Final

1999 LONG-TERM REVEGETATION MONITORING REPORT

New World Mining District
Response And Restoration Project

Prepared for:

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Northern Region
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1.0 INTRODUCTION

This Long-Term Revegetation Monitoring Report for the New World Mining District (District) Response and Restoration Project was prepared by Maxim Technologies, Inc. (Maxim) for the United States Department of Agriculture - Forest Service (USDA-FS). The USDA-FS is undertaking non-time-critical removal actions in the District to respond to and restore natural resources affected by historic gold, silver, copper, and lead mining. The District is located in a 40 square mile area surrounding Cooke City, Montana (Figure 1).

The objectives of revegetating disturbed areas in response and restoration are to provide an effective erosion control measure and to produce a self-sustaining vegetation community that reflects the natural conditions of the undisturbed, native communities in the District. The primary purpose of revegetation monitoring is to ensure that these objectives are being met and to provide a mechanism for corrective action if the objectives are not being met. To this end, long-term revegetation monitoring consists of the following: collecting annual data over the life of the project on existing and newly reclaimed areas; documenting trends in vegetation parameters over time; identifying areas where revegetation may be failing; and providing recommendations for maintaining revegetated areas.

This report presents the results of area-wide monitoring and cover monitoring performed by Maxim in 1999 in accordance with the Long-Term Revegetation Monitoring Plan (Maxim, 1999 draft). This monitoring report is one of several project monitoring programs that will provide input to the development of annual non-time critical response actions. Monitoring was initially conducted on about 26 acres of reclaimed disturbed areas and about 9.8 miles of reclaimed roads that are present in the District as of May 1999 (Figure 2). Additional disturbed areas are expected to be reclaimed and subsequently monitored during each year of the project life.

1.1 SITE LOCATION AND DESCRIPTION

The District is located in Park County in south-central Montana. It is bounded on the south by the Montana-Wyoming state line, on the west by Yellowstone National Park and on the north and east by the Absaroka-Beartooth Wilderness area boundary (Figure 1). The District is characteristic of subalpine regions of the northern Rocky Mountains with elevations that range from approximately 7,000 feet to over 10,000 feet. Accumulated snow pack in the higher elevations range from 10 feet to over 20 feet deep where drifting occurs. The ground is generally snow covered from late October through mid May at the lower elevations and from early October through late July at the higher elevations. Perennial and semi-perennial snow fields occupy the north facing slopes of the highest mountain peaks.

Three drainage basins have been identified as potentially being impacted by the proposed response and restoration actions: 1) Fisher Creek and the Clarks Fork of the Yellowstone River; 2) Daisy Creek and the Stillwater River drainage basin; and, 3) Miller Creek and Soda Butte Creek drainage basin.

Predominant native vegetation communities in the project area include upland forest types, upland herbaceous and shrub types, bottomland types, and avalanche complex types. Upland forests generally predominate below 9600 feet; however, several types composed of whitebark pine (*Pinus albicaulis*) and subalpine fir (*Abies lasiocarpa*) extend into mid and upper slopes above this elevation primarily on southerly slopes. Several upland herbaceous and shrub types exist, their distribution determined by factors such as elevation, slope, aspect, topographic position, and soil characteristics. Bottomland forests extend along riparian areas throughout the project area, increasing in tree cover with decreasing elevation. Avalanche areas are present in upper Fisher Creek and at the head of other drainages. Vegetation communities vary with intensity and frequency of snow movement, topographic features, and soil characteristics (Scow et al., 1992).

1.2 RECLAMATION HISTORY

In August 1998, Crown Butte Mines, Inc.(CBMI) entered into a consent decree (Decree) with the United States Government, the State of Montana, and several non-profit organizations. The Decree provided funding for, and guidance on, response and restoration actions to be implemented on historic mine related disturbances in the District. The USDA-FS became the lead agency in the clean-up effort. The work, among other aspects, includes evaluating revegetation efforts that have been completed in the past as well as those revegetation projects that will be completed over the expected 8-year life of the project.

Mitigation of historic mining wastes has been an on-going interest of numerous parties since the 1970s. One of the first to investigate revegetation in the District was the USDA-FS Intermountain Research Station (Brown, 1996). This research has focused on reclamation of high elevation mine disturbances including species selection, fertilization, planting season, organic amendments, acid soil amendments, and surface soil treatments. Larger scale reclamation efforts have also been conducted by numerous parties involved in reclamation of the McLaren Tailings near Cooke City (Figure 1). In 1969, the Bear Creek Mining Company covered the McLaren Tailings with soil and rerouted Soda Butte Creek. In 1989, the EPA constructed a dam at the lower end of the tailings to stabilize the banks of Soda Butte Creek (UOS, 1998). Other areas of the tailings have been recontoured and revegetated since that time.

Some reclamation work was completed by CBMI on “District Property” as part of CBMI’s exploration and proposed mine development work (Figure 2). In 1991, CBMI completed surface reclamation activities in the following areas (Kirk, 1992):

- Drill roads and pads in the Miller Creek development and “T-Zone” exploration areas and at all geotechnical drill sites in upper and lower Fisher Creek; and,
- Several abandoned mine areas in Fisher Creek (three large drill-pads), the Glengarry Mine area, five bulldozer trenches on the east side of Fisher Mountain, and several short roads in the “T-Zone” area.

All areas were fertilized and seeded, and re-contouring was performed on all roads, pads, and bulldozer trenches. Fertilizer was applied at a minimum rate of 50 pounds per acre and seed was applied at a rate of between 25 and 40 pounds per acre using a mix prescribed by the USDA-FS for high altitude acidic soil conditions. Hydromulching techniques were used for seed and fertilizer application, but only in easily accessible or open portions of the Miller Creek area. Topsoil replacement was performed where sufficient material was available (i.e., at lower elevation sites). Considerable trash cleanup and surface water diversions were additionally required at the Glengarry Mine area.

