PROGRESSIVE RECLAMATION AT THE KEMESS SOUTH MINE
"DOING WHAT COMES NATURALLY"

Scott Davidson, M.Sc., P.Geo.
Wade Stogran, R.P.Bio

Kemess Mines Ltd.
Box 3519 Smithers, BC
V0J 2N0

ABSTRACT

The progressive reclamation program at the Kemess Mine focuses on the reclamation of disturbed areas using a successional approach to revegetation. The aim of the successional approach is to reduce the time required to develop a self-sustaining vegetative cover through the use of plant species that are found naturally in the area of the minesite. Research into native species is being conducted at the site as part of the annual reclamation program to allow for refinement of the reclamation program.

INTRODUCTION

The Kemess South Mine is an open-pit gold-copper mine located approximately 15 km east of Thutade Lake, in the northern Omineca Mountains of north central British Columbia (Figure 1), within a claims area of approximately 15,057 ha (150 square km). The mine is approximately 300 km northwest of Mackenzie at latitude 57 00"N, and longitude 126 45' W. The project site is accessible via the Omineca Resource Access Road (ORAR), an all weather main line industrial road from Mackenzie, British Columbia. This road provides for transportation of mine supplies and concentrate. A 5,200 foot airstrip allows for air access, with the majority of personnel being flown from Prince George and Smithers.

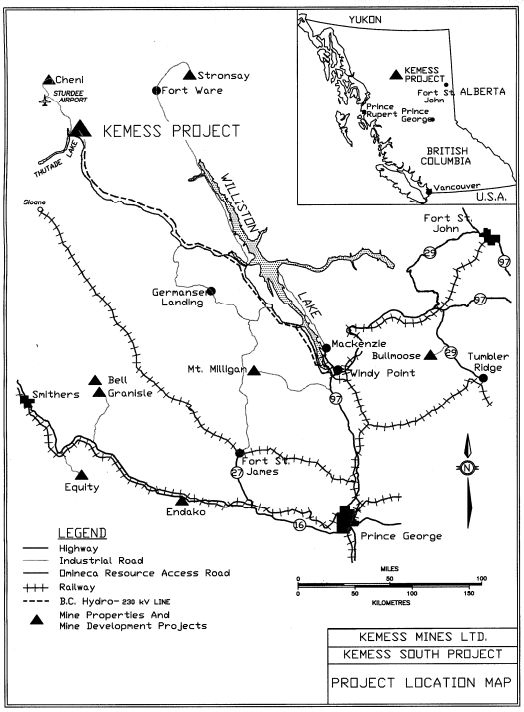


Fig 1 Site Location Map

The annual Progressive Reclamation Program focuses on the systematic reclamation of areas that are no longer required for operational purposes at the site. The program incorporates traditional reclamation techniques that have been successfully applied at this and other sites, including slope

re-contouring, hydroseeding, and re-vegetation. Kemess has taken a successional approach to revegetation in order to help reduce the time required for the development of a self-sustaining vegetative cover.

RECLAMATION UNIT PRESCRIPTIONS FOR WILDLIFE HABITAT

Most of the site was considered forested ground with limited grazing and forage areas prior to development. The End Land Use designation for a large portion of the minesite is Wildlife Habitat. To meet this objective site specific re-vegetation prescriptions are applied to reclamation units on the minesite. The overall goal of the prescription approach is to provide a mosaic to the landscape that enhances the habitat over the pre development landscape.

The type of prescriptions used need to be flexible to reflect current practices and incorporate the results of previous reclamation studies. Two examples of prescription types are shown below. These prescriptions are applied based on site factors such as soils, topography, and moisture.

Mixed Grassland and Vegetation Islands (M-GVI)

Vegetation islands have been designed for use as sub-units within the overall reclamation unit. The islands are developed around areas with wetter soil to increase the chance of successful development of a self-sustaining vegetative cover. The size and shape of each vegetation island is determined based on site-specific factors.

Under successional reclamation, the sub-units identified as being suitable for vegetative islands are first planted with willow whips to initiate or to enhance the development of self-sustaining vegetation on the sites. In addition, some select seeding may be conducted using plants suited to wetter soil depending on seed availability and the size of the areas to be treated. The planting of coniferous vegetation within some of the vegetation islands is dependent on site conditions.

