303 Irene Street
P.O. Box 4699
Helena, MT 59604

(406) 443-5210
Fax: (406) 449-3729

TECHNICAL MEMORANDUM

TO: Bob Kirkpatrick – Northern Region
Mary Beth Marks – On-Scene Coordinator

FROM: Gretchen Meier - Plant Ecologist
Michael Cormier

DATE: November 8, 2002

RE: 2002 Reclamation Monitoring
New World Mining District Response and Restoration Project

This memorandum describes results of reclamation monitoring performed in 2002 by Maxim Technologies, Inc.® (Maxim) as part of the New World Mining District Response and Restoration Project. Mine waste removal areas reclaimed in 2001 were monitored for potential erosion problems and revegetation success, as well as long-term monitoring that was conducted at the McLaren Triangle and selected roads reclaimed during 1993 to 1996 by Crown Butte Mining, Inc. (CBMI).

The scope of work for reclamation monitoring is described in the 2002/2003 Work Plan. Work included area-wide monitoring of dumps and roads as well as cover assessment and monitoring of vegetation present in the McLaren Triangle. The main objective of area-wide and cover monitoring is to identify areas that may require maintenance in the form of reseeding, refertilization, or other reclamation amendments. Methods and results of monitoring are summarized below, followed by recommendations for further work at the sites monitored.

METHODS

Area-wide and cover monitoring were conducted according to methods described in the 2002/2003 Work Plan (Maxim, 2002), the Long-Term Revegetation Monitoring Plan (Maxim, 1999a), and the Site-Wide Sampling and Analysis Plan (Maxim, 1999b). The goal of area-wide monitoring in 2002 is to establish whether germination was successful at the waste dumps reclaimed in 2001, and to document erosional features that adversely affect vegetation establishment. Maxim conducted area-wide monitoring at the following reclaimed mine dumps and tailings sites:

- Upper Tredennic Dumps 1 and 2
- Upper Tredennic access roads and loading area
- Middle Tredennic Dump 1
- Lower Tredennic Dump 1
- Small Como Dump
- Lower Spalding Dump and access road
- Upper and Middle Spalding Dump
- Soda Butte Tailings
- Rommel Tailings and borrow area
- Access roads used to access the 2001 mine waste sites, and exploration roads reclaimed by CBMI in the 1993-1996 period

Observations recorded at each site included presence/absence of salts, steepness of slope, pooling or ponding of water, lack of vegetation, erosional features such as rills or gullies, all-terrain vehicle (ATV) use, and visual estimates of vegetation cover and surface rock.

Areas that were observed to be barren of vegetation may require additional maintenance to ensure adequate vegetation cover and to prevent erosion. Barren areas were defined in the field as 10% or more of the reclaimed area. A visual estimate of the area lacking vegetation was recorded in the field notebook and soil samples were collected.

Soil samples were submitted to Northern Analytical Laboratories in Billings, Montana and analyzed for the following parameters: total arsenic, cadmium, copper, lead, and zinc; saturated paste pH and electrical conductivity; and, plant available nutrients (nitrate-nitrogen, phosphorus, and potassium). Analyses were conducted according to methods and procedures described in the Site-Wide Sampling and Analysis Plan (Maxim, 1999b).

For area-wide monitoring of the CBMI road reclamation work, roads were divided into three sampling strata by elevation. The upper (highest) elevation roads occurred on exposed scree slopes at elevations greater than 9,900 feet above mean sea level (ft amsl). Mid-elevation roads occurred at elevations ranging from 9,600 to 9,900 ft amsl, and lower elevation roads occur at elevations below 9,600 ft amsl.

The goal of vegetation cover assessment at the McLaren Triangle was to establish if plant cover had improved from previous years' monitoring (1999 and 2000). Cover monitoring methods are described in the Long-Term Revegetation Monitoring Plan (Maxim, 1999a) with the following modifications:

- Four additional transects were established to bring the number of quadrates to 52. The initial quadrate placement along each transect was determined by a random number between 0 and 8.3 feet. Quadrates were systematically placed 8.3 feet from the initial quadrate location along each transect. Each quadrate contained 10 hits, recorded at the intersection of a wire grid on the quadrate.

