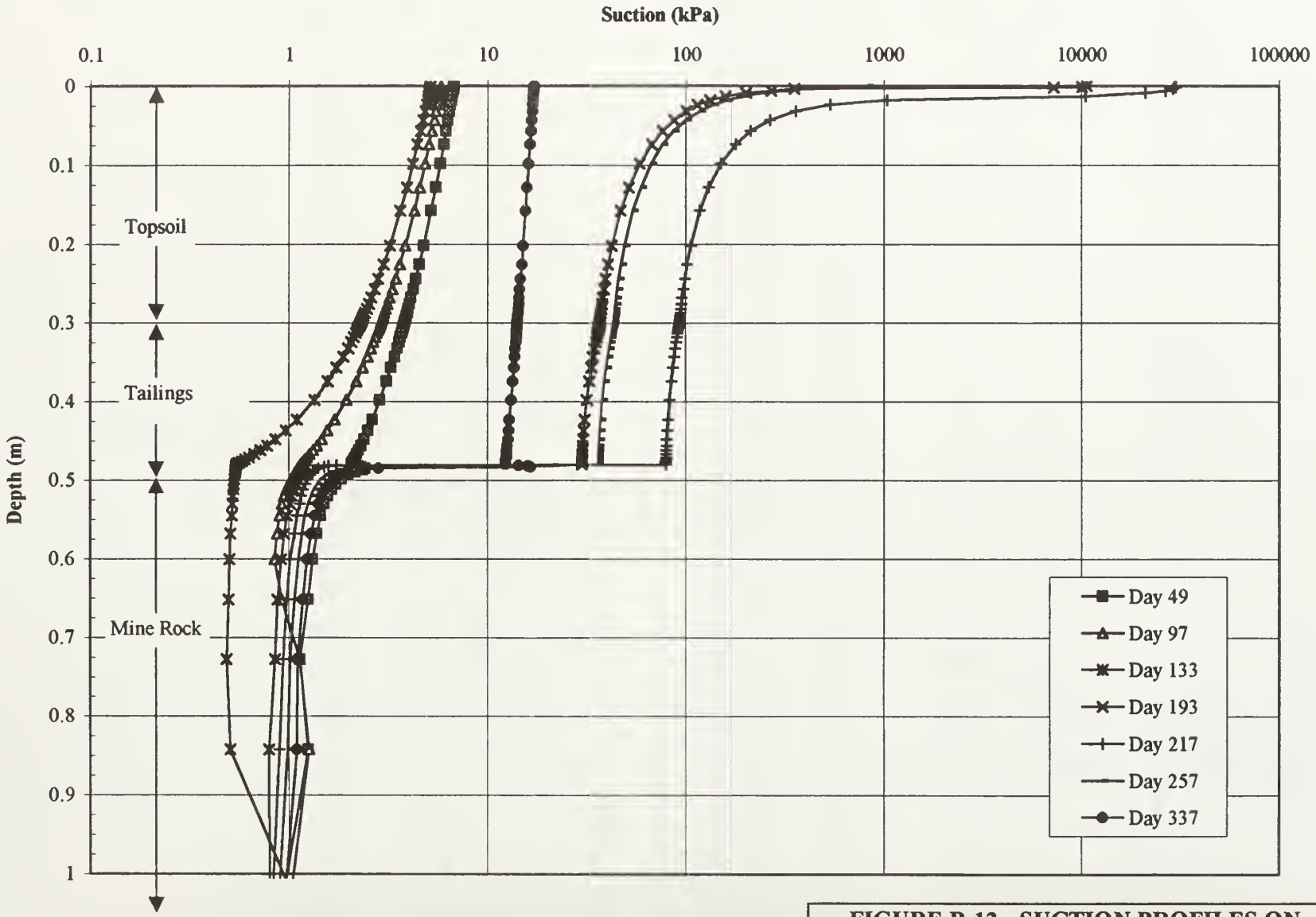


FIGURE B-12 - SUCTION PROFILES ON SELECTED DATES FOR COVER SCENARIO OF 12" TOPSOIL OVER 7" TAILINGS

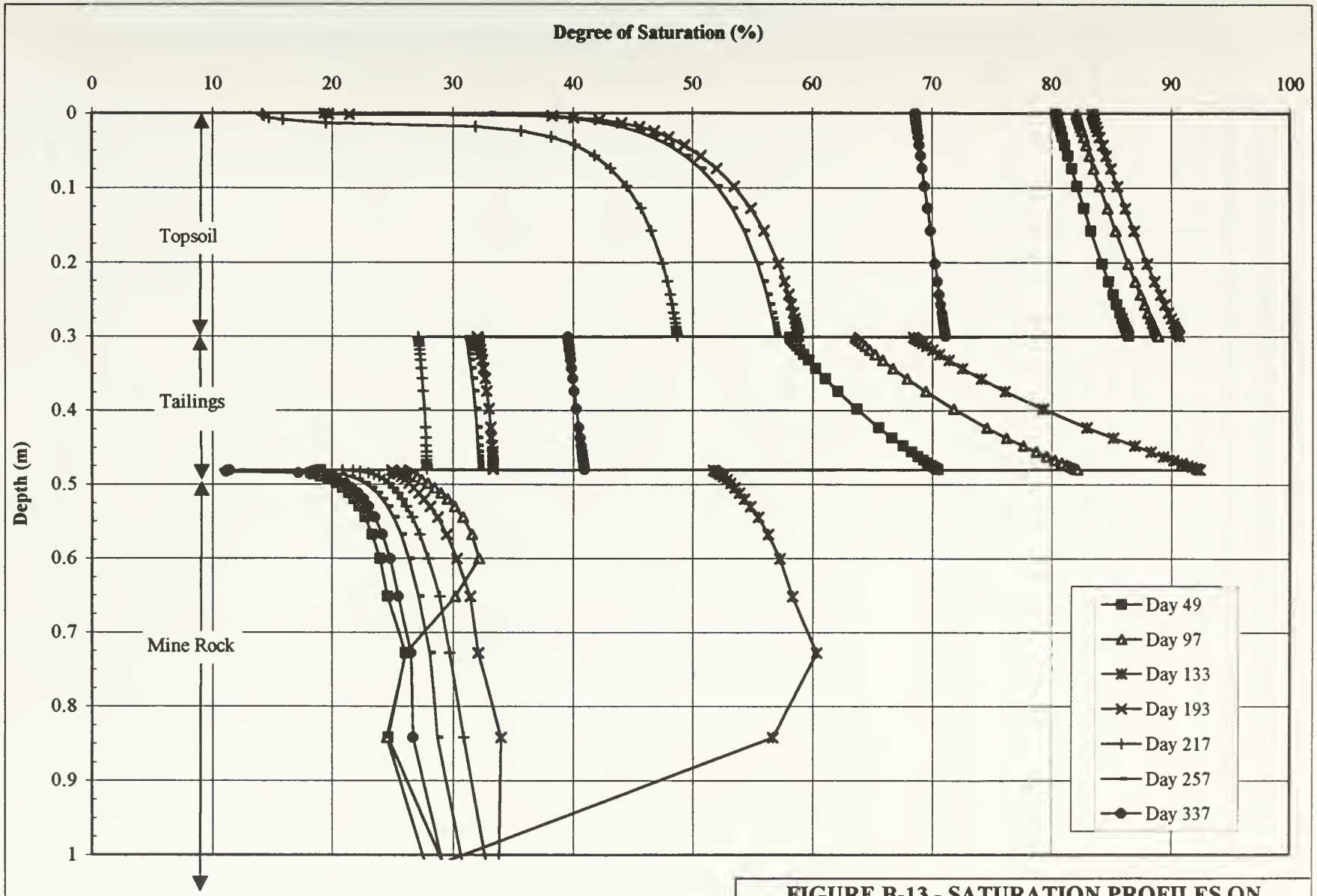


FIGURE B-13 - SATURATION PROFILES ON SELECTED DATES FOR COVER SCENARIO OF 12" TOPSOIL OVER 7" TAILINGS

Table B-10 - Summary of Sensitivity Analyses Using 12" Topsoil - 7" Tailings Cover Scenario.

Run ID	Description	Year	Precip. (inches)	Total Pot. Evap. (inches)	Net Percolation		
					mm	inches	% of Precip
Cover Type: 12" topsoil over 7" tailings							
Run 1m89a	Cover Type - 30 cm (11.8") topsoil, 18 cm (7") tailings, 10 m waste rock (using Kidston Waste Rock) - where both max and min RH is 100%, pan evap=0; where max RH is 100%, pan evap=25% ; use 1989 climate data	1989	19.7	27.0	88	3.5	18%
Sensitivity on Material Properties							
Run 0	as Run1m89a but use SWCC of fine tailings (Z-3) instead of coarse tailings (Z-1)	1989	19.7	27.0	87	3.4	2541%
Run 2	as Run0 except: decrease porosity of topsoil by 15% from 0.373 to 0.317				88	3.4	345%
Run 2	as Run 0 except: decrease topsoil Ksat from 5.6e-4 to 1e-4				87	3.4	17%
Run 3	as Run 0 except: increase topsoil Ksat from 5.6e-4 to 1e-3				111	3.4	22%
Run 0	as Run 0 except: decrease porosity of tailing by 15% from 0.385 to 0.327				85	3.4	17%
Run 0	as Run 0 except: increase tailings Ksat from 2e-2 to 5e-2				87	3.4	17%
Run 0	as Run 0 except: decrease tailings Ksat from 2e-2 to 5e-3				89	3.5	13%
Run 2	as Run 0 except: decrease waste rock Ksat from 1e-2 to 5e-2				76	3.0	15%
Run 0	as Run 0 except: increase waste rock Ksat from 1e-2 to 1e-1				78	3.1	16%
Run 0	as Run 0 except: use Z-84 waste rock in place of Kidston Waste Rock				66	2.6	13%
Sensitivity on Climate Parameters							
Run 10	as Run 0 except: 0.65 of pan evap equivalent to potential evap and decrease evap by 25% (regradless of % RH)	1989	19.7	20.2	120	4.7	24%
Run 11	as Run 0 except: 0.65 of pan evap equivalent to potential evap (did not take changes in RH into consideration)			30.3	39	1.5	8%
Run 12	as Run 0 except: 0.55 of pan evap equivalent to potential evap (take changes in RH into consideration)			25.7	97	3.8	19%
Run 13	as Run 0 except: increase precipitation by 25%		24.6	27.0	183	7.2	36%

The large variation in net percolation for different precipitation rates (average vs very wet year) has been discussed already (see Table B-9). The results of the sensitivity analyses support these findings. Apart from precipitation, the rate of potential evaporation (both in overall magnitude as well as temporal distribution) has an equally strong influence on the total net percolation.

These results of the sensitivity analysis highlight the importance of using representative climate data for cover performance modeling. They also indicate that differences in climate conditions have to be taken into account when extrapolating these model results to the field. For example, the same cover may perform differently at Zortman compared to Landusky due to local differences in climate conditions. Orographic effects also have to be considered when evaluating cover performance. In areas with significant topographic relief the same cover may even perform different depending on the micro-climate conditions (with higher elevation sites typically being less favorable for cover performance than low-elevation sites).

While care was taken to obtain site-specific climate data some critical parameters (in particular pan evaporation) were not measured on site and were therefore estimated. Hence there is some uncertainty associated with the modeled net percolation and some deviation from actual field performance can be expected. There is much less uncertainty, however, when comparing the net percolation for different cover alternatives assuming the same climate conditions.

Comparison of Cover Alternatives

All seventeen alternative cover scenarios were evaluated using the climate data of the "average wet" year 1989. The majority of these simulations were carried out in Phase 1 of the cover performance modeling work (RGC Report 075001/5). Seven of these covers (i.e. those finally incorporated into the various reclamation alternatives) were evaluated in Phase 2 of the cover performance modeling work using both "average wet" conditions (year 1989) as well as "very wet" conditions (year 1997). The latter conditions were evaluated to provide an upper bound on likely net percolation ("worst-case" scenario). The year 1997 was selected for this analysis in order to correlate the modeling results with the site water balance (Spectrum Engineering, 2000e and 2000f).

Table B-9 summarizes the SoilCover modeling results for the various alternative cover scenarios. The net percolation for all cover alternatives varied from a low of 0.09% to 0.12% for the ROD-specified water barrier cover to a high of 28% to 54% for the 8" topsoil cover over NAG. In the following discussion we briefly summarize the performance of the various cover alternatives.

The cover consisting of the mixture of 19" of topsoil/tailings has a seasonal pattern in net percolation similar to that of the cover of 11" topsoil layered overtop of 7" of tailings, i.e. most of the net percolation occurs during the very wet period from day 131 to 180. However, the topsoil/tailings mixture allowed significantly more additional net percolation during the early spring and late fall/early winter. The higher cover fluxes resulted in generally wetter conditions in the mine rock profile early in the year as demonstrated by overall lower suction values and a higher degree of saturation (see RGC Report No. 075001/5, RGC July 2000). The higher annual net percolation is a

result of the overall poorer moisture retention capacity of the topsoil/tailings mixture relative to the layered topsoil/tailings profile.

The cover type with a thicker topsoil layer (29") over 7" of tailings resulted in an increased storage capacity of the thicker topsoil layer which "buffers" the first very intense rainstorm events resulting in much reduced net percolation during these first days of the recharge period. However, once this additional storage demand is met subsequent rain events result in similar net percolation as were observed in the thinner cover types. The thicker topsoil layer results in much more uniform moisture conditions in the underlying tailings as evidenced by much smaller variations in suction and degree of saturation throughout the year.

The water storage cover consisting of 12" of topsoil overlying 18" of non-compacted Goslin Flats material does not show the steep "breakthrough" of net percolation in response to specific rainfall events observed for the simpler, covers described above. Instead, the net percolation occurs more steadily throughout the wet season (including winter and early spring) (RGC, July 2000).

The relatively high net percolation of this type of cover appears counterintuitive at first but can be explained by comparing the unsaturated properties of the various cover materials. During the recharge period, the soil suction in the Goslin Flats material (near the cover-mine rock interface) typically ranged from ~1 to 20 kPa. In this suction range, the hydraulic conductivity of the Goslin Flats material is nearly constant (~5×10^{-6} cm/s) whereas the hydraulic conductivities of the other cover materials and the coarse mine rock decline significantly (Figure B-6). During intense rainstorm events when the entire soil profile approaches saturation and suctions fall to very low values (<10 kPa) the Goslin Flats material has the lowest hydraulic conductivity and limits the rate of net percolation. In contrast, during less intense wet periods and dry periods the hydraulic conductivity of the Goslin Flats material is indeed greater than that of the coarser cover materials resulting in greater net percolation.

The cover that includes the non-compacted Goslin Flats material remains near saturation for most of the year. The high degree of saturation throughout the year is a result of the high AEV of this silty material. The very limited reduction in soil moisture during the drier summer/fall periods indicates that the Goslin Flats material does not provide a good storage capacity for the simulated range in soil suction for 1989.

The cover with the compacted Goslin Flats layer (i.e. 18" of topsoil overlying 12" of compacted Goslin Flats material) shows a very small, but steady increase in net percolation throughout the wet spring/early summer period with essentially short-term fluctuations due to intense rainstorm events. Due to the low hydraulic conductivity of the barrier layer and the limited storage capacity in the overlying topsoil, the cover reached full saturation on several occasions throughout the year resulting in significant surface runoff (total of 2.7 inches or 68 mm).

The compacted Goslin Flats material remained very close to saturation throughout the year, however, field experience has shown that it is very difficult to maintain saturation in fine-grained water barrier layers in semi-arid climates such as at Zortman, at least in the long-term.

Figure B-14 compares the cumulative net percolation rates for the above six cover types. This figures demonstrates the importance of the very intense rainfall periods (in particular on day 133) on the net percolation for all water storage covers. Only the cover with the compacted clay layer shows no immediate response (in terms of increased net percolation) in response to individual rainfall events. The success of a water storage type cover in controlling net percolation depends significantly on the distribution of rainfall throughout the year. The rainfall conditions for the 1989 calendar year (i.e. an "average wet" year) were not favorable for a storage cover in that a very heavy rainfall event (2.44 inches in 3 days) followed a very wet spring which had depleted most of the available storage. A review of the precipitation statistics for the Zortman-Landusky area suggests that this pattern is quite common (see Table B-8). The model results indicate that the cover thickness of a water storage cover would have to be significantly greater than 36 inches to reduce the net percolation to levels similar to those predicted for a cover with a compacted clay layer. This statement assumes that the identified materials would be used and that the modeled material properties are applicable.

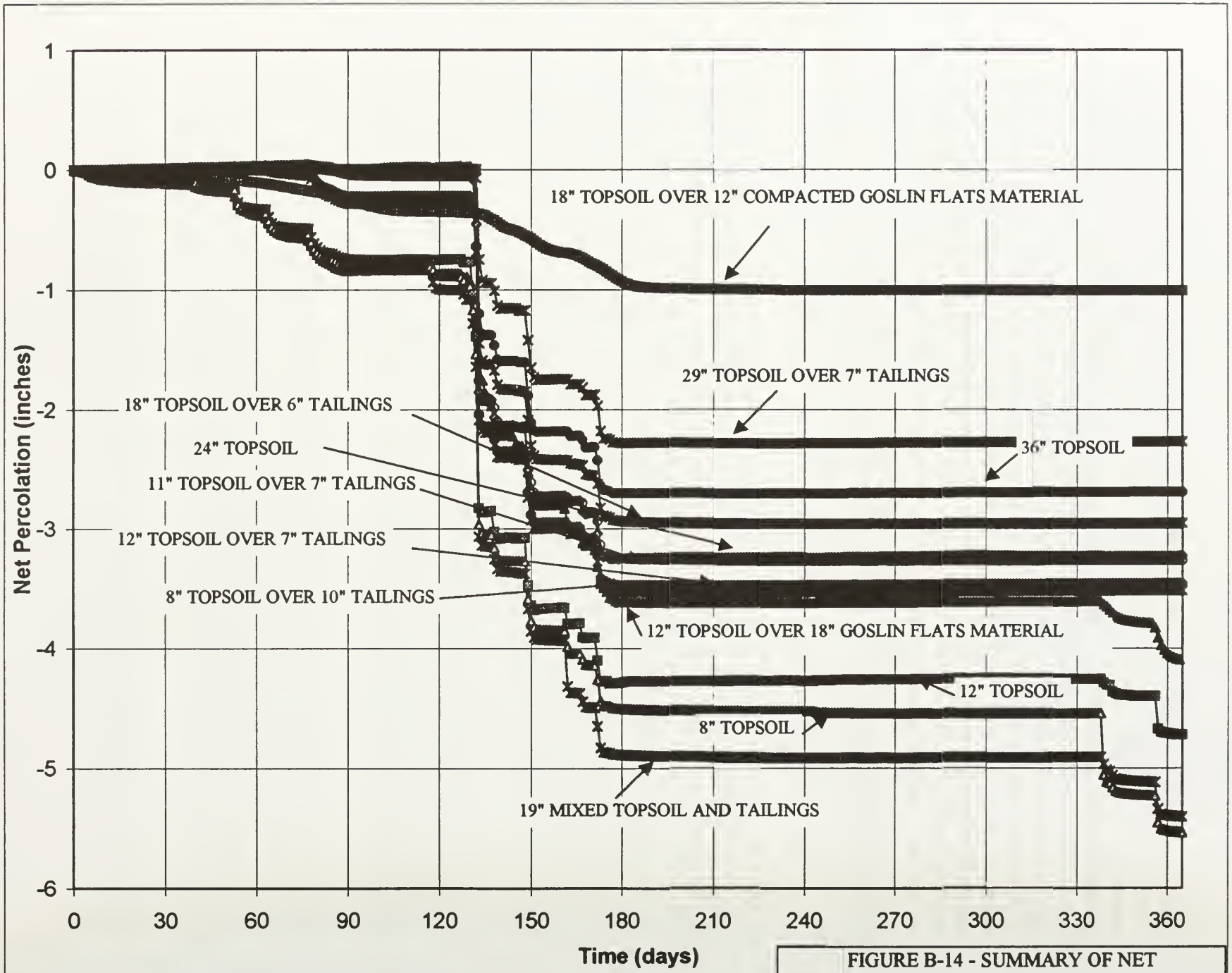


FIGURE B-14 - SUMMARY OF NET PERCOLATION FOR VARIOUS COVER TYPES

Comparison of Soilcover Modeling and Water Balance Calculations

Spectrum Engineering has developed a water balance for the Zortman and Landusky mine sites based on a review of climate data, site conditions and water collected at various discharge points (streams and/or collection points of leach pads) (Spectrum Engineering, 2000e and 2000f). Of particular interest for comparison with the cover modeling results is the water balance developed for the Carter Gulch capture system. The Carter Gulch system captures drainage from the Alder waste rock (foot print area of about 19.3 acres), which was covered with 0.5-3 ft of topsoil. Note that the total drainage area at the collection point is estimated to be 38.7 acres, i.e. the waste rock dump represents about 50% of the total drainage area.

Over the period October 22nd 97 to March 31st 1999 a total of 51 inches of precipitation fell (at the Zortman gage) (Spectrum Engineering, 2000e). Over the same time period a total equivalent of 27 inches or about 53 % of the total precipitation) were collected in the Carter Gulch capture system. These observations suggest that the net percolation through a water storage cover (using topsoil) may be significantly higher than was simulated using SoilCover in the Phase 1 modeling study (with estimates ranging from 6-28% depending on cover thickness and climate conditions).

Some of this discrepancy can be readily attributed to the amount of precipitation that fell during the observation period. The observation period for the water balance study (10/97 to 03/99) was very wet with total annual precipitation in the order of 25 inches per year. Among the model years simulated in the Phase 1 SoilCover modeling the model year 1993 is most comparable to these climate conditions with 24.4 inches total precipitation. The net percolation for the model year 1993 was simulated to be 28% of total precipitation for a cover of 12" topsoil overlying 7" tailings (RGC Report 075001/5). However, a direct comparison of the two estimates (53 vs 28%) is still not possible since the distribution of precipitation throughout the year, which undoubtedly influences net percolation, differed between 1993 and 1997.

For the Phase 2 of the cover performance modeling, which was aimed at assessing cover scenarios which were finally incorporated into the various reclamation alternatives, the observation period 1997-1998 was modeled in order to provide a direct comparison to the water balance estimates of net percolation through already placed cover systems (RGC Report No. 075001/7). Sensitivity analyses carried out earlier (see Table B10) had indicated that the model parameters most significantly influencing the rate of net percolation are (i) precipitation and (ii) pan evaporation. In the Phase 2 Soilcover modeling the same precipitation records as for the water balance study (i.e. from Zortman site) were used. Hence the only "unknown" parameter was pan evaporation which was adjusted to provide a reasonable fit with the observed capture rate in the Carter Gulch capture system (see RGC Report 075001/7 for details). Sensitivity analyses indicated that a reasonable fit with the observed discharge could be obtained by using pan evaporation rates measured at the Mocassin station for those days when no precipitation occurred and assuming no evaporation for the days where precipitation was recorded at Zortman. Using these adjusted pan evaporation rates and 1997 climate data the net percolation for a 24 inch cover consisting of topsoil was simulated to be 43.6% (RGC Report 075001/7). This percolation rate was still somewhat lower than the observed capture

rate (53%). However, in light of the complexity in the natural processes controlling net percolation through a cover system as well as uncertainty in both approaches to estimating the rate of net percolation, the two estimates of net percolation were judged to be in good agreement. Hence, all remaining cover simulations for very wet conditions (i.e. 1997, see upper bound of projected net percolation rates in Table B-9) were carried out using the same approach (i.e. adjusting Mocassin evaporation rates by Zortman precipitation).

Infiltration rates may be higher than those modeled due to channelized flow through root holes and/or other macropores that result in water "by-pass" of the cover layer resulting in direct infiltration into the leach pad. The sharp peaks observed in the hydrographs of the capture systems shortly (several days) after very intense rainstorms support this contention (see Spectrum 2000e and 2000f). Surface ponding during these intense events would facilitate the development of channelized flow through "macropores" in the cover. This type of flow (called Non-Darcian, or turbulent flow) in macropores cannot be simulated with the SoilCover model;

Similarly, if the covers are been placed with little or no quality control and/or are eroded over time (in particular along steep slopes) resulting in very variable cover thickness, significant preferential infiltration may occur in those locations with very little cover (in particular if encountered along a surface runoff pathway). Also, there may be some run-on and/or groundwater discharge in specific drainage areas resulting in a higher seepage collection compared to percolation through the cover.

1.04 COVER PERFORMANCE ON SLOPED SURFACES

Modeling Approach

In the previous analyses it was assumed that the soil cover is placed on a flat (or nearly flat) surface resulting in essentially vertical infiltration. However, a significant proportion of the surface area of the mine rock dumps and leach pads at the Zortman-Landusky mine sites represent slopes. The finite-element code SEEP/W was used to assess the performance of a water storage cover on such sloped surfaces. SEEP/W is commercially available through GEOSLOPE in Calgary, Alberta, and simulates two-dimensional saturated and/or unsaturated flow using Darcy's Law (Geoslope, 1994).

To evaluate the cover performance on the slopes, it was assumed that the mine rock piles would be re-sloped to 3:1 prior to cover placement. The maximum slope length was assumed to be 150 ft with an optional road (or drainage ditch) that was "cut" into the slope one half the way up between the base and the top. The purpose of the road would be to break the slope length (for erosion protection) and to allow drainage of moisture moving down-slope in the storage/drainage layer.

Numerical Methods

Figure B-15 shows the model geometry and boundary conditions for the case with a road (drainage ditch) cut into the cover at mid-slope. Note that the erosion layer (consisting of durable oxidized

mine rock or other coarse material) was not included in the finite element model. The coarse nature of this material would not have a significant effect on cover infiltration and/or movement of soil moisture within the cover layer.

A head boundary of pressure equal to 0 KPa was applied at the toe of the slope just beneath the cover (Figure B-15). This base boundary is typical of what may be experienced in the field and it has been used successfully in other slope seepage modeling analyses carried out. In SEEP/W the surface flux at the top of the cover has to be specified by the user (SEEP/W is not capable of calculating the surface flux from atmospheric conditions as does SoilCover).

As a first approximation the surface flux applied on the slope was assumed to be equal to the surface flux (i.e. precipitation minus actual evaporation) computed by SoilCover. In order to reflect "average recharge conditions" the yearly surface flux of about 150mm was applied over 8 months to create a slightly "wetter" than normal top flux.

In Phase 1 of the cover performance modeling several precipitation events were simulated to assess cover performance (in particular whether the capillary break is maintained) for wet to very wet conditions. The SoilCover precipitation data was scanned for the worst-case "wet" periods. For the data provided, there were two periods of time where between 50 and 60 mm of rain fell over a 5 day period. The rain periods were followed by periods of drying, or a net negative evaporative flux. Based on these ranges, the SEEP/W was set up to various sensitivity analyses.

In Phase 2 of the cover performance modeling the seasonal behavior of a sloped soil cover was evaluated. For this purpose the daily infiltration values calculated by SoilCover for the growing season of 1989 (i.e., days 120 – 190) were used as (daily) surface flux boundary conditions and the SEEP/W model was run in hourly time steps.

Average Recharge Conditions

Figure B-16 shows the model results for average recharge conditions (150 mm/ 8 months) for the case where a road (or drainage ditch) is present at mid-slope. This figure also shows the pressure profile (in m pressure head) for the entire slope after 8 months. The velocity flux vectors are plotted in proportion to the flux indicating that the vast majority of flow occurs down slope in the cover layer only. As the length of the slope increases down from the top (i.e., longer infiltration surface) the size of the flux vectors increase but there is no positive pressure build up in the cover. However, at the point where the cover is intersected by the road, there is evidence that a zero pressure point exists. This would indicate that there is open seepage at this point in the slope.

Figure B-17 shows the model results for the same average (low-intensity) recharge conditions but for the case of a continuous 150ft long slope (no road or drainage ditch is present). Again the pressure head is shown at the end of 8 months. Again, the flux vectors are contained with the cover indicating that all surface flux travels in the sloped storage/drainage layer with no appreciable net percolation through the cover and into the mine rock profile.

Precipitation Events

Figure B-18 shows the pressure profile and flux vectors immediately following the mid-intensity precipitation event (25mm over a three-day period). As for the average recharge conditions, all flux vectors remain in the cover layer and there is no evidence of pressure build up in the bottom end of the cover suggesting that the capillary break between the cover and the mine rock profile remained effective. Other analyses using variable precipitation events (see RGC Report No. 075001/5; RGC, July 2000) also suggest that little net percolation through the cover on the sloped surfaces would be expected when a capillary break is utilized in the cover. In other words, the net percolation along the sloped surfaces could be significantly reduced (compared to flat surfaces) provided a storage/drainage layer is used as cover material that results in the development of a capillary barrier at the interface of the coarse mine rock and the finer-grained cover layer.

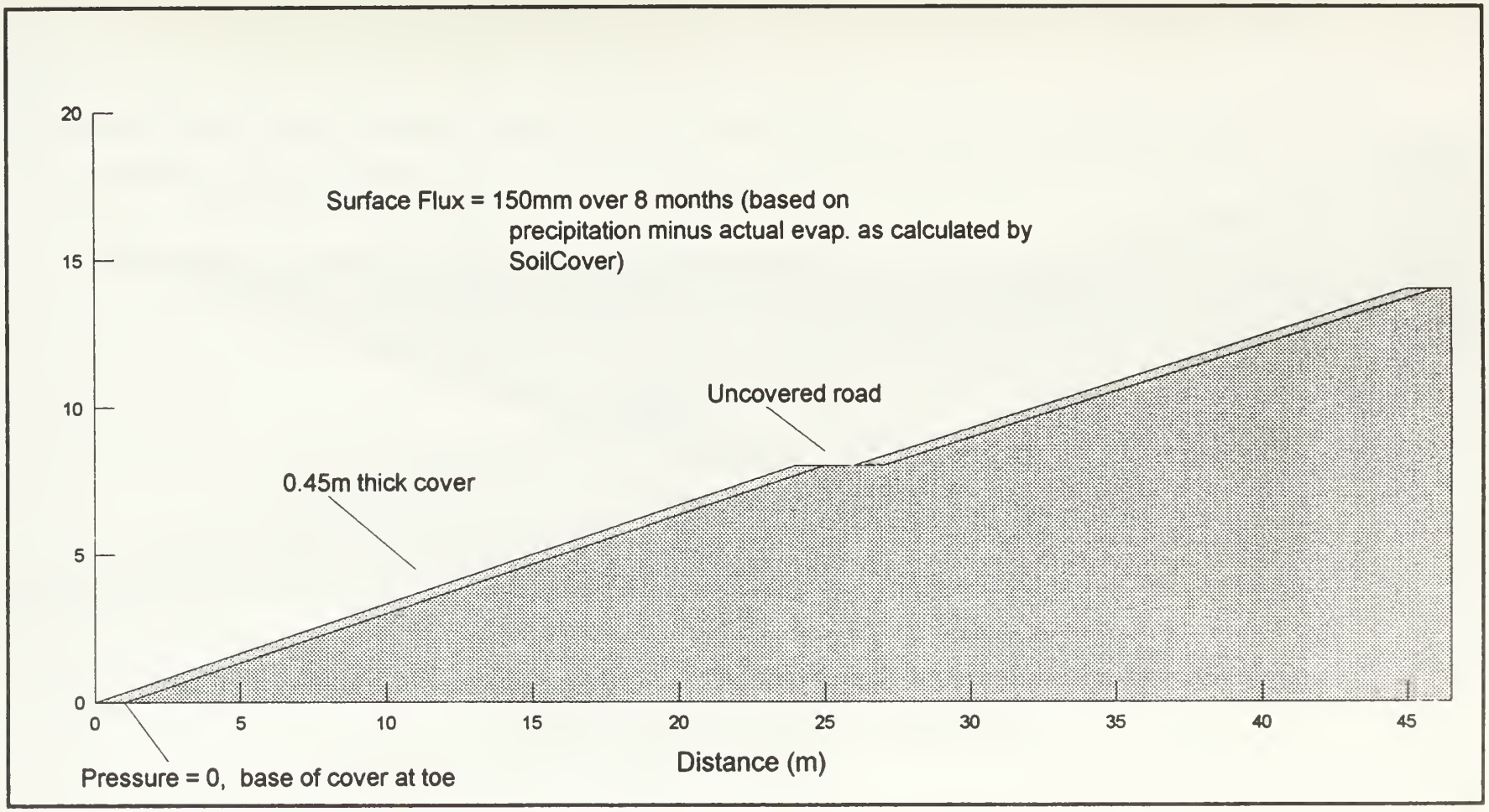


FIGURE B-15 – MODEL GEOMETRY FOR 150 FT LONG SLOPE WITH ROAD AT 75 FT DISTANCE

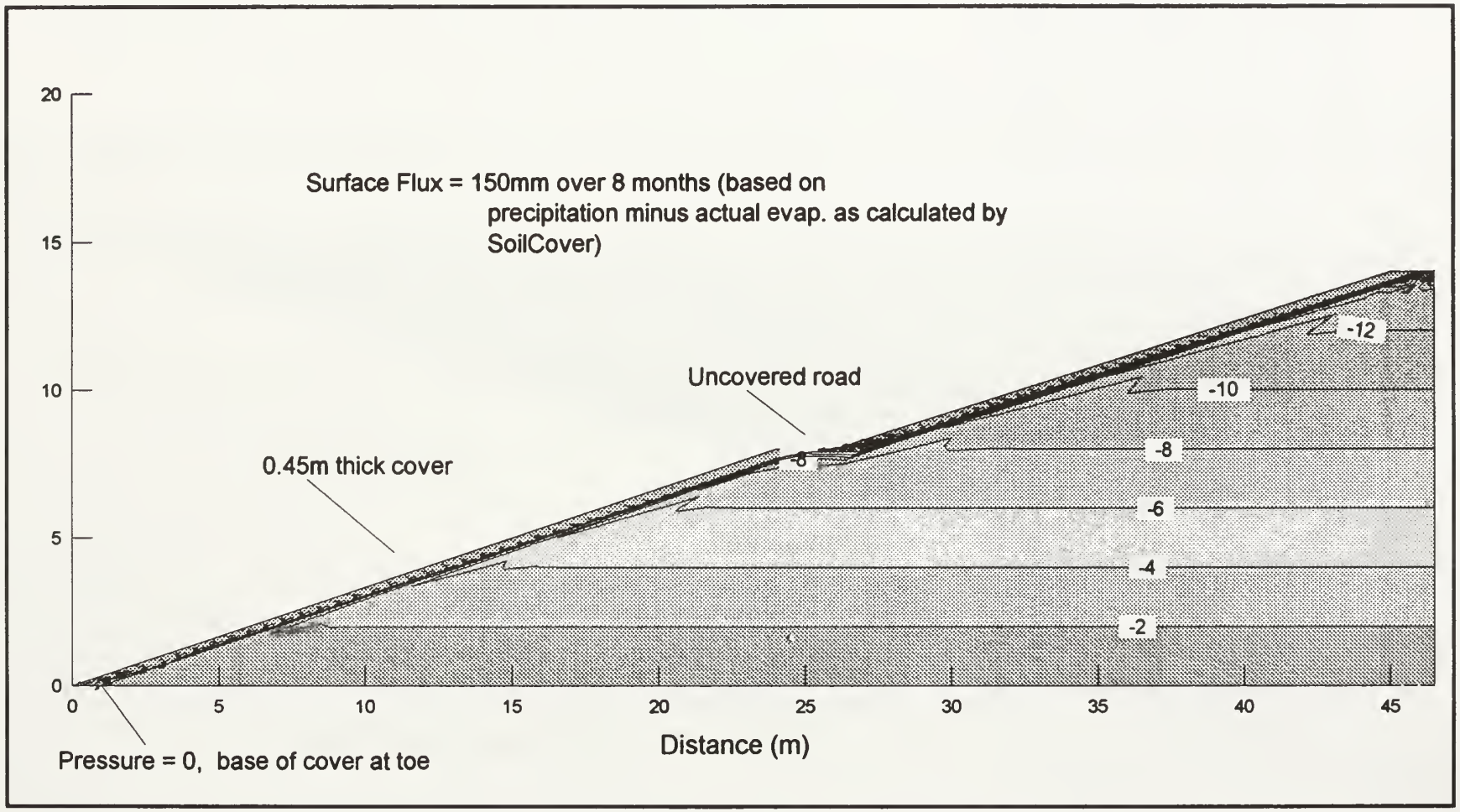


FIGURE B-16 – SIMULATED PRESSURE HEADS AND FLUX VECTORS AFTER 8 MONTHS FOR AVERAGE SURFACE FLUX CONDITIONS (6" OVER 8 MONTHS) ON 150 FT LONG SLOPE WITH ROAD AT 75 FT DISTANCE.