Mixed Grassland and Vegetation Corridors (M-GVC)

Vegetation corridors are strips of vegetated zones designed to provide cover for animals and link naturally vegetated areas along linear disturbances. This approach provides valuable grazing and browsing habitat in addition to providing continuous vegetation cover across disturbed areas.

Vegetation corridors are established through the planting willows and selected species. Corridors cross disturbed areas and are spaced along linear disturbances.

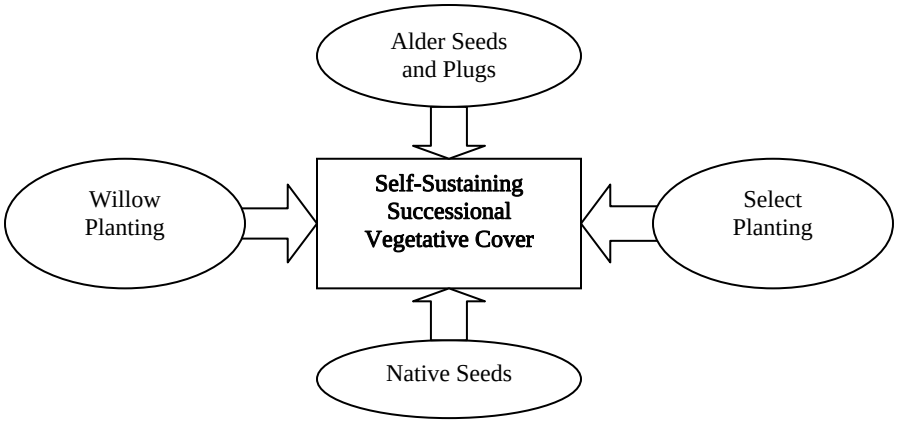
Initial vegetation corridors are approximately 30 m in width with selected conifer planting at a density of 1,300 stems per hectare and willow planting at an approximate density of 650 cuttings per hectare. Some of the sub-units designated for vegetation corridors already have some natural coniferous growth. The level of existing coniferous and deciduous vegetation is surveyed for each area at the time of planting. Willow planting in these corridors is conducted during the spring to maximize the success and growth of cuttings and to help reduce browsing pressure on coniferous seedlings.

SUCCESSIONAL RECLAMATION APPROACH TO REVEGETATION

Kemess Mine takes a successional species approach to reclamation in areas reclaimed under the Progressive Reclamation Program. The successional approach involves the introduction of pioneer native species within the reclamation unit to advance the rate at which a self-sustaining vegetative cover is established.

The intent of the program is to reduce the number of years for an area to be designated reclaimed and removed from the disturbed footprint of the minesite. Smyth and Kovack (2002) found at the Line Creek Mine that native species took approximately 10 years to begin to colonize disturbed areas that had been revegetated with non-native species. After approximately 8 years following colonization the species richness (number of species) approached that of undisturbed test plots.

Multiple application techniques were used for the revegetation program in order to maximize the potential gains from reclamation expenditures. The schematic below shows the four main groups that were utilized during revegetation along with the more traditional commercial grass seeding.



Multiple Vegetative Approach Flowchart for Successional Vegetation Establishment

Willow Planting

The primary vegetation utilized for successional reclamation are willow cuttings. The willow cuttings, which are locally collected, are live planted into areas known to have relatively high soil moisture contents. The establishment of willow cuttings on previously grass seeded and wet areas assists in the rapid development of vegetation and stabilization of soils on disturbed areas. The local collection of willows was conducted efficiently using small handcrews with cuttings bundled and transported to soaks for storage.

At Kemess it was possible to collect the 3,000 cuttings used during 2003 over a three day period. Willow cuttings were stored in non-woven geotextile bundles submerged under water until time for installation. One drawback noted during the use of this method is that cuttings used later in the season tend to have a lower survival rate than those used during the spring.