AREA-WIDE MONITORING RESULTS

Field data sheets were used to record area-wide monitoring observations. These field sheets are contained in Attachment A. Site photographs of the reclaimed dumps are contained in Attachment B.
Soil sample analytical reports are contained in Attachment C.

Upper Tredennic Dumps One and Two, Access Roads, and Loading Area

Revegetation on Upper Tredennic Dump One was extremely sparse and uneven, primarily resulting from the approximately 80% rock cover of 3-inch plus rocks. The slope is stable with small patches of grasses growing in crevices on the lower portion of the dump. Though this area was seeded, the quantity and size of the surface rock does not provide a suitable growth substrate. A small depression is centrally located in the slope. The rock surface is iron- and manganese-stained in some places.

One soil sample, FCSI-96-15 (Attachment C), was collected from the Upper Tredennic Dump One. The saturated paste pH of the dump is ultra acid (2.6 standard units), which likely precludes the opportunity for vegetation to establish on the rocky surface. The low pH is due to the fact that lime and topsoil could

not be applied to the reclaimed surface because there was no access to the steep slope with equipment. Total metals concentrations in the sample are below human health cleanup guidelines, but copper (372 milligrams per kilogram [mg/kg]) and lead (611 mg/kg) concentrations are higher than phytotoxicity guidelines. Arsenic, cadmium, and zinc concentrations are below phytotoxicity guidelines.

Revegetation at Upper Tredennic Dump Two was sparse and uneven though without large bare areas. Germination was successful though plants were small. Tufted hairgrass (*Deschampsia cespitosa*) was the only species identifiable. An ATV or other vehicle had torn the erosion mat in places, although the tears did not appear to create erosion problems.

The Upper Tredennic access road contained sparse to very sparse vegetation. Tufted hairgrass and alpine bluegrass (*Poa alpina*) were the dominant species, although a substantial number of new species were growing within the roadbed. The roadbed contained minor rilling and impacts from vehicle traffic.

The loading area contained moderate revegetation. Vegetation was extremely patchy although plants were robust in some areas. The surface of the loading area contains scattered rocks.

Middle Tredennic Dump 1

New plant growth was even, though sparse in some areas, and there were no large bare areas present. Diverse, native species are present on edges of the dump. Erosion mat is holding well below the backfilled adit. Above the backfilled adit, some minor rilling is occurring under the erosion mat and some water pooling is occurring. Sediments contain some iron and manganese staining.

Lower Tredennic Dump 1

Revegetation is excellent at the Lower Tredennic Dump. Slender wheatgrass (*Agropyron trachycaulum*) is fairly abundant, covering approximately 15 to 20 % of the area. Few tufted hairgrass plants are present. Lewis monkeyflower (*Mimulus lewisii*) occurs within the rock-lined channel. Vegetation is sparser in areas without erosion mat.

Small Como Dump

Overall, revegetation at the Small Como Dump was poor at the time of monitoring as vegetation cover was sparse and patchy. Areas with erosion mat contained slightly more vegetation cover; areas without erosion mat contained little or no vegetation cover. Based on visual observations of Forest Service personnel, revegetation cover improved later in the summer on the reclaimed area, largely due to the frequent rains that fell in August.

Rills and gullies located adjacent to the northern edge of the reclaimed site are beginning to erode onto the reclaimed site. Surface water flow appears to be limiting vegetation growth in the lower portion of the dump and soil chemical properties appear to be affecting plant growth on the upper portion of the dump.

The soil sample collected from the bare area at the upper end of the Small Como Dump (Attachment C) exhibits a neutral pH and levels of phosphorous and potassium that are adequate for vegetation. Organic matter content (3.4%) is higher than the design specification of 3%, but nitrate-nitrogen content is in the

very low range. Total metals concentrations were below human health cleanup guidelines and below phytotoxicity guidelines except for copper, which was measured at 206 mg/kg. This concentration of copper is slightly higher than the phytotoxicity guideline of 125 mg/kg.

Lower Spalding Dump and Access Road

Revegetation on the Lower Spalding Dump and access road is even and without large barren areas. Slender wheatgrass is the most successful species though tufted hairgrass is present as well. Surface rocks, which appear to be limiting vegetation growth, cover approximately 10% of the surface area.