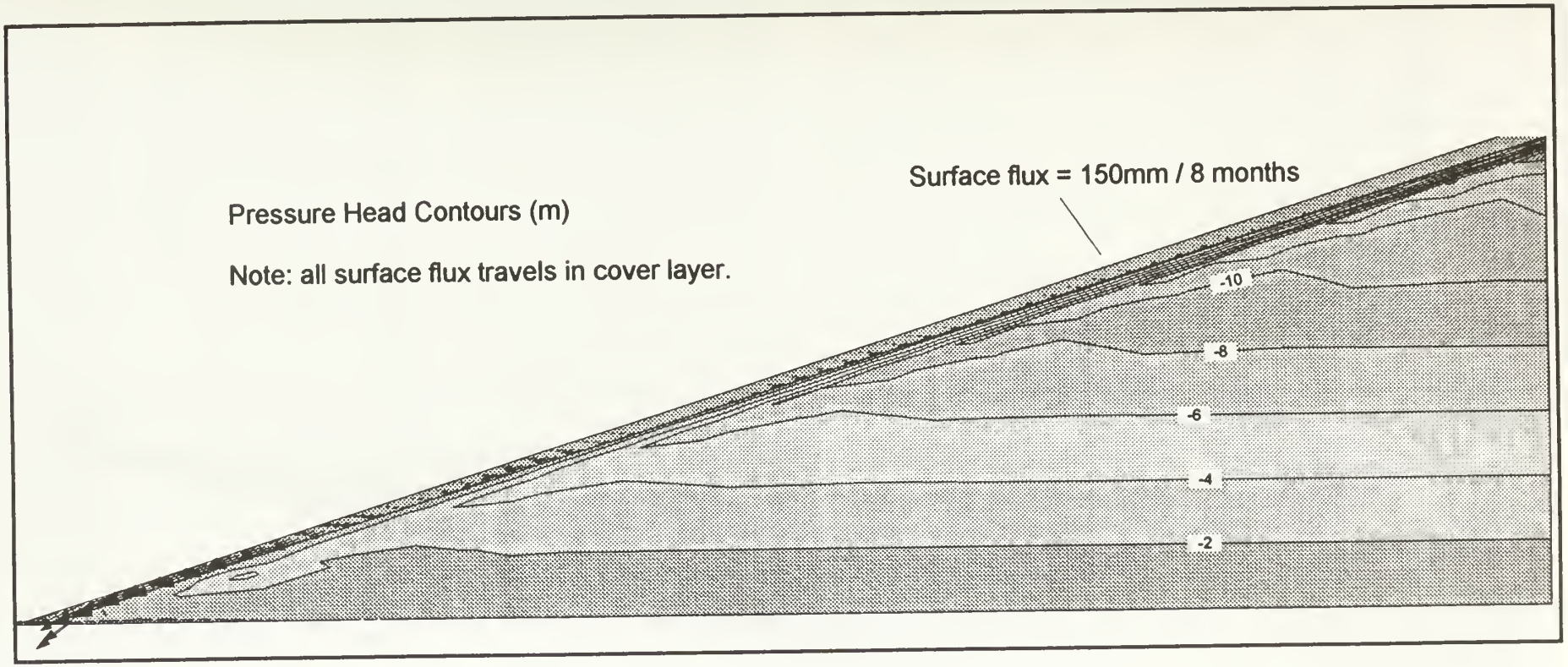


FIGURE B-17 – SIMULATED PRESSURE HEADS AND FLUX VECTORS AFTER 8 MONTHS OF AVERAGE SURFACE FLUX CONDITIONS ON 150 FT CONTINUOUS SLOPE (NO ROAD)

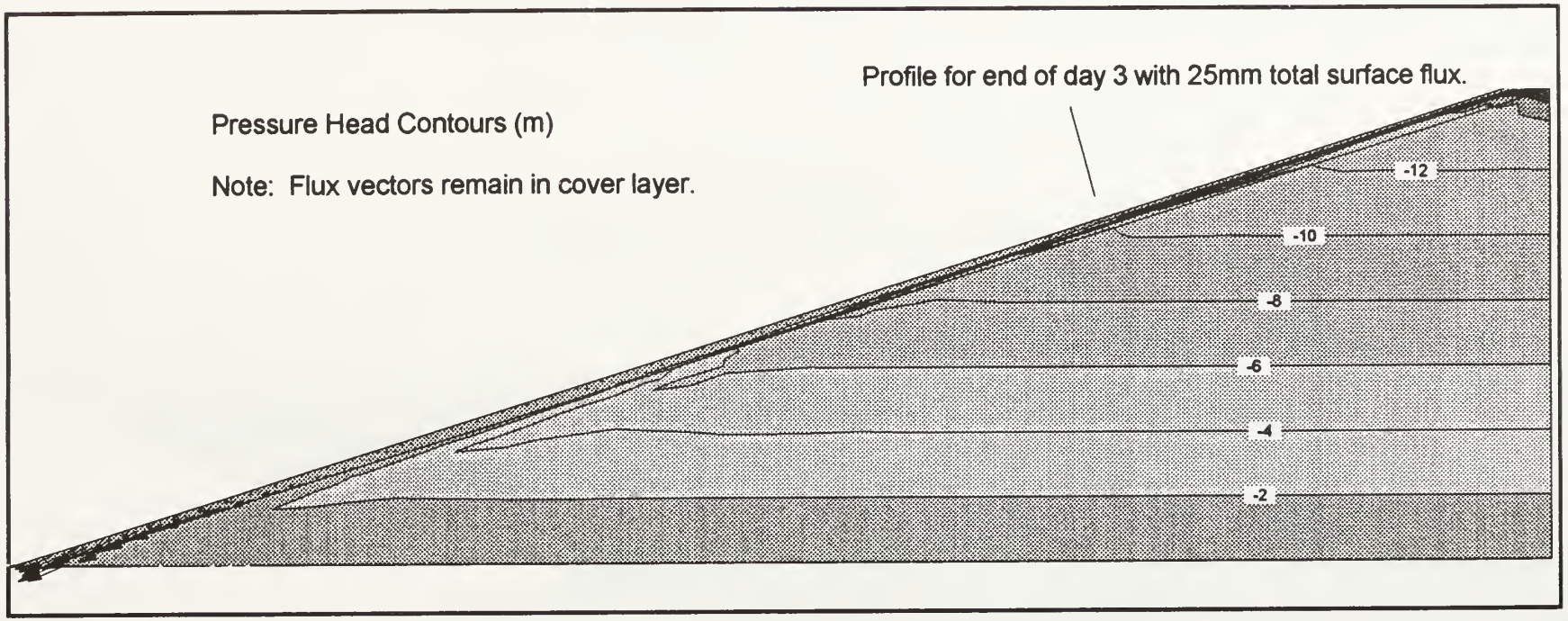


FIGURE B-18 – SIMULATED PRESSURE HEADS AND FLUX VECTORS AFTER 3 DAYS, MID-INTENSITY PRECIPITATION EVENT (1" OVER 3 DAYS) ON 150 FT LONG CONTINUOUS SLOPE

Seasonal Behavior

In Phase 2 of the cover performance modeling the seasonal behavior of a water storage cover (24 inch topsoil) over a re-sloped waste rock surface (3H:1V) was evaluated using a transient analysis with daily inputs of surface infiltration. SEEP/W is not capable of calculating the surface flux (precipitation-actual ET); instead the daily surface fluxes calculated with SoilCover for a 24-inch topsoil cover (on a flat surface) were used as surface flux boundary conditions. The model period covered days 120-190 of the "average wet" year 1989. SoilCover modeling indicated that this period of late spring/early summer generates most of the annual net percolation.

Figures B-19 and B-20 show the moisture retention characteristics (soil water characteristic curve, SWCC) and the hydraulic conductivity functions for the cover material ("topsoil") and the default mine rock ("waste rock"), respectively. Figure B-21 summarizes the results of the SEEP/W cover modeling analysis (assuming the default mine rock properties) showing cumulative fluxes of infiltration, lateral flow within the cover, and vertical flux into waste rock. Note that the infiltration flux is an input to the SEEP/W model (i.e. an output from the SoilCover model). The lateral flow within the cover represents the flux of water flowing within the soil cover (parallel to the slope face) and emerging at the toe of the covered mine rock pile. The vertical flux into waste rock represents the net percolation into the mine rock (expressed as a unit flux over the entire slope length of 100 ft).

Figure B-21 illustrates that the vast majority (>95%) of infiltrating water is moving laterally within the cover (parallel to the slope) and exits at the toe of the mine rock pile without entering the mine rock. In other words the interface between the finer-grained topsoil and the coarse mine rock represents a very effective capillary break which inhibits vertical movement of soil moisture into the rock pile. Note that during most of the modeled time period (days 12-62) the infiltration is greater than the lateral flux out of the base of the cover, i.e. the cover stores incoming precipitation. In subsequent days the cumulative infiltration drops below the lateral flux out of the base of the cover, i.e. the soil moisture stored within the cover is depleted due to evapotranspiration. In these periods of negative surface flux (i.e. evapotranspiration dominates over precipitation) there is no flow out of the base of the cover (Figure B-21).

Note that these 2D cover modeling results are not consistent with field observations in capture systems from Carter Gulch and other leach pads (which are predominantly sloped rather than flat). As mentioned earlier a water balance analysis of the captured flows suggest a rate of net percolation in the order of 50% of precipitation. In contrast the 2D modeling results would suggest that, if a capillary break effect was present, the net percolation into the covered mine rock pile on sloped surfaces should be very small (i.e. less than say 5% of precipitation). However, the capillary break effect is known to be very sensitive to material properties and a high quality control during construction (in terms of materials used and cover thickness/continuity) is required to ensure proper functioning of such a cover.

In order to illustrate this sensitivity the same cover scenario was rerun assuming a somewhat finer waste rock was present in the rock pile. The finer mine rock used for this sensitivity run is shown in Figures B-19 and B-20 (labeled "interface soil"). Note that the moisture retention characteristics of this hypothetical, finer mine rock are well within the range of properties of mine rock observed at other mines (see e.g. SWCC data for samples from Golden Sunlight, Montana, plotted in Figure B-19 for comparison).

Figure B-22 summarizes the results of this sensitivity run. It is seen that the presence of a finer-grained mine rock greatly reduces the efficacy of a capillary break between the topsoil and the mine rock. In this scenario the amount of lateral flow (within the soil cover) is greatly reduced and slightly more than 50% of all infiltration occurring during the recharge period (days 12-62) percolates into the waste rock.

The 2D modeling results suggest that a capillary break may form along the interface between the finer-grained cover material (topsoil) and the coarse mine rock. This capillary break has the potential to greatly reduce the net percolation on a slope face where the incoming infiltration can drain laterally (parallel to the slope) within the soil cover. However, the efficiency of the reduction in net percolation is very sensitive to the material properties, the cover thickness and the quality control exercised during construction of the soil cover. One of the greatest concerns with the reliance on a capillary break layer is the long-term performance. With time, fines can be expected to move from the cover layer into the upper profile of the coarse mine rock resulting in a deterioration of the capillary break effect. In general, the use of a geofabric placed between the cover layer and the mine rock would greatly facilitate initial placement of the soil cover and would prevent entrainment of finer particles into the mine rock (at least for the life time of the geofabric). In addition, erosion of the topsoil may result in a breakdown of the capillary break effect, in particular if relatively thin covers are utilized (18 inches or less).

Based on the 2D modeling results and recognition of the limitations in implementing/maintaining a capillary break in the field, the following general guidelines were applied for estimating the rate of net percolation on a sloped surface covered with a finer-grained soil layer (c. Table B-9):

- Assume 50% reduction in net percolation for sloped surfaces if geofabric is placed between cover layer and mine rock;
- Assume 25% reduction in net percolation if a thick soil cover (24" or greater) is placed on mine rock;
- Assume 10% % reduction in net percolation if a thick soil cover (24" or greater) is placed on mine rock;
- Assume 15% reduction in net percolation if a layered topsoil/tailings cover is placed on mine rock.

1.05 REFERENCES

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APPENDIX C

MPDES PERMITS

Draft 04-09-01

FACT SHEET

for Proposed Permit Limits (Permit Renewal)

PERMITTEE:	Department of Environmental Quality Zortman Mine P.O. Box 313 Zortman, MT 59546
CONTACT:	Director Montana Department of Environmental Quality P.O. Box 200901 Helena, MT 59620-0901
PHONE:	(406) 444-2544
PERMIT NO.:	MT-0024856
LOCATION:	West half T25N, R25E Phillips County, Montana
RECEIVING WATERS:	Ruby Gulch, Alder/Carter Gulch, Goslin Flats, Lodgepole Creek and associated ground water systems

A. Status of Permit

MPDES Permit No.: MT-0024856 was issued, on January 3, 1987, to Zortman Mining Inc, (ZMI) Zortman Mine Site for the discharge of storm water to Glory Hole Creek and the East Fork Ruby Gulch. The permit expired on October 31, 1991.

In August 1993, a suit was filed in District Court by the State of Montana against ZMI and Pegasus Gold, alleging violations of the Montana Water Quality Act. This was due in part to ARD at the mine sites. The Environmental Protection Agency (EPA) filed suit in Federal District Court in June 1995, alleging that discharges from the mine sites in seven drainages were in violation of the Federal Clean Water Act (Civil Action No. 95-95-BLG-JDS). The State of Montana then filed in Federal District Court and citizen suits were also filed in Federal District Court by Island Mountain Protectors and the Fort Belknap Indian Community Council (Fort Belknap) (Civil Action No. 95-96-BLG-JDS). Settlement discussions among the parties occurred during 1995 and early 1996 to resolve the complaints. A Consent Decree was lodged in Federal District Court on July 22, 1996. After a public comment period, the Consent Decree became effective on September 27, 1996.

A new MPDES permit application was submitted by Zortman Mining, Inc. on December 20, 1996 pursuant to Paragraph 16.a of the Consent Degree. The permit application identified process water, mine drainage and storm water outfalls. This Fact Sheet and

Permit were originally being prepared in response to the permit application and Consent Degree. The Consent Degree is to terminate one year after the effective date of this permit provided that the permittee complies with the terms and conditions of the discharge permit.

Since the 1996 permit application was submitted ZMI has filed for bankruptcy protection. ZMI assets are now being liquidated under Chapter 7. The reclamation bond is held by a surety company and administrated by the Department of Environmental Quality (DEQ). The DEQ and Bureau of Land Management (BLM) are responsible for the reclamation at the site. The 1996 permit application envisioned continued mining at the site and is no longer accurate. A revised permit application is being prepared by the DEQ, which reflects the current reclamation status of the mine. The revised permit will be issued to the DEQ and signed by the current director.

A Metal Mine Reclamation Act (MMRA) operating permit was issued to ZMI on May 17, 1979. A ground water mixing zone was implied in this permit. Although the MMRA permit remains in effect it is no longer applicable to an operating mine and the ground water mixing zone designation and compliance monitoring have been moved to the MPDES permit.

The DEQ and BLM are preparing a draft Environmental Impact Statement (EIS) on the final reclamation plan for the Zortman and Landusky Mine sites. The EIS is scheduled to be finalized in the year 2001. The draft permit and this Fact Sheet shall be attached as an appendix to the draft EIS.

B. Description of the Discharging Facility

Zortman Mining Inc. (ZMI) operated two gold mines: the Zortman Mine and the Landusky Mine from 1979 until 1996. The two mines lie adjacent to one another in the Little Rocky Mountains in Phillips County, Montana. In 1998 ZMI filed for bankruptcy protection and the mine went into a reclamation mode. Prior to the bankruptcy ZMI had constructed two mechanical wastewater treatment systems, one in Montana Gulch and one in Ruby Gulch.

The treatment system in Ruby Gulch at the Zortman Mine consists of a mechanical lime addition plant sized to discharge approximately 1,000 gpm (Outfall 667). Three capture systems feed the mechanical plant. Outfalls have been designated for each capture system in case of a pump failure or large precipitation event (Outfalls 696, 692, and 695).

There are ten storm water outfalls located on site (Outfalls 694, 605, 606, 607, 608, 609, 611, 612, 613 and 614). A storm water management plan was submitted by ZMI to the Department in August of 1996. Storm water BMPs consist of diversion ditches, control berms, sediment basins, check dams, filter fence, etc (see Special Conditions Section I) (Hydrometrics, Inc. 1996)

Reclamation in the form of regarding and capping of waste dumps and leach pads is in process and expected to continue for from 2 to 5 years.

Process water from the heaps, located at both the Landusky and Zortman Mines, is discharged by land application on Goslin Flats during May through October at approximately 100 million gallons a year. Goslin Flats has been designated as a source area of pollutants and an outfall assigned in this permit.

C. Description of Discharge and Discharge Points

1. **Past Discharge Data**

The original permit MPDES No.: MT-0024856 issued to Zortman Mining Inc, Zortman Mine Site was for the discharge of storm water from open mine pits to Glory Hole Creek and the East Fork of Ruby Gulch. The discharges to Glory Hole Creek and the East Fork of Ruby Gulch are two of 18 outfalls currently under consideration at the site. The outfalls include the discharge of mine drainage after treatment, overflows of mine drainage from capture systems, storm water, and ground water. Compliance monitoring is at the designated outfalls, in groundwater monitoring wells, and one surface water monitoring site.

Data is available on all the new proposed outfalls and background surface water and ground water quality in the Water Protection Bureau (WPB) and Environmental Management Bureau (EMB) files. During the life of the original permit there were no discharge of mine pit water.

2. **Surface Water Outfalls:**

Serial Number Description of Mine Drainage Discharge Points

667	At the end of a **discharge pipe** which contains the discharge from the wastewater treatment plant in **Ruby Gulch** located at approximately 47°55'42" N latitude, 108°32'38" W longitude.
696	At the end of a **capture trench**, emptying to **Ruby Gulch** located at approximately 47°55'43" N latitude, 108°32'41" W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.
697	693 At a **capture pond overflow**, emptying to **Ruby Gulch** located at approximately 47°55'47" N latitude, 108°32'45" W longitude. A discharge from this outfall occurs only as a result c pump failure or storm event, which overwhelms the pumpir capacity.

698 695 At the end of a **capture trench**, emptying to **Carter Gulch** located at approximately 47°55'31" N latitude, 108°33'47" W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

699 At the end of a **capture trench**, emptying to **Alder Spur** located at approximately 47°55'27" N latitude, 108°32'59" W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

Serial Number Description of Storm Water Discharge Points

694 At the overflow of a **storm water sediment basin**, emptying to **Ruby Gulch** located at approximately 47°55'41" N latitude, 108°33'46" W longitude.

605 At the end of a **storm water diversion**, emptying to **Alder Spur** located at approximately 47°55'21" N latitude, 108°32'48" W longitude.

606 At the end of a **storm water diversion**, emptying to **Alder Spur** located at approximately 47°55'25" N latitude, 108°32'58" W longitude.

607 At the end of a **storm water diversion**, emptying to **Alder Spur** located at approximately 47°55'27" N latitude, 108°33'10" W longitude.

608 At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'49" N latitude, 108°33'49" W longitude.

609 At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'41" N latitude, 108°33'49" W longitude.

611 At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'30" N latitude, 108°33'42" W longitude.

612 At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'30" N latitude, 108°33'45" W longitude.

613 At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'35" N latitude, 108°33'49" W longitude.

614 At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'31" N latitude, 108°33'49" W longitude.

3. **Ground water Outfalls**

Description of Ground Water Discharges, Compliance Wells, and the Surface Water Compliance Sites S-1 9 (Ross Gulch) and Z-22C (Goslin Flats)

Ruby Gulch — Seepage to ground water from portions of the 79, 82 and 83 leach pads and all of the 85/86 and 89 leach pads, the OK and Ruby Gulch waste rock repository and the South Alabama, North Alabama, OK, Ruby, and Mint mine pits. Compliance well ZL-142 is located approximately 2.0 miles down gradient (south) from the upper drainage divide.

Alder/Carter Gulch — Seepage to ground water from the Alder Gulch waste rock repository in Carter Gulch, portions of the 79, 82 and 83 leach pads and all of the 80/81 and 84 leach pads located in Alder Spur and the Alder Gulch land application disposal area (LAD). Compliance wells AG-202 and ZL-323 are located approximately 2.0 miles down gradient (south and east) from the upper drainage divide.

Lodgepole Creek — Seepage to ground water from the north end of the Ross Pit. Compliance well ZL-209 (Glory Hole Gulch) and surface water compliance sites S-1 (Ross Gulch) are located approximately 1/4 to 1/2 mile down gradient (north) from the upper drainage divide.

Goslin Flats — Seepage to ground water from the land application of wastewater on Goslin Flats. Compliance well ZL-217 and surface water compliance site Z-22C are located approximately 300 feet down gradient (south) from the lower edge of the land application area.

D. Description of Receiving Water

Surface water in the mine area emanates from beneath waste rock repositories, heap leach facilities or springs and seeps effected by mining. The outfalls have been designated at these points except Outfall 667. Outfall 667 is the discharge to Ruby Gulch from the wastewater treatment plant. Flow data from the treatment plant (Outfall 667) for the first 10 months of the year 2000 indicate an average annual flow of 108 gpm. This annual average flow from the treatment plant was used to calculate the waste load allocations. The volume

of 108 gpm is equal to the combination of the individual capture systems (Outfalls 696, 692 and 695). The discharge occurs approximately 3 days a week for 8 hours a day.

Surface Water Outfalls 667, 696, 697, 698, and 699, Storm Water Outfalls 694, 605, 605, 607, 608, 609, 611, 612,613, and 614, Groundwater Outfalls in Ruby Gulch, Alder/Carter Gulch, and Goslin Flats

Ruby Gulch and Alder Gulch and their tributaries, in the area of the discharge are classified as "C-3" [ARM 17.30.610(5)]. Waters classified "C-3" are considered suitable for bathing, swimming, and recreation, growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agricultural and industrial water supply [ARM 17.30.629(1)].

Ruby Gulch from the headwaters to 1 mile below the town of Zortman is listed on Montana's 1996 303(d) list and is given a low priority for development of total maximum daily loads (TMDLs). The water body number for the affected segment of Ruby Gulch is MT40EJ002-7). The probable impaired uses are warm water fishery, drinking water supply, aquatic life support and swimming. The probable causes for impairment are metals, pH flow alteration and other habitat alteration. The probable source is listed as surface mining and resource extraction.

Alder Spur and Carter Gulch are both tributaries to Alder Gulch. Alder Gulch, in the area of the discharges, is listed on Montana's 1996 303(d) list and is given a low priority for TMDL development. The water body number for the affected segment of Alder Gulch is MT40EJ002-5. The probable impaired uses are cold water fishery, drinking water supply, aquatic life support and swimming. The probable causes for impairment are metals, suspended solids and pH and the probable source is listed as resource extraction and surface mining.

Groundwater Outfall in Lodgepole Creek

Glory Hole Creek is a tributary of Lodgepole Creek, which is located in the Peoples Creek drainage. The Peoples Creek drainage in the area of the discharges is classified as "B-1" [ARM 17.30.610(8)(d)]. Waters classified "B-1" are considered suitable for drinking, culinary, and food-processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply [ARM 17.30.623(1)].

Lodgepole Creek and its tributary Glory Hole Creek are not listed on Montana's 1996 303(d) list.

On September 21, 2000, a U.S. District Judge issued an order stating that until all necessary total maximum daily loads (TMDLs) under Section 303(d) of the Clean Water Act are established for a particular water quality limited segment (WQLS), the State is not to issue any new permits or increase permitted discharges under the MPDES

program. The order was issued in the lawsuit Friends of the Wild Swan v. U.S. EPA, *et al.*, CV 97-35-M-DWM, District of Montana, Missoula Division. This section of the Statement of Basis establishes justification for renewal of this permit under the September 21, 2000 order.

The Montana Water Quality Act authorizes the issuance of point source discharge permits on a listed water body pending completion of a TMDL provided that: 1) the discharge in compliance with the provisions of 75-5-303, MCA (Nondegradation Policy); 2) the discharge will not cause a decline in water quality for the parameters for which the water body is listed; and, 3) the minimum treatment requirements are met.

The limits set in this permit will serve as the TMDLs for each limited parameter. Compliance with the limits set in the permit will insure that water quality standards are met and beneficial uses protected and improved. With completion of all reclamation work and the implementation of all reasonable land soil and water conservation practices the department will consider the delisting of these stream segments.

The discharges to Ruby Gulch, Alder Gulch and Glory Hole Creek were in existence prior to April 29,1993 and as such are not considered new or increased sources. (ARM 17.30.702(16)) The provisions of the nondegradation policy only apply to new or increased sources. (ARM 17.30.705(1))

Metals, pH and habitat alteration caused by resource extraction impair the streams in the areas of the discharges. This permit sets limits on metals that do not exceed the lowest applicable standards and improve existing water quality. The pH in the discharges is maintained at between 6 and 9 standard units. The permit does not allow a discharge, which will cause habitat alteration.

This permit requires minimum treatment limits for TSS and all other parameters if they are more restrictive than water quality based limits.

E. Mixing Zone

The mixing zones for all surface water outfalls are considered instantaneous because they represent the headwaters of the stream and therefore the mean daily flow of the discharge exceeds the 7-day, 10-year low flow of the receiving water. (ARM 17.30.516(3)(d)) The 7 –day, 10-year low flow for the capture system outfalls is zero. During storm events when storm water will provide dilution capacity for the discharge from the capture systems the mixing zone shall extend 10 stream widths. (ARM 17.30.516(4))

Ground water mixing zones have been established for each drainage which contain either mine waste rock repositories, leach pads, mine pits, or seeps and springs effected by mine activities. These ground water mixing zones have been established based on the disturbances and the geology at the mine site. Mining took place within the core of a tertiary syenite complex ringed by Paleozoic sedimentary rocks. The mixing zones extend

from the headwaters of the drainages within the syenite complex down gradient to the contact with the Paleozoic formations. Compliance wells and surface water compliance sites (Goslin Flats and Ross Gulch) are located near the end of the mixing zones to monitor for compliance with the water quality standards.

F. Proposed Wastewater Effluent Limits

1. **Technology Based Effluent Limits**

Active mines are subject to technology-based effluent limits for metals (cadmium, copper, lead, mercury and zinc), pH and TSS as defined in 40 CFR Part 440 – Ore Mining and Dressing Point Category Source Category, Subpart J – Copper, Lead, Zinc, Gold, Silver, and Molybdenum Ores Subcategory. The limits which apply in this permit are the New Source Performance Standards (NSPS) [40 CFR 440.104(a)]. Water quality based limits for all parameters, except TSS, in all outfalls were more stringent than the NSPS standards.

Inactive mines are not subject to technology based limits. No WQBEL were developed for TSS, therefore the technology-based limit will be imposed. The TSS limit shall only apply to Outfall 667 where mechanical treatment is proposed.

2. **Water Quality Based Effluent Limits**

Water quality based effluent limits (WQBEL) are generally derived from a dilution model based on the concentration of and the 7-day 10-year low flow in the receiving stream and the high flow and concentration in the discharge. The resulting instream concentrations are the lowest of either human health or chronic aquatic water quality standard from WQB-7 (September 1999).

Because the discharges covered by this permit are the first waters to exist in the various drainages which emanate from the sources themselves no mixing in receiving water is available to impute into a dilution model. For this reason no modeling has been done and the WQBEL are equal to the applicable standards. Standards for metals vary based on the hardness of the water. Data from monitoring site Z-15 in Ruby Gulch indicate that the hardness is greater than 400 mg/L therefor the water quality standards for metals were calculated using a hardness of 400 mg/L. A hardness of 150 mg/L, which is the arithmetic mean of the data at monitoring site Z-8 from 1997 through 1998, was used to calculate limits in Carter Gulch, Alder Spur and Goslin Flats. Based on data from Swift Gulch, which is similarly on the north side of the mining area, a hardness of 150 mg/L was used to calculate limits in Ross Gulch.

Mercury was sampled monthly for 17 months from the end 1997 through 1999. These samples failed to detect mercury at a detection limit of 0.0006 mg/L. Because technology based limits do not apply mercury sampling shall not be required in this permit.

Ground water limits are based on the human health standard. Human health standards are not hardness dependent.

The 30-day average limit was set at the standard and 1.5 times that limit was set as the instantaneous maximum.

Storm Water

Storm water limits have been set the same as for the *General Discharge permit for Storm Water Associated with Mining and with Oil and Gas Facilities,* Permit No MT-R300000.

G. Final Wastewater Effluent Limitations

1. **Surface Water Final Effluent Limitations**

Mine Drainage Outfalls: 667, 693, and 696

TABLE 1: NUMERIC SURFACE WATER EFFLUENT LIMITATIONS

Parameter[3]	**Concentration (mg/L)** [1]		**Allocated Annual Average Load** [2] **(lb./day)**	**Rationale**
	30-Day Average	**Instantaneous Maximum**		
Total suspended Solids (TSS)[4]	20	30	26	NSPS Guidelines for Ore Mining (40 CFR 440.104(a))
Aluminum, dissolved	0.087	0.13	0.113	Water Quality Standard (Chronic Aquatic WQB-7)
Arsenic, total recoverable	0.018	0.027	0.023	Water Quality Standard (Human Health WQB-7)
Cadmium, total recoverable	0.005	0.008	0.0065	Water Quality Standard (Human Health WQB-7)
Copper, total recoverable	0.031	0.046	0.04	Water Quality Standard (Chronic Aquatic WQB-7)
Cyanide, total recoverable	0.0052	0.0076	0.007	Water Quality Standard (Chronic Aquatic WQB-7)
Iron, total recoverable	1.0	1.5	1.3	Water Quality Standard (Chronic Aquatic WQB-7)
Nickel, total recoverable	0.10	0.15	0.13	Water Quality Standard (Human Health WQB-7)
Nitrate/Nitrite total as N	10	15	13.0	Water Quality Standard (Human Health WQB-7)
Selenium, total recoverable	0.005	0.008	0.0065	Water Quality Standard (Chronic Aquatic WQB-7)

TABLE 1: NUMERIC SURFACE WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/L) [1]		Allocated Annual Average Load [2] (lb./day)	Rationale
	30-Day Average	Instantaneous Maximum		
Zinc, total recoverable	0.388	0.582	0.5	Water Quality Standard (Chronic Aquatic WQB-7)
Whole Effluent Toxicity (WET)[4]	N/A	1.0 TUa	N/A	Water Quality Standard (ARM 17.30.629(2)(h)(I))

(1) See the definitions in Part I.A for explanation of terms.

(2) The allocated loads for Ruby Gulch are based on the 30-day average limit and the annual average values of flow from the water treatment plant Outfall 667of 108 gpm Load limits apply only to Outfall, 667, which is the discharge from the wastewater treatment plant. This is the only outfall expected to discharge.

(3) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

(4) This parameter applies only to the discharge from the water treatment plant (Outfall 667).

Mine Drainage Outfalls and Surface Water Compliance Sites: 692 and 695 (Alder/Carter Gulch), S-1 (Ross Gulch), Z-22C (Goslin Flats)

TABLE 2: NUMERIC SURFACE WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/*l*) [1]		Allocated Annual Average Load [2] (lb./day)	Rationale
	30-Day Average	Instantaneous Maximum		
Aluminum, dissolved	0.087	0.13		Water Quality Standard (Chronic Aquatic WQB-7)
Arsenic, total recoverable	0.018	0.027		Water Quality Standard (Human Health WQB-7)
Cadmium, total recoverable	0.0034	0.005		Water Quality Standard (Chronic Aquatic WQB-7)
Copper, total recoverable	0.0132	0.02		Water Quality Standard (Chronic Aquatic WQB-7)
Cyanide, total recoverable[4]	0.0052	0.0076		Water Quality Standard (Chronic Aquatic WQB-7)
Iron, total recoverable	1.0	1.5		Water Quality Standard (Chronic Aquatic WQB-7)
Nickel, total recoverable	0.073	0.110		Water Quality Standard (Chronic Aquatic WQB-7)
Nitrate/Nitrite total as N	10	15		Water Quality Standard (Human Health WQB-7)

TABLE 2: NUMERIC SURFACE WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/*l*) [1]		Allocated Annual Average Load [2] (lb./day)	Rationale
	30-Day Average	Instantaneous Maximum		
Selenium, total recoverable	0.005	0.008		Water Quality Standard (Chronic Aquatic WQB-7)
Zinc, total recoverable	0.169	0.253		Water Quality Standard (Chronic Aquatic WQB-7)

(1) See the definitions in Part I.A for explanation of terms.

