RECLAMATION AT HIGHLAND VALLEY COPPER
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Mr. Chairman, Ladies and Gentlemen; we intend to give you an overview of Reclamation at Highland Valley Copper with the theme of this conference in mind which is "Mine Reclamation In Changing Economic Times".

Highland Valley Copper operates the largest base metal mine in North America, a copper/molybdenum operation in the Highland Valley of British Columbia, approximately fifty kilometres southwest of Kamloops and three hundred kilometres northeast of Vancouver. The operation presently produces approximately three hundred sixty million pounds of copper and five million pounds of molybdenum annually. Employing nearly fourteen hundred people and utilizing nearly one thousand vendors and contractors within the Province, Highland Valley Copper makes a significant contribution to British Columbia's economy. This world class mine is one of the largest of its kind producing and delivering high grade material to smelters in the Far East, Europe and Canada.

In terms of tonnage milled, Highland Valley Copper ranks second in the world only to Bougainville Copper. In terms of tonnage mined, Highland Valley Copper ranks third.

Allow me to give you a tour of the Highland Valley on this aerial view. This is the Lornex pit and its wrap around waste dumps. The Lornex tailings pond with its three dams is over ten kilometres long. The H-H Dam upstream and the major L-L Dam downstream contain the tailings within the impoundment. The J-J Dam in the middle was breached in 1987. The L-L Dam is one of the largest earthworks structures in the Province. When mine operations are complete, this major structure and impoundment will remain as a valuable asset for agricultural irrigation and possible hydro electric power generation. The Bethlehem site is on the north side of the Highland Valley. The Heustis Jersey and Iona pits are mined out. The Bethlehem plant is supplied ore from the Valley pit on the south side of the valley. At present, it is a long adverse truck haul to supply ore to the old plant. Tailings from the Bethlehem mill were originally deposited in the Main Pond, now inactive. The Trojan Dam provided additional tailings disposal area which was used until early this year. The Heustis pit has been filled with mine tailings; present works are underway to allow dumping of Bethlehem tailings into the Jersey pit. The inactive Highmont Mine with its two abandoned pits, waste disposal areas and water reservoir; the Highmont tailings pond is just outside of the picture towards Logan Lake.

To realize the effect of changing economics on reclamation at Highland Valley Copper, let us go back to early 1986.

In 1986 Lornex Mining Corporation was operating on the Lornex orebody discovered in the early 1960's by Egil Lorntzen. The average milling rate was just over 80,000 tons/day.

Cominco owned both the Valley Copper deposit and the Bethlehem Mine. Mining ceased in the Jersey pit on the Bethlehem site in 1982 and ore was released from the Valley pit to feed the Bethlehem Mill. In 1986 the average daily milling rate was 27,000 tons/day.
The Highmont property had been shut down since 1984 to adverse economic conditions.

Low base metal prices, prevailing since 1982 prevented Lornex and the Copper Division of Cominco from achieving desired levels of profitability. The partnership of Highland Valley Copper, effective July 1, 1986, took advantage of the synergy of the Valley orebody and the modern Lornex mill. By December 2, 1987 an inpit crushing conveying system was installed in record time to facilitate ore transport from the valley pit to the Lornex plant. The system, two semi-mobile crushing plants and dual conveyors, "is the highest capacity hardrock inpit crushing and conveying system in existence",

The effect of all this activity on reclamation planning was significant. The new sequence of mining resulted in areas on the Lornex site, for the first time reverting to non-active status. The reclamation department now had to meld the Cominco reclamation plan for the Bethlehem and Valley properties with the Lornex reclamation plan to reflect the partnership agreement. An ambitious plan was proposed to begin active reclamation on the Lornex site and to rejuvenate the reclamation efforts that had stalled on the Cominco-Bethlehem site. This plan addresses site reclamation through to end of mine life. Initially, the plan is to complete the major portion of final reclamation of the Bethlehem site by year end 1992. A significant portion of the abandoned Lornex dump surfaces (100 hectares) will also be reclaimed in this time period.

As this reclamation plan was being developed and presented to the appropriate branch of the civil service for approval, negotiations to include Teck Corporation Highmont property in the partnership were in full swing. Highmont was bought into the partnership in January of 1988. An expansion project is now in progress to transfer the Highmont Mill Complex to its new location adjacent to the Lornex mill. The Highmont Mine is inoperative. Research work is in progress to determine the most effective means of reclaiming the Highmont property. A plan addressing the reclamation of the Highmont property will be presented for approval before year end 1988. The effect of this move was to present an entire mine site for reclamation.

In all of our research and operational reclamation work at Highland Valley Copper, we chose to contract the expertise to assist us in developing and operating and effective reclamation program. C.E. Jones and Associates were the candidates selected to do so. Allow me to introduce the expertise to describe specific reclamation research and activity at Highland Valley Copper.

Objectives

A primary objective of the reclamation program at Highland Valley Copper has been the determination of the most cost-effective method of achieving a self-sustaining vegetative cover which meets the land use objectives for the various types of disturbed areas. Research activities to assess the suitability of various potential and land uses have been reported previously at the B.C. Mine Reclamation Symposium (Jones, 1985; Hackinen, 1987) and at the Annual meeting of the Canadian Land Reclamation Association (Jones and McTavish, 1986). These research programs addressed issues such as; species suitability, effect of inter-species competition, site treatment, optimum season for planting, metal uptake by species, and the effect of waste material weathering on
plant nutrient availability. The information gained from these research programs has refined the list of potential land uses to those which are both suitable and economic.