Upper and Middle Spalding Dump

Revegetation on the Upper Spalding Dump is very poor and very patchy. Vegetation success is most pronounced on the edges of the dump where several native species occur. The seed source for these species is likely the adjacent vegetated areas. Site limiting factors appear to be lack of moisture and physical or chemical properties of the soil. Surface rocks are abundant.

The soil sample collected from the Upper Spalding dump exhibited a moderately acid pH (5.8 s.u.), a non-saline electrical conductivity (0.49 millimhos per centimeter [mmhos/cm]), and adequate phosphorus, potassium, and nitrate as nitrogen levels. The coarse fragment content of 65.1% is high, though, and organic matter content of 0.9% is lower than desired. Only copper, which was measured at 626 mg/kg, exceeds a phytotoxicity guideline; no human heath guidelines are exceeded for total metals concentrations.

Revegetation on the Middle Spalding dump is fairly good especially on the eastern edge of the dump and poor to moderate on the remainder. Slender wheatgrass appears most frequently and tufted hairgrass is infrequent. Erosional features are absent, although there is some surface water flow and seeping. Site limiting factors are surface rocks and possibly soil chemical properties (low pH).

Soda Butte Tailings

Revegetation on the Soda Butte Tailings is excellent. Vegetation cover is approximately 20 to 25%, with the grasses six to eight inches tall. Slender wheatgrass and tufted hairgrass are the most successful species. Water appears to be pooling, creating small areas barren of vegetation. Revegetation on the road is successful though patchy.

Rommel Tailings and Borrow Area

Revegetation is excellent in most areas, although a large barren area occurs in the south central portion of the site. Site limiting factors appear to be lack of fine soil and abundant surface rock. Construction debris present earlier in the season has been removed. The large barren area was apparently used for storing erosion mat and has been reseeded. The access road is thoroughly obstructed with logs and boulders. Revegetation on the road is good, although the most successful species appears to be timothy (*Phleum pratense*), an exotic pasture grass easily mistaken for alpine timothy (*Phleum alpina*), which was the species specified in the construction contract. Timothy appears to be invading adjacent vegetation, although it is unlikely this species will persist for long due to adverse environmental conditions.

The soil sample collected from the bare area at the Rommel site exhibits a neutral pH (7.5 s.u.), a relatively high coarse fragment content of 75.4%, and relatively low fertility and organic matter levels. No human health guidelines were exceeded for any of the metals, and only total copper, which was measured at 325 mg/kg, exceeds a phytotoxicity guideline.

CBMI Reclaimed Roads

Roads in the higher elevation road strata occur along exposed scree slopes. Revegetation in these areas is, for the most part, unsuccessful, due to the lack of fine soil and abundance of rock. After recontouring, these roads appear similar to the surrounding terrain, which lacks vegetation as well. Three roads were visited, Forest District Road (FDR) 18, 15, and 112. Percent rock on these roads ranged from 90 to 100%. Isolated patches of native species, tufted hairgrass, fireweed (*Epilobium angustifolium*), smooth woodrush (*Luzula hitchcockii*), and sedge (*Carex spp.*) were scattered in areas with accumulated fine soil. Forbs are an insignificant portion of the vegetative cover.

Gullies are present on the north face of Fisher Mountain above the Como Basin. Reclaimed roads (FDR numbers 14, 25, 12, the lower portion of 18, and 28) cross this area.

Roads in the mid-elevation road strata frequently occur adjacent to conifer stands and typically contain much more vegetation than the upper elevation road strata. Three roads were visited, FDR 45, 44, and 38. These roads contained 5 to 15% vegetation cover. Obvious species are tufted hairgrass, alpine bluegrass (*Poa alpina*), smooth woodrush, and fireweed. Fine soil ranged from 50 to 70 % of the soil surface. Surface rock ranged from 15 to 50 % of the soil surface. Significant erosional features were not evident in this road strata.

Roads in the lower elevation road strata are typically very well vegetated and lacked notable erosional features.

MCLAREN TRIANGLE RESULTS

At the McLaren Triangle, Maxim sampled 131 vegetation quadrates on nine transects. Attachment A contains the field data sheets, which are summarized in Table 1. Photographs of the McLaren Triangle and randomly selected quadrates are contained in Attachment B. Successful species are tufted hairgrass, alpine bluegrass and an unidentified moss. Alpine bluegrass was most abundant averaging 6.3% cover; moss and tufted hairgrass were less frequently encountered and averaged 4.5 and 4.3% cover, respectively. Overall percent cover of vegetation was 15.0%. Sedge and fireweed occurred infrequently across the site.