(2) Because of the lack of flow data in the drainages loads have not been allocated. Data developed over the five-year term of the permit will be used to develop load allocations in the future.

(3) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

(4) This parameter is not required at sampling site S-1 in Ross Gulch.

The pH of the discharge shall remain between 6 and 9 standard units (ARM 17.30.629(2)(f)).

There shall be no discharge of floating solids or visible foam in other than trace amounts (ARM 17.30.629(2)(f))(ARM 17.30.623(2)(f)).

There shall be no discharge, which causes visible oil sheen in the receiving stream (ARM 17.30.637(1)(b)).

There shall be no discharge of wastewater, which reacts or settles to form an objectionable sludge deposit or emulsion beneath the surface of the receiving stream or upon adjoining shorelines (ARM 17.30.637(1)(a)).

There shall be no acute toxicity in the effluent discharged by the facility and no chronic toxicity outside the boundaries of the mixing zone (ARM 17.30.629(2)(h)(i)).

2. Ground Water Final Compliance Limitations

Ground Water Compliance Wells: ZL-142 (Ruby Gulch) AG-202, ZL-323 (Alder Gulch/Carter Gulch) ZL-217 (Goslin Flats) and ZL-209 (Glory Hole Gulch)

TABLE 3: NUMERIC GROUND WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/*l*) [1]		Rationale
	30-Day Average	Instantaneous Maximum	
Arsenic, dissolved	0.02	0.03	Water Quality Standard (Human Health WQB-7)

TABLE 3: NUMERIC GROUND WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/l) [1]		Rationale
	30-Day Average	Instantaneous Maximum	
Cadmium, dissolved	0.005	0.008	Water Quality Standard (Human Health WQB-7)
Copper, dissolved	1.3	2.0	Water Quality Standard (Human Health WQB-7)
Cyanide, total recoverable[3]	0.2	0.3	Water Quality Standard (Human Health WQB-7)
Nickel, dissolved	0.10	0.15	Water Quality Standard (Human Health WQB-7)
Nitrate/Nitrite total as N	10	15	Water Quality Standard (Human Health WQB-7)
Selenium, dissolved	0.05	0.08	Water Quality Standard (Human Health WQB-7)
Zinc, dissolved	2.1	3.1	Water Quality Standard (Human Health WQB-7)

(1) See the definitions in Part I.A for explanation of terms.

(2) For determination of metals use the dissolved method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983.

(3) This parameter is not required at sampling site Z-209 in Glory Hole Gulch.

C. Self-Monitoring Requirements

As a minimum, upon the effective date of this permit, the following constituents shall be monitored at the frequency and with the type of measurement indicated; samples or measurements shall be representative of the volume and nature of the monitored discharge. If no discharge occurs during the entire monitoring period, it shall be stated on the Discharge Monitoring Report Form (EPA No. 3320-1) that no discharge or overflow occurred.

For purposes of determining compliance if a single sample is collected for a monthly reporting period, that sample must be less than the monthly average. If multiple samples (greater than 1) are collected in the month than the arithmetic mean of all the samples must be less than the 30-day average limit and no single sample shall exceed the instantaneous maximum limit.

1. Surface Wastewater Discharge Monitoring

Mine Drainage Outfall: 667 Wastewater Treatment Plant in Ruby Gulch

TABLE 4: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Daily	Grab
Specific Conductance, umho/cm	Daily	Grab
Total Suspended Solids, mg/L	Daily	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab
Cyanide WAD, mg/L	Twice weekly	Grab
Cyanide, total recoverable, mg/L	Twice weekly	Grab
Arsenic, total recoverable, mg/L	Monthly	Grab
Cadmium, total recoverable, mg/L	Monthly	Grab
Copper, total recoverable, mg/L	Monthly	Grab
Iron, total recoverable, mg/L	Monthly	Grab
Manganese, total recoverable, mg/L	Monthly	Grab
Nickel, total recoverable, mg/L	Monthly	Grab
Selenium, total recoverable, mg/L	Monthly	Grab
Zinc, total recoverable, mg/L	Monthly	Grab
Whole Effluent Toxicity (WET)	Quarterly	Grab

[1] See the definitions in Part I.A. of the permit.

Mine Drainage Outfalls: 693 and 696 (Ruby Gulch), 692 (Alder Spur), 695 (Carter Gulch)

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Weekly	Grab
Specific Conductance, umho/cm	Weekly	Grab
Total Suspended Solids, mg/L	Weekly	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Cyanide, WAD, mg/L	Weekly	Grab
Cyanide, total recoverable, mg/L	Weekly	Grab
Aluminum, dissolved, mg/L	Weekly	Grab
Arsenic, total recoverable, mg/L	Weekly	Grab
Cadmium, total recoverable, mg/L	Weekly	Grab
Copper, total recoverable, mg/L	Weekly	Grab
Iron, total recoverable, mg/L	Weekly	Grab
Manganese, total recoverable, mg/L	Weekly	Grab
Nickel, total recoverable, mg/L	Weekly	Grab
Selenium, total recoverable, mg/L	Weekly	Grab
Zinc, total recoverable, mg/L	Weekly	Grab

(1) A sample shall be collected at the first sign of a discharge and weekly thereafter.
(2) See the definitions in Part I.A. of the permit.

Surface Water Compliance Sites: S-1 (Glory Hole Gulch), Z-22C (Goslin Flats)

TABLE 6: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	April[3], May, June, October[3]	Instantaneous
pH, standard units	April[3], May, June, October[3]	Grab
Specific Conductance, umho/cm	April[3], May, June, October[3]	Grab
Total Suspended Solids, mg/L	April[3], May, June, October[3]	Grab
Sulfate, mg/L	April[3], May, June, October[3]	Grab
Hardness, mg/L	April[3], May, June, October[3]	Grab
Nitrate/Nitrite total as N, mg/L	April[3], May, June, October[3]	Grab
Cyanide WAD, mg/L[2]	April[3], May, June, October[3]	Grab
Cyanide, total recoverable, mg/L[2]	April[3], May, June, October[3]	Grab
Aluminum, dissolved, mg/L	April[3], May, June, October[3]	Grab
Arsenic, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Cadmium, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Copper, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Iron, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Manganese, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Nickel, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Selenium, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Zinc, total recoverable, mg/L	April[3], May, June, October[3]	Grab

(1) See the definitions in Part I.A. of the permit.

(2) This parameter is not required at sampling sites Z-64 and S-1 (Lodgepole Creek).

(3) Late April and October from the 15th to the end of the month.

Storm Water Outfalls - 694, 605, 606, 607, 611, 612, 609, 608, 613 and 614

TABLE 7: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency(1)	Type(2)
Effluent Flow Rate, gpm	Semi-annual	Instantaneous
pH, standard units	Semi-annual	Grab
Specific Conductance, umho/cm	Semi-annual	Grab
Total Suspended Solids, mg/L	Semi-annual	Grab
Nitrate/Nitrite total as N, mg/L	Semi-annual	Grab
Arsenic, total recoverable, mg/L	Semi-annual	Grab
Cadmium, total recoverable and dissolved, mg/L	Semi-annual	Grab
Copper, total recoverable, mg/L	Semi-annual	Grab
Nickel, total recoverable, mg/L	Semi-annual	Grab
Selenium, total recoverable, mg/L	Semi-annual	Grab
Zinc, total recoverable and dissolved, mg/L	Semi-annual	Grab

(1) One sample in May or June during a spring runoff event, and another sample during July, August or September during a thunderstorm event.

(2) See the definitions in Part I.A. of the permit

2. Evaluation of Storm Water Quality Monitoring Test Results

Upon the completion of each sampling event, and upon receipt of the sampling test results by the Permittee, the Permittee shall evaluate each parameter test result by comparison with the pertinent benchmark value stated in Table 9 of this Permit, which is entitled "Storm Water Discharge Parameter Benchmark Values. If there is an exceedance of the benchmark value, the Permittee shall evaluate the source and reason of the exceedance, and consider additional BMPs and/or other facility management measures which may need to be initiated to improve the quality of storm water discharges. These measures shall be implemented as necessary and updated in the facility SWPPP as required. A summary of this evaluation of storm water quality data, any exceedances of the benchmark values, and additional BMP and/or other measures which may be necessary shall be attached to the stormwater Discharge Monitoring Reports (DMR).

TABLE 8: STORM WATER DISCHARGE PARAMETER BENCHMARK VALUES(1)

Parameter Name	Benchmark Level
Total Suspended Solids	100 mg/L
Nitrate + Nitrite Nitrogen	0.68 mg/L
pH	6.0-9.0 s.u.

Arsenic, Total	0.16854 mg/L
Cadmium, Total	0.0159 mg/L
Copper, Total	0.0636 mg/L
Nickel, Total	1.417 mg/L
Selenium, Total	0.2385 mg/L
Zinc, Total	0.117 mg/L

(1) Source of Table: EPA's 10/30/00 Final NPDES Storm Water Multi-Sector General Permit for Industrial Activities

3. Ground Water Wastewater Discharge Monitoring

Ground Water Compliance Wells - ZL-142 (Ruby Gulch) AG-202, ZL-323 (Alder Gulch/Carter Gulch) ZL-217 (Goslin Flats) and ZL-209 (Glory Hole Gulch)

TABLE 9: GROUND WATER MONITORING REQUIREMENTS

Parameter	Frequency	Type (1)
Static water level, gpm	July and November	Instantaneous
pH, standard units	July and November	Grab
Specific Conductance, umho/cm	July and November	Grab
Sulfate, mg/L	July and November	Grab
Hardness, mg/L	July and November	Grab
Nitrate/Nitrite total as N, mg/L	July and November	Grab
Cyanide WAD, mg/L(2)	July and November	Grab
Cyanide, total recoverable, mg/L(2)	July and November	Grab
Arsenic, total recoverable, mg/L	July and November	Grab
Cadmium, total recoverable, mg/L	July and November	Grab
Iron, total recoverable, mg/L	July and November	Grab
Manganese, total recoverable, mg/L	July and November	Grab
Selenium, total recoverable, mg/L	July and November	Grab
Zinc, total recoverable, mg/L	July and November	Grab

(1) See the definitions in Part I.A. of the permit.

(2) Does not include Lodgepole Creek sampling site Z-209

J. Special Conditions

Storm Water Pollution Prevention Plan (SWPPP)

The permittee shall be required to implement the *Storm Water Management Plan for Zorman and Landusky Mine Sites* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated August 1996. This plan was approved by the Department and incorporated into the final *Water Quality improvement and Monitoring Complinance Plan* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated July 1996.

Administrative Requirements for the SWPPP

The plan shall:

1. be retained on site in accordance with Part VI.A. of this permit for active mine sites or retained in the nearest field office for inactive mine sites and oil and gas facilities;

2. be amended whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to state surface waters, or if the SWPPP proves to be ineffective in achieving the general objectives of controlling pollutants in storm water discharges associated with mine reclamation activities. A copy of any plan amendments must be submitted to the Department within 7 working days of any change.

I. Information Sources

While developing the effluent limitations, monitoring requirements and special conditions for the draft permit, the following information sources were used to establish the basis of the draft permit and are hereby referenced:

(1) ARM Title 17, Chapter 30, Sub-chapter 5 - Mixing Zones in Surface and Ground Water.

(2) ARM Title 17, Chapter 30, Sub-chapter 6 - Surface Water Quality Standards.

(3) ARM Title 17, Chapter 30, Sub-chapter 7 - Nondegradation of Water Quality.

(4) ARM Title 17, Chapter 30, Sub-chapter 13 - Montana Pollutant Discharge Elimination System (MPDES) Standards.

(5) Consent Decree, (1996), In the United States District Court for the District of Montana Billings Division, Civil Action No. 95-95-Blg-JDS and No. 95-96-Blg-JDS

(6) Consolidated MPDES Permit Application Form 1 and Short Form 2C, received December 24, 1996.

(7) Environmental Management Bureau Discharge Monitoring Reports.

(8) Harvey, Kevin C., (1998), Background Surface Water Quality at the Zortman Landusky Mine Sites, pp.31.

(9) Hydrometrics, Inc., (1996) Storm Water Management Plan for Zortman and Landusky Mine Sites.

(10) Montana Water Quality Act, MCA 75-5-101 et seq.

(11) Montana (1996) 303(d) List, list of Waterbodies in Need of Total Maximum Daily Load Development.

(12) MPDES Permit File No. MT-0000396, effective date of January 3 1987, expiration date of October 31, 1991.

(13) Updated MPDES Permit Application for the Landusky Mine Site Phillips County, Montana, dated December 20, 1996.

PREPARED BY: TERRY WEBSTER, MARCH 2001

Signature Date Finalized

Major Industrial
With Bio-monitoring
Permit No.: MT-0024856

Draft 04-09-01

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

AUTHORIZATION TO DISCHARGE UNDER THE

MONTANA POLLUTANT DISCHARGE ELIMINATION SYSTEM (MPDES)

In compliance with Mont. Code Annot. Section 75-5-101 *et seq.* and ARM Title 17, Chapter 30, Subchapters 5, 6, 7, and 13.

Department of Environmental Quality
Zortman Mine Site
P.O. Box 313
Zortman, MT 59546

is authorized to discharge from one water treatment plant, seven waste water capture systems, eleven storm water outfalls and five ground water outfalls

to receiving waters named, **Ruby Gulch, Carter Gulch and Alder Spur and associated ground water systems**

in accordance with discharge point(s), effluent limitations, monitoring requirements and other conditions set forth herein. Authorization for discharge is limited to those outfalls specifically listed in the permit. Specified load allocations support and serve to define total maximum daily loads for the receiving waters affected.

This permit shall become effective 30 days after the date of issuance.

This permit and the authorization to discharge shall expire at midnight five years after the date of issuance.

FOR THE MONTANA DEPARTMENT OF
ENVIRONMENTAL QUALITY

Jan P. Sensibaugh
Director
Department of Environmental Quality

Dated this_____ day of

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DRAFT

I. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

A. Definitions.

1. The "**30-day (and monthly) average**," other than for fecal coliform bacteria, is the arithmetic average of all samples collected during a consecutive 30-day period or calendar month, whichever is applicable. Geometric means shall be calculated for fecal coliform bacteria. The calendar month shall be used for purposes of reporting self-monitoring data on discharge monitoring report forms.

2. The "**7-day (and weekly) average**," other than for fecal coliform bacteria, is the arithmetic mean of all samples collected during a consecutive 7-day period or calendar week, whichever is applicable. Geometric means shall be calculated for fecal coliform bacteria. The 7-day averages are applicable only to those effluent characteristics for which there are 7-day average effluent limitations. The calendar week which begins on Sunday and ends on Saturday, shall be used for purposes of reporting self-monitoring data on discharge monitoring report forms. Weekly averages shall be calculated for all calendar weeks in the month that have at least 4 days. For example, if a calendar week overlaps two months, the weekly average is calculated only in the month that contains four or more days of that week.

3. The "**Annual Average Load**" is the arithmetic mean of all 30-day or monthly average loads reported during the calendar year for a monitored parameter.

4. The "**Arithmetic Mean**" or "**Arithmetic Average**" for any set of related values means the summation of the individual values divided by the number of individual values.

5. "**Bypass**" means the intentional diversion of waste streams from any portion of a treatment facility.

6. "**Composite samples**" shall be flow proportioned. The composite sample shall, as a minimum, contain at least four (4) samples collected over the compositing period. Unless otherwise specified, the time between the collection of the first sample and the last sample shall not be less than six (6) hours nor more than 24 hours. Acceptable methods for preparation of composite samples are as follows:

   a. Constant time interval between samples, sample volume proportional to flow rate at time of sampling;

   b. Constant time interval between samples, sample volume proportional to total flow (volume) since last sample. For the first sample, the flow rate at the time the sample was collected may be used;

   c. Constant sample volume, time interval between samples proportional to flow (i.e., sample taken every "X" gallons of flow); and,

   d. Continuous collection of sample, with sample collection rate proportional to flow rate.

7. A "**Daily Maximum Limit**" specifies the maximum allowable discharge of a pollutant

during a calendar day. Expressed as units of mass, the daily discharge is cumulative mass discharged over the course of the day. Expressed as a concentration, it is the arithmetic average of all measurements taken that day.

8. "**Department**" means the Montana Department of Environmental Quality (MDEQ).

9. "**Director**" means the Director of the United States Environmental Protection Agency's Water Management Division.

10. "**EPA**" means the United States Environmental Protection Agency.

11. A "**grab**" sample, for monitoring requirements, is defined as a single "dip and take" sample collected at a representative point in the discharge stream.

12. An "**instantaneous**" measurement, for monitoring requirements, is defined as a single reading, observation, or measurement.

13. "**Load limits**" are mass-based discharge limits expressed in units such as lb./day.

14. A "**mixing zone**" is a limited area of a surface water body or aquifer where initial dilution of a discharge takes place and where water quality changes may occur. Also recognized as an area where certain water quality standards may be exceeded.

15. "**Nondegradation**" means the prevention of a significant change in water quality that lowers the quality of high-quality water for one or more parameters. Also, the prohibition of any increase in discharge that exceeds the limits established under or determined from a permit or approval issued by the Department prior to April 29, 1993.

16. The "**Regional Administrator**" is the administrator of the EPA Region with jurisdiction over federal water pollution control activities in the State of Montana.

17. "**Severe property damage**" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

18. The term "**TMDL**" means the total maximum daily load limitation of a parameter, representing the estimated assimilative capacity for a water body before other designated uses are adversely affected. Mathematically, it is the sum of wasteload allocations for point sources, load allocations for non-point and natural background sources, and a margin of safety.

19. "**TSS**" is the parameter total suspended solids.

20. "**Upset**" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed

treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

B. Description of Discharge Points

The authorization to discharge provided under this permit is limited to those outfalls specifically designated below as discharge locations. Discharges at any location not authorized under an MPDES permit is a violation of the Montana Water Quality Act and could subject the person(s) responsible for such discharge to penalties under the Act. Knowingly discharging from an unauthorized location or failing to report an unauthorized discharge within a reasonable time from first learning of an unauthorized discharge could subject such person to criminal penalties as provided under Section 75-5-632 of the Montana Water Quality Act.

1. **Surface Water Outfalls:**

Serial Number	Description of Mine Drainage Discharge Points
667	At the end of a **discharge pipe** which contains the discharge from the wastewater treatment plant in **Ruby Gulch** located at approximately 47°55'42" N latitude, 108°32'38" W longitude.
696	At the end of a **capture trench**, emptying to **Ruby Gulch** located at approximately 47°55'43" N latitude, 108°32'41" W longitude.
693	At a **capture pond overflow**, emptying to **Ruby Gulch** located at approximately 47°55'47" N latitude, 108°32'45" W longitude.
695	At the end of a **capture trench**, emptying to **Carter Gulch** located at approximately 47°55'31" N latitude, 108°33'47" W longitude..
692	At the end of a **capture trench**, emptying to **Alder Spur** located at approximately 47°55'27" N latitude, 108°32'59" W longitude.

Serial Number	Description of Storm Water Discharge Points
694	At the overflow of a **storm water sediment basin**, emptying to **Ruby Gulch** located at approximately 47°55'41" N latitude, 108°33'46" W longitude.
605	At the end of a **storm water diversion**, emptying to **Alder Spur** located at approximately 47°55'21" N latitude, 108°32'48" W longitude..
606	At the end of a **storm water diversion**, emptying to **Alder Spur** located at approximately 47°55'25" N latitude, 108°32'58" W longitude.
607	At the end of a **storm water diversion**, emptying to **Alder Spur** located at approximately 47°55'27" N latitude, 108°33'10" W longitude.
611	At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'30" N latitude, 108°33'42" W longitude.

612	At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'30" N latitude, 108°33'45" W longitude.
609	At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'41" N latitude, 108°33'49" W longitude.
608	At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'49" N latitude, 108°33'49" W longitude.
613	At the end of a storm water diversion, emptying to Carter Gulch located at approximately 47°55'35" N latitude, 108°33'49" W longitude. The mixing zone is instantaneous as it represents the entire flow of the stream.
614	At the end of a **storm water diversion**, emptying to **Carter Gulch** located at approximately 47°55'31" N latitude, 108°33'49" W longitude.

2. **Ground Water Outfalls**

Description of Ground Water Water Discharge Points and Monitoring Wwells

Ruby Gulch	Seepage to ground water from portions of the 79, 82 and 83 leach pads and all of the 85/86 and 89 leach pads, the OK and Ruby Gulch waste rock repository and the South Alabama, North Alabama, OK, Ruby, and Mint mine pits. Compliance well ZL-142 is located approximately 2.0 miles down gradient (south) from the upper drainage divide.
Alder Gulch	Seepage to ground water from the Alder Gulch waste rock repository in Carter Gulch, portions of the 79, 82 and 83 leach pads and all of the 80/81 and 84 leach pads located in Alder Spur and the Alder Gulch land application disposal area (LAD). Compliance wells AG-202 and ZL-323 are located approximately 2.0 miles down gradient (south and east) from the upper drainage divide.
Lodgepole Creek	Seepage to ground water from the north end of the Ross Pit. Compliance well ZL-209 (Glory Hole Gulch) and surface water compliance sites S-1 (Ross Gulch) are located approximately 1/4 to 1/2 mile down gradient (north) from the upper drainage divide.
Goslin Flats	Seepage to ground water from the land application of wastewater on Goslin Flats. Compliance well ZL-217 and surface water compliance site Z-22C are located approximately 300 feet down gradient (south) from the lower edge of the land application area.

Specific Limitations

Wastewater Effluent Limitations

Effective immediately and lasting through the term of the permit, the quality of effluent discharged by the facility shall, as a minimum, meet the limitations as set forth below:

Mine Drainage Outfalls Ruby Gulch 667, 693 and 696

TABLE 1: NUMERIC SURFACE WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Total suspended Solids (TSS)[4]	20	30
Aluminum, dissolved	0.087	0.13
Arsenic, total recoverable, mg/L	0.018	0.027
Cadmium, total recoverable, mg/L	0.005	0.008
Copper, total recoverable, mg/L	0.031	0.046
Cyanide, total recoverable, mg/L	0.0052	0.0076
Iron, total recoverable, mg/L	1.0	1.5
Nickel, total recoverable, mg/L	0.1	0.15
Nitrate/Nitrite as N, total recoverable, mg/L	10	15
Selenium, total recoverable, mg/L	0.005	0.008
Zinc, total recoverable, mg/L	0.388	0.582
Whole Effluent Toxicity (WET)[3]	N/A	1.0 TUa

(1) See the definitions in Part I.A for explanation of terms.
(2) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).
(3) This parameter applies only to the discharge from the water treatment plant (Outfall 667).

Mine Drainage Outfalls Alder Spur 692 and Carter Gulch 695

TABLE 2: NUMERIC SURFACE WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Aluminum, dissolved	0.087	0.13
Arsenic, total recoverable, mg/L	0.018	0.027
Cadmium, total recoverable, mg/L	0.0034	0.005
Copper, total recoverable, mg/L	0.0132	0.02
Cyanide, total recoverable, mg/L[3]	0.0052	0.0076
Iron, total recoverable, mg/L	1.0	1.5
Nickel, total recoverable, mg/L	0.073	0.110
Nitrate/Nitrite as N, total recoverable, mg/L	10	15
Selenium, total recoverable, mg/L	0.005	0.008
Zinc, total recoverable, mg/L	0.169	0.253

(1) See the definitions in Part I.A for explanation of terms.
(2) For determination of metals, except aluminum, use Total Recoverable method of

digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

(3) This parameter is not required at sampling site S-1 in Ross Gulch.

The pH of the discharge shall remain between 6 and 9 standard units.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

There shall be no discharge which causes visible oil sheen in the receiving stream.

There shall be no discharge of wastewater which reacts or settles to form an objectionable sludge deposit or emulsion beneath the surface of the receiving stream or upon adjoining shorelines.

There shall be no acute toxicity in the effluent discharged by the facility and no chronic toxicity outside the boundaries of the mixing zone.

Ground Water Monitoring Wells ZL-1423 (Ruby Gulch) AG-202, ZL-323 (Alder Gulch) ZL-217 (Goslin Flats) and Z-209 (Glory Hole Gulch)

TABLE 3: NUMERIC GROUND WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Arsenic, total recoverable, mg/L	0.02	0.03
Cadmium, total recoverable, mg/L	0.005	0.008
Copper, total recoverable, mg/L	1.3	2.0
Cyanide, total recoverable, mg/L	0.2	0.3
Nickel, total recoverable, mg/L	0.10	0.15
Nitrate/Nitrite Total as N, mg/L	10	15
Selenium, total recoverable, mg/L	0.05	0.08
Zinc, total recoverable, mg/L	2.1	3.1

(1) See the definitions in Part I.A for explanation of terms.

(2) For determination of metals use the dissolved method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

D. Self-Monitoring Requirements

As a minimum, upon the effective date of this permit, the following constituents shall be monitored at the frequency and with the type of measurement indicated; samples or measurements shall be representative of the volume and nature of the monitored discharge. If no discharge occurs during the entire monitoring period, it shall be stated on the Discharge Monitoring Report Form (EPA No. 3320-

1) that no discharge or overflow occurred.

For purposes of determining compliance if a single sample is collected for a monthly reporting period, that sample must be less than the monthly average. If multiple samples (greater than 1) are collected in the month than the arithmetic mean of all the samples must be less than the 30-day average limit and no single sample shall exceed the instantaneous maximum limit.

Mine Drainage Outfall: 667 Wastewater Treatment Plant in Ruby Gulch

TABLE 4: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Daily	Grab
Specific Conductance, umho/cm	Daily	Grab
Total Suspended Solids, mg/L	Daily	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab
Cyanide WAD, mg/L	Twice weekly	Grab
Cyanide, total recoverable, mg/L	Twice weekly	Grab
Arsenic, total recoverable, mg/L	Monthly	Grab
Cadmium, total recoverable, mg/L	Monthly	Grab
Copper, total recoverable, mg/L	Monthly	Grab
Iron, total recoverable, mg/L	Monthly	Grab
Manganese, total recoverable, mg/L	Monthly	Grab
Nickel, total recoverable, mg/L	Monthly	Grab
Selenium, total recoverable, mg/L	Monthly	Grab
Zinc, total recoverable, mg/L	Monthly	Grab
Whole Effluent Toxicity (WET)	Quarterly	Grab

[1] See the definitions in Part I.A. of the permit.

Mine Drainage Outfalls: 693 and 696 (Ruby Gulch), 692 (Alder Spur), 695 (Carter Gulch)

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Weekly	Grab
Specific Conductance, umho/cm	Weekly	Grab
Total Suspended Solids, mg/L	Weekly	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency(1)	Type(2)
Cyanide, WAD, mg/L	Weekly	Grab
Cyanide, total recoverable, mg/L	Weekly	Grab
Aluminum, dissolved, mg/L	Weekly	Grab
Arsenic, total recoverable, mg/L	Weekly	Grab
Cadmium, total recoverable, mg/L	Weekly	Grab
Copper, total recoverable, mg/L	Weekly	Grab
Iron, total recoverable, mg/L	Weekly	Grab
Manganese, total recoverable, mg/L	Weekly	Grab
Nickel, total recoverable, mg/L	Weekly	Grab
Selenium, total recoverable, mg/L	Weekly	Grab
Zinc, total recoverable, mg/L	Weekly	Grab

(1) A sample shall be collected at the first sign of a discharge and weekly thereafter.

(2) See the definitions in Part I.A. of the permit.

Surface Water Compliance Sites: S-1 (Glory Hole Gulch), Z-22C (Goslin Flats)

TABLE 6: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type (1)
Effluent Flow Rate, gpm	April(3), May, June, October(3)	Instantaneous
pH, standard units	April(3), May, June, October(3)	Grab
Specific Conductance, umho/cm	April(3), May, June, October(3)	Grab
Total Suspended Solids, mg/L	April(3), May, June, October(3)	Grab
Sulfate, mg/L	April(3), May, June, October(3)	Grab
Hardness, mg/L	April(3), May, June, October(3)	Grab
Nitrate/Nitrite total as N, mg/L	April(3), May, June, October(3)	Grab
Cyanide WAD, mg/L(2)	April(3), May, June, October(3)	Grab
Cyanide, total recoverable, mg/L(2)	April(3), May, June, October(3)	Grab
Aluminum, dissolved, mg/L	April(3), May, June, October(3)	Grab
Arsenic, total recoverable, mg/L	April(3), May, June, October(3)	Grab
Cadmium, total recoverable, mg/L	April(3), May, June, October(3)	Grab
Copper, total recoverable, mg/L	April(3), May, June, October(3)	Grab

TABLE 6: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type (1)
Iron, total recoverable, mg/L	April(3), May, June, October(3)	Grab
Manganese, total recoverable, mg/L	April(3), May, June, October(3)	Grab
Nickel, total recoverable, mg/L	April(3), May, June, October(3)	Grab
Selenium, total recoverable, mg/L	April(3), May, June, October(3)	Grab
Zinc, total recoverable, mg/L	April(3), May, June, October(3)	Grab

(1) See the definitions in Part I.A. of the permit.

(2) This parameter is not required at sampling sites Z-64 and S-1 (Lodgepole Creek).

(3) Late April and October from the 15th to the end of the month.

Storm Water Outfalls - 694, 605, 606, 607, 611, 612, 609, 608, 613 and 614

TABLE 7: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency(1)	Type(2)
Effluent Flow Rate, gpm	Semi-annual	Instantaneous
pH, standard units	Semi-annual	Grab
Specific Conductance, umho/cm	Semi-annual	Grab
Total Suspended Solids, mg/L	Semi-annual	Grab
Nitrate/Nitrite total as N, mg/L	Semi-annual	Grab
Arsenic, total recoverable, mg/L	Semi-annual	Grab
Cadmium, total recoverable and dissolved, mg/L	Semi-annual	Grab
Copper, total recoverable, mg/L	Semi-annual	Grab
Nickel, total recoverable, mg/L	Semi-annual	Grab
Selenium, total recoverable, mg/L	Semi-annual	Grab
Zinc, total recoverable and dissolved, mg/L	Semi-annual	Grab

(1) One sample in May or June during a spring runoff event, and another sample during July, August or September during a thunderstorm event.

(2) See the definitions in Part I.A. of the permit.

Evaluation of Storm Water Quality Monitoring Test Results

Upon the completion of each sampling event, and upon receipt of the sampling test results by the Permittee, the Permittee shall evaluate each parameter test result by comparison with the pertinent benchmark value stated in Table 9 of this Permit, which is entitled "Storm Water Discharge Parameter Benchmark Values. If there is an exceedance of the benchmark value, the Permittee shall evaluate the source and reason of the exceedance, and consider additional BMPs and/or other facility management measures which may need to be initiated to improve the quality of storm water discharges. These measures shall be implemented as necessary and updated in the facility SWPPP as required. A summary of this evaluation of storm water quality data, any exceedances of the benchmark values, and additional BMP and/or other measures which may be necessary shall be attached to the stormwater

Discharge Monitoring Reports (DMR).

TABLE 8: STORM WATER DISCHARGE PARAMETER BENCHMARK VALUES(1)

Parameter Name	Benchmark Level
Total Suspended Solids	100 mg/L
Nitrate + Nitrite Nitrogen	0.68 mg/L
pH	6.0-9.0 s.u.
Arsenic, Total	0.16854 mg/L
Cadmium, Total	0.0159 mg/L
Copper, Total	0.0636 mg/L
Nickel, Total	1.417 mg/L
Selenium, Total	0.2385 mg/L
Zinc, Total	0.117 mg/L

(1) Source of Table: EPA's 10/30/00 Final NPDES Storm Water Multi-Sector General Permit for Industrial Activities

Ground Water Wastewater Discharge Monitoring

Ground Water Compliance Wells - ZL-142 (Ruby Gulch) AG-202, ZL-323 (Alder Gulch/Carter Gulch) ZL-217 (Goslin Flats) and ZL-209 (Glory Hole Gulch)

TABLE 9: GROUND WATER MONITORING REQUIREMENTS

Parameter	Frequency	Type(1)
Static water level, gpm	July and November	Instantaneous
pH, standard units	July and November	Grab
Specific Conductance, umho/cm	July and November	Grab
Sulfate, mg/L	July and November	Grab
Hardness, mg/L	July and November	Grab
Nitrate/Nitrite total as N, mg/L	July and November	Grab
Cyanide WAD, mg/L(2)	July and November	Grab
Cyanide, total recoverable, mg/L(2)	July and November	Grab
Arsenic, total recoverable, mg/L	July and November	Grab
Cadmium, total recoverable, mg/L	July and November	Grab
Iron, total recoverable, mg/L	July and November	Grab
Manganese, total recoverable, mg/L	July and November	Grab
Selenium, total recoverable, mg/L	July and November	Grab
Zinc, total recoverable, mg/L	July and November	Grab

(1) See the definitions in Part I.A. of the permit.

(2) Does not include Lodgepole Creek sampling site Z-209

Whole Effluent Toxicity Testing - Acute Toxicity

Starting in the first calendar quarter following the effective date of the permit, the permittee shall, at least once each calendar quarter conduct an acute static renewal toxicity test on a dechlorinated or prechlorinated composite sample of the effluent. Testing will employ one species per quarter and the permittee shall alternate between the two test species from one quarter to the next. Samples shall be collected on a two day progression; i.e., if the first yearly sample is on a Monday, the second yearly sample shall be on a Wednesday, etc. Saturdays, Sundays and Holidays will be skipped in the progression.