Willow is considered to one of the primary vegetations for reclamation as it will sprout and grow from cuttings. Willow cuttings tend to be most successful if harvested during the spring and installed during the early summer. During the 2002 field season Kemess Mine planted approximately 300 willow whips in South Dam Borrow 3 and 200 whips in the riparian zone of El Condor Creek. Kemess Mine planted an estimated 3,000 willow cuttings during the 2003 field season. Kemess intends to plant approximately 5,000 willow cuttings over the next three years to assist in the preparations for larger scale reclamation following the end of mine life.

Planting Alder Seeds and Plugs

Alder seeds will be applied to the slopes in seepage areas and in test patches on open slopes using hand seeding. A total of 3 kg of red alder seed was applied during the 2003 field season. Alder plugs grown at Woodmere Nurseries in Telkwa, BC will be planted during 2004 in selected areas around the site. The cost per planted plug will be compared with the cost and effectiveness of direct alder seeding.

Coniferous Seedling Planting

Kemess Mine plans on conducting select planting of coniferous species in areas where there is deemed to be a good existing vegetative cover and suitable soils. The coniferous planting program has been designed to assist in the development of a climax vegetative cover. Lodgepole pine will be used as the main reclamation coniferous species for open slope and drier sites and black spruce will be planted in wetter areas. Black spruce was chosen over white spruce for the program as black spruce has better frost hardiness and good snow press resistance.

Balsam and sub-alpine fir have also been grown for planting during the 2004 season in areas selected based on the availability of seedlings. The tree species selection and proposed planting densities were based on discussions with Arboreal Forestry Consulting of Telkwa, B.C and the seedlings are grown at Woodmere Nursery.

Native Seed Planting

To promote the rapid redevelopment of a self-sustaining vegetative cover, Kemess Mine is moving towards incorporating native seed into the seed mixtures that it uses on areas reclaimed annually under the progressive reclamation program. Native seed used in coming years will provide greater seed stock for natural re-colonization of reclaimed areas.

For the purposes of the Kemess Mine Reclamation Program, a self-sustaining vegetative cover is defined as a cover of plant species that require no further inputs to maintain the vegetative cover. Typical input requirements are grass seeding of barren areas and the application of fertilizer. At Kemess Mine, it has been necessary to apply fertilizer at intervals of approximately 3 years.

Fertilizer application rates have varied depending on the success of existing vegetation. However, average rates range from 200 kg/ha to 250 kg/ha of 19-18-19 fertilizer.

The incorporation of native seeds into the reclamation program is not intended to replace more economic commercial seed mixtures, but is intended to reduce the reliance on commercial seed species in areas that may not be suitable due to local climactic conditions. Suitable areas for native seed application are areas where no further disturbances (i.e. placement of organics, slope stabilization, material removal, etc.) are scheduled to occur.

Native species identified as being either present at the Kemess South minesite or found in similar biogeoclimatic zones have been targeted as potential candidates for use in native seeding. Native seed species are often more suited to the revegetation of reclaimed areas. These species have a better chance of being able to withstand the environmental conditions at the minesite and therefore have a better chance of developing a self-sustaining vegetative cover. Native seed planted during the next three years will provide valuable seed source for the re-establishment of native vegetation on reclaimed soils.

RECLAMATION RESEARCH

This section outlines the efforts of reclamation research component of the progressive reclamation program at Kemess Mine. Further revision and implementation of projects is to be conducted during the 2004 field season.

Natural Sediment Barriers Use for Metals Uptake and Sediment Discharge Reduction

Kemess Mine has begun investigating the use of vegetation to create natural sediment barriers in areas where turbidity is a concern. The BXL pond series (Photo 1) was used as a test area to evaluate the effectiveness of cattails for sediment management and the control of Total Suspended Solids in the discharged water. CRV Greenhouse of Mackenzie one of the sources of cattails used by Kemess Mine and 2,500 cattails were planted within the BXL sediment pond system during the 2003 field season. The effectiveness of the cattails for sediment control was evaluated by planting some of the cattails in linear rows across the direction of flow at intervals between 0.15 m and 0.3 m.