In 1992, surface reclamation was completed at Como Basin, McLaren Pit, Miller Creek, Alice E., Fisher Creek, Gold Dust adit, and Glengarry Mine (Kirk et al., 1993). The following work was done:

- Water was diverted from the collar area of two shafts in the Como Basin by cat-trenching;
- All disturbances created by CBMI in the McLaren Pit and pre-existing drill roads in the area were re-contoured (including the pit) and fertilized and seeded (all areas but the pit);
- Most disturbances created by historical mining, and all of those created by CBMI (roads and pads), in the Miller Creek deposit area were reclaimed by re-contouring, fertilizing, and seeding;
- All drill pads, roads, and trenches in the Alice E., Fisher Creek, and Gold Dust adit areas created by CBMI were reclaimed by re-contouring, fertilizing, and seeding; and,
- Historic disturbances at the Glengarry mine dump were re-contoured and the stream re-channeled.

Figure 1

Figure 1 (back)

Figure 2

Figure 2 (back)

Though not described in the New World Project 1992 Year End Report (Kirk et al., 1993), reclamation techniques are presumed to have been similar to those described above for 1991 reclamation activities.

Between late 1992 and 1994, CBMI completed intense surface reclamation activities at the Como Basin, McLaren Pit, and the Glengarry Mine. Miscellaneous reclamation activities were also completed in outlying areas. These activities are described in the New World Project 1993 and 1994 Year End Reports (Kirk et al., 1995), relevant sections of which are included in Appendix A. Specific purposes of activities included: re-contouring, diversion and interceptor ditches, lined and armored ditches, armored outlets, revegetation, and erosion and sediment control. Activities undertaken at each of the areas included:

- McLaren Pit Area
  - Recontouring of about 20 acres of unconsolidated surficial material left in benches, open-cuts, and road-cuts above the main haul road (except the high-wall);
  - Four lined and amored drainage pathways were constructed during re-contouring of the pit area (above the main haul road);
  - A pit high-wall diversion ditch was constructed along a pre-existing drill road to divert surface water flow above the pit high-wall;
  - A lined and armored diversion ditch was constructed along the base of the high-wall to divert surface water flow around the pit;
  - All pre-existing drill roads on the west side of Fisher Mountain (except the main access road and diversion ditch) were re-contoured, fertilized, and seeded;
  - The regraded McLaren Pit area was shallow-limed (except on the Melissa claim), amended with organic material, mulched (where appropriate), covered with erosion blanket (where appropriate), and seeded; and,
  - Erosion control devices including culverts, straw bales, and silt fences were placed at numerous locations within the re-contoured pit and along the main haul road.

- Como Basin Area
  - Lining and armoring of the surface water interceptor diversion ditch around the collar area of the two shafts located at the bottom of the Como pit;
  - Recontouring and regrading of about six acres of disturbance in the pit area to approximate pre-existing topography;
  - Recontouring and revegetation of all drill roads in the area, including those on the north face of Fisher Mountain;
  - Construction of a side-hill surface water runoff diversion ditch along the high-wall of the Como pit;
  - Removal of, recontouring, and topsoil replacement of a breached settling pond dam created by an access road that crossed a small drainage channel on the north end of the pit;
  - Surface drainage (runoff) controls were initiated during recontouring of the Como Basin area consisting of drainage channels on the west and east side of the Basin;
  - Fertilization and reseeding of approximately one-quarter of the Como Basin area in areas of non-acidic soil;

- Revegetation in areas of acidic soil in the Como Basin area consisting of shallow liming, fertilizing, organic matter amendment, mulching (where necessary), and erosion blankets (where appropriate); and,
- Various devices were installed to control erosion until revegetation was established, including hay bales, silt fences, and erosion blankets.

- Glengarry Mine
  - Completion of recontouring of surface disturbances;
  - Construction of a lined armored diversion channel to relocate Glengarry adit discharge around the mine area; and,
  - Fertilization and seeding of all outlying disturbance areas associated with the site, with the exception of the waste rock dump, activities which required follow-up refertilization and re-seeding.

- Miscellaneous Areas
  - Numerous roads were reclaimed throughout the District, including: all roads on the east side of Fisher Mountain, including upper and lower pre-existing roads at the south end of the mountain and spur roads created by CBMI; roads, trenches, and bulldozer cuts on the west side of Lulu Pass; the lower and middle pre-existing access roads to the Spaulding tunnels (north of the Como Pit area, south of Scotch Bonnet Mountain); and, areas along the side of access roads and along the road-trail system in the Gold Dust adit area;
  - Two adit areas and waste rock dumps were reclaimed on the west flank of Fisher Mountain between the Como and McLaren Pit areas;
  - The Black Warrior shaft (on the southwest flank of Crown Butte) was backfilled, regraded, fertilized, and seeded; and,
  - All remaining areas disturbed in the Miller Creek deposit area were reclaimed, including planting of about 50 white bark pine seedlings.

Appendix A contains correspondence with CBMI that documents the determination and implementation of application rates for lime, fertilizer, organic matter, and seeding in the McLaren Pit and Como Basin. Rates of hydrated lime application were between 2.0 and 17.5 tons per acre. Sawdust and woodchips were spread along with the lime and worked into the soil by tractor and chisel plow or cat and scarifier. Both the Como Basin and McLaren Pit areas received about 500 pounds per acre of Biosol. Both areas were seeded at rates between 40 and 45 pounds per acre. Seed mix consisted of slender wheatgrass, alpine bluegrass, timothy, and tufted hairgrass. Seeded areas were either dragged with a meadow harrow or tracked with a crawler, depending on slope. Though not noted in this correspondence, application rates for all other reclaimed areas (e.g., roads, drill pads, trenches, cuts, and dumps) would be similar where they apply; however, application techniques would vary depending on factors such as accessibility and slope.