The toxicity tests shall be conducted in general accordance with the procedures set out in the latest revision of Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, EPA-600/4-90/027 and the Region VIII EPA NPDES Acute Test Conditions - Static Renewal Whole Effluent Toxicity Test testing protocols. The permittee shall conduct an acute 48-hour static renewal toxicity test using *Ceriodaphnia sp.* and an acute 96-hour static renewal toxicity test using fathead minnows (*Pimephales promelas*) as the alternating species. The control of pH in the toxicity test utilizing CO2 enriched atmospheres is allowed to prevent rising pH drift. The target pH selected must represent the pH value of the combination of effluent and receiving water at the dilution that corresponds to the toxicity limitation. This target pH value is determined before the actual toxicity sample is collected by preparing a one liter mixture of effluent and receiving water at the concentration representing the toxicity limitation. The mixture is allowed to equilibrate in a beaker at room temperature for three hours. At the end of this period, the pH is measured and reported to the laboratory conducting the toxicity analysis.

The acute toxicity measured in the effluent shall not exceed the effluent limitation expressed in Toxic Units Acute (TUa). If more than 10 percent control mortality occurs, the test is considered invalid and shall be repeated until satisfactory control survival is achieved, unless a specific individual exception is granted by the Department. This exception may be granted if less than 10 percent mortality was observed at the dilutions containing high effluent concentrations.

If acute toxicity exceeds the effluent limitation in a routine test, an additional test shall be conducted within two weeks of the date when the permittee is informed of the exceedance. Should acute toxicity exceed the effluent limitation in the second test, testing shall occur once a month until further notified by the Department.

The quarterly test results from the laboratory shall be reported along with the Discharge Monitoring Report (DMR) form submitted for the end of the reporting calendar quarter (e.g., whole effluent results for the reporting quarter ending March 31 shall be reported with the March DMR due April 28, with the remaining quarterly reports submitted with the June, September, and December DMRs). The format for the laboratory report shall be consistent with the latest revision of the EPA form Region VIII Guidance for Acute Whole Effluent Reporting, and shall include all chemical and physical data as specified.

Toxicity Reduction Evaluation (TRE)
Toxicity Identification Evaluation (TIE)

Should the effluent exceed the acute toxicity limitation in a routine test and is confirmed by the additional test, a TIE-TRE shall be undertaken by the permittee to establish the cause of the toxicity, locate the source(s) of the toxicity, and develop control of, or treatment for the toxicity. Failure to initiate, or conduct an adequate TIE-TRE, or delays in the conduct of such tests, shall not be considered a justification for noncompliance with the whole effluent toxicity limits contained in Part I.C.1 of this permit. A TRE plan needs to be submitted to the permitting authority within 45 days after confirmation of the continuance of the effluent toxicity.

II. MONITORING RECORDING AND REPORTING REQUIREMENTS

A. Representative Sampling. Samples taken in compliance with the monitoring requirements established under Part I shall be collected from the effluent stream prior to discharge into the receiving waters. Samples and measurements shall be representative of the volume and nature of the monitored discharge.

B. Monitoring Procedures. Monitoring must be conducted according to test procedures approved under Part 136, Title 40 of the Code of Federal Regulations, unless other test procedures have been specified in this permit. All flow-measuring and flow-recording devices used in obtaining data submitted in self-monitoring reports must indicate values within 10 percent of the actual flow being measured.

C. Penalties for Tampering. The Montana Water Quality Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than six months, or by both.

D. Reporting of Monitoring Results. Self-monitoring results will be reported monthly. Monitoring results obtained during the previous reporting period shall be summarized and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period. If no discharge occurs during the reporting period, "no discharge" shall be reported. Legible copies of these, and all other reports required herein, shall be signed and certified in accordance with the "Signatory Requirements" (see Part IV.G of this permit), and submitted to the Department and the Regional Administrator at the following addresses:

a) Montana Department of Environmental Quality
Water Protection Bureau
P.O. Box 200901
Helena, Montana 5 9620-0901
Phone: (406) 444-3080

b) U.S. Environmental Protection Agency
301 South Park Avenue
Drawer 10096
Helena, Montana 5 9626
Phone: (406) 441-1123

E. Compliance Schedules. Reports of compliance or noncompliance with, or any progress reports on interim and final requirements contained in any Compliance Schedule of this permit shall be submitted no later than 14 days following each schedule date.

F. Additional Monitoring by the Permittee. If the permittee monitors any pollutant more frequently than required by this permit, using approved analytical methods as specified in this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report. Such increased frequency shall also be indicated.

G. Records Contents. Records of monitoring information shall include:

1. The date, exact place, and time of sampling or measurements;

2. The initials or name(s) of the individual(s) who performed the sampling or measurements;

3. The date(s) analyses were performed;

4. The time analyses were initiated;

5. The initials or name(s) of individual(s) who performed the analyses;

6. References and written procedures, when available, for the analytical techniques or methods used; and

7. The results of such analyses, including the bench sheets, instrument readouts, computer disks or tapes, etc., used to determine these results.

H. Retention of Records. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least three years from the date of the sample, measurement, report or application. This period may be extended by request of the Department at any time. Data collected on site, copies of Discharge Monitoring Reports, and a copy of this MPDES permit must be maintained on site during the duration of activity at the permitted location.

I. Twenty-four Hour Notice of Noncompliance Reporting.

1. The permittee shall report any serious incidents of noncompliance as soon as possible, but no later than twenty-four (24) hours from the time the permittee first became aware of the circumstances. The report shall be made to the Water Protection Bureau at (406) 444-3080 or the Office of Disaster and Emergency Services at (406) 841-3911. The following examples are considered serious incidents:

   a. Any noncompliance which may seriously endanger health or the environment;

   b. Any unanticipated bypass which exceeds any effluent limitation in the permit (See Part III.G of this permit, "Bypass of Treatment Facilities".); or

   c. Any upset which exceeds any effluent limitation in the permit (See Part III.H of this permit, "Upset Conditions".).

2. A written submission shall also be provided within five days of the time that the permittee becomes aware of the circumstances. The written submission shall contain:

   a. A description of the noncompliance and its cause;

   b. The period of noncompliance, including exact dates and times;

   c. The estimated time noncompliance is expected to continue if it has not been corrected; and

   d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

3. The Department may waive the written report on a case-by-case basis if the oral report has been received within 24 hours by the Water Protection Bureau, by phone, (406) 444-3080.

4. Reports shall be submitted to the addresses in Part II.D of this permit, "Reporting of Monitoring Results".

J. Other Noncompliance Reporting. Instances of noncompliance not required to be reported within 24 hours shall be reported at the time that monitoring reports for Part II.D of this permit are submitted. The reports shall contain the information listed in Part II.I.2 of this permit.

K. Inspection and Entry. The permittee shall allow the head of the Department or the Director, or an authorized representative thereof, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

2. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

3. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

4. Sample or monitor at reasonable times, for the purpose of assuring permit compliance, any substances or parameters at any location.

III. COMPLIANCE RESPONSIBILITIES

A. Duty to Comply. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. The permittee shall give the Department or the Regional Administrator advance notice of any planned changes at the permitted facility or of an activity which may result in permit noncompliance.

B. Penalties for Violations of Permit Conditions. The Montana Water Quality Act provides that any person who violates a permit condition of the Act is subject to civil or criminal penalties not to exceed $10,000 per day of such violation. Any person who willfully or negligently violates permit conditions of the Act is subject to a fine of not more than $50,000 per day of violation, or by imprisonment for not more than 2 years, or both, for subsequent convictions. MCA 75-5-611(a) also provides for administrative penalties not to exceed $10,000 for each day of violation and up to a maximum not to exceed $100,000 for any related series of violations. Except as provided in permit conditions on Part III.G of this permit, "Bypass of Treatment Facilities" and Part III.H of this permit, "Upset Conditions", nothing in this permit shall be construed to relieve the permittee of the civil or criminal penalties for noncompliance.

C. Need to Halt or Reduce Activity not a Defense. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

D. Duty to Mitigate. The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

E. Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit. However, the permittee shall operate, as a minimum, one complete set of each main line unit treatment process whether or not this process is needed to achieve permit effluent compliance.

F. Removed Substances. Collected screenings, grit, solids, sludges, or other pollutants removed in the course of treatment shall be disposed of in such a manner so as to prevent any pollutant from entering any waters of the state or creating a health hazard. Any sludges removed from the facility shall be disposed of in accordance with 40 CFR 503, 258 or other applicable rule. EPA and MDEQ shall be notified at least 180 days prior to such disposal taking place.

G. Bypass of Treatment Facilities:

1. Bypass not exceeding limitations. The permittee may allow any bypass to occur which

does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of Parts III.G.2 and III.G.3 of this permit.

2. Notice:

   a. Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least 10 days before the date of the bypass.

   b. Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass as required under Part II.I of this permit, "Twenty-four Hour Reporting".

3. Prohibition of bypass.

   a. Bypass is prohibited and the Department may take enforcement action against a permittee for a bypass, unless:

      (1) The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

      (2) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgement to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

      (3) The permittee submitted notices as required under Part III.G.2 of this permit.

   b. The Department may approve an anticipated bypass, after considering its adverse effects, if the Department determines that it will meet the three conditions listed above in Part III.G.3.a of this permit.

H. Upset Conditions.

1. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with technology based permit effluent limitations if the requirements of Part III.H.2 of this permit are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review (i.e., Permittees will have the opportunity for a judicial determination on any claim of upset only in an enforcement action brought for noncompliance with technology-based permit effluent limitations).

2. Conditions necessary for a demonstration of upset. A permittee who wishes to

establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

a. An upset occurred and that the permittee can identify the cause(s) of the upset;

b. The permitted facility was at the time being properly operated;

c. The permittee submitted notice of the upset as required under Part II.I of this permit, "Twenty-four Hour Notice of Noncompliance Reporting"; and

d. The permittee complied with any remedial measures required under Part III.D of this permit, "Duty to Mitigate".

3. Burden of proof. In any enforcement proceeding, the permittee seeking to establish the occurrence of an upset has the burden of proof.

I. Toxic Pollutants. The permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

J. Changes in Discharge of Toxic Substances. Notification shall be provided to the Department as soon as the permittee knows of, or has reason to believe:

1. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

a. One hundred micrograms per liter (100 μg/*l*);

b. Two hundred micrograms per liter (200 μg/*l*) for acrolein and acrylonitrile; five hundred micrograms per liter (500 μg/*l*) for 2,4-dinitrophenol and for 2-methyl-4, 6-dinitrophenol; and one milligram per liter (1 mg/*l*) for antimony;

c. Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or

d. The level established by the Department in accordance with 40 CFR 122.44(f).

2. That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

a. Five hundred micrograms per liter (500 μg/*l*);

b. One milligram per liter (1 mg/*l*) for antimony;

c. Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or

The level established by the Department in accordance with 40 CFR 122.44(f).

IV. GENERAL REQUIREMENTS

A. Planned Changes. The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when the alteration or addition could significantly change the nature or increase the quantity of pollutant discharged. This notification applies to pollutants which are not subject to effluent limitations in the permit.

B. Anticipated Noncompliance. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

C. Permit Actions. This permit may be revoked, modified and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

D. Duty to Reapply. If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit. The application must be submitted at least 180 days before the expiration date of this permit.

E. Duty to Provide Information. The permittee shall furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for revoking, modifying and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

F. Other Information. When the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or any report to the Department, it shall promptly submit such facts or information with a narrative explanation of the circumstances of the omission or incorrect submittal and why they weren't supplied earlier.

G. Signatory Requirements. All applications, reports or information submitted to the Department or the EPA shall be signed and certified.

1. All permit applications shall be signed as follows:

   a. For a corporation: by a responsible corporate officer;

   b. For a partnership or sole proprietorship: by a general partner or the proprietor, respectively;

   c. For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official.

2. All reports required by the permit and other information requested by the Department shall be signed by a person described above or by a duly authorized representative of that person. A person is considered a duly authorized representative only if:

a. The authorization is made in writing by a person described above and submitted to the Department, and

b. The authorization specified either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility .for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under Part IV.G.2 of this permit is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of Part IV.G.2 of this permit must be submitted to the Department prior to or together with any reports, information, or applications to be signed by an authorized representative.

4. Certification. Any person signing a document under this section shall make the following certification:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

H. Penalties for Falsification of Reports. The Montana Water Quality Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction be punished by a fine of not more than $25,000 per violation, or by imprisonment for not more than six months per violation, or by both.

I. Availability of Reports. Except for data determined to be confidential under 40 CFR Part 2, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. As required by the Clean Water Act, permit applications, permits and effluent data shall not be considered confidential.

J. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Clean Water Act.

K. Property or Water Rights. The issuance of this permit does not convey any property or water rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of federal, state or local laws

or regulations.

L. Severability. The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

M. Transfers. This permit may be automatically transferred to a new permittee if:

1. The current permittee notifies the Department at least 30 days in advance of the proposed transfer date;

2. The notice includes a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage, and liability between them;

3. The Department does not notify the existing permittee and the proposed new permittee of an intent to revoke or modify and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in Part IV.M.2 of this permit; and

4. Required annual and application fees have been paid.

N. Fees. The permittee is required to submit payment of an annual fee as set forth in ARM 17.30.201. If the permittee fails to pay the annual fee within 90 days after the due date for the payment, the Department may:

1. Impose an additional assessment consisting of 15% of the fee plus interest on the required fee computed at the rate established under 15-31-510(3), MCA, or

2. Suspend the processing of the application for a permit or authorization or, if the nonpayment involves an annual permit fee, suspend the permit, certificate or authorization for which the fee is required. The Department may lift suspension at any time up to one year after the suspension occurs if the holder has paid all outstanding fees, including all penalties, assessments and interest imposed under this sub-section. Suspensions are limited to one year, after which the permit will be terminated.

O. Reopener Provisions. This permit may be reopened and modified (following proper administrative procedures) to include the appropriate effluent limitations (and compliance schedule, if necessary), or other appropriate requirements if one or more of the following events occurs:

1. Water Quality Standards: The water quality standards of the receiving water(s) to which the permittee discharges are modified in such a manner as to require different effluent limits than contained in this permit.
2. Water Quality Standards are Exceeded: If it is found that water quality standards or trigger values in the receiving stream are exceeded either for parameters included in the permit or others, the department may modify the effluent limits or water management plan.

3. TMDL or Wasteload Allocation: TMDL requirements or a wasteload allocation is developed and approved by the Department and/or EPA for incorporation in this permit.

4. Water Quality Management Plan: A revision to the current water quality management plan is approved and adopted which calls for different effluent limitations than contained in this permit.

5. Toxic Pollutants: A toxic standard or prohibition is established under Section 307(a) of the Clean Water Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit.

V. SPECIAL CONDITIONS

A. Storm Water Pollution Prevention Plan (SWPPP)

The permittee shall be required to implement the *Storm Water Management Plan for Zorman and Landusky Mine Sites* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated August 1996. This plan was approved by the Department and incorporated into the final *Water Quality improvement and Monitoring Complinance Plan* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated July 1996.

Administrative Requirements for the SWPPP

The plan shall:

1. be retained on site in accordance with Part VI.A. of this permit for active mine sites or retained in the nearest field office for inactive mine sites and oil and gas facilities;

2. be amended whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to state surface waters, or if the SWPPP proves to be ineffective in achieving the general objectives of controlling pollutants in storm water discharges associated with mine reclamation activities. A copy of any plan amendments must be submitted to the Department within 7 working days of any change.

Draft 04-09-01

FACT SHEET

for Proposed Permit Limits (Permit Renewal)

PERMITTEE:	Department of Environmental Quality Landusky Mine P.O. Box 313 Zortman, MT 59546
CONTACT:	Director Montana Department of Environmental Quality P.O. Box 200901 Helena, MT 59620-0901
PHONE:	(406) 444-2544
PERMIT NO.:	MT-0024864
LOCATION:	East half T25N, R24E Phillips County, Montana
RECEIVING WATERS:	Rock Creek/Sullivan Gulch, Mill Gulch, Montana Gulch, King Creek, Swift Gulch and associated ground water systems

A. Status of Permit

MPDES Permit No.: MT-0024864 was issued, on January 3, 1987, to Zortman Mining Inc, (ZMI) Landusky Mine Site for the discharge of storm water to King Creek. The permit expired on October 31, 1991.

In August 1993, a suit was filed in District Court by the State of Montana against ZMI and Pegasus Gold, alleging violations of the Montana Water Quality Act. This was due in part to ARD at the mine sites. The Environmental Protection Agency (EPA) filed suit in Federal District Court in June 1995, alleging that discharges from the mine sites in seven drainages were in violation of the Federal Clean Water Act (Civil Action No. 95-95-BLG-JDS). The State of Montana then filed in Federal District Court and citizen suits were also filed in Federal District Court by Island Mountain Protectors and the Fort Belknap Indian Community Council (Fort Belknap) (Civil Action No. 95-96-BLG-JDS). Settlement discussions among the parties occurred during 1995 and early 1996 to resolve the complaints. A Consent Decree was lodged in Federal District Court on July 22, 1996. After a public comment period, the Consent Decree became effective on September 27, 1996.

A new MPDES permit application was submitted by Zortman Mining, Inc. on December 20, 1996 pursuant to Paragraph 16.a of the Consent Degree. The permit application

identified process water, mine drainage and storm water outfalls. This Fact Sheet and Permit were originally being prepared in response to the permit application and Consent Degree. The Consent Degree is to terminate one year after the effective date of this permit provided that the permittee complies with the terms and conditions of the discharge permit.

Since the 1996 permit application was submitted ZMI has filed for bankruptcy protection. ZMI assets are now being liquidated under Chapter 7. The reclamation bond is held by a surety company and administrated by the Department of Environmental Quality (DEQ). The DEQ and Bureau of Land Management (BLM) are responsible for the reclamation at the site. The 1996 permit application envisioned continued mining at the site and is no longer accurate. A revised permit application is being prepared by the DEQ, which reflects the current reclamation status of the mine. The revised permit will be issued to the DEQ and signed by the current director.

A Metal Mine Reclamation Act (MMRA) operating permit was issued to ZMI on May 17, 1979. A ground water mixing zone was implied in this permit. Although the MMRA permit remains in effect it is no longer applicable to an operating mine and the ground water mixing zone designation and compliance monitoring have been moved to the MPDES permit.

The DEQ and BLM are preparing a draft Environmental Impact Statement (EIS) on the final reclamation plan for the Zortman and Landusky Mine sites. The EIS is scheduled to be finalized in the year 2001. The draft permit and this Fact Sheet shall be attached as an appendix to the draft EIS.

B. Description of the Discharging Facility

Zortman Mining Inc. (ZMI) operated two gold mines: the Zortman Mine and the Landusky Mine from 1979 until 1996. The two mines lie adjacent to one another in the Little Rocky Mountains in Phillips County, Montana. In 1998 ZMI filed for bankruptcy protection and the mine went into a reclamation mode. Prior to the bankruptcy ZMI had constructed two mechanical wastewater treatment systems, one in Montana Gulch and one in Ruby Gulch.

The treatment system in Montana Gulch at the Landusky Mine consists of a mechanical lime addition plant sized to discharge 700 gpm (Outfall 591). Four capture systems located in Montana Gulch, Mill Gulch and Rock Creek/Sullivan Gulch feed wastewater to the mechanical plant. Wastewater originates from beneath waste rock repositories and heap leach facilities located in these drainages. Outfalls have been designated for each capture system in case of a pump failure or large precipitation event (Outfalls 599, 598, 595, and 587). Two passive biological treatment plants are scheduled to be located in King Creek and Swift Gulch (Outfalls 590 and 571). Treatment designs for these passive systems are not yet available (see Special Conditions Section I).

There are eleven storm water outfalls located on site (Outfalls 504, 505, 506, 508, 511, 512, 514, 517, 519, 596 and 597). A storm water management plan was submitted by ZMI to the Department in August of 1996. Storm water BMPs consist of diversion ditches, control berms, sediment basins, check dams, filter fence, etc (see Special Conditions Section I) (Hydrometrics, Inc. 1996).

Reclamation in the form of regarding and capping of waste dumps and leach pads is in process and expected to continue for from 2 to 5 years.

Process water from the heaps, located at both the Landusky and Zortman Mines, is discharged by land application on Goslin Flats during May through October at approximately 100 million gallons a year. Goslin Flats has been designated as a source area of pollutants and an outfall assigned in the Zortman Permit N0.: MT-0024864.

C. Description of Discharge and Discharge Points

1. **Past Discharge Data**

The original permit MPDES No.: MT-0024864 issued to Zortman Mining Inc, Landusky Mine Site was for the discharge of storm water to King Creek. The discharge to King Creek is only one of 24 outfalls currently under consideration at the site. The outfalls include the discharge of mine drainage after treatment, overflows of mine drainage from capture systems, storm water, and ground water. Compliance monitoring is at the designated outfalls, in groundwater monitoring wells, and one surface water monitoring site.

Data is available on all the new proposed outfalls and background surface water and ground water quality in the Water Protection Bureau (WPB) and Environmental Management Bureau (EMB) files. During the life of the original permit only one storm water discharge event took place from the sediment control pond in King Creek.

2. **Surface Water Outfalls:**

Serial Number Description of Mine Drainage Discharge Points

591 At the outfall of a lined collection pond which contains the discharge from a **waste water treatment plant** and the mine drainage from Montana Gulch, emptying to **Montana Gulch** located at approximately 47°54′30 N latitude, 108°37′47 W longitude

571 At the end of a **passive treatment system**, emptying to **Swift Gulch** located at approximately 47°55′34″ N latitude, 108°35′50″ W longitude.

590 At the end of a **passive treatment system**, emptying to **King Creek** located at approximately 47°55□26□ N latitude, 108°37□00□ W longitude.

599 At the end of a **capture trench**, emptying to **Montana Gulch** located at approximately 47°54□19□ N latitude, 108°37□34□ W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

592 At the end of a **staging pond**, emptying to **Montana Gulch** located at approximately 47°54□21□ N latitude, 108°37□34□ W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

598 At the end of a **capture trench**, emptying to **Mill Gulch** located at approximately 47°54□30□ N latitude, 108°36□28□ W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

595 At the end of a **capture trench**, emptying to **Rock Creek/Sullivan Gulch** located at approximately 47°54□41□ N latitude, 108°35□53□ W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

587 At the end of a **capture pond**, emptying to **Rock Creek/Sullivan Gulch** located at approximately 47°54□43□ N latitude, 108°35□54□ W longitude. A discharge from this outfall occurs only as a result of pump failure or storm event, which overwhelms the pumping capacity.

<u>Serial Number Description of Storm Water Discharge Points</u>

508 At the end of a water **sediment basin**, emptying to **Swift Gulch** located at approximately 47°55□18□ N latitude, 108°35□50□ W longitude.

596 At the end of a water **sediment basin**, emptying to **King Creek** located at approximately 47°55□35□ N latitude, 108°37□03□ W longitude.

514 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°55□00□ N latitude, 108°37□31□ W longitude.

597 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°54□29□ N latitude, 108°37□48□ W longitude.

519 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°55□25 N latitude, 108°37□45□ W longitude.

512 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°54□17□ N latitude, 108°37□35□ W longitude.

511 At the end of a **storm water diversion**, emptying to **Mill Gulch** located at approximately 47°54□18□ N latitude, 108°37□09□ W longitude.

517 At the end of a **storm water diversion**, emptying to **Mill Gulch** located at approximately 47°54□37□ N latitude, 108°37□01□ W longitude.

506 At the end of a **storm water diversion**, emptying to **Mill Gulch** located at approximately 47°54□29□ N latitude, 108°36□28□ W longitude.

505 At the end of a **storm water diversion**, emptying to **Sullivan Park** located at approximately 47°54□40□ N latitude, 108°35□52□ W longitude.

504 At the end of a **storm water diversion**, emptying to **Sullivan Park** located at approximately 47°54□55□ N latitude, 108°35□41□ W longitude

3. **Ground Water Outfalls**

Description of Ground Water Discharges, Compliance Wells, and the Surface Water Compliance Site for Swift Gulch

Montana Gulch Seepage to ground water from the 80-82 pad, 83 pad, 85-86 pad, Montana Gulch waste rock repository, Gold Bug Pit backfill, and the Queen Rose Pit located in the upper Montana Gulch drainage. Compliance wells ZL-319 and ZL-113 are located approximately 1.5 miles down gradient (southeast) from the upper drainage divide.

Mill Gulch Seepage to ground water from the Mill Gulch waste rock repository, the Mill Gulch pad and the 87-91 pad. Compliance well ZL-136 is located approximately 1.5 miles down gradient (southwest) from the upper drainage divide.

Rock Creek/Sullivan	Seepage to ground water from the Sullivan Gulch pad and the 87-91 pad. Compliance wells ZL-308 and ZL-310 are located approximately 1.5 miles down gradient (southwest) from the upper drainage divide.
Swift Gulch	Seepage to ground water from a number of seeps and springs in upper Swift Gulch. Seepage will be collected and treated prior to discharge to surface water through Outfall 571. Surface water compliance station L-49 is located approximately 1 mile down the drainage (northwest) from the upper drainage divide.
King Creek	Seepage to ground water from the August #2 waste rock repository located in upper King Creek. Seepage will be collected and treated prior to discharge to surface water through Outfall 590. Compliance well ZL-139 is located approximately 1/2 mile down gradient (west) from the upper drainage divide.

D. Description of Receiving Water

Surface water in the mine area emanates from beneath waste rock repositories, heap leach facilities or springs and seeps effected by mining. The outfalls have been designated at these points except Outfall 591. Outfall 591 is the discharge to Montana Gulch from the wastewater treatment plant. The annual average flow from the treatment plant is 357 gpm and is equal to the combination of the individual capture systems (Outfalls 599, 598, 595, and 587). This annual average flow from the treatment plant was used to calculate the waste load allocations.

Surface Water Outfalls 591, 599, 592, 598, 595, and 587, Storm Water Outfalls 514, 597, 519, 512, 511, 517, 506, 505, and 504, Groundwater Outfalls in Montana Gulch, and Mill Gulch, Rock Creek/Sullivan

Rock Creek and its tributaries, in the area of the discharge are classified as "C-3" [ARM 17.30.610(5)]. Waters classified "C-3" are considered suitable for bathing, swimming, and recreation, growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl, and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agricultural and industrial water supply [ARM 17.30.629(1)].

Rock Creek in the area of discharges is listed on Montana's 1996 303(d) list. In the list Rock Creek is given a low priority for development of total maximum daily loads (TMDLs). The water body numbers for the affected segments are Mill Gulch (MT40EJ002-10), Sullivan Creek (MT40EJ002-11) and Rock Creek (MT40EJ002-9). The probable impaired uses are warm water fishery, drinking water supply, aquatic life support and swimming. The probable causes for impairment in Mill Gulch and Sullivan Creek are metals and pH and the probable source is resource extraction. Causes for impairment in Rock Creek are

listed as metals, nutrients and other habitat alteration and the probable causes are agriculture and resource extraction.

Surface Water Outfalls 571 and Storm Water Outfall 590, 508, and 596, Groundwater Outfalls in King Creek and Swift Gulch

Swift Gulch and King Creek are located in the Peoples Creek drainage. The Peoples Creek drainage in the area of the discharges is classified as "B-1" [ARM 17.30.610(8)(d)]. Waters classified "B-1" are considered suitable for drinking, culinary, and food-processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers; and agricultural and industrial water supply [ARM 17.30.623(1)].

Swift Gulch is a tributary to Big Horn Creek. Big Horn Creek, in the area of the Swift Gulch discharge, is listed on Montana's 1996 303(d) list and is given a low priority for TMDL development. The water body number for the affected segment in Big Horn Creek is MT40I001-3. The probable impaired uses are cold water fishery, drinking water supply and aquatic life support and swimming. The probable causes for impairment are metals and the probable source is listed as resource extraction.

King Creek in the area of the discharge is listed on Montana's 1996 303(d) list and is given a low priority for TMDL development. The water body number for the affected segment in King Creek is MT40I001-4. The probable impaired uses are cold water fishery, drinking water supply and aquatic life support. Causes for impairment in King Creek are listed as metals and other habitat alteration and the probable cause is resource extraction.

On September 21, 2000, a U.S. District Judge issued an order stating that until all necessary total maximum daily loads (TMDLs) under Section 303(d) of the Clean Water Act are established for a particular water quality limited segment (WQLS), the State is not to issue any new permits or increase permitted discharges under the MPDES program. The order was issued in the lawsuit Friends of the Wild Swan v. U.S. EPA, *et al.*, CV 97-35-M-DWM, District of Montana, Missoula Division. This section of the Statement of Basis establishes justification for renewal of this permit under the September 21, 2000 order.

The Montana Water Quality Act authorizes the issuance of point source discharge permits on a listed water body pending completion of a TMDL provided that: 1) the discharge in compliance with the provisions of 75-5-303, MCA (Nondegradation Policy); 2) the discharge will not cause a decline in water quality for the parameters for which the water body is listed; and, 3) the minimum treatment requirements are met.

The limits set in this permit will serve as the TMDLs for each limited parameter. Compliance with the limits set in the permit will insure that water quality standards are met and beneficial uses protected and improved. With completion of all reclamation work and the implementation of all reasonable land soil and water conservation practices the department will consider the delisting of these stream segments.

The discharges to Rock Creek/Sullivan Gulch, Montana Gulch, Mill Gulch, King Creek and Swift Gulch were in existence prior to April 29,1993 and as such are not considered new or increased sources. (ARM 17.30.702(16)) The provisions of the nondegradation policy only apply to new or increased sources. (ARM 17.30.705(1))

Metals and habitat alteration caused by resource extraction impair the streams in the areas of the discharges. This permit sets limits on metals that do not exceed the lowest applicable standards and improve existing water quality. The permit does not allow a discharge, which will cause habitat alteration.

This permit requires minimum treatment limits for TSS and all other parameters if they are more restrictive than water quality based limits.

E. Mixing Zone

The mixing zones for all surface water outfalls are considered instantaneous because they represent the headwaters of the stream and therefore the mean daily flow of the discharge exceeds the 7-day, 10-year low flow of the receiving water. (ARM 17.30.516(3)(d)) The 7-day, 10-year low flow from the capture system outfalls is zero. During storm events when storm water will provide dilution capacity for the discharge from the capture systems the mixing zone shall extends 10 stream widths. (ARM 17.30.516(4))

Ground water mixing zones have been established for each drainage which contain either mine waste rock repositories, leach pads, mine pits, or seeps and springs effected by mine activities. These ground water mixing zones have been established based on the disturbances and the geology at the mine site. Mining took place within the core of a tertiary syenite complex ringed by Paleozoic sedimentary rocks. The mixing zones extend from the headwaters of the drainages within the syenite complex down gradient to the contact with the Paleozoic formations. Compliance wells and the surface water compliance site in Swift Gulch are located near the end of the mixing zones to monitor for compliance with the water quality standards.

F. Proposed Wastewater Effluent Limits

1. Technology Based Effluent Limits

Active mines are subject to technology-based effluent limits for metals (cadmium, copper, lead, mercury and zinc), pH and TSS as defined in 40 CFR Part 440 – Ore Mining and Dressing Point Category Source Category, Subpart J – Copper, Lead, Zinc, Gold, Silver, and Molybdenum Ores Subcategory. The limits which apply in this permit are the New Source Performance Standards (NSPS) [40 CFR 440.104(a)]. Water quality based limits for all parameters, except TSS, in all outfalls were more stringent than the NSPS standards.

Inactive mines are not subject to technology based limits. No WQBEL were developed for TSS, therefore the technology-based limit will be imposed. The TSS limit shall only apply to Outfall 591 where mechanical treatment is proposed.

2. Water Quality Based Effluent Limits

Mine Drainage

Water quality based effluent limits (WQBEL) are generally derived from a dilution model based on the concentration in the receiving stream and the 7-day 10-year low flow and the discharge high flow and concentration. The resulting instream concentrations may not exceed the lowest of either the human health or chronic aquatic life water quality standard from WQB-7 (September 1999).

Because the discharges are the first waters in the drainages no mixing in receiving water is available to input into a dilution model. For this reason no modeling has been done and the WQBEL are equal to the applicable standards. Standards for metals vary based on the hardness of the water. The water quality standards for metals were calculated using a hardness of 400 mg/L for the drainages to Rock Creek/Sullivan Gulch, Mill Gulch, Montana Gulch, and for King Creek. The hardness was based on the data at monitoring sites L-38 (August Drain), L-3 (Gold Bug Adit), L-17 (Lower Montana Gulch Capture System), L-39 (King Creek). These data indicate that the arithmetic mean value for hardness is greater than 400 mg/L. A hardness of 150 mg/L, which is the arithmetic mean of the data at monitoring site L-19 from 1985 through 1995, was used to calculate limits in Swift Gulch.

Mercury was sampled monthly for 17 months from the end 1997 through 1999. These samples failed to detect mercury at a detection limit of 0.0006 mg/L. Because technology based limits do not apply mercury sampling shall not be required in this permit.

Ground water limits are based on the human health standard. Human health standards are not hardness dependent.

The 30-day average limit was set at the standard and 1.5 times that limit was set as the instantaneous maximum.

Storm Water

Storm water limits have been set the same as for the *General Discharge permit for Storm Water Associated with Mining and with Oil and Gas Facilities,* Permit No MT-R300000.

G. Final Wastewater Effluent Limitations

1. **Surface Water Final Effluent Limitations**

Mine Drainage Outfalls: 591, 592, and 599 (Montana Gulch), 598 (Mill Gulch), 587 and 595 (Rock Creek/Sullivan Gulch), and 590 (King Creek)

TABLE 1: NUMERIC SURFACE WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/L) [1]		Allocated Annual Average Load [2] (lb./day)	Rationale
	30-Day Average	Instantaneous Maximum		
Total suspended Solids (TSS)[4]	20	30	86 MG	NSPS Guidelines for Ore Mining (40 CFR 440.104(a))
Aluminum, dissolved	0.087	0.13	0.37 MG 0.023 KC	Water Quality Standard (Chronic Aquatic WQB-7)
Arsenic, total recoverable	0.018	0.027	0.077 MG 0.005 KC	Water Quality Standard (Human Health WQB-7)
Cadmium, total recoverable	0.005	0.008	0.021 MG 0.0013 K C	Water Quality Standard (Human Health WQB-7)
Copper, total recoverable	0.031	0.046	0.13 MG 0.008 KC	Water Quality Standard (Chronic Aquatic WQB-7)
Cyanide, total recoverable[5]	0.0052	0.0076	0.021 MG 0.0014 KC	Water Quality Standard (Chronic Aquatic WQB-7)
Iron, total recoverable	1.0	1.5	4.3 MG 0.26 KC	Water Quality Standard (Chronic Aquatic WQB-7)
Nickel, total recoverable	0.10	0.15	0.43 MG 0.026 KC	Water Quality Standard (Human Health WQB-7)
Nitrate/Nitrite total as N	10	15	43 MG 2.6 KC	Water Quality Standard (Human Health WQB-7)
Selenium, total recoverable	0.005	0.008	0.021 MG 0.0013 KC	Water Quality Standard (Chronic Aquatic WQB-7)
Zinc, total recoverable	0.388	0.582	2.1 MG 0.10 KC	Water Quality Standard (Chronic Aquatic WQB-7)
Whole Effluent Toxicity (WET)[4]	Not Applicable	1.0 TUa	Not Applicable	Water Quality Standard (ARM 17.30.629(2)(h)(I))

(1) See the definitions in Part I.A for explanation of terms.