Table 1
McLaren Triangle 2002 Reclamation Monitoring - Transect and Quadrate Data

Species	Transect									Total hits	Percent cover[1]
	1	2	3	4	5	4.5	3.5	2.5	1.5		
Tufted hairgrass	4	0	6	3	2	2	5	1	0	23	4.3
Alpine bluegrass	1	1	2	5	8	12	4	1	0	34	6.3
Moss	0	0	3	4	4	10	3	0	0	24	4.4
Litter	3	3	12	9	6	9	9	9	1	61	11.3
Bare ground	28	31	34	31	27	24	34	42	15	266	49.4
Rock	4	15	23	18	13	13	14	17	14	131	24.3
Total hits per transect	40	50	80	70	60	70	69	70	30	539	--

Notes: 1 Percent cover is calculated as the number of individual hits / total number of hits x 100.

Fine soil or bare ground accounted for 49% of the soil surface. Rock covered approximately 24% of the soil surface and litter covered approximately 11%.

Data from long term revegetation monitoring in 1999 and 2000 (Maxim 1999, Maxim 2000) indicated that percent cover is very low and has not improved. Overall percent cover in 1999 and 2000 was 11.3% and 16.6%, respectively.

The composite soil sample collected from the McLaren Triangle exhibited a strongly acid pH of 4.5 s.u. Coarse fragment content is relatively high at 67.4%. Organic matter was measured at 1%, and fertility levels are adequate for phosphorus, but in the low to very low range for potassium and nitrate as nitrogen.

RECOMMENDATIONS

At the time of reclamation monitoring, revegetation growth on the reclaimed sites visited in 2002 was considered poor to moderate based on visual estimates. However, following the monitoring event, a considerable amount of moisture fell through the month of August, and on-site USDA Forest Service personnel noted that vegetation cover appeared to substantially improve as a result of this moisture. Because the 2001 reclaimed waste rock dump sites did not contain large bare areas or significant erosional features at the time of the monitoring event, and because the large bare area at the Rommel Tailings was seeded and fertilized in August 2002, additional maintenance to improve vegetation cover at the 2001 reclaimed sites is not necessary. Cover monitoring should be performed again in 2003 to monitor vegetation success on these sites. No further monitoring of vegetation on CBMI reclaimed roads is needed.

Vegetation cover at the McLaren Triangle could be improved with fertilizer, reseeding, and addition of organic matter applied in the fall of 2003. Seeding and fertilizing should occur after September 15th. Recommended seeding rates are specified in Table 2 and follow rates established by Brown et al (1996).

Table 2
Recommended Reseeding Rates for McLaren Triangle

Common Name	*Scientific Name*	Cultivar	Seeds/kg	Seeding Rate (kg PLS/ha)
Tufted hairgrass	*Deschampsia cespitosa*	Notran	5,500,000	2.5
Alpine bluegrass	*Poa alpina*	--	2,200,000	6.5
Alpine timothy	*Phleum alpina*	Molas Pass Collection	2,860,000	4.5
Slender wheatgrass	*Agropyron trachycaulum*	San Luis	349,800	37.5

Brown et al. (1996) recommends refertilization to increase biomass on reclaimed mine soils. Fertilizer rates are specified for nitrogen and phosphorus. Nitrogen should be applied at a rate of 100 lbs N per acre in a balanced (16-16-16 N-P-K) granular fertilizer. In terms of bulk fertilizer, approximately 625 pounds (100/0.16) of 16-16-16 bulk granular fertilizer will produce approximately 100 lbs of elemental nitrogen. Seeding should be done using broadcast methods.

In addition to seeding and fertilizing at the McLaren Triangle, a topical application of agricultural limestone would help to partially alleviate acid conditions in the seedbed (upper inch of soil). The limitation for topical application is necessary because incorporating the limestone amendment would damage the existing vegetation. A suggested rate for topical application is 1,000 pounds per acre. The topical application could be spread with a fertilizer spreader towed behind a small tractor. To minimize damage to existing vegetation, limestone and fertilizer could be spread in one operation prior to seeding after September 15th.