2.0 COVER MONITORING RESULTS

This section presents data obtained during the 1999 revegetation cover monitoring event completed in the District. Personnel from Maxim and Synergy Environmental (Synergy) conducted revegetation cover monitoring activities at the McLaren Pit, Como Basin, and reclaimed road areas between August 4, 1999 and August 11, 1999 in accordance with protocols described in the Draft Long-Term Revegetation Monitoring Plan (Monitoring Plan) (Maxim, 1999 draft). Activities completed include measuring vegetation cover, density, and species composition on native and reclaimed areas using the point-quadrat method described in the Monitoring Plan. Field notes can be found in Appendix B and field data sheets in Appendix C. These data were reduced to provide monitoring strata summaries of frequency, cover, and density in addition to measures of species diversity (Appendix D). Cover was measured on a subsample of monitoring locations using the 35mm slide method to validate field measurements (Appendix D).

Upon reconnaissance of site conditions, three deviations from the Draft Monitoring Plan were instituted in the field. First, monitoring strata in the McLaren Pit and reclaimed road areas were redefined to better reflect ecological factors and potential influences on revegetation performance. Revised definitions are provided in the discussion below. Second, because of the limited number of possible representative sample locations, the initial numbers of transects located in native reference areas were reduced. Information on sample intensity is also discussed below. Finally, no cover monitoring was conducted in the lower elevation road stratum. This adjustment was made in consideration of observed vegetation performance and lack of barren areas in this stratum and level of effort. Overall, these modifications allowed for a more effective cover monitoring effort meeting project objectives than that dictated by protocols originally described in the Draft Monitoring Plan.

2.1 MCLAREN PIT

The McLaren Pit is the largest contiguous reclaimed area in the District, comprising an area of about 24 acres. It is located at the headwaters of the Stillwater River on the north side of Daisy Pass (Figure 2). For vegetation cover monitoring, the McLaren Pit was stratified into the following three areas, based on ecological factors (Figure 3): 1) the upper level, an area located north of the mined high-wall; 2) the lower area, located downslope of the mined high-wall; and 3) the southern triangle (about four acres) characterized by relatively shaded conditions free of persistent snowpack. Five transects were randomly sited within each reclaimed area. One native transect was located northwest of the McLaren Pit to represent reference conditions for the upper and lower areas and one transect similar to the triangle was located south of the triangle area. Ten quadrats were sampled along each transect. Strata summaries of cover monitoring data for native and reclaimed transects are presented in Tables D-1 through D-5 (Appendix D).

Cover monitoring indicated similar cover and density at all reclaimed monitoring strata within the McLaren Pit. Vegetative cover percent in the three strata ranged between 11.6 to 13.8 percent, and consisted almost entirely of grasses. Density (plants per square meter) of vegetation at these sites ranged from 157 to 281. *Poa alpina* (alpine bluegrass) and *Deschampsia caespitosa* (tufted hairgrass) were the dominant species present, accounting for 97 percent of the vegetative cover and 95 percent of the total plant density on these transects. Rock was the dominant cover feature encountered, with values ranging from 49.0 to 58.2 percent. Litter values ranged from 11.2 to 34.2 percent and bare ground cover ranged from 6.6 to 21.0 percent.

Shannon diversity indices were calculated for both cover and density-based frequency measures. These indices provide an expression of the relative number of species (richness) and proportionate distribution of species (evenness) within the sample data. It is based on the assumption that the more species there are and the more even the distribution, the greater the diversity (or higher the index value) (Chambers and Brown, 1983). There is no mathematical way to compare values obtained from dissimilar communities (e.g., reclaimed versus native areas). When comparing values from differing communities it is more important to note the reasons for values (e.g., species and apportionment) as it is to note the value itself. The Shannon diversity index for cover on the three strata ranged from 0.080 to 0.295, indicating relatively low diversity. Shannon diversity indices based on total plant density ranged from 0.125 to 0.275. The lower values were observed for the lower strata where alpine bluegrass cover accounted for 95 percent of the two species encountered. The higher values for the triangle strata were a result of a relatively more even distribution of alpine bluegrass and tufted hairgrass.

Vegetative cover on native reference transects for the upper/lower and the triangle strata were 19 and 40 percent, respectively. Density values were 276 and 312 plants per square meter, respectively. Species encountered on the native transects were primarily forbs, with *Vaccinium scopartium* (grouse whortleberry) dominating both transects. Notable cover is represented by *Antenaria lanata* (pussytoes), *Poa reflexa*, *Claytonia lanceolata* (springbeauty), and *Hieracium gracile* (hawkweed). Rock, litter, and bare ground cover values were more or less evenly distributed on the native transect associated with the upper and lower strata. Litter was the predominant non-vegetative cover on the triangle area native transect.

Shannon diversity indices based on cover frequency were 0.665 for the reference transect associated with the upper and lower strata and 0.389 for the native transect for the triangle stratum. Density-based indices were 0.931 and 0.484, respectively. These values indicate a relatively higher species diversity compared to those observed for the reclaimed transects. Higher Shannon diversity indices in reference areas reflect the higher relative cover and density of more species. Higher diversity indices on the native transect associated with the upper and lower strata reflects a relatively even distribution of species frequencies compared to the transect for the triangle stratum.