The uptake of metals by cattails is also being evaluated during this program. This is being conducted by quantifying any decrease in metal concentrations at WQ-BXL as a result of the cattails. Copper concentrations in the water have been elevated at WQ-BXL and this is believed to be a result of metals leaching from past tailings spills into Pond #3 (P3 in Photo 1) of the BXL ponds, which may have occurred in the past. Water quality sampling is routinely conducted at the water quality site WQ-BXL, which is located immediately downstream of the discharge from Pond #4. These data will be evaluated to determine the impact of the cattails on the water quality at that site.

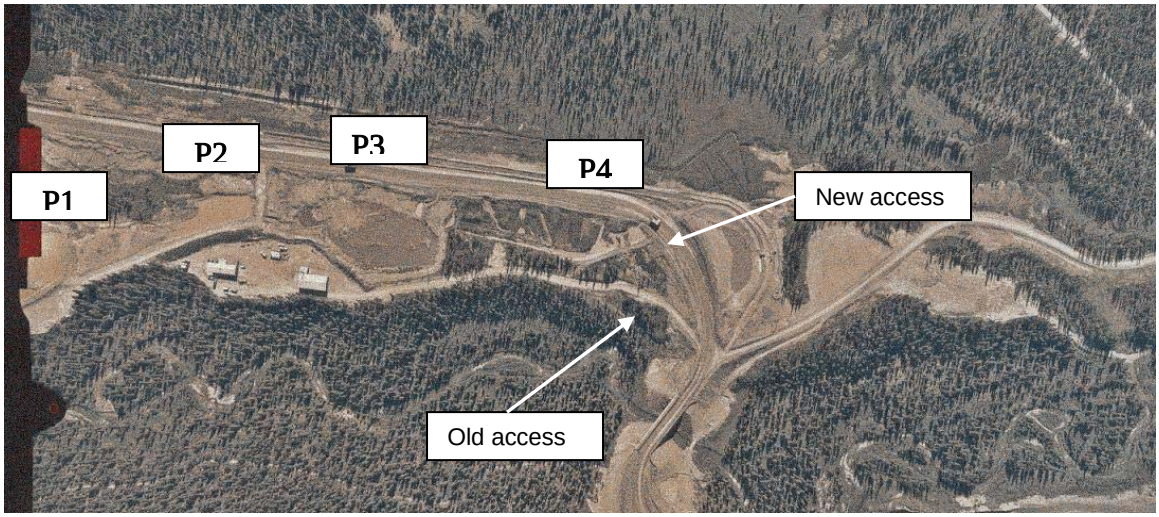


Photo 1: BXL SEDIMENTATION PONDS

Native Seed Trials

During 2003 Kemess Mines began to use a native only seed mixture for select reclamation activities at the site. The species were selected from available seed stock developed under FRBC funding programs by Symbios Research & Restoration Limited of Smithers, BC. The seed was collected from northwestern British Columbia sites and is now grown by contract farmers for supply to reclamation projects. The application rate for the seed was calculated based on a 1,500 Pure Live Seed (PLS)/m^2 rather than on the traditional weight/ha basis that is common with agronomic seed mixtures. The species breakdown for the mix used at Kemess Mine is shown in the Table 1 below. Approximately 2 ha were treated using this native only seed mixture. Merten's Sedge was used in select seepage areas in the borrow at other areas around the minesite.