Following seeding, fertilizer, and limestone application, lightweight erosion mat (North American Green 75BN or equivalent) should be installed. Erosion matting will add a moderate amount of organic matter and reduce the loss of seed that can occur during windy periods.

REFEERENCES CITED

Brown, R.W., M.C. Amacher, B.D. Williams, W.F. Mueggler. 1996. Reclamation Research in the New World: 1995 Report of Research. USDA Forest Service Intermountain Research Station Forestry Sciences Laboratory, Logan UT.

Maxim Technologies, Inc. 1999a. Long-Term Revegetation Monitoring Plan. Appendix E of the Overall Project Work Plan, New World Mining District Response and Restoration Project. Prepared for USDA Forest Service Northern Region Missoula, Montana. November 10.

Maxim Technologies, Inc. 1999b. Site-Wide Sampling and Analysis Plan. Appendix B of the Overall Project Work Plan, New World Mining District Response and Restoration Project. Prepared for USDA Forest Service Northern Region Missoula, Montana. November 10.

Maxim Technologies, Inc. 2000a. 1999 Long-Term Revegetation Monitoring Report. New World Mining District Response and Restoration Project. Prepared for USDA Forest Service Northern Region Missoula, Montana. March 7.

Maxim Technologies, Inc. 2000b. 2000 Long-Term Revegetation Monitoring Report. New World Mining District Response and Restoration Project. Prepared for USDA Forest Service Northern Region Missoula, Montana. November 19.

Maxim Technologies, Inc. 2002. 2002/2003 Work Plan. New World Mining District Response and Restoration Project. Final. Prepared for USDA Forest Service Northern Region Missoula, Montana. July 22.

ATTACHMENT A

DATA SHEETS, SUMMARY TABLES, AND FIELD NOTES
2002 Reclamation Monitoring Memorandum
New World Mining District Response and Restoration Project

ATTACHMENT B

PHOTOGRAPHS
2002 Reclamation Monitoring Memorandum
New World Mining District Response and Restoration Project

Photo 1. Upper Tredennic Dump 1.

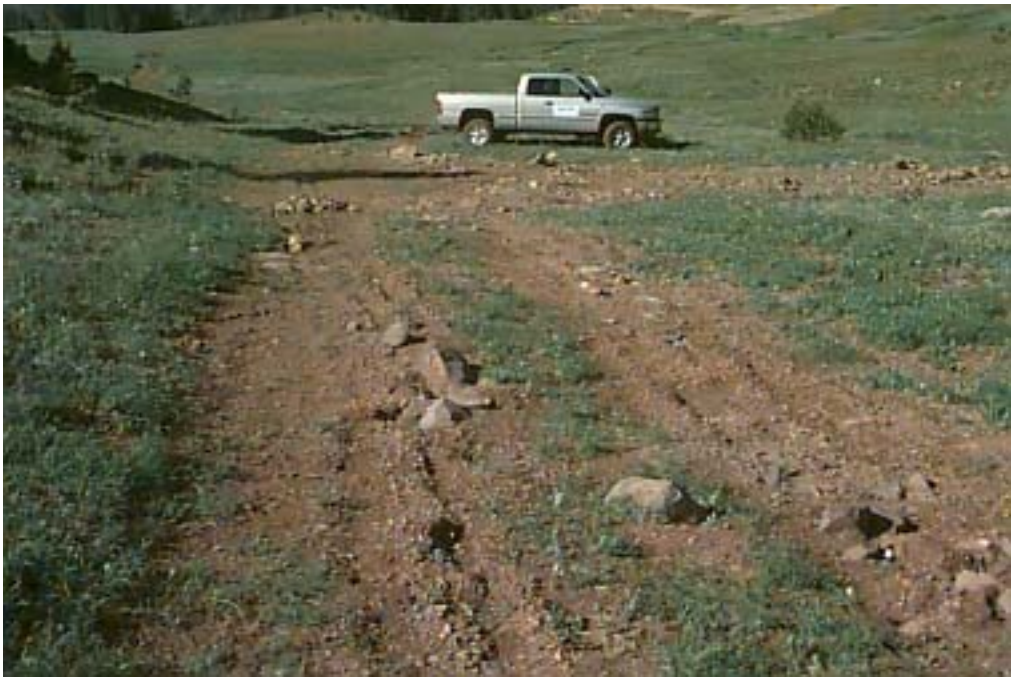

Photo 2. Upper Tredennic access road.

