Prepared for:

Reclamation in the Eastern Slopes of Alberta,
a conference sponsored by
Alberta Chapter, Canadian Land Reclamation Association
September 25 - 26, 1986.
Overlander Lodge, Hinton.

REFORESTATION OPERATIONS ON RECLAIMED LANDS AT THE COAL VALLEY MINE, ALBERTA.

Prepared by:

Curtis Brinker, R.P.F.
Senior Environmental Planner
Luscar Sterco (1977) Ltd.

and

Rick Ferster, R.P.F.
Senior Environmental Planner
Luscar Ltd.

INTRODUCTION

Alberta's Land Surface Conservation and Reclamation Act was promulgated in 1973. Pursuant to this Act, guidelines for reclamation of surface disturbances were developed in 1977 to express the government's expectations of land reclamation. Expectations are defined in terms of prescribed post-disturbance land uses, which in the Green Zone of Alberta can include the establishment of forest vegetation.

The Coal Valley Mine, approved in 1976, was the first Alberta mine with a prescribed post-disturbance forest end land use. At that time, unlike reclamation of mined lands on an agricultural land base, the technology and methodology for reclamation to a forest land base were not well established. Considerable information existed regarding reforestation of forestry cut-blocks and other such disturbances, and these general principles were applied to reforestation of reclaimed mined lands. However, because initial site conditions on newly reclaimed lands differ from those on cut-blocks, it is necessary to modify to standard reforestation operations. Strict adherence to proper reforestation practices is essential for reclamation success.

This report provides an overview of reforestation experiences at the Coal Valley Mine and discusses techniques which have proven successful for the operation's site-specific conditions.

OVERVIEW OF MINE

General Setting:

The Coal Valley Mine is located 80 km southwest of the town of Edson, Alberta. Natural vegetation is predominantly Upper Foothills Boreal Forest (Rowe, 1972), containing fire-origin lodgepole pine (Pinus contorta var. latifolia), black spruce (Picea mariana) and aspen (Populus tremuloides), and typical understory shrubs including Labrador tea (Ledum groenlandicum), willow species (Salix spp.), dwarf birch (Betula pumila), and green alder (Alnus crispa). Topography is hilly and ridged, with well-drained upper slopes and poorly drained muskeg in the valleys. Elevation averages 1,400 m A.S.L. Climate is characterized by long, cold winters and short, cool summers (EPEC, 1976). Annual precipitation averages 620 mm, of which 475 mm fall during the May - September growing period. Chinook winds are occassionally experienced in winter. Soils are generally classified as shallow Brunisolic Gray Luvisols developed mainly on sandy loam to sandy clay loam till over sandstone. Upper soil horizons are strongly acidic (pH of 3.8 - 5.0)(Dumanski, et. al., 1972).

Mine Operations:

Coal Valley is a surface mining operation employing open pit and strip methods to extract the coal resource. Mining operations began in 1978. The general development/mining procedures are as follows:

- Exploration drilling programs are conducted to define the mineable coal seams;
- Timber is cleared and salvaged from the pit areas, slash debris is 'grubbed' (piled and burned) and soil is salvaged (including LFH, Ae, B, and C horizons) to ensure an adequate replacement depth;
- The overburden (rock overlying the coal seam) is blasted and stripped, coal is extracted and hauled to the cleaning plant;
- The overburden spoil and highwalls are sloped to a maximum gradient of 50% (27^{o}), then coversoil is replaced to prescribed depths;
- A grass-legume ground cover is established for erosion control; tree and shrub seedlings are planted subsequent to the establishment of ground cover.

Mining disturbs 30 - 50 ha. per year, and reclamation operations keep pace with mining disturbance.

Post-Reclamation Setting:

Subsequent to levelling and soil replacement, newly reclaimed areas are initially devoid of any vegetation. These areas are seeded as soon as possible (Lemtal annual ryegrass, