INNOVATIVE RECLAMATION AT QUINTETTE:
HIGH ELEVATION/HIGH LATITUDE CHALLENGES

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ABSTRACT

Since 1982, Quintette has conducted reclamation on mining disturbances each and every year, resulting in completion on a total of 983 hectares (ha). During this period, Quintette has been lauded by the province for excellence in reclamation, winning the overall Mine Reclamation award in 1983, two citations for coal and exploration reclamation in 1989 and the coal mining citation in 1993. The latter was awarded for the comprehensive research program which has been ongoing at the mine for the last 7 years. It is from this that Quintette derives operational answers to the challenges of reclamation in a high elevation/high latitude environment and for low elevation seeding programs and planting of native forb, grass, shrub and tree species.

In order to work successfully in zones ranging from the high elevation environment of the Mesa/Wolverine mine, which is located at 1850 metres (m), to the Shikano mine at 900 m, Quintette has implemented several innovative and progressive spoil preparation techniques and employed many non-traditional revegetation materials and application methods. These measures are required to ensure an outcome which fulfills both end land use objectives and supplementary permit conditions. This paper will summarize the program methodology currently implemented at Quintette for reclamation of high and low elevation disturbances.

INTRODUCTION

Quintette Operating Corporation is located in northeastern British Columbia, approximately 100 km from Chetwynd and 200 km from Dawson Creek. The town of Tumbler Ridge, located 20 km from the mine, was built in 1981 to service and accommodate the mine and
its employees (population 4,500). Quintette is an open pit coal mine which produces 4.35 million tonnes per year for export to Japan. The mine comprises two operational areas; Mesa/Wolverine which is 1200 ha in size and Shikano at 750 ha, located on mountain top and in river valley respectively. The mines are conventional open pit truck and shovel operations with coincident large rock dump areas and pits with rock highwalls. Figure 1 illustrates the Quintette property and infrastructure.

The Quintette mine is located in the eastern foothills of the Rocky Mountain Hart Ranges at latitude 55°03'42” north. Mesa/Wolverine is situated in the Alpine tundra and Engelmann spruce, subalpine fir biogeoclimatic zone and the Shikano mine in the Sub-boreal spruce zone. The region is characterized by long, cold winters and short, cool summers. The growing period (frost free days) in the high elevation area averages 60 days, whereas at low elevation the period increases to 160 days. An average of 500 mm of precipitation falls in the form of rain and snow each year.

The prime end land use objective at Quintette is the re-establishment of wildlife habitat with a dual end land use objective of wildlife and forest resources in the Shikano mine. Target wildlife species which have been identified for the high elevation reclamation plan include mountain goat, grizzly, caribou, ptarmigan and marmot. In low elevation areas, the target species are deer (mule and whitetail), elk, moose, migrating woodland caribou, bear, small mammals, raptors and other bird species. As Shikano must provide a woodland caribou migration route, a forested corridor is a major component of the reclamation plan.

The intention of the overall Quintette reclamation program is to assist, rather than supplant the natural restorative process. The main objective is therefore to stimulate the re-establishment of indigenous flora and fauna on spoil dumps in an ecological manner. Due to elevation and soil differences, reclamation planning and implementation is very different between the two mining areas. A description of the programs for both mines is provided.
RECLAMATION PERMIT

The Quintette reclamation permit was last amended in October 1991 further to the need for Teck Mining Group to establish current liability for reclamation to 2003. The reclamation bond was set to fulfill costs for total reclamation, including demolition of large concrete structures (silos), to 2003. To accommodate annual increases in the cost of reclamation, an interest bearing Safekeeping Agreement was established, the interest from which is returned to the bond. In addition, clauses regarding "Land Capability", instead of Land Productivity and the succession of native species islands were agreed to. Among the various innovative permit conditions afforded Quintette, the following were established:

> The level of land capability, and the percentage of land in a given capability class, to be achieved on reclaimed areas shall not be less than existed prior to mining on an average property basis unless evidence is provided which demonstrates the impracticality of doing so.

> Native species islands in the Mesa/Wolverine area shall be established and the land revegetated to either a self sustaining state or to a state where the ecological succession of native species islands will lead to achievement of the approved land use capability within 20 years.

