QUINSAM COAL MINE RECLAMATION
25 YEARS OF RECLAMATION EXPERIENCE

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ABSTRACT

Quinsam Coal Corporation (QCC), wholly owned by Hillsborough Resources Limited, operates the Quinsam Coal Mine, located 25 km west of the city of Campbell River on the east coast of Vancouver Island in British Columbia, Canada. Initially opened as an open pit mine in 1986, a switch from open pit mining to underground mining was made in 1993 with open-pit mining ceasing in 1994. Environmental studies, including reclamation research were initiated at the mine property in the early 1980s. Reclamation test plots were established at one of the bulk sample sites and were used to evaluate various tree re-establishment (reforestation) methods. Reclamation objectives at the mine are directed towards forestry and wildlife habitat production. This paper presents an overview of the reclamation work that has been conducted at the mine as well as a detailed look at the reclamation strategies for the development of productive forests and wildlife habitat. Reclamation test plots established in 1982 have provided 25 years of important long term data on the development of productive forest and habitat sites. Incorporation of nitrogen fixing species, including various agronomic legumes and the native red alder (*Alnus rubra* (Ait.) Pursh)[3] in the establishment of forests appears to enhance productivity on the reclaimed areas. Comparisons with naturally occurring second growth forests in the mine area are used to demonstrate productive capacity that is as good as or better than that which existed prior to mining.

[3] Nomenclature used in this paper follows Douglas et al. 1998 – 2002.

INTRODUCTION

Reclamation is an integral part of the mining process. At the Quinsam Coal Mine, reclamation research and reclamation planning was initiated in the early 1980s, prior to the start of mining in 1986. Reclamation at the Quinsam Coal Mine is directed at returning forest productivity as well as providing valuable wildlife habitat to the areas disturbed by mining. The mine was initially designed as an open pit operation and the first mining was conducted in the 2 North area. In 1991, open pits were developed in the 1, 2 & 3 South areas. In 1993, underground mining was initiated followed by the cessation of open pit operations in 1994. Since 1994, mining is conducted entirely underground and the footprint of the mine has not expanded since 1994. A variety of reclamation programs have been conducted on the completed disturbances associated with the open pit operations.

Coal processing is conducted at a heavy media bath and cyclone circuits to remove the non coal fraction or waste material. The non coal fraction is stockpiled either as coarse reject or as tailings in a portion of

the 2 North pit area while clean coal is stockpiled adjacent to the preparation plant prior to trucking to the Middle Point Barge terminal just north of Campbell River. Most of the coal is sold to cement manufacturers and pulp mills in the local area although as much as one third of production is available for sale on the spot market.

This paper presents a summary of the results of reclamation work that has been completed on mining disturbances and plans for future reclamation. Reclamation trials, established in the early 1980s have been used to provide valuable information on the long-term success of reclamation strategies and to confirm the assertion that reclamation at the Quinsam Coal Mine will restore forest productivity to pre-mining levels. Where pre-mining site conditions and forest productivity were poor, such as where shallow soils over bedrock precluded summer moisture retention, the reclamation program will actually improve productive capability, on the land.

MINING

Quinsam Coal Corporation is a wholly owned subsidiary of Hillsborough Resources Limited. Hillsborough (HLB) is publicly owned Canadian company listed on the Toronto Stock Exchange. Mining at the Quinsam property was initiated in 1986 with the development of open pit operations in the 2N area. In 1991, three additional open pit operations (1, 2 & 3 South pits) were developed approximately 5 km south of the 2 North operation. A switch from open pit mining to underground mining was made in 1993 with open pit mining ceasing in 1994. The mine is considered a shallow depth mine with cover averaging from as low as 15 m (50 ft) to 170 m (550 ft). Quinsam Coal's mining fleet consists of JOY Continuous miners, Joy 10SC32 Shuttle cars, and more recently, Jeffery 4100 ramcars. Roofbolting has been by means of Fletcher CHDDR roofbolters. At present mining is carried out exclusively in the No. 1 coal seam at the 3North/2 North mine employing retreat room and pillar methods. In 2006, Quinsam Coal produced 459,000 tonnes of clean, low sulfur, super compliance thermal coal for domestic and international markets at a rate of 3,500 raw tonnes/day.