2.2 COMO BASIN

The Como Basin consists of about six acres of reclaimed land located in the Fisher Creek watershed on the south side of Lulu Pass (Figure 2). It was not be stratified for data collection purposes. Five transects were randomly located within the reclaimed area (Figure 4). One native transect was located northwest of the Como Basin, on the north face of Scotch Bonnet Mountain, to represent reference conditions on a site with similar slope, aspect, and elevation. Ten quadrats were sampled along each transect. Strata summaries for reclaimed and native transects are presented in Tables D-6 and D-7, respectively (Appendix D).

Vegetative cover in the reclaimed area was 9.4 percent and consisted almost entirely of grasses. Density at this site was 133 plants per square meter. *Poa alpina* (alpine bluegrass) was the dominant species present, accounting for about 95 percent of the vegetative cover and 86 percent of the total plant density on the transects. Rock was the dominant cover feature encountered, with a value of 44.4 percent. Bare ground was 35.8 percent and litter cover was 8.2 percent. The Shannon diversity index for cover was 0.103, indicating relatively low diversity. The Shannon diversity index based on total plant density on the reclaimed area was 0.228; the higher diversity index a result of more species sampled.

Vegetative cover on the native reference transect was 22.0 percent. Density was about 757 plants per square meter. Species encountered on the native transects were primarily forbs, with *Epilobium alpinum* (alpine fireweed) and *Antenaria lanata* (pussytoes) dominating. Notable cover is represented for *Hieracium gracile* (hawkweed), *Luzula parviflora* (woodrush), *Claytonia lanceolata* (springbeauty), and *Sibbaldia procumbens* (sibbaldia). Rock, litter, and bare ground cover were 39, 33, and 6 percent respectively. The Shannon index based on cover frequency was 1.037 and 1.081 based on density. This indicates a higher species diversity on the native transects, reflecting a greater number and more even distribution of species compared to the reclaimed area.

Figure 3

Figure 3 (back)

Figure 4

Figure 4 (back)

2.3 RECLAIMED ROADS

About 20 kilometers of reclaimed roads occur in the District, the majority of which are located on Fisher and Henderson Mountain (Figure 2). Approximately 15.4 kilometers of road were covered during this monitoring event. Reclaimed roads were stratified into the following three groups for data collection based on elevation, slope, rockiness, and tree cover (Figure 5): 1) upper elevation roads which consisted of exposed, steep scree slopes at elevations generally above 9900 feet; 2) middle elevation roads which were present at elevations generally between 9600 feet and 9900 feet with lower rock content, gentler slopes, and scattered tree cover; and, 3) lower elevation roads below about 9600 feet in heavier cover. Five transects were randomly sited within the upper and middle elevation monitoring strata. One native transect was sited for each of these two monitoring strata to represent reference conditions. Ten quadrats were sampled along each transect. No sample locations were located within the lower elevation monitoring strata in consideration of observed vegetation performance and lack of barren areas in this stratum and level of effort. Strata summaries for reclaimed and native transects are presented in Tables D-8 through D-11 (Appendix D).

Cover monitoring indicated lower cover and density in the upper monitoring stratum (3.8 percent and 35 plants per square meter) compared to the middle elevation monitoring strata (10.4 percent and 135 plants per square meter). *Deschampsia caespitosa* (tufted hairgrass) and *Poa alpina* (alpine bluegrass) were the predominant species present; however, there was incidental representation from other forbs. Rock was the dominant cover feature encountered in the upper elevation monitoring strata (about 77 percent), whereas a higher proportion of sand and silt (about 31 percent) was observed in the middle elevation monitoring stratum relative to coarser rock (about 40 percent). Litter was practically absent in the upper elevation roads, but represented about 19 percent of the cover in the middle elevation roads stratum. Compared to reclaimed strata at the McLaren Pit and Como Basin, Shannon diversity indices calculated for both reclaimed road strata were relatively high. Cover based values were 0.688 and 1.000 in the upper and middle elevation strata, respectively, and density based values were 0.990 and 1.013, respectively. Higher values were due to representation by more native species at relatively equal, albeit low, percentages.

Vegetative cover on native reference transects was relatively higher than that on reclaimed areas; however, diversity was more or less comparable. Vegetation cover was 22 and 31 percent for upper and middle elevation strata, respectively, and density values were 361 and 475 plants per square meter, respectively. Predominating species encountered on upper stratum native transect include: *Sibbaldia procumbens*, *Potentilla diversifolia* (cinquefoil), *Deschampsia caespitosa* (tufted hairgrass), *Silene repens* (campion), and *Artemisia scopulorm* (sagebrush). Predominant species in the middle elevation transect include: *Erigeron peregrinus* (daisy), *Sibbaldia procumbens* (sibbaldia), *Agoseris glauca* (false-dandelion), *Rannuculus eschscholtzii* (buttercup), and *Aster alpigenus* (aster). Rock was the predominant cover on upper elevation roads (about 58 percent) with no bare ground represented. Conversely, litter and bare ground predominate on middle elevation roads (30 and 24 percent respectively), with only 15 percent cover from rock. Shannon diversity indices based on cover were 0.927 and 1.053 in the upper and middle elevation strata, respectively, and density based values were 1.231 and 1.191, respectively.

2.4 DATA QUALITY AND VALIDATION

Data validation and quality was based on three assessments detailed in the Monitoring Plan. To ensure that data were correctly transferred from the field forms into the database, 10% of the data was independently checked and verified. Comparison of cover measurements was performed on a subsample of monitoring locations using the 35mm slide method to assess precision and potential bias (Appendix D). Finally, sample size determinations were calculated from sample variance for each stratum. Calculations used allowable error of +/-5% vegetation cover to provide a basis for comparison with sampling intensity in this monitoring event (Appendix D). Based on results of data validation, these monitoring summaries provide representative indications of revegetation performance in these monitoring strata. Discussion of these results follows below for each reclaimed area.