(2) The allocated loads for Montana Gulch (MG) are based on the 30-day average limit and the annual average values of flow from the water treatment plant Outfall 591of 357 gpm. The allocated loads for King Creek (KC) are based on the 30-day average limit and a flow of 22 gpm at the surface water compliance site L-39 based on the percent of the watershed which contains mine related disturbances (Spectrum 2001). Load limits apply only to Outfall 591, which is the discharge from the wastewater

treatment plant, and Outfall 590, which is the discharge to King Creek. These are the only outfalls expected to discharge.

(3) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

(4) This parameter applies only to the discharge from the water treatment plant (Outfall 591).

(5) This parameter is not required at Outfall 590 in King Creek.

Mine Drainage Outfall and Surface Water Compliance Site: 571 and L-49 (Swift Gulch)

TABLE 2: NUMERIC SURFACE WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/L) [1]		Allocated Annual Average Load [2] (lb./day)	Rationale
	30-Day Average	Instantaneous Maximum		
Aluminum, dissolved	0.087	0.13	0.026	Water Quality Standard (Chronic Aquatic WQB-7)
Arsenic, total recoverable	0.018	0.027	0.005	Water Quality Standard (Human Health WQB-7)
Cadmium, total recoverable	0.0034	0.005	0.001	Water Quality Standard (Chronic Aquatic WQB-7)
Copper, total recoverable	0.0132	0.02	0.004	Water Quality Standard (Chronic Aquatic WQB-7)
Iron, total recoverable	1.0	1.5	0.3	Water Quality Standard (Chronic Aquatic WQB-7)
Nickel, total recoverable	0.073	0.110	0.02	Water Quality Standard (Chronic Aquatic WQB-7)
Nitrate/Nitrite total as N	10	15	3.0	Water Quality Standard (Human Health WQB-7)
Selenium, total recoverable	0.005	0.008	0.0015	Water Quality Standard (Chronic Aquatic WQB-7)
Zinc, total recoverable	0.169	0.253	0.05	Water Quality Standard (Chronic Aquatic WQB-7)

(1) See the definitions in Part I.A for explanation of terms.

(2) The allocated loads for Swift Gulch are based on the 30-day average limit and a flow of 25 gpm at the surface water monitoring site L-19 based on the percent of the watershed which contains mine related disturbances (Spectrum 2001).

(3) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

The pH of the discharge shall remain between 6 and 9 standard units (ARM 17.30.629(2)(f)).

There shall be no discharge of floating solids or visible foam in other than trace amounts (ARM 17.30.629(2)(f))(ARM 17.30.623(2)(f)).

There shall be no discharge, which causes visible oil sheen in the receiving stream (ARM 17.30.637(1)(b)).

There shall be no discharge of wastewater, which reacts or settles to form an objectionable sludge deposit or emulsion beneath the surface of the receiving stream or upon adjoining shorelines (ARM 17.30.637(1)(a)).

There shall be no acute toxicity in the effluent discharged by the facility and no chronic toxicity outside the boundaries of the mixing zone (ARM 17.30.629(2)(h)(i)).

2. **Ground Water Final Compliance Limitations**

Ground Water Compliance Wells: ZL-319 and ZL-113 (Montana Gulch), ZL-136 (Mill Gulch), ZL-308 and ZL-310 (Rock Creek/Sullivan Gulch) and ZL-139 (King Creek)

TABLE 3: NUMERIC GROUND WATER EFFLUENT LIMITATIONS

Parameter[3]	Concentration (mg/L) [1]		Rationale
	30-Day Average	Instantaneous Maximum	
Arsenic, dissolved	0.02	0.03	Water Quality Standard (Human Health WQB-7)
Cadmium, dissolved	0.005	0.008	Water Quality Standard (Human Health WQB-7)
Copper, dissolved	1.3	2.0	Water Quality Standard (Human Health WQB-7)
Cyanide, dissolved[3]	0.2	0.3	Water Quality Standard (Human Health WQB-7)
Nickel, dissolved	0.10	0.15	Water Quality Standard (Human Health WQB-7)
Nitrate/Nitrite total as N	10	15	Water Quality Standard (Human Health WQB-7)
Selenium, dissolved	0.05	0.08	Water Quality Standard (Human Health WQB-7)
Zinc, dissolved	2.1	3.1	Water Quality Standard (Human Health WQB-7)

(1) See the definitions in Part I.A for explanation of terms.

(2) For determination of metals use the dissolved method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983.

(3) This parameter is not required at sampling site ZL-139 in King Creek.

H. Self-Monitoring Requirements

As a minimum, upon the effective date of this permit, the following constituents shall be monitored at the frequency and with the type of measurement indicated; samples or measurements shall be representative of the volume and nature of the monitored discharge. If no discharge occurs during the entire monitoring period, it shall be stated on the Discharge Monitoring Report Form (EPA No. 3320-1) that no discharge or overflow occurred.

For purposes of determining compliance if a single sample is collected for a monthly reporting period, that sample must be less than the monthly average. If multiple samples (greater than 1) are collected in the month than the arithmetic mean of all the samples must be less than the 30-day average limit and no single sample shall exceed the instantaneous maximum limit.

1. **Surface Wastewater Discharge Monitoring**

Mine Drainage Outfall: 591 Wastewater Treatment Plant in Montana Gulch

TABLE 4: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Daily	Grab
Specific Conductance, umho/cm	Daily	Grab
Total Suspended Solids, mg/L	Daily	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab
Cyanide, WAD, mg/L	Twice weekly	Grab
Cyanide, total recoverable, mg/L	Twice weekly	Grab
Aluminum, dissolved, mg/L	Monthly	Grab
Arsenic, total recoverable, mg/L	Monthly	Grab
Cadmium, total recoverable, mg/L	Monthly	Grab
Copper, total recoverable, mg/L	Monthly	Grab
Iron, total recoverable, mg/L	Monthly	Grab
Manganese, total recoverable, mg/L	Monthly	Grab
Nickel, total recoverable, mg/L	Monthly	Grab
Selenium, total recoverable, mg/L	Monthly	Grab
Zinc, total recoverable, mg/L	Monthly	Grab
Whole Effluent Toxicity (WET)	Quarterly	Grab

[1] See the definitions in Part I.A. of the permit.

Mine Drainage Outfalls: 592 and 599 (Montana Gulch), 598 (Mill Gulch), 587 and 595 (Rock Creek/Sullivan Gulch)

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Weekly	Grab
Specific Conductance, umho/cm	Weekly	Grab
Total Suspended Solids, mg/L	Weekly	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab
Cyanide, WAD, mg/L	Weekly	Grab
Cyanide, total recoverable, mg/L	Weekly	Grab
Aluminum, dissolved, mg/L	Weekly	Grab
Arsenic, total recoverable, mg/L	Weekly	Grab
Cadmium, total recoverable, mg/L	Weekly	Grab
Copper, total recoverable, mg/L	Weekly	Grab
Iron, total recoverable, mg/L	Weekly	Grab
Manganese, total recoverable, mg/L	Weekly	Grab
Nickel, total recoverable, mg/L	Weekly	Grab
Selenium, total recoverable, mg/L	Weekly	Grab
Zinc, total recoverable, mg/L	Weekly	Grab

(1) A sample shall be collected at the first sign of a discharge and weekly thereafter.

(2) See the definitions in Part I.A. of the permit.

Mine Drainage Outfalls: 571 Passive Treatment System in Swift Gulch and 590 Passive Treatment System in King Creek

TABLE 6: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type[1]
Effluent Flow Rate, gpm	Monthly	Instantaneous
pH, standard units	Monthly	Grab
Specific Conductance, umho/cm	Monthly	Grab
Total Suspended Solids, mg/L	Monthly	Grab
Hardness, mg/L	Monthly	Grab
Sulfate, mg/L	Monthly	Grab
Nitrate/Nitrite total as N, mg/L	Monthly	Grab
Aluminum, dissolved, mg/L	Monthly	Grab

TABLE 6: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Arsenic, total recoverable, mg/L	Monthly	Grab
Cadmium, total recoverable, mg/L	Monthly	Grab
Copper, total recoverable, mg/L	Monthly	Grab
Iron, total recoverable, mg/L	Monthly	Grab
Manganese, total recoverable, mg/L	Monthly	Grab
Nickel, total recoverable, mg/L	Monthly	Grab
Selenium, total recoverable, mg/L	Monthly	Grab
Zinc, total recoverable, mg/L	Monthly	Grab

(1) See the definitions in Part I.A. of the permit.

Surface Water Compliance Sites: L-49 (Swift Gulch)

TABLE 7: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	April[3], May, June, October[3]	Instantaneous
pH, standard units	April[3], May, June, October[3]	Grab
Specific Conductance, umho/cm	April[3], May, June, October[3]	Grab
Total Suspended Solids, mg/L	April[3], May, June, October[3]	Grab
Sulfate, mg/L	April[3], May, June, October[3]	Grab
Hardness, mg/L	April[3], May, June, October[3]	Grab
Nitrate/Nitrite total as N, mg/L	April[3], May, June, October[3]	Grab
Cyanide WAD, mg/L[2]	April[3], May, June, October[3]	Grab
Cyanide, total recoverable, mg/L[2]	April[3], May, June, October[3]	Grab
Aluminum, dissolved, mg/L	April[3], May, June, October[3]	Grab
Arsenic, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Cadmium, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Copper, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Iron, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Manganese, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Nickel, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Selenium, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Zinc, total recoverable, mg/L	April[3], May, June, October[3]	Grab

(1) See the definitions in Part I.A. of the permit.

(2) This parameter is not required at sampling sites L-39 (King Creek) and L-49 (Swift Gulch).

(3) Late April and October from the 15th to the end of the month.

Storm Water Outfalls: 504, 505, 506, 508, 511, 512, 514, 517, 519, 596 and 597

TABLE 8: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Effluent Flow Rate, gpm	Semi-annual	Instantaneous
pH, standard units	Semi-annual	Grab
Specific Conductance, umho/cm	Semi-annual	Grab
Total Suspended Solids, mg/L	Semi-annual	Grab
Nitrate/Nitrite total as N, mg/L	Semi-annual	Grab
Arsenic, total recoverable, mg/L	Semi-annual	Grab
Cadmium, total recoverable and dissolved, mg/L	Semi-annual	Grab
Copper, total recoverable, mg/L	Semi-annual	Grab
Nickel, total recoverable, mg/L	Semi-annual	Grab
Selenium, total recoverable, mg/L	Semi-annual	Grab
Zinc, total recoverable and dissolved, mg/L	Semi-annual	Grab

(1) One sample in May or June during a spring runoff event, and another sample during July, August or September during a thunderstorm event.

(2) See the definitions in Part I.A. of the permit

2. Evaluation of Storm Water Quality Monitoring Test Results

Upon the completion of each sampling event, and upon receipt of the sampling test results by the Permittee, the Permittee shall evaluate each parameter test result by comparison with the pertinent benchmark value stated in Table 9 of this Permit, which is entitled "Storm Water Discharge Parameter Benchmark Values. If there is an exceedance of the benchmark value, the Permittee shall evaluate the source and reason of the exceedance, and consider additional BMPs and/or other facility management measures, which may need to be initiated to improve the quality of storm water discharges. These measures shall be implemented as necessary and updated in the facility SWPPP as required. A summary of this evaluation of storm water quality data, any exceedances of the benchmark values, and additional BMP and/or other measures, which may be necessary, shall be attached to the storm water Discharge Monitoring Reports (DMR).

TABLE 9: STORM WATER DISCHARGE PARAMETER BENCHMARK VALUES [1]

Parameter Name	Benchmark Level
Total Suspended Solids	100 mg/L
Nitrate + Nitrite Nitrogen	0.68 mg/L
pH	6.0-9.0 s.u.
Arsenic, Total	0.16854 mg/L
Cadmium, Total	0.0159 mg/L
Copper, Total	0.0636 mg/L

Nickel, Total	1.417 mg/L
Selenium, Total	0.2385 mg/L
Zinc, Total	0.117 mg/L

(1) Source of Table: EPA's 10/30/00 Final NPDES Storm Water Multi-Sector General Permit for Industrial Activities

3. **Ground Water Wastewater Discharge Monitoring**

Ground Water Compliance Wells: ZL-319, ZL-113 (Montana Gulch), ZL-136 (Mill Gulch), ZL-308, ZL-310 (Rock Creek/Sullivan Gulch), ZL-139 (King Creek)

TABLE 10: GROUND WATER MONITORING REQUIREMENTS

Parameter	Frequency	Type[1]
Static water level, gpm	July and November	Instantaneous
pH, standard units	July and November	Grab
Specific Conductance, umho/cm	July and November	Grab
Sulfate, mg/L	July and November	Grab
Hardness, mg/L	July and November	Grab
Nitrate/Nitrite total as N, mg/L	July and November	Grab
Cyanide, WAD, mg/L[2]	July and November	Grab
Cyanide, total recoverable, mg/L[2]	July and November	Grab
Arsenic, dissolved, mg/L	July and November	Grab
Cadmium, dissolved, mg/L	July and November	Grab
Iron, dissolved, mg/L	July and November	Grab
Manganese, dissolved, mg/L	July and November	Grab
Selenium, dissolved, mg/L	July and November	Grab
Zinc, dissolved, mg/L	July and November	Grab

(1) See the definitions in Part I.A. of the permit.

(2) This parameter is not required at sampling site ZL-139 in King Creek.

I. Special Conditions

1. **Compliance Schedules (ARM 17.30.1350)**

<u>King Creek Passive Treatment System</u>

A treatment system design shall be developed and reviewed by the state and final designs approved no later than March 31, 2002. The permittee shall notify the

Department within 14 days of this date its compliance or noncompliance with this interim requirement.

The system shall be constructed and limits achieved no later than September 30, 2003. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this final requirement.

Swift Gulch Passive Treatment System

Designs for a passive treatment system in Swift Gulch shall be completed no later than September 30, 2001. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this interim requirement.

Bench scale testing shall be completed no later than September 30, 2002. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this interim requirement.

The system shall be constructed and limits achieved no later than September 30, 2003. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this final requirement.

2. Storm Water Pollution Prevention Plan (SWPPP)

The permittee shall be required to implement the *Storm Water Management Plan for Zortman and Landusky Mine Sites* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated August 1996. This plan was approved by the Department and incorporated into the final *Water Quality improvement and Monitoring Compliance Plan* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated July 1996.

Administrative Requirements for the SWPPP

The plan shall:

1. be retained on site in accordance with Part VI.A. of this permit for active mine sites or retained in the nearest field office for inactive mine sites and oil and gas facilities;

2. be amended whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to state surface waters, or if the SWPPP proves to be ineffective in achieving the general objectives of controlling pollutants in storm water discharges associated with mine reclamation activities. A copy of any plan amendments must be submitted to the Department within 7 working days of any change.

J. Information Sources

While developing the effluent limitations, monitoring requirements and special conditions for the draft permit, the following information sources were used to establish the basis of the draft permit and are hereby referenced:

(1) ARM Title 17, Chapter 30, Sub-chapter 5 - Mixing Zones in Surface and Ground Water.

(2) ARM Title 17, Chapter 30, Sub-chapter 6 - Surface Water Quality Standards.

(3) ARM Title 17, Chapter 30, Sub-chapter 7 - Nondegradation of Water Quality.

(4) ARM Title 17, Chapter 30, Sub-chapter 13 - Montana Pollutant Discharge Elimination System (MPDES) Standards.

(5) Consent Decree, (1996), In the United States District Court for the District of Montana Billings Division, Civil Action No. 95-95-Blg-JDS and No. 95-96-Blg-JDS

(6) Consolidated MPDES Permit Application Form 1 and Short Form 2C, received December 24, 1996.

(7) Environmental Management Bureau Discharge Monitoring Reports.

(8) Harvey, Kevin C., (1998), Background Surface Water Quality at the Zortman Landusky Mine Sites, pp.31.

(9) Hydrometrics, Inc., (1996) Storm Water Management Plan for Zortman and Landusky Mine Sites.

(10) Montana Water Quality Act, MCA 75-5-101 et seq.

(11) Montana (1996) 303(d) List, list of Waterbodies in Need of Total Maximum Daily Load Development

(12) MPDES Permit File No. MT-0000396, effective date of January 3 1987, expiration date of October 31, 1991.

(13) Updated MPDES Permit Application for the Landusky Mine Site Phillips County, Montana, dated December 20, 1996.

PREPARED BY: TERRY WEBSTER, MARCH 2001

Signature Date Finalized

Major Industrial
No Bio-monitoring
Permit No.: MT-0024864

Draft 04-09-01

MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

AUTHORIZATION TO DISCHARGE UNDER THE

MONTANA POLLUTANT DISCHARGE ELIMINATION SYSTEM (MPDES)

In compliance with Mont. Code Annot. Section 75-5-101 *et seq.* and ARM Title 17, Chapter 30, Subchapters 5, 6, 7, and 13.

Department of Environmental Quality
Landusky Mine Site
P.O. Box 313
Zortman, MT 59546

is authorized to discharge from one water treatment plant, seven waste water capture systems, eleven storm water outfalls and five ground water outfalls

to receiving waters named, **Montana Gulch, Swift Gulch, King Creek, Mill Gulch, and Sullivan Park, and associated ground water systems**

in accordance with discharge point(s), effluent limitations, monitoring requirements and other conditions set forth herein. Authorization for discharge is limited to those outfalls specifically listed in the permit. Specified load allocations support and serve to define total maximum daily loads for the receiving waters affected.

This permit shall become effective 30 days after the date of issuance.

This permit and the authorization to discharge shall expire at midnight five years after the date of issuance.

FOR THE MONTANA DEPARTMENT OF
ENVIRONMENTAL QUALITY

Jan P. Sensibaugh
Director
Department of Environmental Quality

Dated this_____ day of

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I. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

A. Definitions.

1. The "**30-day (and monthly) average**," other than for fecal coliform bacteria, is the arithmetic average of all samples collected during a consecutive 30-day period or calendar month, whichever is applicable. Geometric means shall be calculated for fecal coliform bacteria. The calendar month shall be used for purposes of reporting self-monitoring data on discharge monitoring report forms.

2. The "**7-day (and weekly) average**," other than for fecal coliform bacteria, is the arithmetic mean of all samples collected during a consecutive 7-day period or calendar week, whichever is applicable. Geometric means shall be calculated for fecal coliform bacteria. The 7-day averages are applicable only to those effluent characteristics for which there are 7-day average effluent limitations. The calendar week which begins on Sunday and ends on Saturday, shall be used for purposes of reporting self-monitoring data on discharge monitoring report forms. Weekly averages shall be calculated for all calendar weeks in the month that have at least 4 days. For example, if a calendar week overlaps two months, the weekly average is calculated only in the month that contains four or more days of that week.

3. The "**Annual Average Load**" is the arithmetic mean of all 30-day or monthly average loads reported during the calendar year for a monitored parameter.

4. The "**Arithmetic Mean**" or "**Arithmetic Average**" for any set of related values means the summation of the individual values divided by the number of individual values.

5. "**Bypass**" means the intentional diversion of waste streams from any portion of a treatment facility.

6. "**Composite samples**" shall be flow proportioned. The composite sample shall, as a minimum, contain at least four (4) samples collected over the compositing period. Unless otherwise specified, the time between the collection of the first sample and the last sample shall not be less than six (6) hours nor more than 24 hours. Acceptable methods for preparation of composite samples are as follows:

   a. Constant time interval between samples, sample volume proportional to flow rate at time of sampling;

   b. Constant time interval between samples, sample volume proportional to total flow (volume) since last sample. For the first sample, the flow rate at the time the sample was collected may be used;

   c. Constant sample volume, time interval between samples proportional to flow (i.e., sample taken every "X" gallons of flow); and,

   d. Continuous collection of sample, with sample collection rate proportional to flow rate.

7. A "**Daily Maximum Limit**" specifies the maximum allowable discharge of a pollutant

during a calendar day. Expressed as units of mass, the daily discharge is cumulative mass discharged over the course of the day. Expressed as a concentration, it is the arithmetic average of all measurements taken that day.

8. "**Department**" means the Montana Department of Environmental Quality (MDEQ).

9. "**Director**" means the Director of the United States Environmental Protection Agency's Water Management Division.

10. "**EPA**" means the United States Environmental Protection Agency.

11. A "**grab**" sample, for monitoring requirements, is defined as a single "dip and take" sample collected at a representative point in the discharge stream.

12. An "**instantaneous**" measurement, for monitoring requirements, is defined as a single reading, observation, or measurement.

13. "**Load limits**" are mass-based discharge limits expressed in units such as lb./day.

14. A "**mixing zone**" is a limited area of a surface water body or aquifer where initial dilution of a discharge takes place and where water quality changes may occur. Also recognized as an area where certain water quality standards may be exceeded.

15. "**Nondegradation**" means the prevention of a significant change in water quality that lowers the quality of high-quality water for one or more parameters. Also, the prohibition of any increase in discharge that exceeds the limits established under or determined from a permit or approval issued by the Department prior to April 29, 1993.

16. The "**Regional Administrator**" is the administrator of the EPA Region with jurisdiction over federal water pollution control activities in the State of Montana.

17. "**Severe property damage**" means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

18. The term "**TMDL**" means the total maximum daily load limitation of a parameter, representing the estimated assimilative capacity for a water body before other designated uses are adversely affected. Mathematically, it is the sum of wasteload allocations for point sources, load allocations for non-point and natural background sources, and a margin of safety.

19. "**TSS**" is the parameter total suspended solids.

20. "**Upset**" means an exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed

treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

B. Description of Discharge Points

The authorization to discharge provided under this permit is limited to those outfalls specifically designated below as discharge locations. Discharges at any location not authorized under an MPDES permit is a violation of the Montana Water Quality Act and could subject the person(s) responsible for such discharge to penalties under the Act. Knowingly discharging from an unauthorized location or failing to report an unauthorized discharge within a reasonable time from first learning of an unauthorized discharge could subject such person to criminal penalties as provided under Section 75-5-632 of the Montana Water Quality Act.

1. **Surface Water Outfalls:**

Serial Number Description of Mine Drainage Discharge Points

591	At the outfall of a lined collection pond which contains the discharge from a **waste water treatment plant** and the mine drainage from Montana Gulch, emptying to **Montana Gulch** located at approximately 47°54'30" N latitude, 108°37'47" W longitude.
571	At the end of a **passive treatment system**, emptying to **Swift Gulch** located at approximately 47°55'34" N latitude, 108°35'50" W longitude.
590	At the end of a **passive treatment system**, emptying to **King Creek** located at approximately 47°55'26" N latitude, 108°37'00" W longitude.
599	At the end of a **capture trench**, emptying to **Montana Gulch** located at approximately 47°54'19" N latitude, 108°37'34" W longitude.
592	At the end of a **staging pond**, emptying to **Montana Gulch** located at approximately 47°54'21" N latitude, 108°37'34" W longitude.
598	At the end of a **capture trench**, emptying to **Mill Gulch** located at approximately 47°54'30" N latitude, 108°36'28" W longitude.
595	At the end of a **capture trench**, emptying to **Sullivan Park** located at approximately 47°54'41: N latitude, 108°35'53" W longitude.
587	At the end of a **capture pond**, emptying to **Sullivan Park** located at approximately 47°54'43" N latitude, 108°35'54" W longitude.

Serial Number Description of Storm Water Discharge Points

508	At the end of a water **sediment basin**, emptying to **Swift Gulch**

located at approximately 47°55'18" N latitude, 108°35'50" W longitude.

596 At the end of a water **sediment basin**, emptying to **King Creek** located at approximately 47°55'35" N latitude, 108°37'03" W longitude.

514 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°55'00" N latitude, 108°37'31" W longitude.

597 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°54'29" N latitude, 108°37'48" W longitude.

519 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°55'25" N latitude, 108°37'45" W longitude.

512 At the end of a **storm water diversion**, emptying to **Montana Gulch** located at approximately 47°54'17" N latitude, 108°37'35" W longitude.

511 At the end of a **storm water diversion**, emptying to **Mill Gulch** located at approximately 47°54'18" N latitude, 108°37'09" W longitude.

517 At the end of a **storm water diversion**, emptying to **Mill Gulch** located at approximately 47°54'37" N latitude, 108°37'01" W longitude.

506 At the end of a **storm water diversion**, emptying to **Mill Gulch** located at approximately 47°54'29" N latitude, 108°36'28" W longitude.

505 At the end of a **storm water diversion**, emptying to **Sullivan Park** located at approximately 47°54'40" N latitude, 108°35'52" W longitude.

504 At the end of a **storm water diversion**, emptying to **Sullivan Park** located at approximately 47°54'55" N latitude, 108°35'41" W longitude.

2. Ground Water Outfalls

Description of Ground Water Discharges, Compliance Wells, and the Surface Water

Compliance Site for Swift Gulch

Montana Gulch Seepage to ground water from the 80-82 pad, 83 pad, 85-86 pad, Montana Gulch waste rock repository, Gold Bug Pit backfill, and the Queen Rose Pit located in the upper Montana Gulch drainage. Compliance wells ZL-319 and ZL-113 are located approximately 1.5 miles down gradient (southeast).

Mill Gulch Seepage to ground water from the Mill Gulch waste rock repository, the Mill Gulch pad and the 87-91 pad. Compliance well ZL-136 is located approximately 1.5 miles down gradient (southwest).

Rock Creek/Sullivan Seepage to ground water from the Sullivan Gulch pad and the 87-91 pad. Compliance wells ZL-308 and ZL-310 are located approximately 1.5 miles down gradient (southwest).

Swift Gulch Seepage to ground water from a number of seeps and springs in upper Swift Gulch. Seepage will be collected and treated prior to discharge to surface water through Outfall 571. Surface water compliance station L-49 is located approximately 1 mile down the drainage (northwest).

King Creek Seepage to ground water from the August #2 waste rock repository located in upper King Creek. Seepage will be collected and treated prior to discharge to surface water through Outfall 590. Compliance well ZL-139 is located approximately 1/2 mile down gradient (west).

C. Specific Limitations

Wastewater Effluent Limitations

Effective immediately and lasting through the term of the permit, the quality of effluent discharged by the facility shall, as a minimum, meet the limitations as set forth below:

Mine Drainage Outfalls: 591, 592 and 599 (Montana Gulch), 598 (Mill Gulch), 587 and 595 (Sulivan Gulch), and 590 (King Creek)

TABLE 1: NUMERIC SURFACE WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Total suspended Solids (TSS)[4]	20	30
Aluminum, dissolved	0.087	0.13
Arsenic, total recoverable	0.018	0.027
Cadmium, total recoverable	0.005	0.008
Copper, total recoverable	0.031	0.046
Cyanide, total recoverable[3]	0.0052	0.0076
Iron, total recoverable	1.0	1.5
Nickel, total recoverable	0.1	0.15

TABLE 1: NUMERIC SURFACE WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Nitrate/Nitrite as N, total recoverable	10	15
Selenium, total recoverable	0.005	0.008
Zinc, total recoverable	0.388	0.582
Whole Effluent Toxicity (WET)[4]	Not Applicable	1.0 TUa

(1) See the definitions in Part I.A for explanation of terms.

(2) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

(3) This parameter is not required at Outfall 590 in King Creek.

(4) This parameter applies only to the discharge from the water treatment plant (Outfall 591).

Mine Drainage Outfall and Surface Water Compliance Site: 571 and L-49 (Swift Gulch)

TABLE 2: NUMERIC SURFACE WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Aluminum, dissolved	0.087	0.13
Arsenic, total recoverable	0.018	0.027
Cadmium, total recoverable	0.0034	0.005
Copper, total recoverable	0.0132	0.02
Iron, total recoverable	1.0	1.5
Nickel, total recoverable	0.073	0.110
Nitrate/Nitrite as N, total recoverable	10	15
Selenium, total recoverable	0.005	0.008
Zinc, total recoverable	0.169	0.253

(1) See the definitions in Part I.A for explanation of terms.

(2) For determination of metals, except aluminum, use Total Recoverable method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).

The pH of the discharge shall remain between 6 and 9 standard units.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

There shall be no discharge which causes visible oil sheen in the receiving stream.
There shall be no discharge of wastewater, which reacts or settles to form an objectionable sludge deposit or emulsion beneath the surface of the receiving stream or upon adjoining shorelines.

There shall be no acute toxicity in the effluent discharged by the facility and no chronic

toxicity outside the boundaries of the mixing zone.

Ground Water Compliance Wells: ZL-319 and ZL-113 (Montana Gulch), ZL-136 (Mill Gulch), ZL-308 and ZL-310 (Rock Creek/Sullivan Gulch) and ZL-139 (King Creek)

TABLE 3: NUMERIC GROUND WATER EFFLUENT LIMITS

Parameter[2]	Concentration (mg/l) [1]	
	30-Day Average	Instantaneous Maximum
Arsenic, total recoverable	0.020	0.030
Cadmium, total recoverable	0.005	0.008
Copper, total recoverable	1.3	2.0
Cyanide, total recoverable[3]	0.2	0.3
Nickel, total recoverable	0.10	0.15
Nitrate/Nitrite Total as N	10	15
Selenium, total recoverable	0.05	0.08
Zinc, total recoverable	2.1	3.1

(1) See the definitions in Part I.A for explanation of terms.
(2) For determination of metals use the dissolved method of digestion in Methods for the Chemical Analysis of Water and Wastes, Section 4.1. EPA-600/4-79-020, revised 1983. Use EPA or Department approved methods of analyses after digestion (40 CFR 136.3).
(3) This parameter is not required at sampling site ZL-139 in King Creek.

D. Self-Monitoring Requirements

As a minimum, upon the effective date of this permit, the following constituents shall be monitored at the frequency and with the type of measurement indicated; samples or measurements shall be representative of the volume and nature of the monitored discharge. If no discharge occurs during the entire monitoring period, it shall be stated on the Discharge Monitoring Report Form (EPA No. 3320-1) that no discharge or overflow occurred.

For purposes of determining compliance if a single sample is collected for a monthly reporting period, that sample must be less than the monthly average. If multiple samples (greater than 1) are collected in the month than the arithmetic mean of all the samples must be less than the 30-day average limit and no single sample shall exceed the instantaneous maximum limit.

1. **Surface Wastewater Discharge Monitoring**

Mine Drainage Outfall: 591 Wastewater Treatment Plant in Montana Gulch

TABLE 4: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]

TABLE 4: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Daily	Grab
Specific Conductance, umho/cm	Daily	Grab
Total Suspended Solids, mg/L	Daily	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab
Cyanide, WAD, mg/L	Twice weekly	Grab
Cyanide, total recoverable, mg/L	Twice weekly	Grab
Aluminum, dissolved, mg/L	Monthly	Grab
Arsenic, total recoverable, mg/L	Monthly	Grab
Cadmium, total recoverable, mg/L	Monthly	Grab
Copper, total recoverable, mg/L	Monthly	Grab
Iron, total recoverable, mg/L	Monthly	Grab
Manganese, total recoverable, mg/L	Monthly	Grab
Nickel, total recoverable, mg/L	Monthly	Grab
Selenium, total recoverable, mg/L	Monthly	Grab
Zinc, total recoverable, mg/L	Monthly	Grab
Whole Effluent Toxicity (WET)	Quarterly	Grab

[1] See the definitions in Part I.A. of the permit.

Mine Drainage Outfalls: 592 and 599 (Montana Gulch), 598 (Mill Gulch), 587 and 595 (Rock Creek/Sullivan Gulch)

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Effluent Flow Rate, gpm	Weekly	Instantaneous
pH, standard units	Weekly	Grab
Specific Conductance, umho/cm	Weekly	Grab
Total Suspended Solids, mg/L	Weekly	Grab
Sulfate, mg/L	Weekly	Grab
Hardness, mg/L	Weekly	Grab
Nitrate/Nitrite total as N, mg/L	Weekly	Grab
Cyanide, WAD, mg/L	Weekly	Grab
Cyanide, total recoverable, mg/L	Weekly	Grab
Aluminum, dissolved, mg/L	Weekly	Grab
Arsenic, total recoverable, mg/L	Weekly	Grab
Cadmium, total recoverable, mg/L	Weekly	Grab

TABLE 5: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency(1)	Type(2)
Copper, total recoverable, mg/L	Weekly	Grab
Iron, total recoverable, mg/L	Weekly	Grab
Manganese, total recoverable, mg/L	Weekly	Grab
Nickel, total recoverable, mg/L	Weekly	Grab
Selenium, total recoverable, mg/L	Weekly	Grab
Zinc, total recoverable, mg/L	Weekly	Grab

(1) A sample shall be collected at the first sign of a discharge and weekly thereafter.

(2) See the definitions in Part I.A. of the permit.

Mine Drainage Outfalls: 571 Passive Treatment System in Swift Gulch and 590 Passive Treatment System in King Creek

TABLE 6: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type (1)
Effluent Flow Rate, gpm	Monthly	Instantaneous
pH, standard units	Monthly	Grab
Specific Conductance, umho/cm	Monthly	Grab
Total Suspended Solids, mg/L	Monthly	Grab
Hardness, mg/L	Monthly	Grab
Sulfate, mg/L	Monthly	Grab
Nitrate/Nitrite total as N, mg/L	Monthly	Grab
Aluminum, dissolved, mg/L	Monthly	Grab
Arsenic, total recoverable, mg/L	Monthly	Grab
Cadmium, total recoverable, mg/L	Monthly	Grab
Copper, total recoverable, mg/L	Monthly	Grab
Iron, total recoverable, mg/L	Monthly	Grab
Manganese, total recoverable, mg/L	Monthly	Grab
Nickel, total recoverable, mg/L	Monthly	Grab
Selenium, total recoverable, mg/L	Monthly	Grab
Zinc, total recoverable, mg/L	Monthly	Grab

(1) See the definitions in Part I.A. of the permit.