Table 1 Native Species Seed Mixture for Kemess Mine

Species	Common Name	PLS /m^2	Proportion of Seeds
Calamagrostis canadensis	Bluejoint, pre-2001	155.0	**10.23%**
Carex macloviana	Thick-Headed Sedge,pre-2001	80.0	**5.28%**
Dryas drummondii	Yellow Mtn-Avens, 2001,2002	18.0	**1.19%**
Dryas drummondii	Yellow Mtn-Avens, low purity	1.7	**0.11%**
Elymus glaucus	Blue Wildrye, pre-2001	15.4	**1.02%**
Elymus glaucus	Blue Wildrye, 2001, 2002	90.0	**5.94%**
Elymus trachycaulus	Slender Wheatgrass, pre-2001	67.0	**4.42%**
Elymus trachycaulus	Slender Wheatgrass, 2001, 2002	135.0	**8.91%**
Epilobium latifolium	Broad-Leaved Willowherb,pre-2001	4.0	**0.26%**
Epilobium latifolium	Broad-Lv.Willowherb,2001,2002	4.3	**0.28%**
Festuca saximontana	Rocky Mtn Fescue, 2001, 2002	36.0	**2.38%**
Leymus innovatus	Hairy Wildrye, pre-2001	3.0	**0.20%**
Leymus innovatus	Hairy Wildrye, 2001, 2002	1.0	**0.07%**
Lupinus arcticus	Arctic Lupine, pre-2001	0.6	**0.04%**
Lupinus arcticus	Arctic Lupine, 2001, 2002	1.8	**0.12%**
Poa alpine	Alpine Bluegrass, 2001, 2002	75.6	**4.99%**
Polemonium pulcherrimum	Jacob's Ladder, 2001, 2002	2.7	**0.18%**
Polemonium pulcherrimum	Jacob's Ladder, low purity	0.1	**0.01%**
Trisetum spicatum	Spiked Trisetum, pre-2001	125.0	**8.25%**
Annual or Sterile Cover Crops:			
Secale cereale	Fall Rye	14.6	**0.96%**
	TOTAL:	1514.6	**100.00%**

Species Replacement Trials

Kemess Mine has begun to evaluate the standard seed mixture for potential species replacement with native species. Adjustments to the current mixture are required due to the inability of some species to successfully establish on seeded areas. The species replacement testing will initially be conducted on a species by species basis to determine which are the most suitable candidates for successful replacement. The selection of species for the 2003 replacement trials was based on a review of the available baseline vegetation species information provided in the Project Application Report (HKP, VIII, 1993).

Kemess Mine currently uses the commercially available grass seed mixture shown in Table 2 below. The numbers for each species is the percentage of that species by weight as opposed to by seed percentage. A target of 1,500 PLS/m2 was used for the set up of the field plots to allow for

plot specific determination of the required quantity of seed. This is a standard method of reporting seed mixtures due to the difference in the weight of seeds for individual species.

Table 2 Grass Seed Mixture

20%	Fall Rye	16%	Creeping Red Fescue	4%	Kay Orchardgrass
10%	Sheep Fescue	8%	Birdsfoot Trefoil	2%	Red Top
4%	Meadow Fescue	4%	Canada Bluegrass	8%	Timothy
12%	Perennial Ryegrass	8%	Single Cut Red Clover	4%	White Clover

During September 2003, Kemess Mine established three sets of species replacement trials at vegetation plots in different locations at the minesite. One series of plots is located at OB5, an inactive overburden dump, a second series is located by El Condor Creek, and a third series is located in Borrow 8 near to the Tailings Storage Facility. Additional plots are planned for establishment during 2004 with the remaining seed. The trials are shown in Table 3 below. In addition to these, one plot at each site was seeded using the native only seed mixture described earlier in this section.

Table 3 Species Seed Replacement Trials

#	Kemess Mine Seed Mixture:		Suitable Symbios Species to Use Instead:		Location
1	*Poa compressa*	Canada Bluegrass	*Poa alpine*	Alpine Bluegrass	B8, El Condor
4	*Festuca ovina*	Sheep Fescue	*Festuca saximontana*	Rocky Mountain Fescue	B8, El Condor
5	*Dactylis glomerata*	Orchardgrass	*Elymus glaucus*	Blue Wildrye	B8, El Condor
6	*Festuca pratensis*	Meadow Fescue	*Elymus trachycaulus*	Slender Wheatgrass	B8, OB5
7	*Festuca pratensis*	Meadow Fescue	*Elymus glaucus*	Blue Wildrye	B8, OB5
8	*Phleum pratense*	Timothy	*Elymus trachycaulus*	Slender Wheatgrass	B8, OB5
9	*Phleum pratense*	Timothy	*Bromus ciliatus*	Fringed Brome	B8, OB5

CONCLUSION

The annual Kemess Mine Progressive Reclamation Program focuses on the reclamation of areas no longer required for operational purposes at the site. The program takes a successional approach to revegetation that utilizes species that are native to the Kemess site or that have been found in similar biogeoclimatic zones. Through the successional approach Kemess Mine aims to reduce the time to develop a self-sustaining vegetative cover on reclaimed areas. Preliminary results are encouraging.

REFERENCES

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