No transcription errors were noted for data entered for the McLaren Pit. Comparison of cover measurements on a subsample of monitoring locations indicate that measurements made via the point-quadrat method are generally comparable to the 35mm slide method. This is evident in subsamples taken in all monitoring strata; however, in isolated instances where vegetation is visibly more developed, the 35mm slide method expectantly yielded higher values than those using the point-quadrat method. Overall, these summaries corroborate general observations that were made during area-wide monitoring. Standard errors for cover estimates for samples from the reclaimed transects represent about 15 percent of respective means. Sample size determinations based on the sample variance indicate that the sample sizes used for this sampling event are adequate. Estimates from native transects represent about 20 percent of the respective means. A higher sampling intensity for native areas than that used during this sampling event would be required to achieve precision comparable to the reclaimed areas and to test for significant differences between populations, should that be required. Consequently, whereas estimates provide representative and precise indications of revegetation performance, only general comparisons of results in native areas to reclaimed areas are appropriate.

No transcription errors were identified through independent verification of data entry for the Como Basin. Relative percent differences of cover measurements from the 35mm slide method versus point-quadrat method were high; however, there is no clear trend of bias in these results. Standard error for the cover estimate in the reclaimed area represented about 20 percent of the mean versus about 30 percent of the cover estimate in the native area. Sample size requirement to achieve an allowable error of +/-5% indicate adequate sampling was performed in the Como Basin; however, higher sampling intensity would be required in the native area to gain comparable results. Therefore, as with the McLaren Pit cover monitoring, these results provide a reasonable basis for discussing revegetation performance, but only general comparisons with results in the native area can be supported.

For data from the reclaimed road monitoring strata, no transcription errors were identified through independent verification of data entry. Aerial cover measurements were not taken for reclaimed road monitoring strata; however, because of the relatively low visible vegetation cover, there is no reason to suspect significant bias in these results. Standard error for the cover estimates in the reclaimed areas represented about 25 percent of the mean in the upper stratum and 20 percent in the middle elevation stratum. Percent error for estimates from the native transects were about 20 and 15 percent, respectively. Sample size requirement to achieve an allowable error of +/-5% indicate adequate sampling was performed in the reclaimed stratum; however, higher sampling intensity would be required in the native area to gain comparable results. Therefore, as with the monitoring strata, these results provide a reasonable basis for discussing revegetation performance, but only general comparisons with results in the native area can be supported by the data.

Figure 5 - north

Figure 5 – north (back)

Figure 5 - south

Figure 5 – south (back)

3.0 AREA-WIDE MONITORING RESULTS

This section presents area-wide monitoring data obtained during 1999. Personnel from Maxim and Synergy conducted area-wide monitoring activities in reclaimed areas between August 2, 1999 and August 5, 1999 in accordance with protocols described in the Monitoring Plan. Activities were conducted on the major reclaimed areas to: 1) record the number, size, and location of revegetated areas bare of vegetation; 2) record the presence, size, and extent of erosional features such as rills and gullies; and 3) assess the cause for the lack of vegetation. Criteria used to determine if an area is barren were: 1) areas that are approximately 10 percent or more of the monitoring strata; and, 2) areas where reclamation treatment has clearly failed. For recording erosional features, a minimum size criterion did not apply; rather, the criterion for noting erosional features were determined by field personnel if erosional features dominated the character of the reclaimed areas. Field notes documenting area-wide monitoring observations can be found in Appendix B. Laboratory analytical results for soil samples collected during area-wide sampling are in Appendix E, as are comprehensive tables summarizing these results. A summary of area-wide monitoring results for each reclaimed area follows.

3.1 MCLAREN PIT

FIELD DESCRIPTIONS

Field monitoring in the McLaren Pit identified five barren areas meeting the criteria outlined above (Figure 6). Barren areas range in size from about 2,400 to 12,000 square feet (sq. ft.) and exhibit a variety of local conditions including: low soil pH; subsurface and surface moisture; ponding and snow accumulation; and post seeding construction activities. A general discussion of field conditions in each of these areas follows.

McLaren Upper 1 is a 12,000 sq. ft. area that is split by a surface drain which was installed, post-reclamation, in 1998 (Figure 7.a). Scattered grass tufts occur within the area. The area north of the drain appears to be primarily overburden, with little or no revegetation cover. Surface characteristics south of the drain vary from saturated seep conditions to dry rocky knobs. It appears that some vegetation removal occurred during the construction of the drain, though additional evidence of soil oxidation was found in the area. Minor erosion is occurring along the drain, with some small gullies forming at the lower end. No ATV use was evident.

McLaren Lower 1 runs along the entire base of the highwall, and contains only sparse vegetation (Figure 7.b). Its approximate size is 600 sq. ft. It appears that the lack of vegetation is due to excess moisture and/or chemical contamination coming out of the adjacent highwall area. The upper end of the site is saturated. Very thin lime deposits are visible on some of the drier surfaces. Field pH values of about 8.0 were observed in these thin crust layers, while subsurface field pH values ranged from 4.0 to 5.0. Small areas of rill erosion were found in association with the existing snowbanks. No ATV use was observed.

McLaren Lower 2 is 6,000 sq. ft. with inclusions of live vegetation on the more gentle slopes. Live vegetation in the area appears to be dying back. Steeper slopes on the site have no vegetation and show some susceptibility to erosion. The area includes portions of a study plot where revegetation was well established but has since died. The site appears to receive adequate moisture, but overland or shallow subsurface flows of acidic water could be impacting the site. No evidence of ATV traffic was found.