Surface Water Compliance Sites: D-7 (Montana Gulch), L-22 (Mill Gulch), RCSS-10 (Rock Creek/Sullivan Gulch), L-39 (King Creek) and L-49 (Swift Gulch)

TABLE 7: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency	Type [1]
Effluent Flow Rate, gpm	April[3], May, June, October[3]	Instantaneous
pH, standard units	April[3], May, June, October[3]	Grab
Specific Conductance, umho/cm	April[3], May, June, October[3]	Grab
Total Suspended Solids, mg/L	April[3], May, June, October[3]	Grab
Sulfate, mg/L	April[3], May, June, October[3]	Grab
Hardness, mg/L	April[3], May, June, October[3]	Grab
Nitrate/Nitrite total as N, mg/L	April[3], May, June, October[3]	Grab
Cyanide WAD, mg/L[2]	April[3], May, June, October[3]	Grab
Cyanide, total recoverable, mg/L[2]	April[3], May, June, October[3]	Grab
Aluminum, dissolved, mg/L	April[3], May, June, October[3]	Grab
Arsenic, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Cadmium, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Copper, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Iron, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Manganese, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Nickel, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Selenium, total recoverable, mg/L	April[3], May, June, October[3]	Grab
Zinc, total recoverable, mg/L	April[3], May, June, October[3]	Grab

(1) See the definitions in Part I.A. of the permit.

(2) This parameter is not required at sampling sites L-39 (King Creek) and L-49 (Swift Gulch).

(3) Late April and October from the 15th to the end of the month.

Storm Water Outfalls: 504, 505, 506, 508, 511, 512, 514, 517, 519, 596 and 597

TABLE 8: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Effluent Flow Rate, gpm	Semi-annual	Instantaneous
pH, standard units	Semi-annual	Grab
Specific Conductance, umho/cm	Semi-annual	Grab

TABLE 8: EFFLUENT MONITORING REQUIREMENTS

Parameter	Frequency[1]	Type[2]
Total Suspended Solids, mg/L	Semi-annual	Grab
Nitrate/Nitrite total as N, mg/L	Semi-annual	Grab
Arsenic, total recoverable, mg/L	Semi-annual	Grab
Cadmium, total recoverable and dissolved, mg/L	Semi-annual	Grab
Copper, total recoverable, mg/L	Semi-annual	Grab
Nickel, total recoverable, mg/L	Semi-annual	Grab
Selenium, total recoverable, mg/L	Semi-annual	Grab
Zinc, total recoverable and dissolved, mg/L	Semi-annual	Grab

(1) One sample in May or June during a spring runoff event, and another sample during July, August or September during a thunderstorm event.

(2) See the definitions in Part I.A. of the permit

2. Evaluation of Storm Water Quality Monitoring Test Results

Upon the completion of each sampling event, and upon receipt of the sampling test results by the Permittee, the Permittee shall evaluate each parameter test result by comparison with the pertinent benchmark value stated in Table 9 of this Permit, which is entitled "Storm Water Discharge Parameter Benchmark Values. If there is an exceedance of the benchmark value, the Permittee shall evaluate the source and reason of the exceedance, and consider additional BMPs and/or other facility management measures which may need to be initiated to improve the quality of storm water discharges. These measures shall be implemented as necessary and updated in the facility SWPPP as required. A summary of this evaluation of storm water quality data, any exceedances of the benchmark values, and additional BMP and/or other measures which may be necessary shall be attached to the stormwater Discharge Monitoring Reports (DMR).

TABLE 9: STORM WATER DISCHARGE PARAMETER BENCHMARK VALUES

Parameter Name	Benchmark Level
Total Suspended Solids	100 mg/L
Nitrate + Nitrite Nitrogen	0.68 mg/L
pH	6.0-9.0 s.u.
Arsenic, Total	0.16854 mg/L
Cadmium, Total	0.0159 mg/L
Copper, Total	0.0636 mg/L
Nickel, Total	1.417 mg/L
Selenium, Total	0.2385 mg/L
Zinc, Total	0.117 mg/L

(1) Source of Table: EPA's 10/30/00 Final NPDES Storm Water Multi-Sector General Permit for Industrial Activities

3. Ground Water Wastewater Discharge Monitoring

Ground Water Compliance Wells: ZL-319, ZL-113 (Montana Gulch), ZL-136 (Mill Gulch), ZL-308, ZL-310 (Rock Creek/Sullivan Gulch), ZL-139 (King Creek)

TABLE 9: GROUND WATER MONITORING REQUIREMENTS

Parameter	Frequency	Type(1)
Static water level, gpm	July and November	Instantaneous
pH, standard units	July and November	Grab
Specific Conductance, umho/cm	July and November	Grab
Sulfate, mg/L	July and November	Grab
Hardness, mg/L	July and November	Grab
Nitrate/Nitrite total as N, mg/L	July and November	Grab
Cyanide, WAD, mg/L(2)	July and November	Grab
Cyanide, total recoverable, mg/L(2)	July and November	Grab
Arsenic, total recoverable, mg/L	July and November	Grab
Cadmium, total recoverable, mg/L	July and November	Grab
Iron, total recoverable, mg/L	July and November	Grab
Manganese, total recoverable, mg/L	July and November	Grab
Selenium, total recoverable, mg/L	July and November	Grab
Zinc, total recoverable, mg/L	July and November	Grab

(1) See the definitions in Part I.A. of the permit.

(2) This parameter is not required at sampling site ZL-139 in King Creek.

4. Whole Effluent Toxicity Testing - Acute Toxicity

Starting in the first calendar quarter following the effective date of the permit, the permittee shall, at least once each calendar quarter conduct an acute static renewal toxicity test on a dechlorinated or prechlorinated composite sample of the effluent. Testing will employ one species per quarter and the permittee shall alternate between the two test species from one quarter to the next. Samples shall be collected on a two day progression; i.e., if the first yearly sample is on a Monday, the second yearly sample shall be on a Wednesday, etc. Saturdays, Sundays and Holidays will be skipped in the progression.

The toxicity tests shall be conducted in general accordance with the procedures set out in the latest revision of Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, EPA-600/4-90/027 and the Region VIII EPA NPDES Acute Test Conditions - Static Renewal Whole Effluent Toxicity Test testing protocols. The permittee shall conduct an acute 48-hour static renewal toxicity test using *Ceriodaphnia sp.* and an acute 96-hour static renewal toxicity test using fathead minnows (*Pimephales promelas*) as the alternating species. The control of pH in the toxicity test utilizing CO2 enriched atmospheres is allowed to prevent rising pH drift. The target pH selected must represent the pH value of the combination of effluent and receiving water at the dilution that corresponds to the toxicity limitation. This target pH value is determined before the actual toxicity sample is collected by preparing a

one liter mixture of effluent and receiving water at the concentration representing the toxicity limitation. The mixture is allowed to equilibrate in a beaker at room temperature for three hours. At the end of this period, the pH is measured and reported to the laboratory conducting the toxicity analysis.

The acute toxicity measured in the effluent shall not exceed the effluent limitation expressed in Toxic Units Acute (TUa). If more than 10 percent control mortality occurs, the test is considered invalid and shall be repeated until satisfactory control survival is achieved, unless a specific individual exception is granted by the Department. This exception may be granted if less than 10 percent mortality was observed at the dilutions containing high effluent concentrations.

If acute toxicity exceeds the effluent limitation in a routine test, an additional test shall be conducted within two weeks of the date when the permittee is informed of the exceedance. Should acute toxicity exceed the effluent limitation in the second test, testing shall occur once a month until further notified by the Department.

The quarterly test results from the laboratory shall be reported along with the Discharge Monitoring Report (DMR) form submitted for the end of the reporting calendar quarter (e.g., whole effluent results for the reporting quarter ending March 31 shall be reported with the March DMR due April 28, with the remaining quarterly reports submitted with the June, September, and December DMRs). The format for the laboratory report shall be consistent with the latest revision of the EPA form Region VIII Guidance for Acute Whole Effluent Reporting, and shall include all chemical and physical data as specified.

5. Toxicity Reduction Evaluation (TRE)
Toxicity Identification Evaluation (TIE)

Should the effluent exceed the acute toxicity limitation in a routine test and is confirmed by the additional test, a TIE-TRE shall be undertaken by the permittee to establish the cause of the toxicity, locate the source(s) of the toxicity, and develop control of, or treatment for the toxicity. Failure to initiate, or conduct an adequate TIE-TRE, or delays in the conduct of such tests, shall not be considered a justification for noncompliance with the whole effluent toxicity limits contained in Part I.C.1 of this permit. A TRE plan needs to be submitted to the permitting authority within 45 days after confirmation of the continuance of the effluent toxicity.

MONITORING RECORDING AND REPORTING REQUIREMENTS

A. Representative Sampling. Samples taken in compliance with the monitoring requirements established under Part I shall be collected from the effluent stream prior to discharge into the receiving waters. Samples and measurements shall be representative of the volume and nature of the monitored discharge.

B. Monitoring Procedures. Monitoring must be conducted according to test procedures approved under Part 136, Title 40 of the Code of Federal Regulations, unless other test procedures have been specified in this permit. All flow-measuring and flow-recording devices used in obtaining data submitted in self-monitoring reports must indicate values within 10 percent of the actual

flow being measured.

C. Penalties for Tampering. The Montana Water Quality Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than six months, or by both.

D. Reporting of Monitoring Results. Self-monitoring results will be reported monthly. Monitoring results obtained during the previous reporting period shall be summarized and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period. If no discharge occurs during the reporting period, "no discharge" shall be reported. Legible copies of these, and all other reports required herein, shall be signed and certified in accordance with the "Signatory Requirements" (see Part IV.G of this permit), and submitted to the Department and the Regional Administrator at the following addresses:

a) Montana Department of Environmental Quality
Water Protection Bureau
P.O. Box 200901
Helena, Montana 5 9620-0901
Phone: (406) 444-3080

b) U.S. Environmental Protection Agency
301 South Park Avenue
Drawer 10096
Helena, Montana 5 9626
Phone: (406) 441-1123

E. Compliance Schedules. Reports of compliance or noncompliance with, or any progress reports on interim and final requirements contained in any Compliance Schedule of this permit shall be submitted no later than 14 days following each schedule date.

F. Additional Monitoring by the Permittee. If the permittee monitors any pollutant more frequently than required by this permit, using approved analytical methods as specified in this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report. Such increased frequency shall also be indicated.

G. Records Contents. Records of monitoring information shall include:

1. The date, exact place, and time of sampling or measurements;

2. The initials or name(s) of the individual(s) who performed the sampling or measurements;

3. The date(s) analyses were performed;

4. The time analyses were initiated;

5. The initials or name(s) of individual(s) who performed the analyses;

6. References and written procedures, when available, for the analytical techniques or methods used; and

7. The results of such analyses, including the bench sheets, instrument readouts, computer disks or tapes, etc., used to determine these results.

H. Retention of Records. The permittee shall retain records of all monitoring information, including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least three years from the date of the sample, measurement, report or application. This period may be extended by request of the Department at any time. Data collected on site, copies of Discharge Monitoring Reports, and a copy of this MPDES permit must be maintained on site during the duration of activity at the permitted location.

I. Twenty-four Hour Notice of Noncompliance Reporting.

1. The permittee shall report any serious incidents of noncompliance as soon as possible, but no later than twenty-four (24) hours from the time the permittee first became aware of the circumstances. The report shall be made to the Water Protection Bureau at (406) 444-3080 or the Office of Disaster and Emergency Services at (406) 841-3911. The following examples are considered serious incidents:

   a. Any noncompliance which may seriously endanger health or the environment;

   b. Any unanticipated bypass which exceeds any effluent limitation in the permit (See Part III.G of this permit, "Bypass of Treatment Facilities".); or

   c. Any upset which exceeds any effluent limitation in the permit (See Part III.H of this permit, "Upset Conditions".).

2. A written submission shall also be provided within five days of the time that the permittee becomes aware of the circumstances. The written submission shall contain:

   a. A description of the noncompliance and its cause;

   b. The period of noncompliance, including exact dates and times;

   c. The estimated time noncompliance is expected to continue if it has not been corrected; and

   d. Steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

3. The Department may waive the written report on a case-by-case basis if the oral report has been received within 24 hours by the Water Protection Bureau, by phone, (406) 444-3080.

4. Reports shall be submitted to the addresses in Part II.D of this permit, "Reporting of Monitoring Results".

J. Other Noncompliance Reporting. Instances of noncompliance not required to be reported

within 24 hours shall be reported at the time that monitoring reports for Part II.D of this permit are submitted. The reports shall contain the information listed in Part II.I.2 of this permit.

K. Inspection and Entry. The permittee shall allow the head of the Department or the Director, or an authorized representative thereof, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

2. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

3. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

4. Sample or monitor at reasonable times, for the purpose of assuring permit compliance, any substances or parameters at any location.

III. COMPLIANCE RESPONSIBILITIES

A. Duty to Comply. The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application. The permittee shall give the Department or the Regional Administrator advance notice of any planned changes at the permitted facility or of an activity which may result in permit noncompliance.

B. Penalties for Violations of Permit Conditions. The Montana Water Quality Act provides that any person who violates a permit condition of the Act is subject to civil or criminal penalties not to exceed $10,000 per day of such violation. Any person who willfully or negligently violates permit conditions of the Act is subject to a fine of not more than $50,000 per day of violation, or by imprisonment for not more than 2 years, or both, for subsequent convictions. MCA 75-5-611(a) also provides for administrative penalties not to exceed $10,000 for each day of violation and up to a maximum not to exceed $100,000 for any related series of violations. Except as provided in permit conditions on Part III.G of this permit, "Bypass of Treatment Facilities" and Part III.H of this permit, "Upset Conditions", nothing in this permit shall be construed to relieve the permittee of the civil or criminal penalties for noncompliance.

C. Need to Halt or Reduce Activity not a Defense. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

D. Duty to Mitigate. The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

E. Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems which are installed by a permittee only when the operation is necessary to achieve compliance with the conditions of the permit. However, the permittee shall operate, as a minimum, one complete set of each main line unit treatment process whether or not this process is needed to achieve permit effluent compliance.

F. Removed Substances. Collected screenings, grit, solids, sludges, or other pollutants removed in the course of treatment shall be disposed of in such a manner so as to prevent any pollutant from entering any waters of the state or creating a health hazard. Any sludges removed from the facility shall be disposed of in accordance with 40 CFR 503, 258 or other applicable rule. EPA and MDEQ shall be notified at least 180 days prior to such disposal taking place.

G. Bypass of Treatment Facilities:

1. Bypass not exceeding limitations. The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to assure efficient operation. These bypasses are not subject to the provisions of Parts III.G.2 and III.G.3 of this permit.

2. Notice:

   a. Anticipated bypass. If the permittee knows in advance of the need for a bypass, it shall submit prior notice, if possible at least 10 days before the date of the bypass.

   b. Unanticipated bypass. The permittee shall submit notice of an unanticipated bypass as required under Part II.I of this permit, "Twenty-four Hour Reporting".

3. Prohibition of bypass.

   a. Bypass is prohibited and the Department may take enforcement action against a permittee for a bypass, unless:

      (1) The bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

      (2) There were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate back-up equipment should have been installed in the exercise of reasonable engineering judgement to prevent a bypass which occurred during normal periods of equipment downtime or preventive maintenance; and

(3) The permittee submitted notices as required under Part III.G.2 of this permit.

b. The Department may approve an anticipated bypass, after considering its adverse effects, if the Department determines that it will meet the three conditions listed above in Part III.G.3.a of this permit.

H. Upset Conditions.

1. Effect of an upset. An upset constitutes an affirmative defense to an action brought for noncompliance with technology based permit effluent limitations if the requirements of Part III.H.2 of this permit are met. No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review (i.e., Permittees will have the opportunity for a judicial determination on any claim of upset only in an enforcement action brought for noncompliance with technology-based permit effluent limitations).

2. Conditions necessary for a demonstration of upset. A permittee who wishes to establish the affirmative defense of upset shall demonstrate, through properly signed, contemporaneous operating logs, or other relevant evidence that:

a. An upset occurred and that the permittee can identify the cause(s) of the upset;

b. The permitted facility was at the time being properly operated;

c. The permittee submitted notice of the upset as required under Part II.I of this permit, "Twenty-four Hour Notice of Noncompliance Reporting"; and

d. The permittee complied with any remedial measures required under Part III.D of this permit, "Duty to Mitigate".

3. Burden of proof. In any enforcement proceeding, the permittee seeking to establish the occurrence of an upset has the burden of proof.

I. Toxic Pollutants. The permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish those standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

J. Changes in Discharge of Toxic Substances. Notification shall be provided to the Department as soon as the permittee knows of, or has reason to believe:

1. That any activity has occurred or will occur which would result in the discharge, on a routine or frequent basis, of any toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels".

a. One hundred micrograms per liter (100 $\mu g/l$);
b. Two hundred micrograms per liter (200 $\mu g/l$) for acrolein and acrylonitrile; five

hundred micrograms per liter (500 μg/*l*) for 2,4-dinitrophenol and for 2-methyl-4, 6-dinitrophenol; and one milligram per liter (1 mg/*l*) for antimony;

c. Five (5) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or

d. The level established by the Department in accordance with 40 CFR 122.44(f).

2. That any activity has occurred or will occur which would result in any discharge, on a non-routine or infrequent basis, of a toxic pollutant which is not limited in the permit, if that discharge will exceed the highest of the following "notification levels":

a. Five hundred micrograms per liter (500 μg/*l*);

b. One milligram per liter (1 mg/*l*) for antimony;

c. Ten (10) times the maximum concentration value reported for that pollutant in the permit application in accordance with 40 CFR 122.21(g)(7); or

The level established by the Department in accordance with 40 CFR 122.44(f).

IV. GENERAL REQUIREMENTS

A. Planned Changes. The permittee shall give notice to the Department as soon as possible of any planned physical alterations or additions to the permitted facility. Notice is required only when the alteration or addition could significantly change the nature or increase the quantity of pollutant discharged. This notification applies to pollutants which are not subject to effluent limitations in the permit.

B. Anticipated Noncompliance. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

C. Permit Actions. This permit may be revoked, modified and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

D. Duty to Reapply. If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit. The application must be submitted at least 180 days before the expiration date of this permit.

E. Duty to Provide Information. The permittee shall furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for revoking, modifying and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

F. Other Information. When the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or any report to the Department, it shall promptly submit such facts or information with a narrative explanation of the circumstances of the omission or incorrect submittal and why they weren't supplied earlier.

G. Signatory Requirements. All applications, reports or information submitted to the Department or the EPA shall be signed and certified.

1. All permit applications shall be signed as follows:

   a. For a corporation: by a responsible corporate officer;

   b. For a partnership or sole proprietorship: by a general partner or the proprietor, respectively;

   c. For a municipality, State, Federal, or other public agency: by either a principal executive officer or ranking elected official.

2. All reports required by the permit and other information requested by the Department shall be signed by a person described above or by a duly authorized representative of that person. A person is considered a duly authorized representative only if:

   a. The authorization is made in writing by a person described above and submitted to the Department, and

   b. The authorization specified either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

3. Changes to authorization. If an authorization under Part IV.G.2 of this permit is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of Part IV.G.2 of this permit must be submitted to the Department prior to or together with any reports, information, or applications to be signed by an authorized representative.

4. Certification. Any person signing a document under this section shall make the following certification:

   "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and

belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

H. Penalties for Falsification of Reports. The Montana Water Quality Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance shall, upon conviction be punished by a fine of not more than $25,000 per violation, or by imprisonment for not more than six months per violation, or by both.

I. Availability of Reports. Except for data determined to be confidential under 40 CFR Part 2, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department. As required by the Clean Water Act, permit applications, permits and effluent data shall not be considered confidential.

J. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Clean Water Act.

K. Property or Water Rights. The issuance of this permit does not convey any property or water rights of any sort, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations.

L. Severability. The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

M. Transfers. This permit may be automatically transferred to a new permittee if:

1. The current permittee notifies the Department at least 30 days in advance of the proposed transfer date;

2. The notice includes a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage, and liability between them;

3. The Department does not notify the existing permittee and the proposed new permittee of an intent to revoke or modify and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in Part IV.M.2 of this permit; and

4. Required annual and application fees have been paid.

N. Fees. The permittee is required to submit payment of an annual fee as set forth in ARM 17.30.201. If the permittee fails to pay the annual fee within 90 days after the due date for the

payment, the Department may:

1. Impose an additional assessment consisting of 15% of the fee plus interest on the required fee computed at the rate established under 15-31-510(3), MCA, or

2. Suspend the processing of the application for a permit or authorization or, if the nonpayment involves an annual permit fee, suspend the permit, certificate or authorization for which the fee is required. The Department may lift suspension at any time up to one year after the suspension occurs if the holder has paid all outstanding fees, including all penalties, assessments and interest imposed under this sub-section. Suspensions are limited to one year, after which the permit will be terminated.

O. Reopener Provisions. This permit may be reopened and modified (following proper administrative procedures) to include the appropriate effluent limitations (and compliance schedule, if necessary), or other appropriate requirements if one or more of the following events occurs:

1. Water Quality Standards: The water quality standards of the receiving water(s) to which the permittee discharges are modified in such a manner as to require different effluent limits than contained in this permit.

2. Water Quality Standards are Exceeded: If it is found that water quality standards or trigger values in the receiving stream are exceeded either for parameters included in the permit or others, the department may modify the effluent limits or water management plan.

3. TMDL or Wasteload Allocation: TMDL requirements or a wasteload allocation is developed and approved by the Department and/or EPA for incorporation in this permit.

4. Water Quality Management Plan: A revision to the current water quality management plan is approved and adopted which calls for different effluent limitations than contained in this permit.

5. Toxic Pollutants: A toxic standard or prohibition is established under Section 307(a) of the Clean Water Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit.

V. SPECIAL CONDITIONS

A. Compliance Schedules (ARM 17.30.1350)

1. **Kink Creek Passive Treatment System**

A treatment system design shall be developed and reviewed by the state and final designs

approved no later than March 31, 2002. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this interim requirement.

The system shall be constructed and limits achieved no later than September 30, 2003. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this final requirement.

2. **Swift Gulch Passive Treatment System**

Designs for a passive treatment system in Swift Gulch shall be completed no later than September 30, 2001. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this interim requirement.

Bench scale testing shall be completed no later than September 30, 2002. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this interim requirement.

The system shall be constructed and limits achieved no later than September 30, 2003. The permittee shall notify the Department within 14 days of this date its compliance or noncompliance with this final requirement.

B. Storm Water Pollution Prevention Plan (SWPPP)

The permittee shall be required to implement the *Storm Water Management Plan for Zorman and Landusky Mine Sites* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated August 1996. This plan was approved by the Department and incorporated into the final *Water Quality improvement and Monitoring Complinance Plan* prepared for Zortman Mining, Inc. by Hydrometrics, Inc. dated July 1996.

Administrative Requirements for the SWPPP

The plan shall:

1. be retained on site in accordance with Part VI.A. of this permit for active mine sites or retained in the nearest field office for inactive mine sites and oil and gas facilities;

2. be amended whenever there is a change in design, construction, operation, or maintenance, which has a significant effect on the potential for the discharge of pollutants to state surface waters, or if the SWPPP proves to be ineffective in achieving the general objectives of controlling pollutants in storm water discharges associated with mine reclamation activities. A copy of any plan amendments must be submitted to the Department within 7 working days of any change.

APPENDIX D

ECONOMIC IMPACTS

Appendix D

Economic Impacts

The tables in this appendix present the data used in the analysis of regional economic impacts in Chapter 4, Section 4.11. Below are summaries of each of these tables. See Section 4.11 for additional descriptions of economic impacts.

Table 1: Lowest Employment/Expenditure Combination of Zortman-Landusky Alternatives. This table shows the direct employment and expenditures of the two least-cost alternatives, one each for Zortman (Alternative Z2) and Landusky (Alternative L2). Combining these two alternatives shows the lowest level of employment and expenditures that could be anticipated for reclamation activities. Table 1 also shows estimated total economic activity, which includes the multiplier effect of additional rounds of spending in the local area due to direct spending by the contractor and wage earners.

Table 2: Highest Employment/Expenditure Combination of Zortman-Landusky Alternatives. This table shows the direct employment and expenditures of the two highest-cost alternatives, one each for Zortman (Alternative Z5) and Landusky (Alternative L6). Combining these two alternatives shows the highest level of employment and expenditures that could be anticipated for reclamation activities. Table 2 also shows estimated total economic activity, which includes the multiplier effect of additional rounds of spending in the local area due to direct spending by the contractor and wage earners.

Table 3: Direct Expenditures for Zortman Reclamation Alternatives. Table 3 shows estimated total employment and reclamation costs for each year of reclamation activity, and also what portion of employment and expenditures would come from the study area vs. outside the study area. These costs are accompanied by an estimated time period for completion of reclamation, based on estimated costs and the nature of the work to be performed under each alternative. It should be noted that once the contract is issued after selection of alternatives, the actual distribution of local vs. non-local expenditures may differ from the analyses presented here as well as the total time needed to complete reclamation.

Table 4: IMPLAN analysis Inputs for Zortman Direct Expenditures. Table 4 shows the total annual costs broken out more specifically into categories which can be input into the INPLAN Input-Output Modelling system in order to estimate the multiplier effect of local spending. For example, costs were broken down by local vs. non-local spending and further broken down by labor (wages), capital (major equipment purchases), and supplies (operating expenses). The category of spending identified as "local expenditures" was then used to estimate the multiplier effect of local spending.

Table 5: Direct Expenditures for Landusky Reclamation Alternatives. This is the same as Table 3 except it presents data for the Landusky Mine.

Table 6: IMPLAN Analysis Inputs for Landusky Direct Expenditures. This is the same as Table 4 except it presents data for the Landusky Mine.

Table 1: Lowest Employment/Expenditure Combination of Zortman - Landusky Alternatives

ALTERNATIVE: Z2	1999	2000	2001		
Years of Reclamation	X	1	2		
Reclamation Workforce:					
Hired locally (Phillips/Blaine)	4	17	22		
Hired from outside local area	2	0	1		
Total Workforce	6	17	23		
Reclamation Costs:					
Capital Purchases	$0	$0	$1,888,000		
Labor Expenses	$216,000	$612,000	$828,000		
Supplies (local purchase)	$50,000	$200,000	$200,000		
Supplies (nonlocal purchase)	$189,000	$2,000,000	$2,476,000		
Total Annual Costs	$455,000	$2,812,000	$5,392,000		
Long-term maintenance and LAD Costs	$1,358,000				
Total Reclamation & Mainteance Costs for Life of Project	**$10,017,000**				
ALTERNATIVE: L2	**1999**	**2000**	**2001**	**2002**	**2003**
Years of Reclamation	X	1	2	3	4
Reclamation Workforce:					
Hired locally (Phillips/Blaine)	6	17	20	10	10
Hired from outside local area	0	0	1	0	0
Total Workforce	6	17	21	10	10
Reclamation Costs:					
Capital Purchases	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$360,000	$360,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$200,000	$200,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,296,000	$4,034,000	$4,033,000
Total Annual Costs	$890,000	$1,842,000	$2,252,000	$4,594,000	$4,593,000
Long-term maintenance and LAD Costs	$5,429,000				
Total Reclamation & Mainteance Costs for Life of Project	**$19,600,000**				
TOTAL COST FOR Z2 & L2 COMBINED	**1999**	**2000**	**2001**	**2002**	**2003**
Years of Reclamation	X	1	2	3	4
Reclamation Workforce:					
Hired locally (Phillips/Blaine)	10	34	42	10	10
Hired from outside local area	2	0	2	0	0
Total Workforce	12	34	44	10	10
Reclamation Costs:					
Capital Purchases	$0	$0	$1,888,000	$0	$0
Labor Expenses	$432,000	$1,224,000	$1,584,000	$360,000	$360,000
Supplies (local purchase)	$150,000	$400,000	$400,000	$200,000	$200,000
Supplies (nonlocal purchase)	$763,000	$3,030,000	$3,772,000	$4,034,000	$4,033,000
Total Annual Costs	$1,345,000	$4,654,000	$7,644,000	$4,594,000	$4,593,000
Long-term maintenance and LAD Costs	$6,787,000				
Total Reclamation & Mainteance Costs for Life of Projects	**$29,617,000**				

Estimated Total Annual Economic Impact to Study Area

	1999	2000	2001	2002	2003
	X	1	2	3	4
Final Demand (Direct Local Expenditures)	N/A	$1,244,600	$1,521,700	$1,120,800	$1,120,800
Total Industry Output	N/A	$1,458,800	$1,765,600	$1,295,700	$1,295,700
Value Added:					
Employee Compensation	N/A	$310,800	$609,100	$239,100	$239,100
Total Value Added	N/A	$658,400	$1,317,700	$518,100	$518,100
Employment (total fulltime and parttime jobs)	N/A	62	96	31	31

Source: Spectrum (2000e); IMPLAN Input-Output Modelling System (1999)

Table 2: Highest Employment/Expenditure Combination of Zortman - Landusky Alternatives

ALTERNATIVE: Z5	1999	2000	2001	2002	2003	2004				
Years of Reclamation	X	1	2	3	4	5				
Reclamation Workforce:										
Hired locally (Phillips/Blaine)	4	17	22	20	20	20				
Hired from outside local area	2	0	3	3	3	3				
Total Workforce	6	17	25	23	23	23				
Reclamation Costs:										
Capital Purchases	$0	$0	$0	$0	$0	$1,888,000				
Labor Expenses	$216,000	$612,000	$900,000	$828,000	$828,000	$828,000				
Supplies (local purchase)	$50,000	$200,000	$200,000	$400,000	$400,000	$400,000				
Supplies (nonlocal purchase)	$189,000	$2,000,000	$8,309,000	$8,309,000	$8,308,000	$8,308,000				
Total Annual Costs	$455,000	$2,812,000	$9,409,000	$9,537,000	$9,536,000	$11,424,000				
Long-term maintenance and LAD Costs	$2,997,000									
Total Reclamation & Mainteance Costs for Life of Project	**$46,170,000**									

ALTERNATIVE: L6	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Years of Reclamation	X	1	2	3	4	5	6	7	8	9
Reclamation Workforce:										
Hired locally (Phillips/Blaine)	6	17	20	20	20	20	20	20	20	20
Hired from outside local area	0	0	1	5	5	5	5	5	5	5
Total Workforce	6	17	21	25	25	25	25	25	25	25
Reclamation Costs:										
Capital Purchases	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,152,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000
Total Annual Costs	$890,000	$1,842,000	$2,108,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000
Long-term maintenance and LAD Costs	$8,363,000									
Total Reclamation & Mainteance Costs for Life of Project	**$157,270,000**									

TOTAL COST FOR Z5 & L6 COMBINED	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Years of Reclamation	X	1	2	3	4	5	6	7	8	9
Reclamation Workforce:										
Hired locally (Phillips/Blaine)	10	34	42	40	40	40	20	20	20	20
Hired from outside local area	2	0	4	8	8	8	5	5	5	5
Total Workforce	12	34	46	48	48	48	25	25	25	25
Reclamation Costs:										
Capital Purchases	$0	$0	$0	$0	$0	$1,888,000	$0	$0	$0	$0
Labor Expenses	$432,000	$1,224,000	$1,656,000	$1,728,000	$1,728,000	$1,728,000	$900,000	$900,000	$900,000	$900,000
Supplies (local purchase)	$150,000	$400,000	$400,000	$900,000	$900,000	$900,000	$500,000	$500,000	$500,000	$500,000
Supplies (nonlocal purchase)	$763,000	$3,030,000	$9,461,000	$27,490,000	$27,489,000	$27,489,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000
Total Annual Costs	$1,345,000	$4,654,000	$11,517,000	$30,118,000	$30,117,000	$32,005,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000
Long-term maintenance and LAD Costs	$11,360,000									
Total Reclamation & Mainteance Costs for Life of Both Projects	**$203,440,000**									

Estimated Total Annual Economic Impact to Study Area

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
	X	1	2	3	4	5	6	7	8	9
Final Demand (Direct Local Expenditures)	N/A	$1,244,600	$2,272,500	$2,743,600	$2,743,600	$2,743,600	$1,495,400	$1,495,400	$1,495,400	$1,495,400
Total Industry Output	N/A	$1,458,800	$2,628,500	$3,224,900	$3,224,900	$3,224,900	$1,758,600	$1,758,600	$1,758,600	$1,758,600
Value Added:										
Employee Compensation	N/A	$310,800	$487,700	$703,500	$703,500	$703,500	$385,500	$385,500	$385,500	$385,500
Total Value Added	N/A	$658,400	$1,055,700	$1,485,200	$1,485,200	$1,485,200	$813,300	$813,300	$813,300	$813,300
Employment (total fulltime and parttime jobs)	N/A	62	84	102	102	102	54	54	54	54

Source: Spectrum (2000e); IMPLAN Input-Output Modelling System (1999)