Reclamation of disturbances at Highland Valley Copper begins as soon as it is practical after areas become permanently inactive. During 1987, thirty-five hectares of waste dumps and seven hectares of tailings were reclaimed on the Bethlehem and Lornex properties. In 1988, reclamation of thirty-three hectares of inactive dumps on the Bethlehem and Lornex properties and twenty-two hectares of the Main Bethlehem tailings deposit are in progress. In this paper we will examine some of the techniques employed in this work, the rationale for choosing these techniques and the relative costs of various techniques.

**Tailings**

Reclaimed tailings deposits in the Highland Valley have the potential to support irrigated agriculture, grazing, wildlife habitat, or forest uses. Research programs have assessed the suitability of these options and have illustrated the economic potential for irrigated agriculture but have also determined a limitation to forage production due to elevated levels of copper and molybdenum in plant tissues (Jones, 1985 and Hackinen 1987). The potential for the production of a non-consumptive crop such as seed is presently being tested. Preliminary field data suggest that over ten to fifteen years precipitation will leach these tailings materials and reduce the pH in the rooting zone to a range which will limit the availability of molybdenum to plants and improve the copper to molybdenum ratio of crops produced. Other work, carried out in 1987 by the B.C. Ministry of Agriculture and Fisheries on natural range conditions in the Logan Lake area, indicates that calves achieved good weight gain when grazed on forage with copper to molybdenum ratios ranging from 1.4 in June to 0.2 in October (Strachan, 1987). This research suggests that limitations to the use of the tailings areas for forage production based on standards set by the National Research Council (1984), and Agriculture Canada (1981), should be readdressed and further studies at Highland Valley Copper are presently on-going.

The reclamation of the Main Bethlehem tailings deposit has begun with revegetating the coarse sand crest of the tailings dam. This area of twenty-two hectares will be seeded and fertilized in the spring of 1988 using standard agricultural equipment. In the fall of 1988 the area will be planted with native shrub species, at a density of 2000 stems/ha, to further stabilize these loose sands and develop a windbreak. Irrigation is necessary to establish vegetation will be moved in subsequent years as the entire tailings deposit is reclaimed.

The costs of reclaiming an area are largely determined by the techniques employed, and we have found that the lowest costs can be achieved on tailings through the use of standard agricultural equipment. In the reclamation of this area we have used a tractor drawn Brillion seeder and cyclone fertilizer application. Approximately 0.7 ha/hour can be seeded and 2 ha/hour fertilized using this technique. Planting of native shrubs on this site ranges from 1000 to 1200 seedlings per planter per day.

**Waste Dumps**

The proposed end land use for waste dumps varies depending upon the elevation
of the dump surface and the location in the valley. At elevations greater than 1500 m on the south side of the valley (Lornex and Highmont properties) the effective precipitation is greater and a broader range of species can be successfully planted. The end land use proposed for these areas is an integrated option emphasizing a forest cover and including wildlife utilization and grazing. Dumps at elevations lower than 1500 m on the south side of the valley (Bethlehem property) are dryer and warmer than the upper dumps and are unlikely to support a forest cover. The end land use for these areas will be wildlife utilization and grazing.

Results of reclamation efforts in the Highland Valley have indicated that compacted waste rock surfaces do not support good plant establishment and that the surface must either be ripped to reduce the compaction or covered with capping of overburden material. The cost involved in transporting and spreading overburden, combined with the low survival of native trees and shrubs planted into this shallow capping, has led to the adoption of ripping as the primary site preparation technique on level waste surfaces.

The prepared sites are seeded in early spring with 35 kg/ha of a mix of agronomic grasses and legumes. A high phosphorous fertilizer is applied at a rate of 400 kg/ha. Maintenance fertilizer is applied in subsequent years at a rate of 200 kg/ha. This fertilizer maintenance is required for two or three years until a large component of legume growth is established.

In the fall following the seeding, during mid to late September, native trees and shrubs are planted in groups or islands at a density of 1000 stems/ha. Research studies have indicated the most successful species for these sites and have also shown the high survival rates which are achieved on sites which have been prepared by ripping. Candidate reclamation species have all maintained high survival rates and displayed good growth on these sites for three to four years.

Ripping the compacted surface of these dumps to a depth of 0.5 m is achieved through the use of a D-9 Cat and averages about 0.3 ha/hour. Seed and fertilizer are applied on ripped waste surfaces by either tractor or helicopter. A tractor powered cyclone seeder can apply seed at the rate of 1.7 ha/hour, while a helicopter cyclone seeder can seed at the rate of 15 ha/hour. Fertilizer can be applied by the tractor cyclone at a rate of 1.5 ha/hour, while the helicopter rate is 7.5 ha/hour. Maintenance fertilizer must be applied by helicopter since the areas have been planted with trees and shrubs. The rate of maintenance fertilizer application is 15 ha/hour. Native species are planted in these level ripped surfaces through the use of chain-saw powered augers to prepare the planting holes. Planting on these sites averages three hundred seedlings per planter per day.

Conclusion

Highland Valley Copper has initiated an ambitious program to reclaim all disturbances as soon as practical after areas become inactive. This commitment to reclamation will result in the revegetation of most of the mine areas prior to mine closure. A range of reclamation techniques will be employed to provide the most cost-effective methods of achieving end land use objectives. An ongoing research program will refine these programs as new information is gained and ensure that the reclamation program continues to meet its objectives.
Survival (%) on Southeast Waste Dump

% Survival

100
90
80
70
60
50
40
30
20
10
0

Willow  Wild Rose  Saskatoon  Buffaloberry  Clematis

Species

Sept. 1985  Sept. 1987
References