McLaren Lower 3 is generally inclusive of the side slope of a constructed diversion ditch at the high wall. Its approximate size is 2,400 sq. ft. The lack of vegetation appears to be due to inadequate seed retention on the steep slopes of the berm, though indications of chemical contamination or acidic conditions are also apparent.

White surface deposits are evident on crowns of dead plants. The area is relatively steeper than most of the site and evidence of straw mat and netting still persists. No erosion or ATV use was found.

McLaren Triangle 1 is approximately 3,600 sq. ft. of bare ground with sparse vegetation interspersed within (Figure 7.d). The barren portions are immediately downslope of a surface mulched area (erosion blanket) which shows generally higher revegetation cover. No notable erosion features were identified on the site. The lack of revegetation cover appears to be due to the lack of seed retention and lack of moisture retention capability as indicated by a lack of organic matter in the soil and absence of erosion netting. No evidence of ATV traffic was found.

SOIL ANALYTICAL RESULTS

Soil samples were collected at each of the five barren areas and two revegetation site transects in the upper and lower monitoring strata as "reference" samples. Selected soil chemistry results are shown in Table E-1 (Appendix E). Soil texture at all sampled locations is classified as sandy loam with coarse fragment content ranging from 39.4 to 63.2 percent. Fertility is relative low as indicated by low nitrogen, phosphorus, and potassium concentrations.

The combination of low pH and relatively high aluminum and copper concentrations indicates an inhibition to plant establishment is probably a factor in plant performance on the barren areas. Barren site soil pH values range from 2.2 to 3.8 in four of the five samples. Soil pH for McLaren Lower 1 was 6.8. Values for the reference samples were 3.8 and 5.4 for upper and lower monitoring stratum, respectively. Aluminum ranged from 3,160 mg/kg to 12,100 mg/kg. Copper content ranged from 355 mg/kg to 867 mg/kg. Due to the high exchangeability of aluminum resulting from the low pH exhibited at these sites, there is likely to be less available nitrogen and a restriction in root development (Kabata-Pendias and Pendias, 1992).

EROSION FEATURES

Erosion in the McLaren Pit was limited to the toe slopes of the surface drain at McLaren Upper 1 and the minor rill erosion occurring near the snow banks at McLaren Lower 1. No other notable erosion features were observed meeting the criteria outlined in the Monitoring Plan.

3.2 COMO BASIN

FIELD DESCRIPTIONS

Field monitoring in the Como Basin identified five barren areas meeting the criteria outlined above (Figure 8). Barren areas exhibit a variety of local conditions, which include low soil pH, subsurface and surface moisture, ponding and snow accumulation, erosion, and high ATV use. A general discussion of field conditions in each of these areas follows.

Como Basin 2 is located approximately 40 meters below the armored ditch on a steep slope. It has patches of sparse vegetation. Minor to significant gully and rill erosion is occurring (Figure 9.a). The lack of revegetation cover appears to be caused by a lack of seed retention due to overflow from the ditch and a possible lack of soil amendments. No ATV use was observed.

Figure 6

Figure 6 (back)

Figure 7

Figure 7 (back)

Figure 8

Figure 8 (back)

Figure 9

Figure 9 (back)

Como Basin 3 is located approximately 30 meters below the armored ditch and has numerous small grass plants. The soil is saturated from snowmelt and drainage (Figure 9.b). Some rill and gully erosion is occurring on the lower end of this area. The lack of revegetation cover appears to be caused by a lack of seed retention and saturated soils. No ATV use was observed.

Como Basin 4 is approximately 6000 sq. ft. of barren ground with patches of live and dying vegetation (Figure 9.c). It is located northeast of the Como Basin research plots. No notable erosion features were identified in this area. Oxidation appears to be occurring in the soil. The lack of revegetation cover appears to be caused by adverse soil characteristics. No ATV use was observed in this area although intensive ATV use was found just below the area.

Como Basin 5 is approximately 2400 sq. ft. of barren ground with sparse patches of healthy vegetation. It is located below the sealed Como shaft (inside the collar area). Minor rill erosion was found in this area. The lack of vegetation cover appears to be caused by adverse soil characteristics. No ATV use was observed.

Como Basin 6 is located just above the Como shaft ditch with seeps all along the toe slope above the collar area. Vegetation is dying and erosion rills are forming above the site. The lack of vegetation cover appears to be associated with adverse soil characteristics and saturated soils. No ATV use was found.

Soil Analytical Results

Soil samples were collected at each of the five barren areas and one sample was collected at a revegetation transect as a "reference" sample. Selected soil chemistry results are shown in Table E-2 (Appendix E). Soil texture at sample locations outside the collar area (including the "reference" site) is classified as sandy loam with coarse fragment content ranging from 33.4 to 49.2 percent. Fertility is relatively low as indicated by low nitrogen, phosphorus, and potassium concentrations, except for Como Basin 2 which has relatively high concentrations of ammonia nitrogen.

The combination of high aluminum and copper concentration with low pH indicates that an inhibition to plant establishment is probably a factor in plant performance in barren areas. Barren area soil pH values ranged from 2.2 to 3.1 in four of the five samples. Soil pH for Como Basin 3 was 7.0 and the reference value was 7.1. Aluminum content ranged from 5,960 mg/kg to 8,360 mg/kg in samples from barren areas and 7,280 within the reference sample. Copper content ranged from 247 mg/kg to 1,910 mg/kg for barren areas and 590 mg/kg for the reference site. The low pH values lead to elevated levels of available aluminum and copper. The inhibition of plant growth could be the result of low base saturation, excess hydrogen ions, or metal toxicity (Kabata-Pendias and Pendias, 1992).