In order to achieve these permit conditions, operational reclamation policies were formulated and agreed to by Senior management. The policy states, "It is the intent of Quintette management to ensure successful dump revegetation in compliance with Reclamation Permit #C-156.". For each mining area, a specific list of reclamation procedures were provided which comprise four general phases; specifically, scrap removal, placement of suitable material for reclamation, dump material modification and timing for all phases including seeding.

RECLAMATION PROGRAM - MESA/WOLVERINE

The intention of the Mesa/Wolverine reclamation program is to provide a cover of agronomic grass species on waste dumps within which diverse communities, or "islands" of alpine native plants are established. These strategically located islands will allow for the
dissemination of native forb, grass, sedge, shrub and tree seed by wind and other means to the reclaimed agronomic areas, thereby facilitating plant succession.

The program begins with the removal of scrap materials (tires, steel, etc.) from the spoil dump. Where reclamation material is available, pit operations stockpile material on the surface of the dump platform or a rehandle site. These free dump piles are later modified to accommodate wildlife habitat enhancement plans (mounds, microsites, island areas). On an annual basis, the pit operations Department is presented with a proposed program and will allocate equipment and trained operators to conduct the agreed upon reclamation work. Equipment hours required to complete the plan are estimated and used for budgeting time required. Fall seeding is the norm at Quintette, therefore the equipment work is accomplished during the period of June (when at this elevation the snow is completely gone) to September.

Dump Modifications:

The dump procedure is divided into two categories; that of modifications to slopes and preparation of benches. A dozer operator is requested to first perform berm removal and crest rounding of the bench top, then using the Quintette "reclamation chain" drags the device over the surface of the dump slope to roughen the material thereon. In cases where availability of fine waste material is adequate, free dump piles will be pushed over the berm and deposited on the surface of the dump slopes for later blending and roughing using the reclamation chain. Typically, however, existing materials on slopes in the upper portion of the dump complex is acceptable for seeding as is.

In many cases in Mesa/Wolverine, fine reclamation material is not readily available, therefore, the preparatory work conducted on dump benches will comprise the ripping of compacted surfaces. A technique we call "grader gridding" has been very successful in establishing good agronomic growth on benches. Gridding, or cross hatch ripping is conducted to a depth of 30 cm using a 16G grader with 5 shanks.
In late September of each year, seed is applied by helicopter at a rate of 75 kg/ha using the seed mixture shown below.

<table>
<thead>
<tr>
<th>NAME</th>
<th>VARIETY</th>
<th>PERCENTAGE OF MIX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creeping Red Fescue</td>
<td>cv. Boreal</td>
<td>12%</td>
</tr>
<tr>
<td>Timothy</td>
<td>cv. Korpa</td>
<td>4%</td>
</tr>
<tr>
<td>Timothy</td>
<td>cv. Alma</td>
<td>1%</td>
</tr>
<tr>
<td>Sheep's Fescue</td>
<td>cv. Common</td>
<td>8%</td>
</tr>
<tr>
<td>Rocky Mtn Sheep's Fescue</td>
<td>cv. Common</td>
<td>9%</td>
</tr>
<tr>
<td>Sheep's Fescue</td>
<td>cv. Nakiska</td>
<td>8%</td>
</tr>
<tr>
<td>Alpine Bluegrass</td>
<td>cv. Common</td>
<td>5%</td>
</tr>
<tr>
<td>Northern Wheatgrass</td>
<td>cv. Elbee</td>
<td>23%</td>
</tr>
<tr>
<td>Slender Wheatgrass</td>
<td>cv. Adanac</td>
<td>30%</td>
</tr>
</tbody>
</table>

In the spring of the following year, fertilizer is applied by helicopter or fixed wing at a formulation of 26-10-10 at 336 kg/ha. Through ongoing research, it has been found that maintenance fertilization must also be conducted on these agronomic reclaim sites every two years.

As you can see, only agronomic grasses are used in this phase of the program. Research conducted from 1986 to 1994 has indicated that agronomic legumes (all varieties of alfalfa, clover, sainfoin and milkvetch) do not survive at this elevation and latitude beyond the first season. Therefore, legume species must be introduced through a different means.