Photo 3. Middle Tredennic Dump.

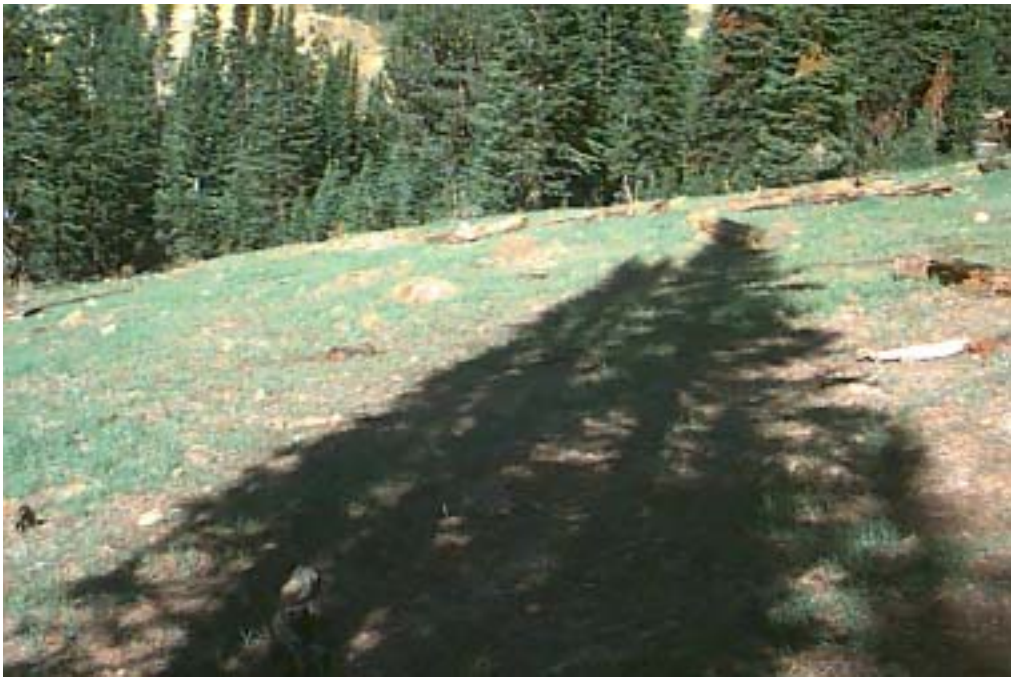

Photo 4. Lower Tredennic Dump.

Photo 5. Small Como Dump.

Photo 6. Middle Spaulding Dump.

Photo 7. Soda Butte Tailings.