Erosion Features

Erosion in the Como Basin is a major concern to the stability of the revegetation of this area. Areas of snow pack on Fisher Mountain and Como Basin remain year-round. Snowmelt at the top of the face of Fisher Mountain creates rills and gullies that move through the basin. Snowmelt on the southwest edge of Como Basin overflows the armored drainage ditch creating saturated conditions and erosion. Gully erosion is occurring in the middle upper basin. In several locations along the armored ditch at the south end of the basin, the sides are washing out, creating the potential for increased erosion during runoff. Material upslope of the sealed shaft area has washed down and filled the ditch around the shaft. Water is flowing through the diversion ditch and going into the shaft. Pedestaling of vegetation was observed across the face of the basin. ATV trails from the northeast to the southwest across the face of Como Basin are creating rills and gullies.

3.3 RECLAIMED ROADS

Area-wide monitoring of reclaimed roads covered almost all "present reclaimed roads" identified by the USDA-FS (1999). Numerous roads were also covered that were not classified as "present reclaimed roads" but were determined in the field to have had recent reclamation activity. More roads were found in the middle and lower strata where vegetation cover obviates photo interpretation. Extensive field reconnaissance was performed to locate these roads; however, these efforts were focused on upper and middle strata in proximity to Fisher and Henderson Mountains. Given this level of certainty, it can be stated that most all reclaimed roads in the upper stratum were covered by area-wide monitoring; however, monitoring in the middle and lower strata covered over half, but not all such roads (Figure 5). No soil samples were collected from reclaimed roads.

FIELD DESCRIPTIONS

Most reclamation concerns were identified by field observation to be on reclaimed roads in the upper and middle elevation monitoring strata. Monitoring of lower elevation roads revealed no barren areas and only minor erosion features meeting the prestated criteria. Most roads in the upper stratum had barren areas reflecting the rocky soils and extreme conditions that typify these sites. Erosion features were generally absent. Conversely, roads in the middle strata generally exhibited adequate cover, but erosion features were more common, particularly on those reclaimed roads where recontouring was not performed as a part of reclamation. One notable exception to these trends were roads below McLaren Pit that, due to the probable influence of soil limitations, had extensive problems with both vegetation cover and resulting erosion. A general discussion of field conditions in these areas follows.

Upper monitoring stratum roads are characterized by steep, rocky conditions with sparse vegetation (less than 5 percent). These conditions are common to roads reclaimed by CBMI on Fisher Mountain above the McLaren Pit (Figure 10.a) and Como Basin (Figure 10.b). Gully erosion features were only identified on roads above Como Basin. No evidence of ATV traffic was found. The lack of revegetation cover on reclaimed roads in this stratum appears to be due to the lack of seed retention and moisture retention capability, which is indicated by the absence of organic matter in the soil and extreme environmental conditions at these elevations.

Roads below McLaren Pit are generally sparsely vegetated and exhibit extensive gully erosion as a result. This condition characterizes most of the area immediately downslope of the lower McLaren Pit (Figure 10.c). It appears that the lack of vegetation is due to poor seed retention and/or contaminated run-on from the adjacent mined area. Gullies associated with these areas average about one meter in width and depth and combine to form even larger erosion features (Figure 10.d). Iron oxide deposits are visible on some of the drier surfaces. No ATV use was observed.

EROSION FEATURES

Erosion in the upper elevation reclaimed road stratum was limited to roads above Como Basin on the north face of Fisher Mountain and on the south end of Fisher Mountain at the saddle between Fisher and Henderson Mountain. Extensive gully and rill erosion is evident throughout the central part of the Como Basin area (Figure 10.b), effects of which extend into the Como Basin itself. Similar erosion patterns are evident in the saddle area, between Fisher Mountain dumps 3 and 4. Otherwise, due to the high rock content of reclaimed roads in this stratum, no other notable erosion features were observed meeting the criteria outlined in the Monitoring Plan.

Figure 10

Figure 10 (back)

Erosion features on roads in the middle elevation stratum were more common, particularly on those reclaimed roads where recontouring was not performed as a part of reclamation. Ditching and culverts are not adequate to handle overland flow which becomes channelized along these roads between cut and fill slopes. Many cut slopes have begun to fail and water kickoffs have also failed along many fill slopes. Snow accumulation and snowmelt further exacerbates the situation.

3.4 LITTLE DAISY ADIT

Field monitoring in the area below the Little Daisy Adit was conducted to observe the whitebark pine trees that had been planted by Crown Butte Mine. Observations were to determine new growth, mortality, and the need for the removal of the protective covering. All locatable trees were dead and 100 percent mortality is assumed. Protective covering and stakes were removed from the site.

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4.0 DISCUSSION OF RESULTS

Revegetation monitoring performed in the New World District during August 1999 identified several areas where revegetation may be failing. Corrective measures may be necessary to improve the ability of these areas to provide effective erosion control and to produce self-sustaining vegetation communities that reflect natural conditions. Specific concerns identified through vegetation cover and area-wide monitoring include the following:

McLaren Pit Area	- Relatively low vegetation cover and species diversity; and, - About 0.5 acre of the McLaren Pit is barren.
Como Basin Area	- Relatively low vegetation cover and species diversity; - Nearly 0.5 acre of the Como Basin is barren; and, - Gully erosion is prevalent throughout the monitoring stratum.
Reclaimed Roads	- Near absence of vegetation cover in the upper elevation stratum; - Relatively low cover in the middle elevation monitoring stratum; - Most roads in the upper elevation road stratum are considered barren; - Roads below the McLaren Pit are considered barren; and, - Gully erosion is associated with numerous roads in the District.