Raw coal is loaded directly onto a conveyor system in the mine that moves the coal to a small heavy media bath and cyclone circuit to separate the coal product from the refuse material. Coarse reject material is used in the construction of the tailings facility for storage of the fine fraction from the wash plant. The clean coal product is stockpiled on site, loaded into 42-tonne "B"-train trucks and transported to the Middle Point Barge Facility, just north of Campbell River. From the barge terminal, the coal is barged (up to 5,000 tonnes) to customers in Vancouver, Seattle and Tacoma, or taken to the ship loading facility on Texada Island located approximately 50 kilometers south that is able to accommodate the loading of oversized ships (up to 75,000 tonne capacity). Much of the coal is used in cement manufacture with some going to local pulp and paper mills. Approximately one third of production is available for sale on the spot market.

EARLY RECLAMATION TRIALS

Brinco Mining Ltd. proposed the development of the Quinsam Coal deposits in the early 1980s. A broad series of environmental studies were conducted in support of the application under the Mine Development

Review Process, including detailed Stage II environmental studies. Development of reclamation plans prior to certification and permitting were critical for the acceptance of the project by the local community. Reclamation trials were established in the spring of 1982 to test the application of reclamation strategies in the context of actual mining disturbances. In addition, the trials were established on an old test pit in a manner that would ensure the test pit was effectively reclaimed with the completion of the trials. This process has been termed operational reclamation trials (Polster, 1985). It can be an effective means of gaining reclamation insights as well as proactively treating an area that needs to be reclaimed in an operational manner that provides information on the operational feasibility of the reclamation approach that is being considered (Norecol Environmental Consultants, 1983).

The reclamation trials tested the use of a variety of substrate materials for growth of trees. Combinations of topsoil, oxidized till and coarse rock were tested with a variety of agronomic grasses and legumes and grass and legume mixes. Of particular interest, was the testing of three legume species, lupines (*Lupinus polyphyllus* Lindl. ssp. *polyphyllus*); sainfoin (*Onobrychis viciifolia* Scop.) and birds-foot trefoil (*Lotus corniculatus* L.) in combination with planted Douglas-fir seedlings. There was a concern that competition between seeded grasses and legumes with the planted tree species would lead to poor tree growth (Greene 1982). In addition, the standard reclamation practice of seeding with an erosion controlling cover of grasses and legumes (Lant, 1978) was found to compete with planted seedlings. Therefore the idea, coming from Germany, of planting forest trees in rows between rows of legumes was tested. Other tests, including construction of a brush layer (Schiechtl, 1980) using local willow cuttings as well as transplanting clumps of cattails along the margins of the pond, were conducted in the 4 South test pit area. Where native red alder (*Alnus rubra* Bong.) had seeded in naturally, these were retained, although the traditional sylvicultural practice then as now, was to remove alder as it was believed to compete with conifers. This has since been found to be untrue (Polster, 1995) and, at the appropriate densities, alder is found to enhance the growth of conifers.

The initial results of these trials were promising with a good cover of the seeded species established; the planted conifers growing well; the willows and cattails growing well; and a number of alder plants establishing naturally. Substantial differences in plant growth between sites with topsoil and with only an oxidized till cover were not found. In addition, it appeared that as long as there was enough soil like material to cover the coarse rocks, the seeded and planted vegetation did well. The broad latitude in reclamation treatments that appeared to provide satisfactory reclamation allowed the reclamation prescriptions for the mine to be relaxed. Requirements for salvage of topsoil separately from subsoil and oxidized till were dropped from the reclamation plans, although the need to continue to provide a suitable soil-like material for plants to root into was maintained as the coarse sandstone and conglomerate that comprised much of the bedrock overlying the coal was found to be of limited value in terms of plant growth. The growth of vegetation on the plots was measured during the preparation of an updated reclamation plan for the mine on February 27, 2007. The results of these measurements as well as those conducted on natural forest sites in the mine area are presented below. The need to keep track of test plots and monitor them on a regular basis is emphasized in developing successful reclamation strategies.