Native Plant Establishment:

The next phase of the reclamation program is the establishment of native species islands. The plant types, spacing, configuration of islands, location on dumps and planting techniques were reviewed at various locations in Mesa/Wolverine commencing in 1991. With several operational questions answered, the native island establishment process commenced in earnest during 1992 with the first operational plant island established on the
Mesa Phase 1 1630 m dump platform. Since that time, a total of 20,646 seedlings have been planted on waste dumps in the Mesa/Wolverine dump complex. The following table indicates the 1994 plant numbers and totals to date across the property.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>1994 ACTIVITY</th>
<th>TOTAL TO DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesa/Wolverine dumps</td>
<td>12,604</td>
<td>19,866</td>
</tr>
<tr>
<td>Mesa 1660 dump failure</td>
<td>0</td>
<td>780</td>
</tr>
<tr>
<td>Shikano dumps</td>
<td>4,074</td>
<td>6,574</td>
</tr>
<tr>
<td>Shikano South dump failure</td>
<td>2,500</td>
<td>2,500</td>
</tr>
<tr>
<td>Research Site - Low elev.</td>
<td>0</td>
<td>1,080</td>
</tr>
<tr>
<td>Seed Multiplication site</td>
<td>0</td>
<td>4,000</td>
</tr>
<tr>
<td>TOTAL SEEDLINGS</td>
<td>19,178</td>
<td>34,800</td>
</tr>
</tbody>
</table>

As shown, 1994 was a year in which a large number of seedlings were established on mine disturbances across the property. Of this amount, a total of 16,700 seedlings were produced by Quintette staff.

To depict the strategic locations of the islands established in Mesa/Wolverine, Figure 2 has been provided to indicate waste dump and island locations, including the prevailing wind direction (S.W.). To date, the operational island program at high elevation has been focused in the large Mesa dump area.

The seedlings which are outplanted to islands are propagated in the Quintette nursery using seed collected by Environment staff from either the adjacent mountains or from the seed multiplication facility established at the mine in 1991. Seed processing, sowing to containers and tending of seedlings in and out of the nursery is also conducted by Quintette. Large scale outplanting is completed with the help of trained planters. Each seedling also receives a Gromax™ packet (fertilizer at 12-5-8, plus gel) which is secured on the surface near the plug. Some of the species currently used in high elevation native islands are listed below.
A total of 46 species were chosen from an original listing of 95 potential alpine varieties using several selection techniques. This included general retention of species for important wildlife needs, preliminary research results and efficacy of seed collection, processing and propagation.

A monitoring program examining the subsequent dissemination of seed and establishment of plants into the agronomic zones has been initiated to comply with permit conditions. In two growing seasons, the transplants have produced viable seed and new plants have been established up to 15 m away from the original colony. The best colonizers so far include *Androsace septentrionalis*, *Agrostis scabra*, *Crepis nana*, *Minuartia rubella*, *Poa alpina*, *Poa arctica*, *Poa pattersonii* and *Trisetum spicatum*. 
SHIKANO RECLAMATION PROGRAM

The objective of the Shikano mine reclamation program is to establish wildlife habitat for key low elevation target species and to provide forest resources on a minimum of 50% of the rock spoil areas. Forest resource objectives are focused on complementing the wildlife habitat plan. This dual end land use also affects the program with respect to conifer species and configuration of transplanting for wildlife habitat.

Waste dump preparation in Shikano begins with the operational scheduling of "reclamation material" placement subsequent to the abandonment of each lift of the rock dumps. Pit operations independently plan and schedule this phase of the operation with the assistance of Environment staff on issues of material quality and amount. A material balance is kept regarding maximum volumes vis-a-vis constraints set on the depth of materials placed on slopes (too much allows excessive erosion and too little does not cover large rocks). If an excess exists over the requirement for surface and slope cover, efficiency of this operation is reduced.

The next phase involves reclamation material modifications to accommodate preparation of benches and slopes for seeding. Each year a program is presented to Pit Operations involving potential sites and equipment hour requests. Once approved, a dozer operator and unit is scheduled to complete the agreed upon program prior to September.

The need to modify (flatten, mould or shape) free dump piles of reclamation material allows for the flexibility to provide visual barriers, diverse and random terrain and locations for communities of appropriate plants on recontoured hummocks of material. In Shikano, creativity and the ability to "think like a deer" is the mark of a prized operator. In addition, berms on the crest of the dump are pushed off and the crest itself is rounded.