Table 3: Direct Expenditures for Zortman Reclamation Alternatives

ALTERNATIVE: Z1								
	1999	2000	2001	2002	2003			
Years of Reclamation	X	1	2	3	4			
Reclamation Workforce								
Hired locally (Phillips/Blaine	4	17	20	10	10			
Hired from outside local area	2	0	1	1	1			
Total Workforce	6	17	21	11	11			
Reclamation Costs:								
Capital Purchases	$0	$0	$0	$0	$0			
Labor Expenses	$216,000	$612,000	$756,000	$396,000	$396,000			
Supplies (local purchase)	$50,000	$200,000	$200,000	$200,000	$200,000			
Supplies (nonlocal purchase)	$189,000	$2,000,000	$5,725,000	$6,095,000	$6,094,000			
Total Annual Costs	$455,000	$2,812,000	$6,681,000	$6,691,000	$6,690,000			
Long-term maintenance and LAD Costs $2,946,000 (annualized over 3 years)	$0	$0	$982,000	$982,000	$982,000			
Total Reclamation & Mainteance Costs for Life of Project	$26,275,000							
ALTERNATIVE: Z2								
	1999	2000	2001					
Years of Reclamation	X	1	2					
Reclamation Workforce								
Hired locally (Phillips/Blaine	4	17	22					
Hired from outside local area	2	0	1					
Total Workforce	6	17	23					
Reclamation Costs:								
Capital Purchases	$0	$0	$1,888,000					
Labor Expenses	$216,000	$612,000	$828,000					
Supplies (local purchase)	$50,000	$200,000	$200,000					
Supplies (nonlocal purchase)	$189,000	$2,000,000	$2,476,000					
Total Annual Costs	$455,000	$2,812,000	$5,392,000					
Long-term maintenance and LAD Cost	$0	$0	$1,358,000					
Total Reclamation & Mainteance Costs for Life of Project	$10,017,000							
ALTERNATIVE: Z3								
	1999	2000	2001					
Years of Reclamation	X	1	2					
Reclamation Workforce								
Hired locally (Phillips/Blaine	4	17	22					
Hired from outside local area	2	0	1					
Total Workforce	6	17	23					
Reclamation Costs:								
Capital Purchases	$0	$0	$0					
Labor Expenses	$216,000	$612,000	$828,000					
Supplies (local purchase)	$50,000	$200,000	$200,000					
Supplies (nonlocal purchase)	$189,000	$2,000,000	$2,856,000					
Total Annual Costs	$455,000	$2,812,000	$3,884,000					
Long-term maintenance and LAD Cost	$0	$0	$2,869,000					
Total Reclamation & Mainteance Costs for Life of Project	$10,020,000							
ALTERNATIVE: Z4								
	1999	2000	2001	2002	2003	2004		
Years of Reclamation	X	1	2	3	4	5		
Reclamation Workforce								
Hired locally (Phillips/Blaine	4	17	22	20	20	20		
Hired from outside local area	2	0	3	3	3	3		
Total Workforce	6	17	25	23	23	23		
Reclamation Costs:								
Capital Purchases	$0	$0	$0	$0	$0	$1,888,000		
Labor Expenses	$216,000	$612,000	$900,000	$828,000	$828,000	$828,000		
Supplies (local purchase)	$50,000	$200,000	$200,000	$400,000	$400,000	$400,000		
Supplies (nonlocal purchase)	$189,000	$2,000,000	$7,511,000	$7,511,000	$7,511,000	$7,511,000		
Total Annual Costs	$455,000	$2,812,000	$8,611,000	$8,739,000	$8,739,000	$10,627,000		
Long-term maintenance and LAD Costs ($2,997,000 over 4 years)	$0	$0	$749,250	$749,250	$749,250	$749,250		
Total Reclamation & Mainteance Costs for Life of Project	$42,980,000							
ALTERNATIVE: Z5								
	1999	2000	2001	2002	2003	2004	2005	2006
Years of Reclamation	X	1	2	3	4	5	6	7
Reclamation Workforce								
Hired locally (Phillips/Blaine	4	17	20	20	20	20	20	20
Hired from outside local area	2	0	3	3	3	3	3	3
Total Workforce	6	17	23	23	23	23	23	23
Reclamation Costs:								
Capital Purchases	$0	$0	$0	$0	$0	$1,888,000	$1,888,000	$1,888,000
Labor Expenses	$216,000	$612,000	$828,000	$828,000	$828,000	$828,000	$828,000	$828,000
Supplies (local purchase)	$50,000	$200,000	$200,000	$400,000	$400,000	$400,000	$400,000	$400,000
Supplies (nonlocal purchase)	$189,000	$2,000,000	$4,481,000	$4,481,000	$4,481,000	$4,481,000	$4,480,000	$4,480,000
Total Annual Costs	$455,000	$2,812,000	$5,509,000	$5,709,000	$5,709,000	$7,597,000	$7,596,000	$7,596,000
Long Term Maintenance and LAD Costs for Life of Project ($3,187,000 over 6 yrs)	$0	$0	$531,167	$531,167	$531,167	$531,167	$531,167	$531,167
Total Reclamation & Mainteance Costs for Life of Project	$46,170,000							
ALTERNATIVE: Z6								
	1999	2000	2001	2002				
Years of Reclamation	X	1	2	3				
Reclamation Workforce								
Hired locally (Phillips/Blaine	4	17	22	25				
Hired from outside local area	2	0	1	1				
Total Workforce	6	17	23	26				
Reclamation Costs:								
Capital Purchases	$0	$0	$0	$0				
Labor Expenses	$216,000	$612,000	$828,000	$936,000				
Supplies (local purchase)	$50,000	$200,000	$200,000	$250,000				
Supplies (nonlocal purchase)	$189,000	$2,000,000	$2,582,000	$3,582,000				
Total Annual Costs	$455,000	$2,812,000	$3,610,000	$4,768,000				
Long-term maintenance and LAD Cost	$0	$0	$2,869,000	$560,000				
Total Reclamation & Mainteance Costs for Life of Project	$15,074,000							

Source: Spectrum (2000e, 2001a)

Table 4: IMPLAN Analysis Inputs for Zortman Direct Expenditures

Z1

		Current Conditions	Impacts (Direct)		
	1999	2000	2001	2002	2003
Local Expenditures:					
Labor	$198,720	$563,040	$1,147,240	$816,040	$816,040
Supplies	$50,000	$200,000	$217,153	$216,112	$216,114
Total Local Expenditures	$248,720	$763,040	$1,364,393	$1,032,152	$1,032,154
Nonlocal Expenditures:					
Capital	$0	$0	$0	$0	$0
Labor:	$17,280	$48,960	$99,760	$70,960	$70,960
Supplies	$189,000	$2,000,000	$6,198,847	$6,569,888	$6,568,886
Total Nonlocal Expenditures.	$206,280	$2,048,960	$6,298,607	$6,640,848	$6,639,846
Total Annual Expenditures	$455,000	$2,812,000	$7,663,000	$7,673,000	$7,672,000
Total Project Exp.			$26,275,000		

Z2

		Current Conditions	Impacts (Direct)
	1999	2000	2001
Local Expenditures:			
Labor	$198,720	$563,040	$1,386,440
Supplies	$50,000	$200,000	$254,847
Total Local Expenditures	$248,720	$763,040	$1,641,287
Nonlocal Expenditures.			
Capital	$0	$0	$1,888,000
Labor:	$17,280	$48,960	$120,560
Supplies	$189,000	$2,000,000	$3,100,153
Total Nonlocal Expenditures	$206,280	$2,048,960	$5,108,713
Total Annual Expenditures	$455,000	$2,812,000	$6,750,000
Total Project Exp.		$10,017,000	

Z3

		Current Conditions	Impacts (Direct)
	1999	2000	2001
Local Expenditures:			
Labor	$198,720	$563,040	$2,081,500
Supplies	$50,000	$200,000	$300,455
Total Local Expenditures	$248,720	$763,040	$2,381,955
Nonlocal Expenditures:			
Capital	$0	$0	$0
Labor:	$17,280	$48,960	$181,000
Supplies	$189,000	$2,000,000	$4,190,045
Total Nonlocal Expenditures	$206,280	$2,048,960	$4,371,045
Total Annual Expenditures	$455,000	$2,812,000	$6,753,000
Total Project Exp.		$10,020,000	

Z4

		Current Conditions	Impacts (Direct)			
	1999	2000	2001	2002	2003	2004
Local Expenditures:						
Labor	198,720	563,040	1,172,655	1,106,415	1,106,415	1,106,415
Supplies	50,000	200,000	209,975	419,951	419,951	419,951
Total Local Expenditures	$248,720	$763,040	$1,382,630	$1,526,366	$1,526,366	$1,526,366
Nonlocal Expenditures:						
Capital	0	0	0	0	0	$1,888,000
Labor:	17,280	48,960	101,970	96,210	96,210	96,210
Supplies	189,000	2,000,000	7,875,650	7,865,674	7,865,674	7,865,674
Total Nonlocal Expenditures	$206,280	$2,048,960	$7,977,620	$7,961,884	$7,961,884	$9,849,884
Total Annual Expenditures	$455,000	$2,812,000	$9,360,250	$9,488,250	$9,488,250	$11,376,250
Total Project Exp.				42,980,000		

Z5

		Current Conditions	Impacts (Direct)					
	1999	2000	2001	2002	2003	2004	2005	2006
Local Expenditures:								
Labor	$198,720	$563,040	$1,006,097	$1,006,097	$1,006,097	$1,006,097	$1,006,097	$1,006,097
Supplies	$50,000	$200,000	$211,854	$423,708	$423,708	$423,708	$423,713	$423,713
Total Local Expenditures	$248,720	$763,040	$1,217,950	$1,429,804	$1,429,804	$1,429,804	$1,429,809	$1,429,809
Nonlocal Expenditures:								
Capital	$0	$0	$0	$0	$0	$1,888,000	$1,888,000	$1,888,000
Labor:	$17,280	$48,960	$87,487	$87,487	$87,487	$87,487	$87,487	$87,487
Supplies	$189,000	$2,000,000	$4,734,730	$4,722,876	$4,722,876	$4,722,876	$4,721,871	$4,721,871
Total Nonlocal Expenditures	$206,280	$2,048,960	$4,822,216	$4,810,362	$4,810,362	$6,698,362	$6,697,357	$6,697,357
Total Annual Expenditures	$455,000	$2,812,000	$6,040,167	$6,240,167	$6,240,167	$8,128,167	$8,127,167	$8,127,167
Total Project Exp.					$46,170,000			

Z6

		Current Conditions	Impacts (Direct)	
	1999	2000	2001	2002
Local Expenditures:				
Labor	$198,720	$563,040	$2,081,500	$1,118,720
Supplies	$50,000	$200,000	$311,115	$269,542
Total Local Expenditures	$248,720	$763,040	$2,392,615	$1,388,262
Nonlocal Expenditures:				
Capital	$0	$0	$0	$0
Labor:	$17,280	$48,960	$181,000	$97,280
Supplies	$189,000	$2,000,000	$3,905,385	$3,842,458
Total Nonlocal Expenditures	$206,280	$2,048,960	$4,086,385	$3,939,738
Total Annual Expenditures	$455,000	$2,812,000	$6,479,000	$5,328,000
Total Project Exp.		$15,074,000		

Note: Labor expenses includes 50% of longterm maint/LAD cost.

Note: for Supplies, 50% of longterm maint/LAD costs are included in same proportion of local/nonlocal as other supplies

Table 5: Direct Expenditures for Lundusky Reclamation Alternatives

ALTERNATIVE: L1

	1999	2000	2001	2002	2003	2004
Years of Reclamation	X	1	2	3	4	5
Reclamation Workforce						
Hired locally (Phillips/Blaine)	6	17	20	15	15	15
Hired from outside local area	0	0	1	1	1	1
Total Workforce						
Reclamation Costs:						
Capital Purchases	$0	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$576,000	$576,000	$576,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$200,000	$200,000	$200,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,019,000	$10,959,000	$10,959,000	$10,959,000
Total Annual Costs	$890,000	$1,842,000	$1,975,000	$11,735,000	$11,735,000	$11,735,000
Long-term maintenance and LAD Costs ($6,278,000 over 4 yrs)	$0	$0	$1,569,500	$1,569,500	$1,569,500	$1,569,500
Total Reclamation & Mainteance Costs for Life of Project	**$46,190,000**					

ALTERNATIVE: L2

	1999	2000	2001	2002	2003
Years of Reclamation	X	1	2	3	4
Reclamation Workforce.					
Hired locally (Phillips/Blaine)	6	17	20	10	10
Hired from outside local area	0	0	1	0	0
Total Workforce	6	17	21	10	10
Reclamation Costs:					
Capital Purchases	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$360,000	$360,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$200,000	$200,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,296,000	$4,034,000	$4,033,000
Total Annual Costs	$890,000	$1,842,000	$2,252,000	$4,594,000	$4,593,000
Long-term maintenance and LAD Costs ($5,429,000 over 3 years)	$0	$0	$1,809,667	$1,809,667	$1,809,667
Total Reclamation & Mainteance Costs for Life of Project	**$19,600,000**				

ALTERNATIVE: L3

	1999	2000	2001	2002	2003
Years of Reclamation	X	1	2	3	4
Reclamation Workforce					
Hired locally (Phillips/Blaine)	6	17	20	10	10
Hired from outside local area	0	0	1	0	0
Total Workforce	6	17	21	10	10
Reclamation Costs:					
Capital Purchases	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$360,000	$360,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$200,000	$200,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,330,000	$5,326,000	$5,326,000
Total Annual Costs	$890,000	$1,842,000	$2,286,000	$5,886,000	$5,886,000
Long-term maintenance and LAD Costs ($5,450,000 over 3 yrs)	$0	$0	$1,816,667	$1,816,667	$1,816,667
Total Reclamation & Mainteance Costs for Life of Project	**$22,240,000**				

ALTERNATIVE: L4

	1999	2000	2001	2002	2003	2004
Years of Reclamation	X	1	2	3	4	5
Reclamation Workforce						
Hired locally (Phillips/Blaine)	6	17	20	15	15	15
Hired from outside local area	0	0	1	1	1	1
Total Workforce	6	17	21	16	16	16
Reclamation Costs:						
Capital Purchases	$0	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$576,000	$576,000	$576,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$200,000	$200,000	$200,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$682,000	$7,664,000	$7,664,000	$7,664,000
Total Annual Costs	$890,000	$1,842,000	$1,638,000	$8,440,000	$8,440,000	$8,440,000
Long-term maintenance and LAD Costs ($6,910,000 over 4 yrs)	$0	$0	$1,727,500	$1,727,500	$1,727,500	$1,727,500
Total Reclamation & Mainteance Costs for Life of Project	**$36,600,000**					

ALTERNATIVE: L5

	1999	2000	2001	2002	2003	2004	2005
Years of Reclamation	X	1	2	3	4	5	6
Reclamation Workforce:							
Hired locally (Phillips/Blaine)	6	17	20	15	15	15	15
Hired from outside local area	0	1	1	1	1	1	1
Total Workforce	6	18	21	16	16	16	16
Reclamation Costs:							
Capital Purchases	$0	$0	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$576,000	$576,000	$576,000	$576,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,238,000	$12,968,000	$12,968,000	$12,968,000	$12,968,000
Total Annual Costs	$890,000	$1,842,000	$2,194,000	$13,744,000	$13,744,000	$13,744,000	$13,744,000
Long-term maintenance and LAD Costs ($8,038,000 over 5 yrs)	$0	$0	$1,607,600	$1,607,600	$1,607,600	$1,607,600	$1,607,600
Total Reclamation & Mainteance Costs for Life of Project	**$67,940,000**						

ALTERNATIVE: L6

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Years of Reclamation	X	1	2	3	4	5	6	7	8	9
Reclamation Workforce										
Hired locally (Phillips/Blaine)	6	17	20	20	20	20	20	20	20	20
Hired from outside local area	0	0	1	5	5	5	5	5	5	5
Total Workforce	6	17	21	25	25	25	25	25	25	25
Reclamation Costs:										
Capital Purchases	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Labor Expenses	$216,000	$612,000	$756,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000	$900,000
Supplies (local purchase)	$100,000	$200,000	$200,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
Supplies (nonlocal purchase)	$574,000	$1,030,000	$1,152,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000	$19,181,000
Total Annual Costs	$890,000	$1,842,000	$2,108,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000	$20,581,000
Long-term maintenance and LAD Costs ($8,363,000 over 8 yrs)	$0	$0	$1,045,375	$1,045,375	$1,045,375	$1,045,375	$1,045,375	$1,045,375	$1,045,375	$1,045,375
Total Reclamation & Mainteance Costs for Life of Project	**$157,270,000**									

Source: Spectrum (2000e)

Table 6: IMPLAN Analysis Inputs for Landusky Direct Expenditures

L1	Current Conditions		Impacts (Direct)				
	1999	2000	2001	2002	2003	2004	
Local Expenditures:							
Labor	$198,720	$563,040	$1,417,490	$1,251,890	$1,251,890	$1,251,890	
Supplies	$100,000	$200,000	$354,024	$214,322	$214,322	$214,322	
Total Local Expenditures	$298,720	$763,040	$1,771,514	$1,466,212	$1,466,212	$1,466,212	
Nonlocal Expenditures:							
Capital	$0	$0	$0	$0	$0	$0	
Labor:	$17,280	$48,960	$123,260	$108,860	$108,860	$108,860	
Supplies	$574,000	$1,030,000	$1,649,726	$11,729,428	$11,729,428	$11,729,428	
Total Nonlocal Expenditures	$591,280	$1,078,960	$1,772,986	$11,838,288	$11,838,288	$11,838,288	
Total Annual Expenditures	$890,000	$1,842,000	$3,544,500	$13,304,500	$13,304,500	$13,304,500	
Total Project Expenditures	$46,190,000						

L2	Current Conditions		Impacts (Direct)		
	1999	2000	2001	2002	2003
Local Expenditures:					
Labor	$198,720	$563,040	$1,527,967	$1,163,647	$1,163,647
Supplies	$100,000	$200,000	$339,635	$244,860	$244,871
Total Local Expenditures	$298,720	$763,040	$1,867,601	$1,408,507	$1,408,518
Nonlocal Expenditures:					
Capital	$0	$0	$0	$0	$0
Labor:	$17,280	$48,960	$132,867	$101,187	$101,187
Supplies	$574,000	$1,030,000	$2,061,199	$4,893,973	$4,892,962
Total Nonlocal Expenditures	$591,280	$1,078,960	$2,194,065	$4,995,160	$4,994,149
Total Annual Expenditures	$890,000	$1,842,000	$4,061,667	$6,403,667	$6,402,667
Total Project Expenditures	$19,600,000				

L3	Current Conditions		Impacts (Direct)		
	1999	2000	2001	2002	2003
Local Expenditures:					
Labor	$198,720	$563,040	$1,531,187	$1,166,867	$1,166,867
Supplies	$100,000	$200,000	$336,591	$234,109	$234,109
Total Local Expenditures	$298,720	$763,040	$1,867,778	$1,400,976	$1,400,976
Nonlocal Expenditures:					
Capital	$0	$0	$0	$0	$0
Labor:	$17,280	$48,960	$133,147	$101,467	$101,467
Supplies	$574,000	$1,030,000	$2,101,742	$6,200,224	$6,200,224
Total Nonlocal Expenditures	$591,280	$1,078,960	$2,234,889	$6,301,691	$6,301,691
Total Annual Expenditures	$890,000	$1,842,000	$4,102,667	$7,702,667	$7,702,667
Total Project Expenditures	$22,240,000				

L4	Current Conditions		Impacts (Direct)			
	1999	2000	2001	2002	2003	2004
Local Expenditures:						
Labor	$198,720	$563,040	$1,490,170	$1,324,570	$1,324,570	$1,324,570
Supplies	$100,000	$200,000	$453,299	$222,540	$222,540	$222,540
Total Local Expenditures	$298,720	$763,040	$1,943,469	$1,547,110	$1,547,110	$1,547,110
Nonlocal Expenditures:						
Capital	$0	$0	$0	$0	$0	$0
Labor	$17,280	$48,960	$129,580	$115,180	$115,180	$115,180
Supplies	$574,000	$1,030,000	$1,292,451	$8,505,210	$8,505,210	$8,505,210
Total Nonlocal Expenditures	$591,280	$1,078,960	$1,422,031	$8,620,390	$8,620,390	$8,620,390
Total Annual Expenditures	$890,000	$1,842,000	$3,365,500	$10,167,500	$10,167,500	$10,167,500
Total Project Expenditures	$36,600,000					

L5	Current Conditions		Impacts (Direct)				
	1999	2000	2001	2002	2003	2004	2005
Local Expenditures:							
Labor	$198,720	$563,040	$1,435,016	$1,269,416	$1,269,416	$1,269,416	$1,269,416
Supplies	$100,000	$200,000	$329,855	$212,397	$212,397	$212,397	$212,397
Total Local Expenditures	$298,720	$763,040	$1,764,871	$1,481,813	$1,481,813	$1,481,813	$1,481,813
Nonlocal Expenditures:							
Capital	$0	$0	$0	$0	$0	$0	$0
Labor	$17,280	$48,960	$124,784	$110,384	$110,384	$110,384	$110,384
Supplies	$574,000	$1,030,000	$1,911,945	$13,759,403	$13,759,403	$13,759,403	$13,759,403
Total Nonlocal Expenditures	$591,280	$1,078,960	$2,036,729	$13,869,787	$13,869,787	$13,869,787	$13,869,787
Total Annual Expenditures	$890,000	$1,842,000	$3,801,600	$15,351,600	$15,351,600	$15,351,600	$15,351,600
Total Project Expenditures	$67,940,000						

L6	Current Conditions		Impacts (Direct)							
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Local Expenditures:										
Labor	$198,720	$563,040	$1,176,393	$1,308,873	$1,308,873	$1,308,873	$1,308,873	$1,308,873	$1,308,873	$1,308,873
Supplies	$100,000	$200,000	$290,744	$513,625	$513,625	$513,625	$513,625	$513,625	$513,625	$513,625
Total Local Expenditures	$298,720	$763,040	$1,467,137	$1,822,498	$1,822,498	$1,822,498	$1,822,498	$1,822,498	$1,822,498	$1,822,498
Nonlocal Expenditures:										
Capital	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Labor	$17,280	$48,960	$102,295	$113,815	$113,815	$113,815	$113,815	$113,815	$113,815	$113,815
Supplies	$574,000	$1,030,000	$1,583,943	$19,690,062	$19,690,062	$19,690,062	$19,690,062	$19,690,062	$19,690,062	$19,690,062
Total Nonlocal Expenditures	$591,280	$1,078,960	$1,686,238	$19,803,877	$19,803,877	$19,803,877	$19,803,877	$19,803,877	$19,803,877	$19,803,877
Total Annual Expenditures	$890,000	$1,842,000	$3,153,375	$21,626,375	$21,626,375	$21,626,375	$21,626,375	$21,626,375	$21,626,375	$21,626,375
Total Project Expenditures	$157,270,000									

Note: Labor expenses includes 50% of longterm maint/LAD costs

Note: for Supplies, 50% of longterm maint/LAD costs are included in same proportion of local/nonlocal as other supplies

APPENDIX E

TOPOGRAPHIC SIMULATIONS OF THE MINE AREAS

Appendix E Figures

Figure E-1. Zortman Mine, Existing Condition.

Figure E-2. Zortman Mine Reclamation, Alternative Z1.

Figure E-3. Zortman Mine Reclamation, Alternative Z2.

Figure E-4. Zortman Mine Reclamation, Alternative Z3.

Figure E-5. Zortman Mine Reclamation, Alternative Z4.

Figure E-6. Zortman Mine Reclamation, Alternative Z5.

Figure E-7. Zortman Mine Reclamation, Alternative Z6.

Figure E-8. Landusky Mine, Existing Condition.

Figure E-9. Landusky Mine Reclamation, Alternative L1.

Figure E-10. Landusky Mine Reclamation, Alternative L2.

Figure E-11. Landusky Mine Reclamation, Alternative L3.

Figure E-12. Landusky Mine Reclamation, Alternative L4.

Figure E-13. Landusky Mine Reclamation, Alternative L5.

Figure E-14. Landusky Mine Reclamation, Alternative L6.