Cover measurements are generally below those reported by Brown and Amacher (1999) for research plots and demonstration areas monitored in the District. However, species composition in the reclaimed areas is comparable to Brown and Amacher demonstration areas when the results are compared to a similar time interval following treatment.

Brown and Amacher (1999) discuss several soil, climatic, and biological factors limiting restoration of high elevation disturbed mine sites. Recommendations presented in their report for restoring native communities on District acidic mine spoils (Appendix F) that directly address these limiting factors include the following:

- Incorporation of lime based on lime incubation and/or acid base accounting tests;
- Incorporate organic matter and fertilizer amendments;
- Broadcast seed with mixture of native successional species and lifeforms;
- Surface mulch with erosion blankets; and,
- Refertilize yearly for 3 to 5 years.

Many of these same recommendations would apply to non-acidic sites, as well (e.g., roads). Based on the Brown and Amacher research, failure to address each and every limiting factor through application of these prescriptions will result in sub-optimal revegetation performance. Based on presentation of reclamation history and monitoring results in this report, there is evidence to suggest that restoration practices did not fully amend or treat these factors in many reclaimed areas. This fact is supported by the following results which show:

- Low soil pH, high metals concentrations, low organic matter, and low nutrient levels in the McLaren Pit area;
- Low soil pH, high metals concentrations, low organic matter, low nutrient levels, erosion features, and poor seed retention in the Como Basin area; and,
- Low organic matter, low nutrient levels, and poor seed retention on reclaimed roads.

Several areas within these monitoring strata are also limited by insufficient control of surface water and insufficient drainage in saturated areas *vis a vis* soil saturation and erosion, as well as impacts from human use, especially ATV use. These factors fundamentally limit the chances for establishment of any vegetation and, in total, the data presented in this report demonstrate the limited restoration performance to date.

4.1 RECOMMENDATIONS

Research results and prescriptions presented by Brown and Amacher (1999) provide a fairly well-demonstrated approach to restoration of native plant communities in the District. Consideration of protective measures for addressing areas that are performing below demonstrated levels should incorporate proven techniques. Sub-optimal performance exists in several areas for which site specific or area-wide corrective measure would be appropriate. Corrective measures that should be considered include the following:

McLaren Pit Area	- Further surface and sub-surface water control measures; - Reapplication of restoration prescriptions over the entire area; and, - Site specific measures for restoring individual barren areas.
Como Basin Area	- Further surface and subsurface water control measures; - Erosion control, including control of ATV traffic, on the area; - Reapplication of restoration prescriptions over the entire area; and, - Site specific measures for restoring individual barren areas.
Reclaimed Roads	- Improve soil organic and nutrient conditions in upper elevation roads; - Erosion control, especially on uncontoured roads; and, - Reapplication of prescriptions on roads below McLaren Pit.

Costs and benefits, calculated in the context of overall response and restoration efforts, should be performed to justify these measures in meeting overall project objectives. Detailed prescriptions would be developed in conjunction with the annual work plan.

In terms of long-term revegetation monitoring, several recommendations can be derived from methods, results, and the level of confidence achieved with this 1999 revegetation monitoring. These recommendations include the following and should be considered for implementation for the 2000 revegetation monitoring event:

- Although results indicate sub-optimal revegetation performance, they only reflect one point in time. Documentation of trends, an objective of long-term revegetation monitoring, cannot be substantiated by these data alone. Therefore, it is recommended that monitoring continue as scheduled in the Monitoring Plan.

- Results of 1999 long-term revegetation monitoring establish the fact that cover, density, and diversity on reclaimed areas is relatively lower than on native transects. Based on revegetation performance reported by Brown and Amacher (1999) on demonstration and research plots, it would be several years before performance would be expected to approach native conditions. Therefore, it is recommended that sampling of native transects be deferred in the 2000 revegetation monitoring effort.

- Results of 1999 long-term revegetation monitoring have led to recommendations for reapplication of restoration prescriptions in many of the monitoring strata. Implicit in this recommendation is that there is little expectation that performance would improve. Nonetheless, an objective of long-term revegetation monitoring is to document trends. It is therefore recommended that an appropriate level of effort for monitoring in these areas would be to: 1) continue area-wide monitoring as prescribed in the Monitoring Plan; and, 2) reduce cover monitoring to only record cover, not density, in order to document trends.

- Based on review of reclamation history, it is clear that reclamation status and delineations used as the basis for this monitoring report require further field verification. Furthermore, the addition of historical reclaimed areas may be needed to meet objectives of the long-term revegetation monitoring program. Surveys to address these information needs are recommended for the 2000 revegetation monitoring event.

- Strata used in this monitoring effort differ from those in the Monitoring Plan. Adjustments to stratification are based on field observation reflecting site conditions. As such, their continued use is recommended.

- Sample sizes are considered adequate for interpretation of cover estimates in reclaimed areas; however, because of transect layout, there may be conditions that are not represented. It is therefore recommended that samples be taken on a systematic grid, randomly placed within monitoring strata, that cover the entire area.

- Sample sizes are not considered adequate within native areas for comparison of cover estimates to associated reclaimed areas. Over time, as succession takes place in reclaimed areas, it may become necessary to perform such tests. Therefore, it is recommended that sample sizes be increased in native areas at some later date. This recommendation will be revisited in the 2000 revegetation monitoring report.

- Criteria for determining barren areas and erosional features differ from those in the Monitoring Plan. Adjustments better reflect site conditions and, as such, their continued use is recommended.

- Observations made during area-wide monitoring in this report are documented in field note books. These are difficult for the reader to review. It is recommended that forms be developed for recordation.

Overall, it is therefore recommended that these adjustments to the Monitoring Plan be incorporated in the Final version of the document.

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