ONGOING RECLAMATION WORK

Resloping of mine wastes, covering the wastes with rooting media and seeding has been an ongoing part of the mining activities at the mine since the cessation of surface mining in 1994. A small tree planting program, conducted in association with a Scouts Canada Trees for Canada program was undertaken at the mine soon after surface mining ended and some of these trees can be found on the #1 and #2 stockpiles in the 2 North area. Unfortunately, these trees were planted into a dense stand of seeded grasses and legumes and many of them died. In addition, insufficient density as well as the lack of alder has allowed these trees to develop as open grown stock with dense branches to the ground. These trees assist in providing habitat for wildlife, but will not make good saw logs and will not achieve satisfactory growth in terms of forest productivity.

Compaction of the underlying waste rock and in some cases the growth media that was placed on the rock also created some sub-optimal growing conditions for trees. In some cases, the dense cover of seeded grasses and legumes has contributed to poor forest growth on the reclaimed areas. Where conditions simulate natural forest soils, tree growth is similar to that found in the natural areas around the mine. However, where compaction and/or lack of any growth material (oxidized till and topsoil) occurs, tree growth is more restricted and poor in comparison to the growth of trees around the mine site. The following section provides a summary of the results of measurements of trees around the mine, including the 4 South test area and the measures that will be taken at the mine to ensure productive tree growth in the future.

MINE RECLAMATION PLANS

Reclamation at the Quinsam Coal Mine is based on the process of ecological restoration as defined by the Society for Ecological Restoration International (SERI 2004). Ecological restoration is defined by the SERI as the process of assisting the recovery of ecosystems that have been damaged, degraded or destroyed. The key to assisting in the recovery of the ecosystems at the Quinsam Coal Mine, as well as in other degraded ecosystems, revolves around mitigating the factors that are preventing or slowing vegetation growth. Compaction, lack of rooting material, and in some cases the poor quality of material in which the plants are growing all contributes to either the lack of growth or poor growth. Re-establishment of the natural successional trajectories is essential to the long term performance of the reclamation.

Reclamation designs for the Quinsam Coal Mine are based on the premise that natural successional processes will provide the most effective model for development of reclamation programs (Polster, 1989). Red alder (*Alnus rubra* Bong.) is an important pioneering species on disturbed sites in the mine area. This species fixes nitrogen and can substantially boost the available nitrogen for growing trees in a forest situation (Haeussler et al., 1990). In addition, provision of suitable substrates that will provide moisture holding capacity while not restricting rooting depth also ensures productive tree growth. The reclamation trials at the 4 South Test Pit area were designed to provide both the nitrogen (legume trials) and the substrates needed to ensure effective tree growth. Comparisons of the growth of trees on the 4 South Test

Pit area with trees growing on undisturbed lands around the mine were conducted in early 2007. Table 1 provides a summary of the information collected during this assessment.

Tree growth on the test plots was found to be as good as or better than the growth on most of the surrounding sites. The best growth was found at a lower slope site adjacent to Middle Quinsam Lake where a stand of red alder and a high moisture zone were located immediately up-slope. The poorest growth was found at a shallow soiled site located immediately above the mine portals in the 2 North Pit area. The soil in this area is very shallow and the growth of forest species suffers from a lack of summer moisture and nutrients.

Growth of trees during their early years of life may influence the productivity later in life. The ability of young trees to be protected from the harsh extremes of the local climate by the pioneering vegetation that naturally occurs on the site can contribute to the productivity of the tree. Red alder is a pioneering species that often occurs on disturbed sites in the mine area. At the appropriate densities, alder can contribute significantly to the growth of conifers (Polster, 1995). Alder provides shade and can moderate the extreme heat of the summer sun while in the winter, the leaves of the alder are gone and any sunny days can be exploited by the evergreen conifers by photosynthetic activity. In the summer, the increased humidity under a canopy of alder allows young conifer trees to keep their stomata (leaf pores) open and thus to maintain photosynthetic activity. In addition, alder provides nitrogen for the growing trees. Care must be taken with the density of the alder as a heavy cover of alder will compete seriously with conifers such as Douglas-fir (Peterson et al., 1996). Natural successional patterns provide this initial cover naturally on severely disturbed sites, although in many cases, the density of naturally occurring alder is too great to allow conifers to establish.

The sylvicultural design for forested areas on the mine site calls for an equal stocking of red alder (*Alnus rubra* Bong.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) at a total stocking rate of 2,400 stems/ha. Although this density is too great for long term productivity, the design calls for a commercial harvest of both the alder and a third of the Douglas-fir at about age 30. At this point, the alder will be nearly mature while the Douglas-fir will provide veneer logs of an ideal dimension. As the lower stems of the Douglas-fir will be knot free, these logs will command a premium price in the market. The remaining 800 stems/ha can then be grown on for an additional 50 years or so and can provide ideal saw logs, the lower portion of which will be knot free.