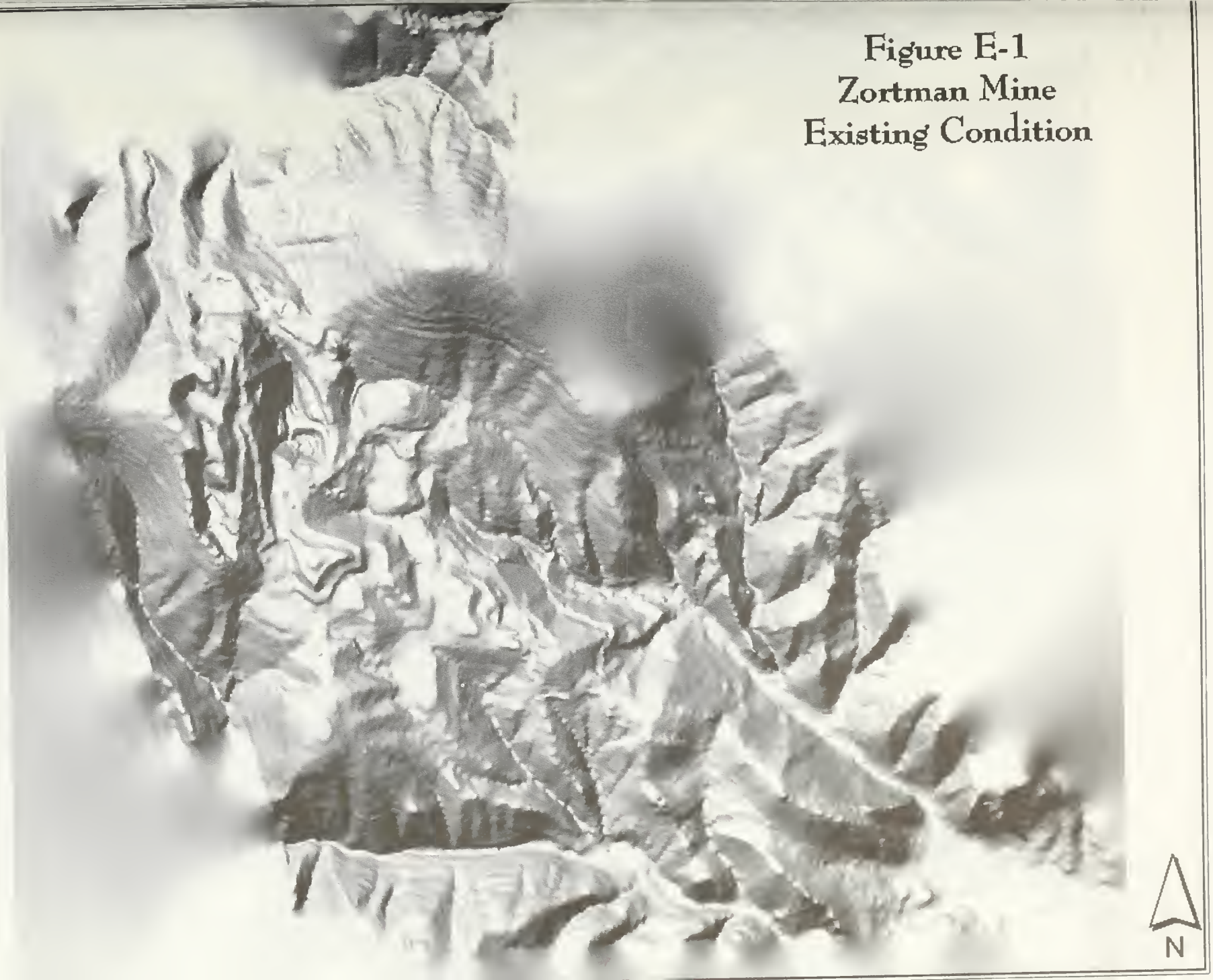


Figure E-1
Zortman Mine
Existing Condition

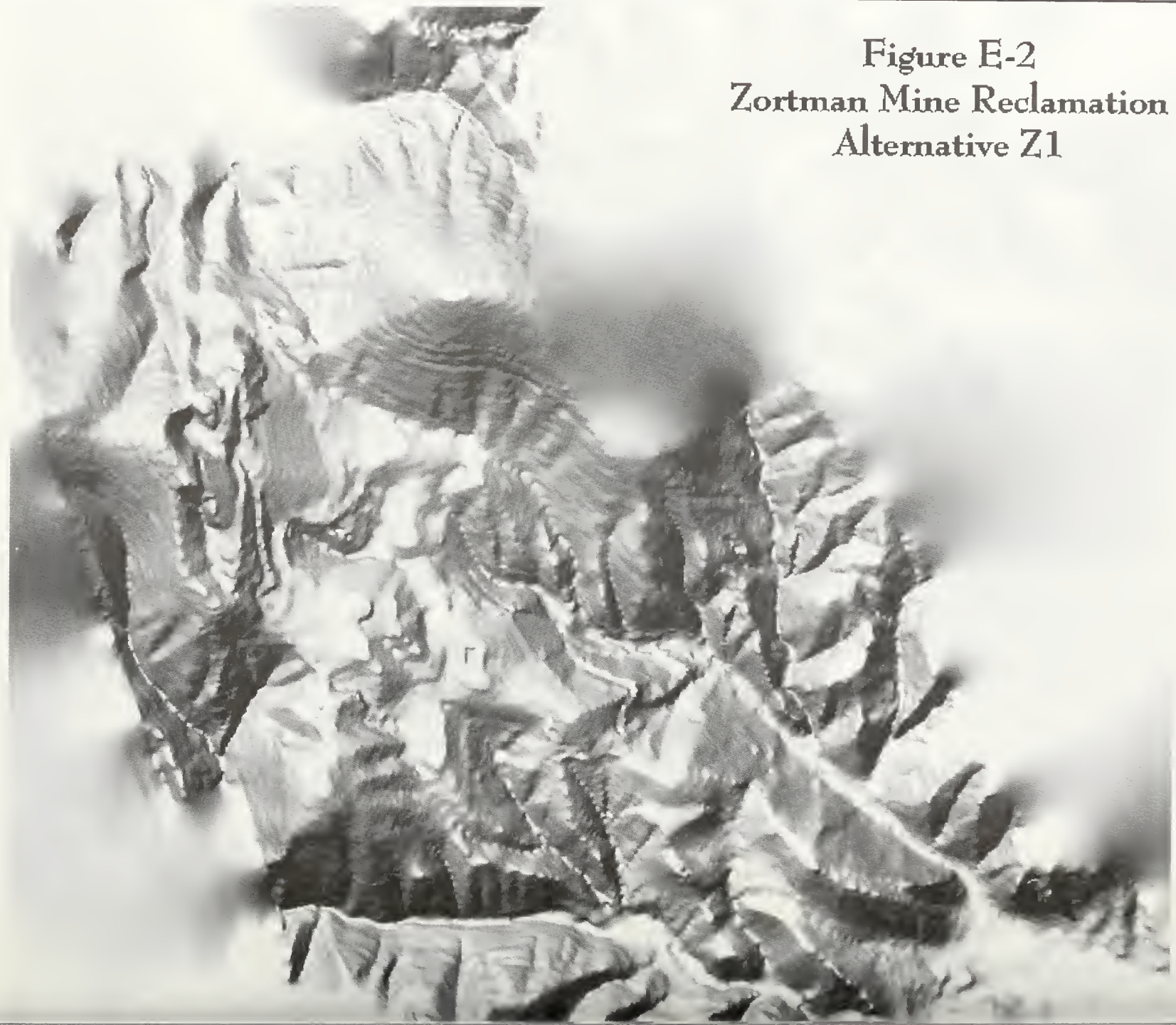


Figure E-2
Zortman Mine Reclamation
Alternative Z1

Figure E-3
Zortman Mine Reclamation
Alternative Z2

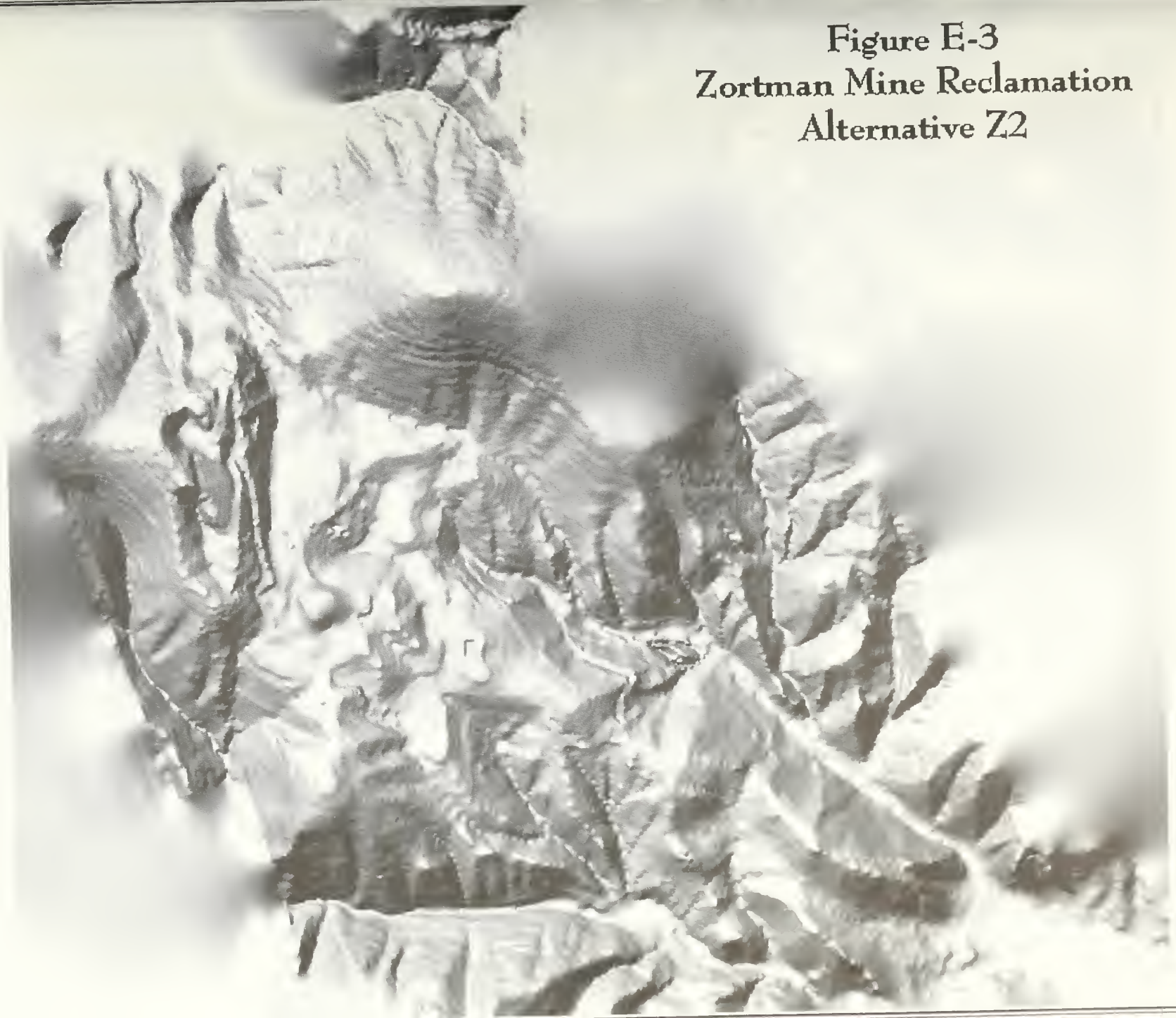


Figure E-4
Zortman Mine Reclamation
Alternative Z3

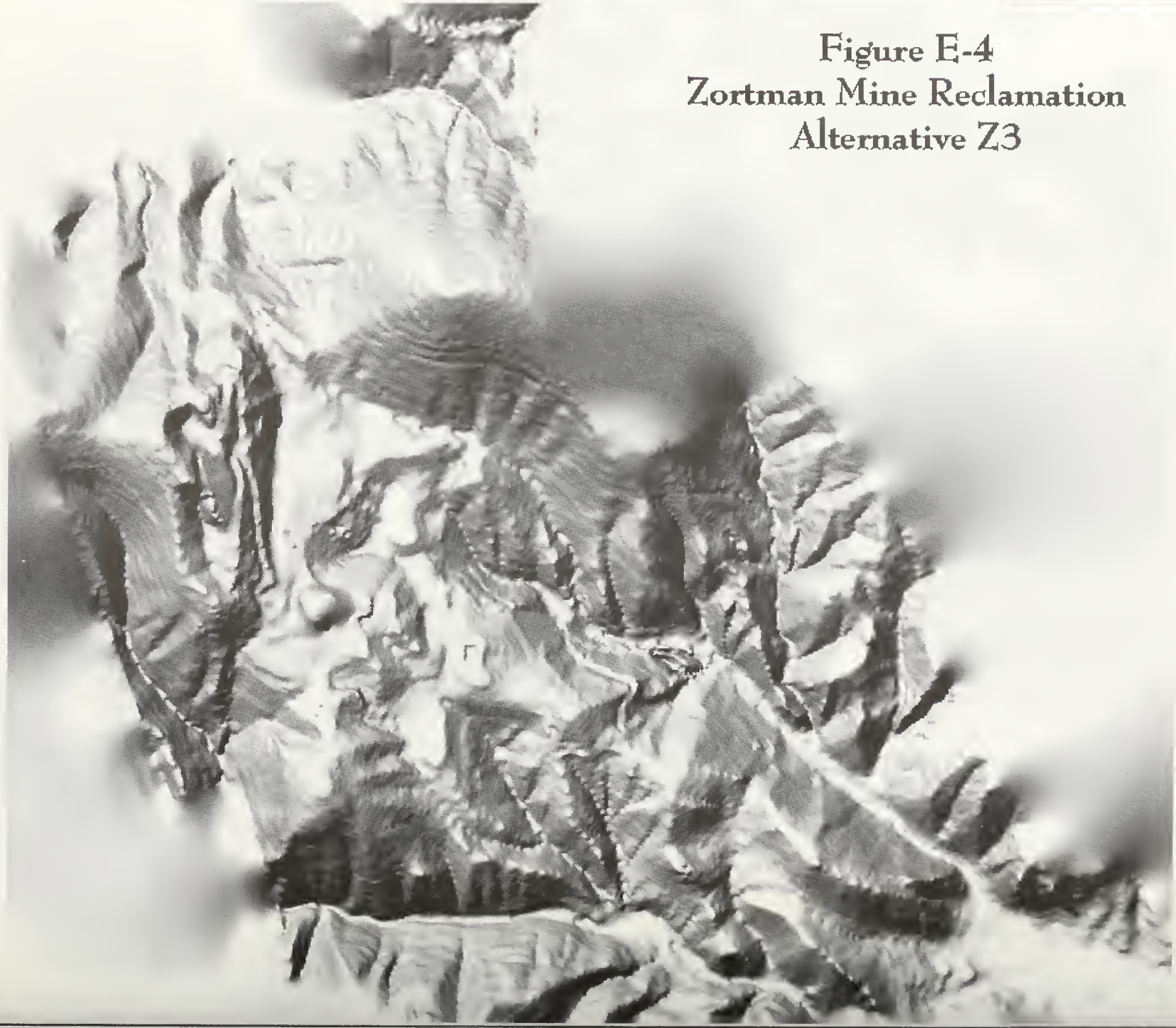
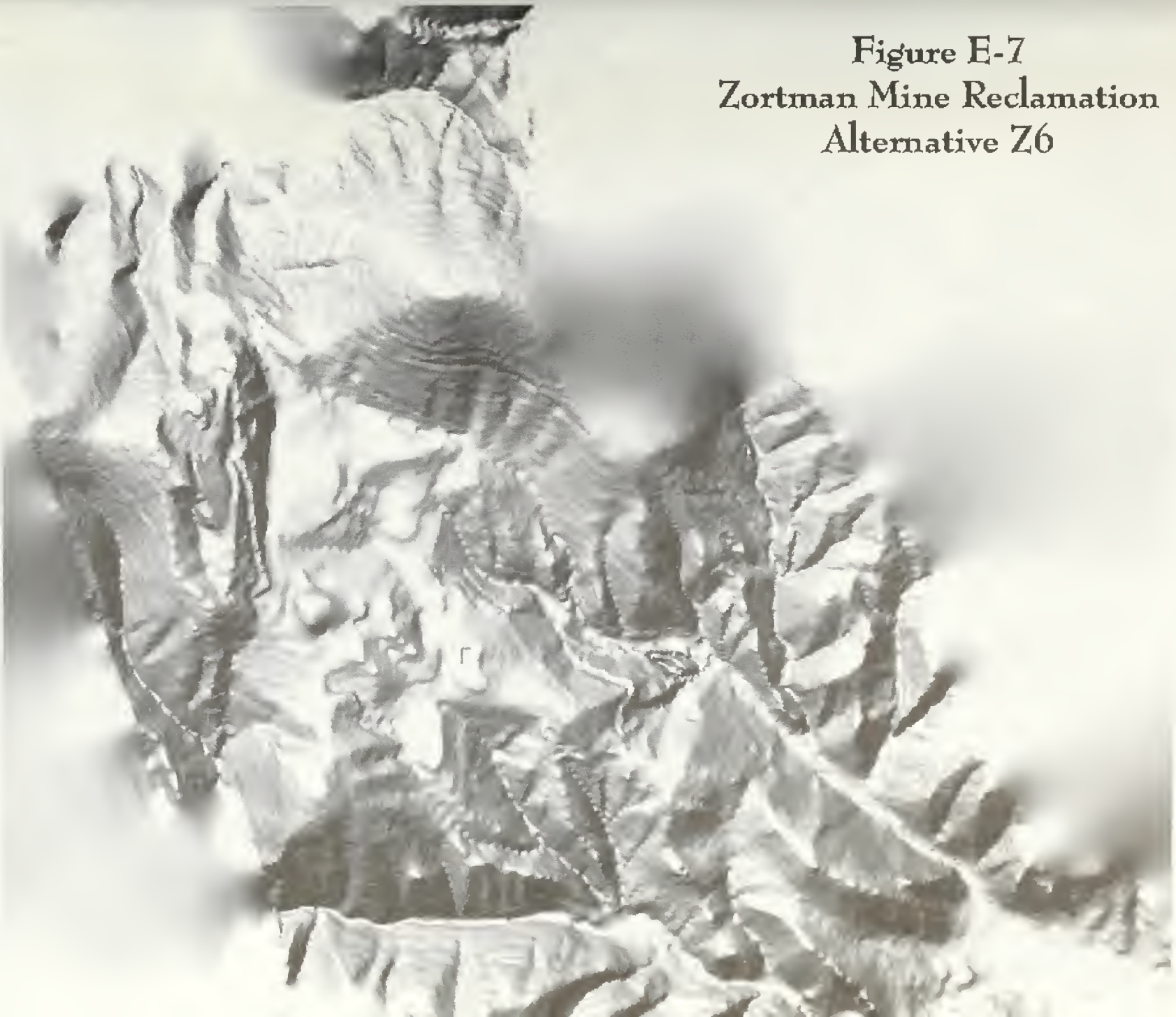


Figure E-5
Zortman Mine Reclamation
Alternative Z4

Figure E-6
Zortman Mine Reclamation
Alternative Z5

Figure E-7
Zortman Mine Reclamation
Alternative Z6



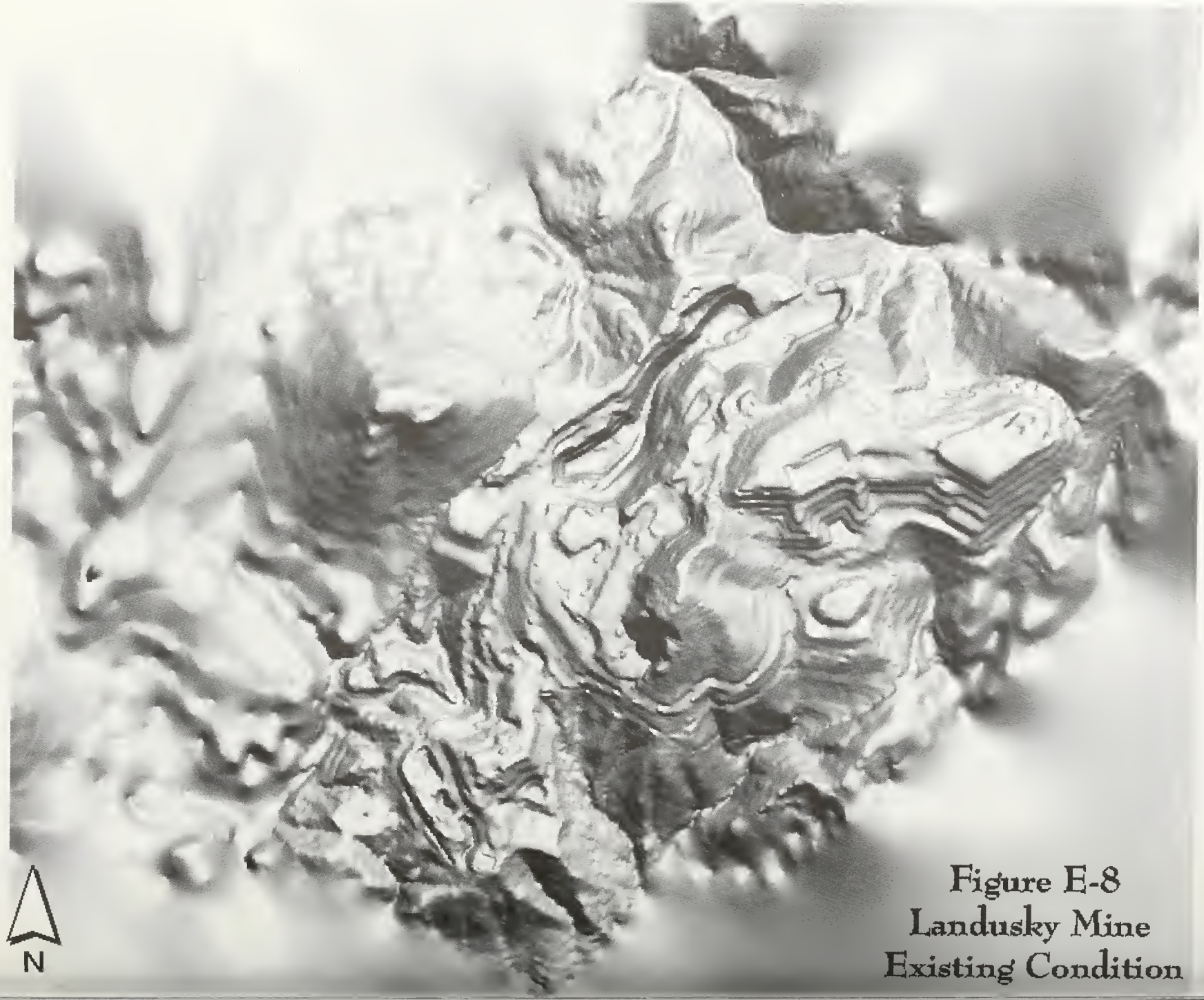


Figure E-8
Landusky Mine
Existing Condition

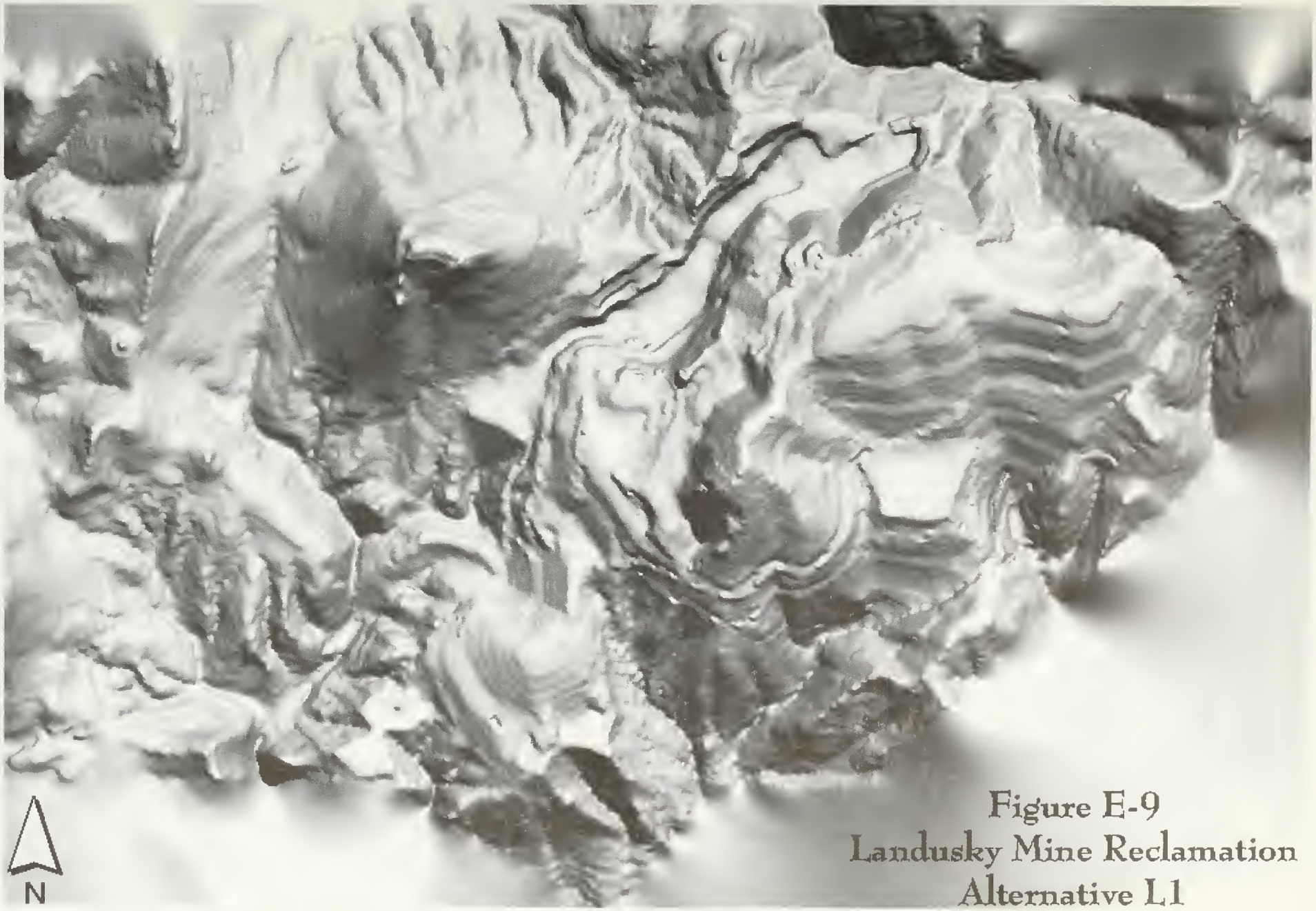


Figure E-9
Landusky Mine Reclamation
Alternative L1

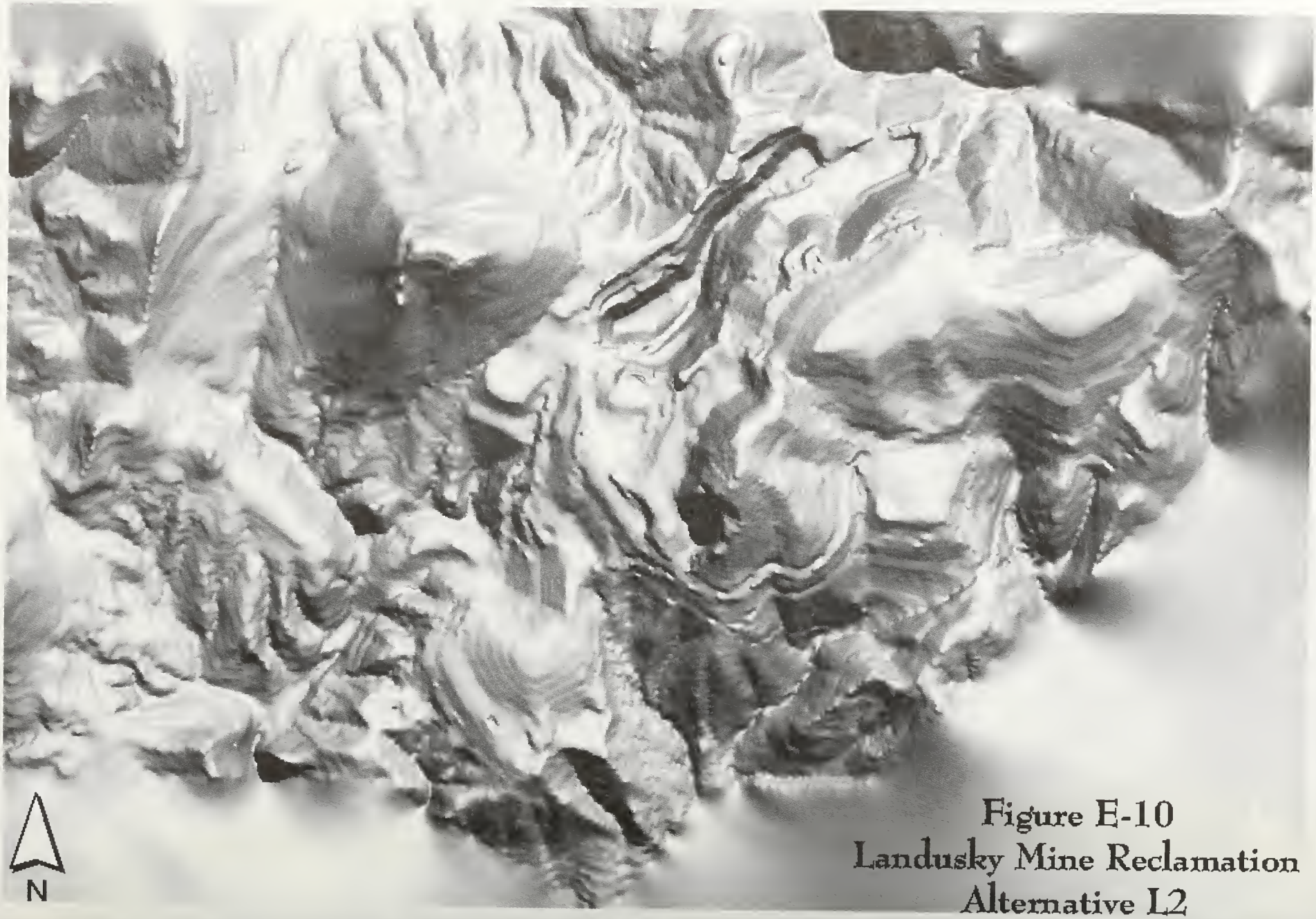


Figure E-10
Landusky Mine Reclamation
Alternative L2

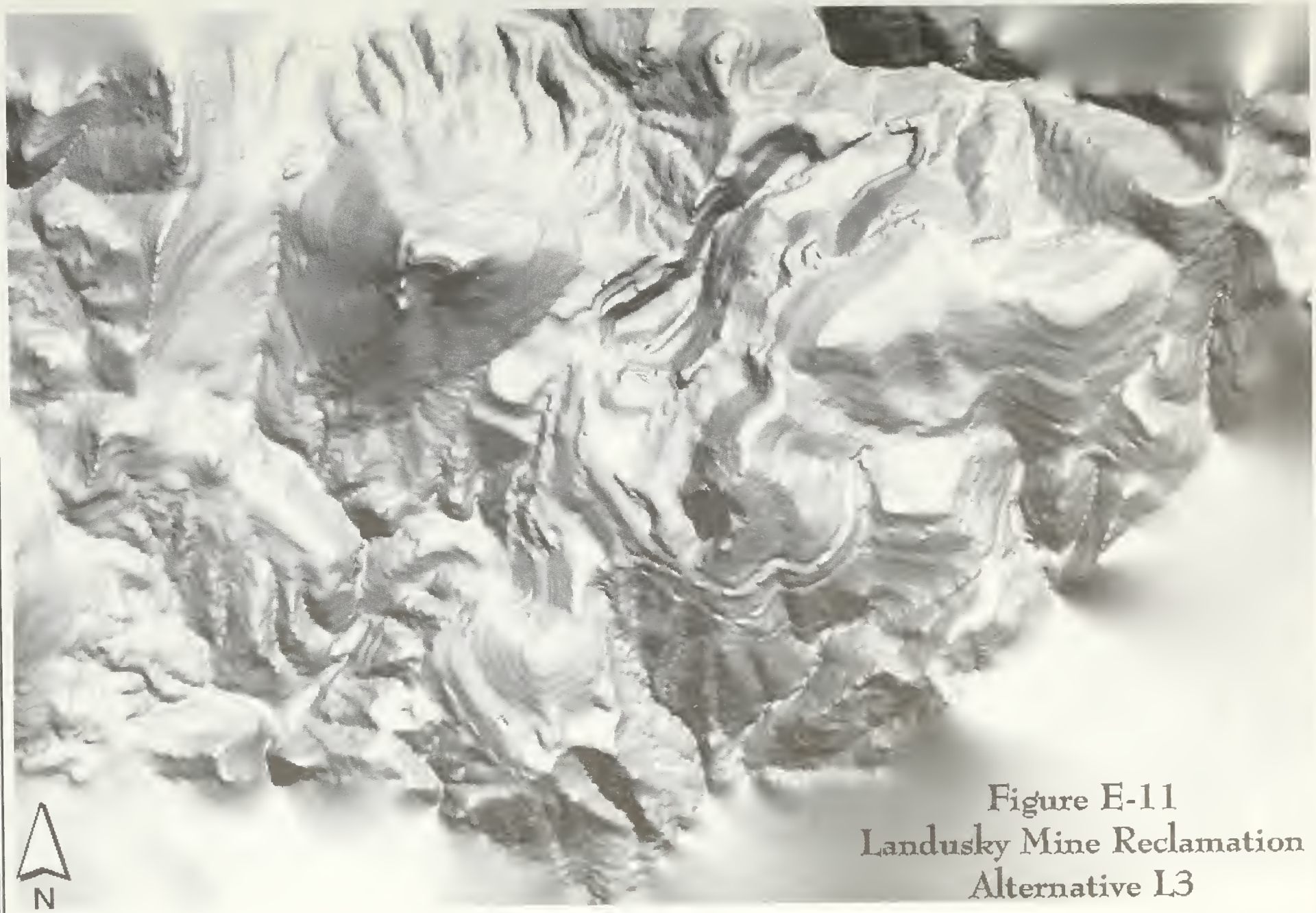


Figure E-11
Landusky Mine Reclamation
Alternative L3

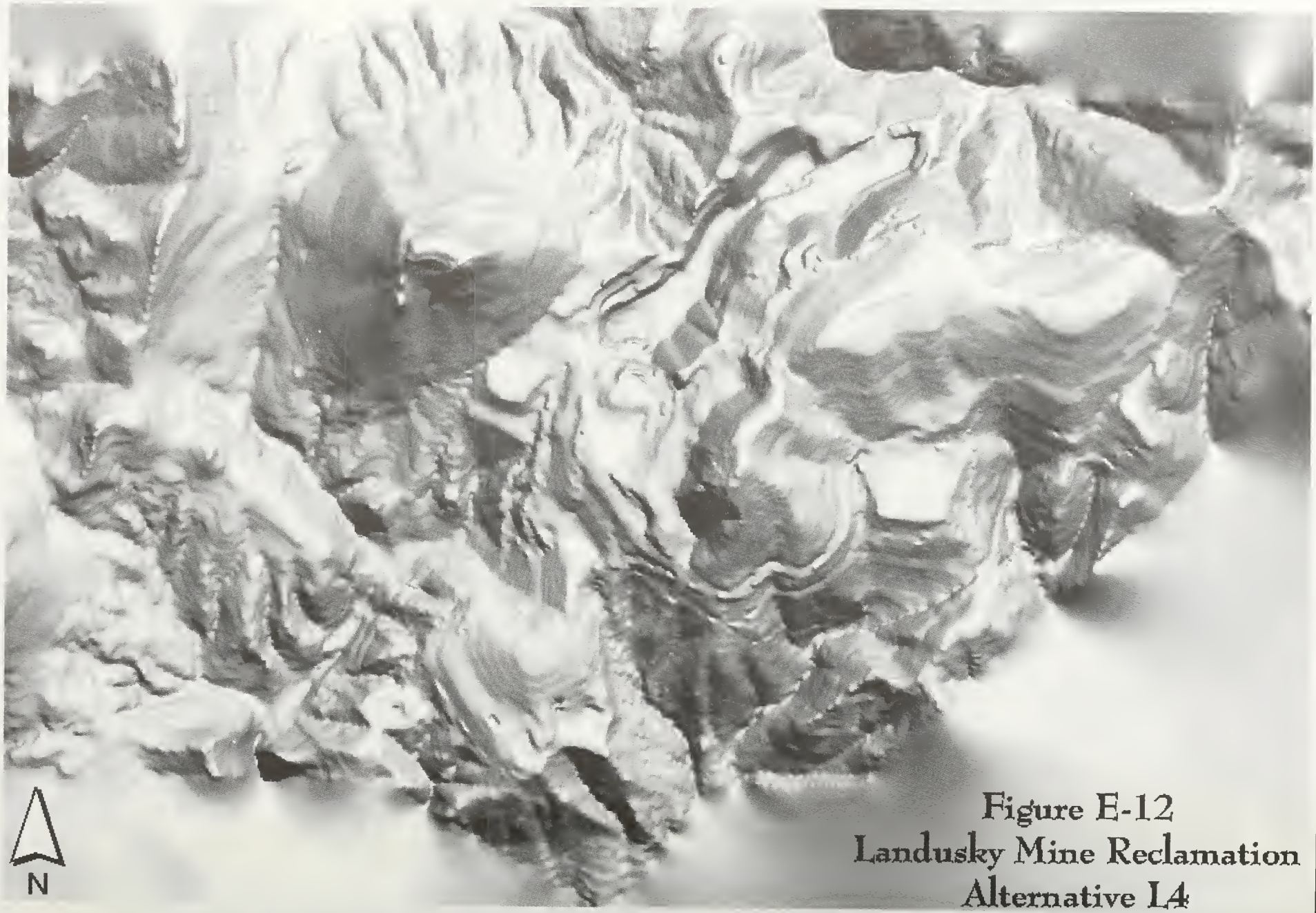


Figure E-12
Landusky Mine Reclamation
Alternative L4

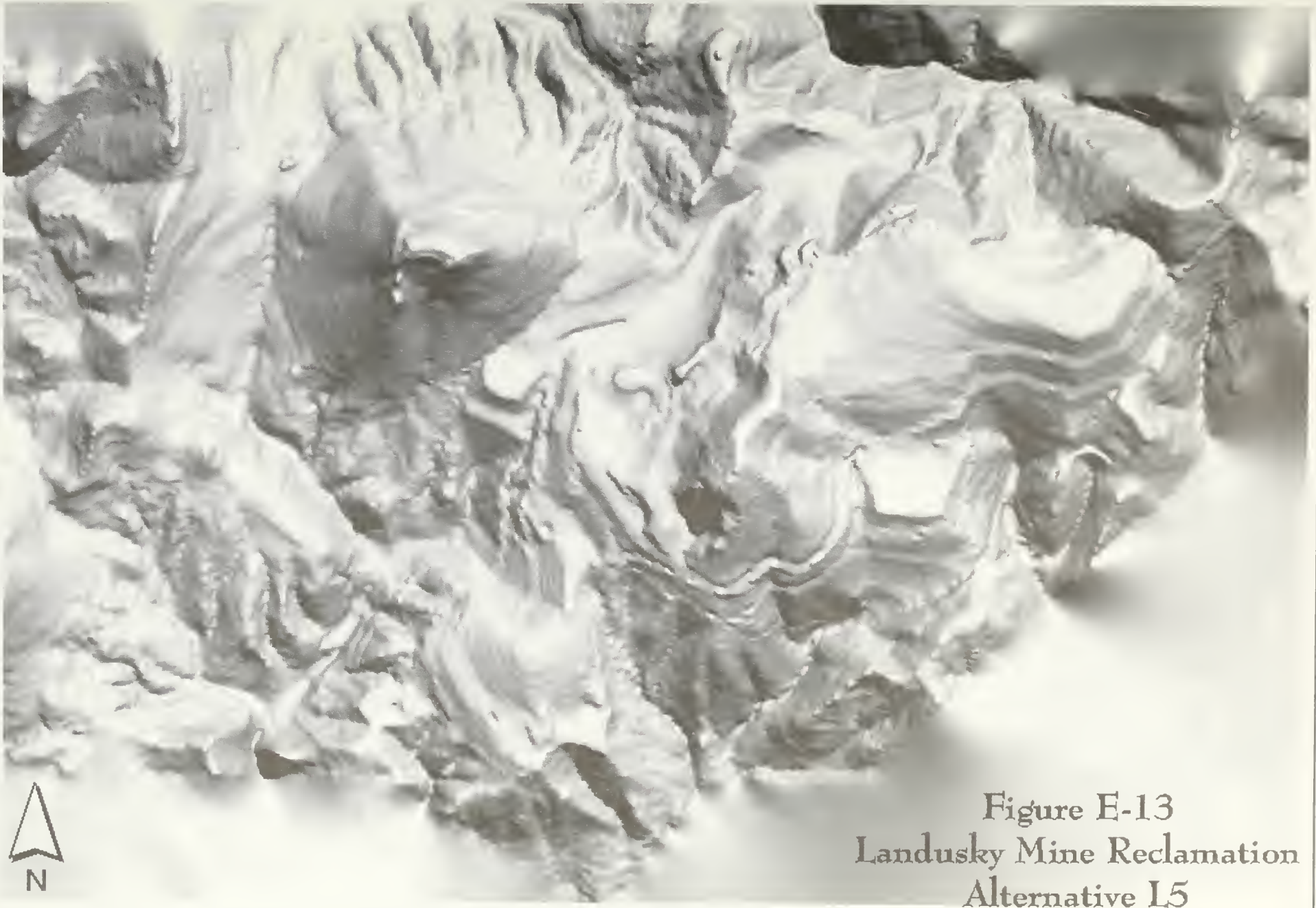


Figure E-13
Landusky Mine Reclamation
Alternative L5

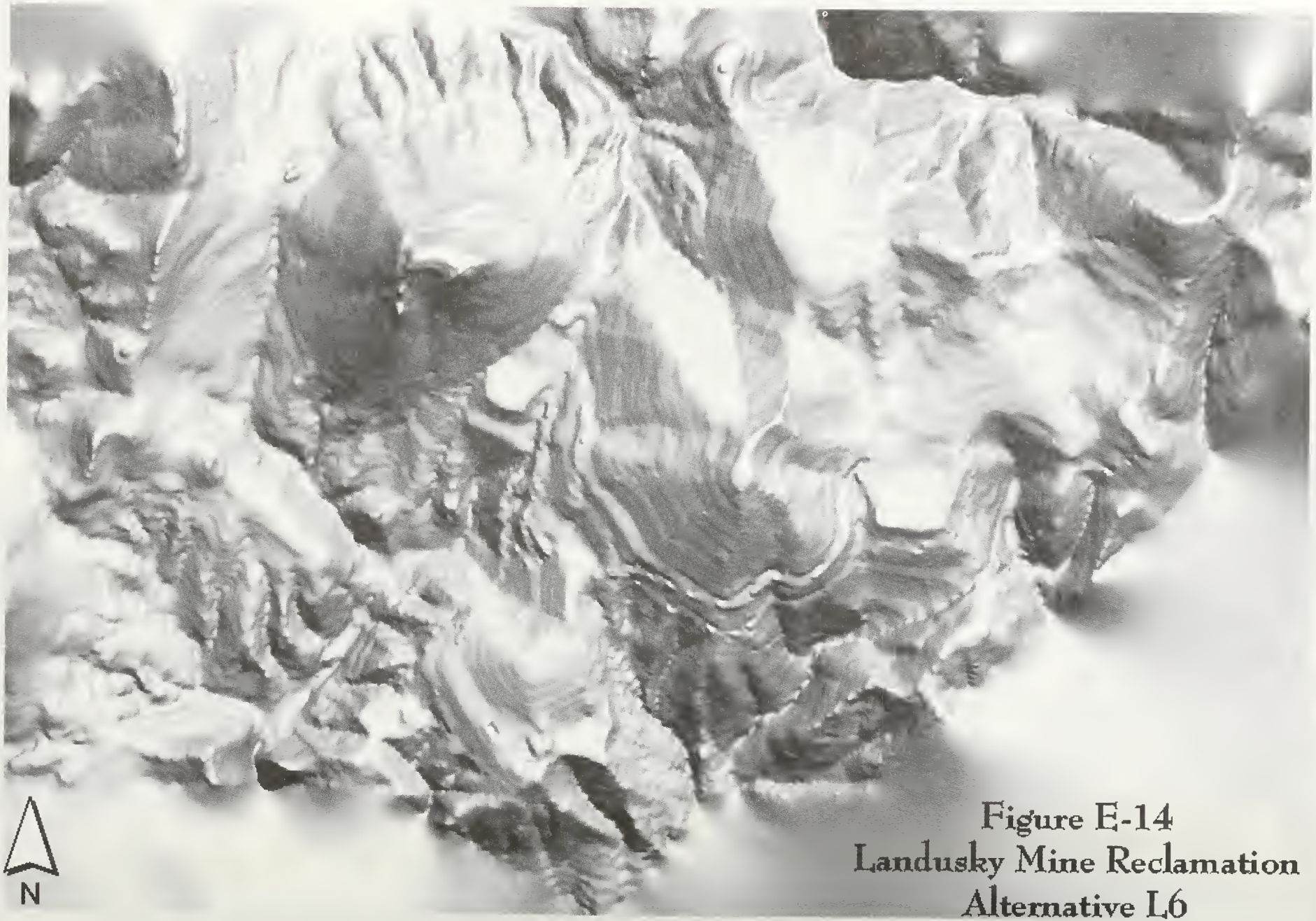


Figure E-14
Landusky Mine Reclamation
Alternative L6