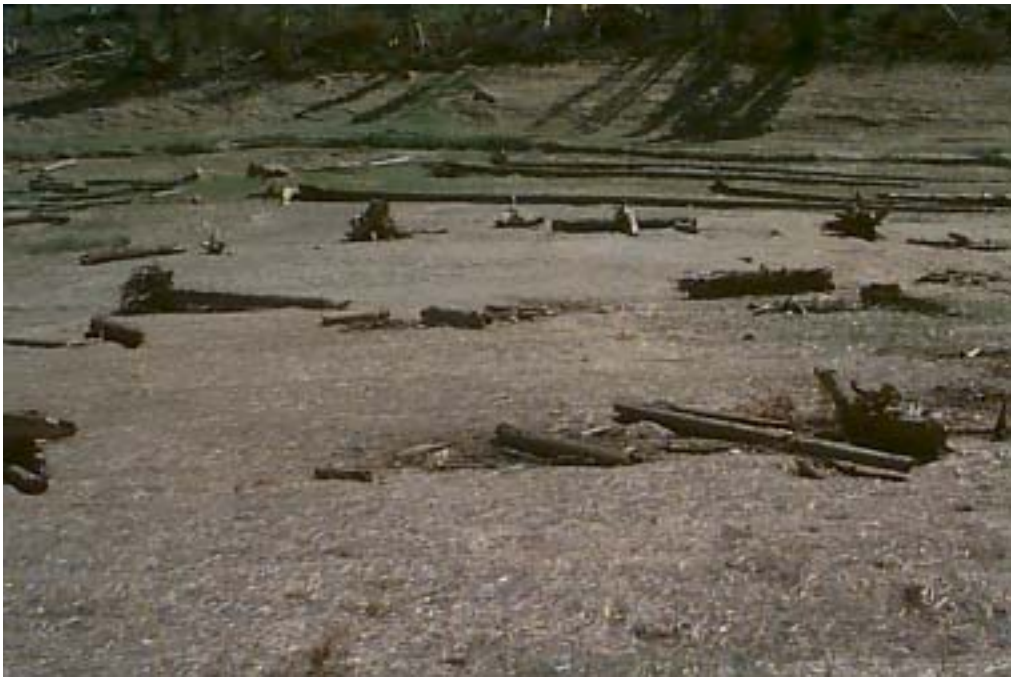

Photo 8. Rommel Tailings

Photo 9. Erosional Features on Road Strata 1, FDR 28, 25, and 14.

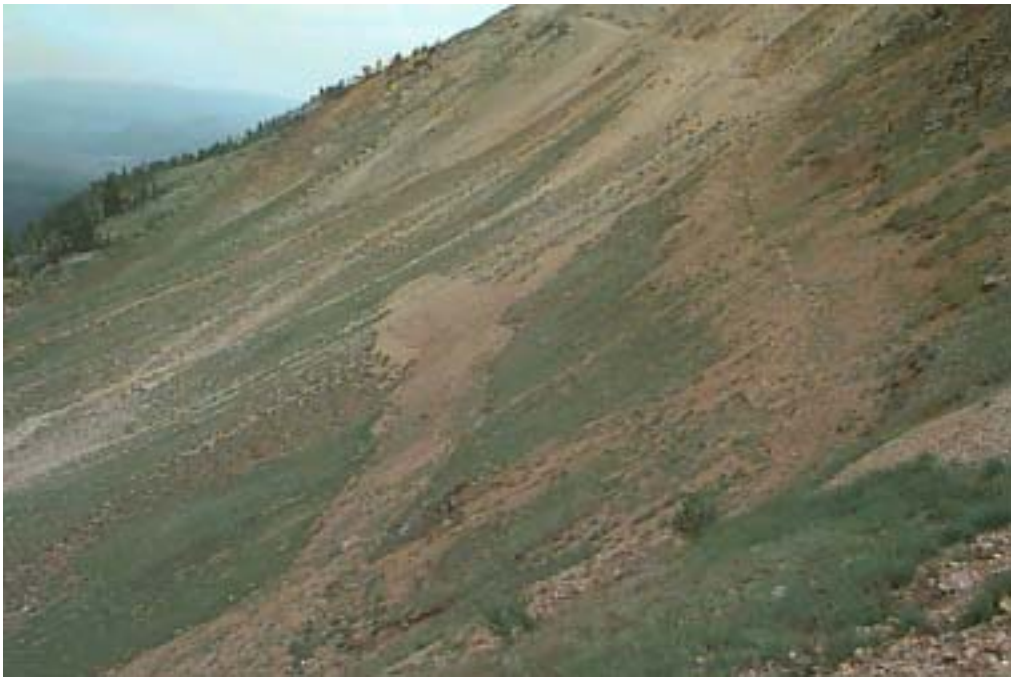

Photo 10. Road Strata 2, FDR 44.