Development of landscapes for wildlife is also an important part of the plans for the Quinsam Coal Mine. Wetlands that are currently used as settling ponds and for treatment of drainage water will be converted to habitat for waterfowl and wetland species. Beaver and a variety of a waterfowl currently make use of some of the aquatic habitats around the mine. Special emergency spillways that are dry except in case of emergencies have been developed so that beaver will not block these. Similarly, wetland vegetation such as cattails and sedges were tested at the 4 South Test Pit area and are naturally establishing around the various ponds on the property. Willow staking and riparian plantings will be used to develop riparian areas along the drainage ditches and interceptor ditches. The use of bioengineering treatments (brush layers) was tested at the 4 South Test Pit area and found to be an effective means of establishing

pioneering vegetation on the disturbed area. Soil bioengineering treatments will be employed for development of wildlife habitats at the mine.

Table 1: Site Indices for Douglas-fir on Natural Ground and at the 4S Test Site in the Quinsam Coal Mine Area

Site	Height (ft)	Height (m)	Age	Ft/yr	m/yr	Stand Origin
1	80	24.38	42	1.9048	0.5806	Natural
2	96	29.26	42	2.2857	0.6967	Natural
3	76	23.16	42	1.8095	0.5515	Natural
4	65	19.81	42	1.5476	0.4717	Natural
5	69	21.03	42	1.6429	0.5007	Natural
6	115	35.05	42	2.7381	0.8346	Natural
7	50	15.24	42	1.1905	0.3629	Natural
8	60	18.29	42	1.4286	0.4354	Natural
9	80	24.38	42	1.9048	0.5806	Natural
103	78	23.77	42	1.8571	0.5661	Natural
104	57	17.37	42	1.3571	0.4137	Natural
Averages				**1.7879**	**0.5449**	
101	55	16.76	27	2.0370	0.6209	4S Test
102	65	19.81	27	2.4074	0.7338	4S Test
105	67	20.42	27	2.4815	0.7564	4S Test
106	54	16.46	27	2.0000	0.6096	4S Test
107	64	19.51	27	2.3704	0.7225	4S Test
Averages				**2.2593**	**0.6886**	

Grassy open areas will be provided in some areas to support grazing by Roosevelt elk, black-tailed deer and black bears. Black bears are fond of the new shoots of legumes while deer and elk make use of the grasses and legumes (Nyberg and Janz 1990). By maintaining forests close to the grassy areas, the wildlife will have habitats to retreat to during the foul winter weather. Large woody debris will be incorporated with the development of substrates on the reclamation sites. The woody debris will help to provide habitat for small mammals that will in turn provide prey for raptors. In addition, woody debris will be colonized by red huckleberry (*Vaccinium parvifolium* Sm.) a favoured food source for a variety of wildlife species including grouse and deer. Including a diversity of habitats as well as a diversity of stand ages within the reclaimed areas at the mine will encourage a diversity of wildlife.

CONCLUSIONS

Reclamation designs for the Quinsam Coal Mine are based on reclamation trials that date back over 25 years. The ability to base the reclamation designs on treatments with a proven effectiveness provides assurance that the goals of the reclamation program will be met. Forest productivity that meets or exceeds the productivity of adjacent stands has been documented on these reclaimed areas and provides

the promise that reclamation at the mine can achieve a satisfactory and prescribed level of productivity in the absence of any maintenance activities. Standard sylvicultural treatments at prescribed times during the life of the established stands such as commercial thinning and selective harvest will be employed. Reclamation designs have also been developed to provide abundant wildlife habitat. Aquatic ecosystems will be restored to provide habitat for waterfowl and aquatic mammals while upland areas will be revegetated to provide habitat for large mammals. Large woody debris will be incorporated into the reclamation designs to provide habitat for small mammals that will in turn be preyed upon by raptors. Reclamation at the Quinsam Coal Mine has been designed to re-establish the natural successional trajectories that will ensure productive ecosystems are available for other land and resource uses in the future once mining is complete.

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