Material is then pushed off the bench onto the dump slopes (dumps do not exceed 22 m in height) and later reworked with a reclamation chain which has rods welded at intervals along it. Over the years, the weight at the end of the chain has been modified from a tire to a drill stabilizer with rods attached. Currently, plans are in the making for a modified sea
mine, or wrecking ball with spikes. The reclamation chain is dragged by the dozer over the surface of the slope whereby the material is flattened and gouged. The rills from the chain facilitate seed growth by providing microsites.

In September of each year, a helicopter or fixed wing, and in certain circumstances, a dozer with harrow, is used to apply an agronomic mix of grasses and legume.

<table>
<thead>
<tr>
<th>LOW ELEVATION AGRONOMIC SEED MIXTURE</th>
<th>QUINTETTE OPERATING CORPORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAME</td>
<td>VARIETY</td>
</tr>
<tr>
<td>Smooth Brome Grass</td>
<td>cv. Common</td>
</tr>
<tr>
<td>Slender Wheatgrass</td>
<td>cv. Revenue</td>
</tr>
<tr>
<td>Creeping Red Fescue</td>
<td>cv. Boreal</td>
</tr>
<tr>
<td>Sheeps Fescue</td>
<td>cv. Common</td>
</tr>
<tr>
<td>Cicer Milkvetch</td>
<td>cv. Common</td>
</tr>
<tr>
<td>Sainfoin</td>
<td>cv. Common</td>
</tr>
</tbody>
</table>

Fertilization is completed in the spring of the following year by helicopter or fixed wing at a formulation of 26-10-10 applied at 200 kg/ha. Thereafter, maintenance fertilization is conducted every second year. We have found that liquid foliar fertilizer applied by fixed wing is the most successful and economical means of completing the maintenance program at this elevation.

Native Plant Establishment:

Native plant species are also propagated at the Quintette nursery for use on the Shikano waste dumps. A total of 9,000 seedlings, of which 2,500 were conifers, have been transplanted in Shikano on rock dump disturbances. A portion of the native species list established for use at low elevation, is provided below.
As in Mesa/Wolverine, fertilizer packets (Gromax™) are secured on the surface beside each native species seedling. In addition, whip transplants are also under review to facilitate the establishment of key shrub species in Shikano.

Conifer seedlings of *Pinus contorta* and *Picea interior* are obtained from a local logging contractor and planted in both island and corridor configurations. High soil pH does pose a problem with the establishment of conifers on Shikano materials using conventional means. The solution to this problem may lie in the blending of other available materials with the soil placed on abandoned dump platforms. This process is currently under review and includes the blending of coarse coal refuse with Shikano reclamation material. Trials involving agronomic growth on coarse coal refuse versus till materials have indicated better growth and vigour on the former. Therefore, an operational blending trial will be established in 1995 to examine this future option. Another proposal in Shikano is the application of biosolids on dump spoil for purposes of amending the growing medium and providing a environmentally responsible disposal means for Quintette sewage sludge.
WILDLIFE HABITAT ENHANCEMENT

Among the many and varied programs established to enhance wildlife habitat within the reclaimed matrix of diverse plant communities, Quintette has conducted habitat work involving: establishment of migration corridors for woodland caribou, grassland habitat and cover/escape corridors for ungulates, establishment of browse species for moose, rock and wood piles for small mammals and perches and nest boxes for raptor and other bird species.

One of the more interesting wildlife programs involved a breeding pair of American kestrels which the Tumbler Ridge Raptor Rehabilitation Centre were housing. A haching box was constructed at the reclaimed 1000 man campsite with the assistance of the Centre's resident expert and students from the Special Needs School in Tumbler Ridge. The fledglings from the breeding pair were placed in the haching box and fed while they imprinted on the reclaimed site. These five birds were released in 1992 and migrated south. Nest boxes were later established on poles in the reclaimed site and as hoped, use by kestrels was confirmed in 1993 and in 1994.

Perches were also established in 1995 on the Shikano south dump for use by raptor and other bird species. This "dead forest", as the equipment operators have coined the area, serves to entice birds to the grassland/sainfoin site which was revegetated in 1991.

CONCLUSION

In this author's opinion, the challenges ascribed to reclamation success in the high elevation/high latitude environment of Mesa/Wolverine and the difficulties in carrying out two widely variable programs due to differences in elevation and biogeoclimatic zones, have been overcome. Through a comprehensive research program and resultant innovative and progressive methodology in local native species use, the land capability which existed prior to operations will be fully realized in both mining areas upon abandonment.