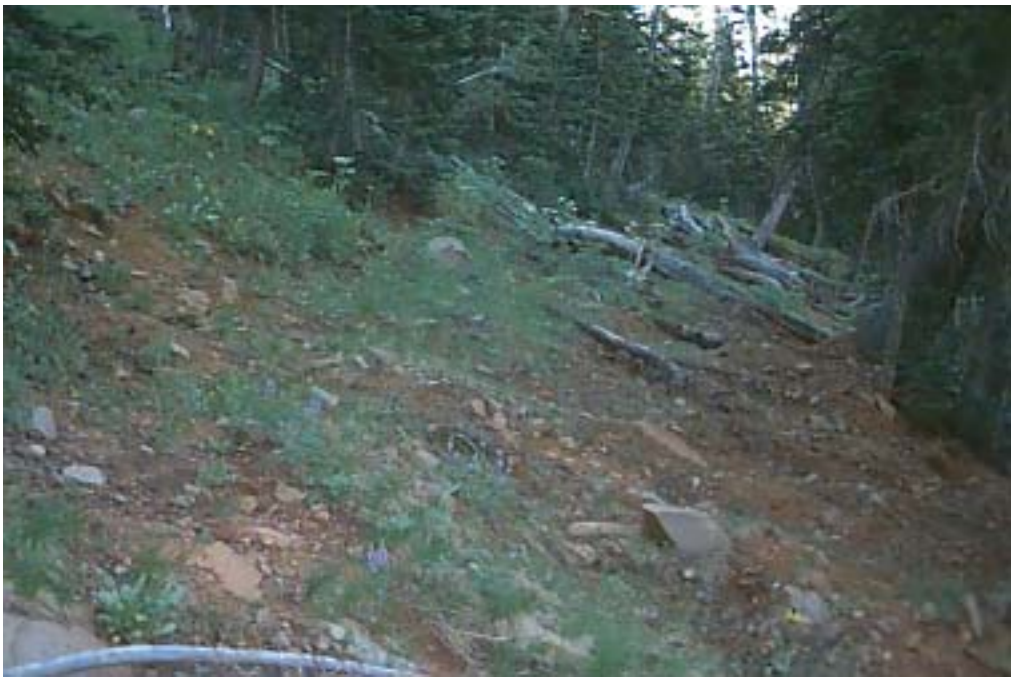

Photo 11. Road Strata 3, FDR 70.

Photo 12. MacLaren Triangle

Photo 13. MacLaren Triangle, Transect 1, Quadrate 4.

Photo 14. MacLaren Triange, Transect 3, Quadrate5.

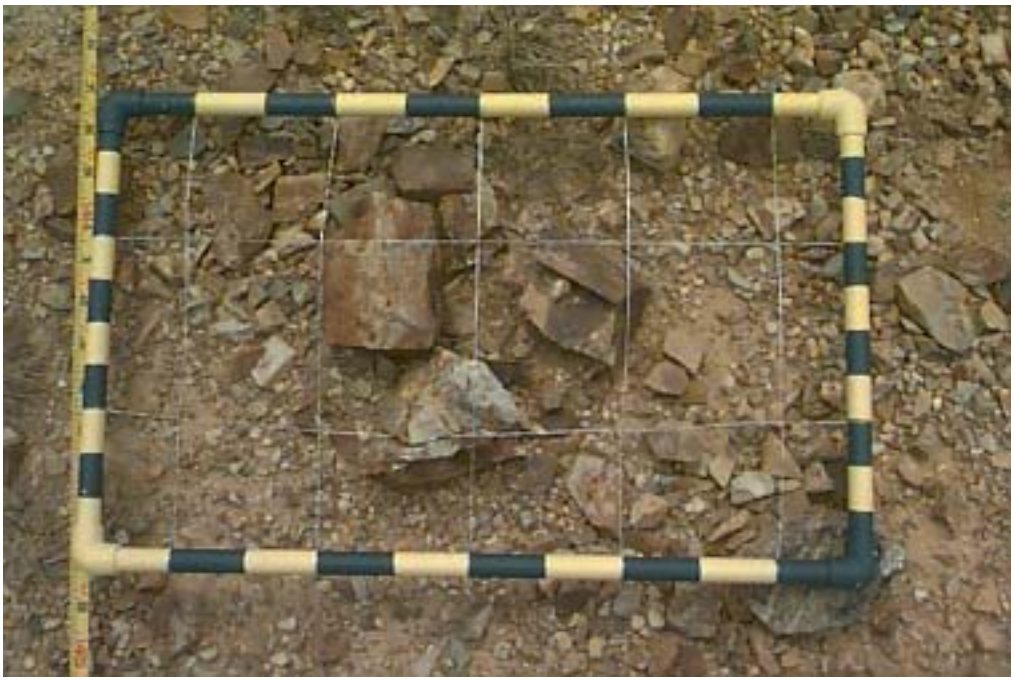

Photo 15. MacLaren Triangle, Transect 5, Quadrate 6.

ATTACHMENT C

SOIL ANALYTICAL REPORTS
2002 Reclamation Monitoring Memorandum
New World Mining District Response and Restoration Project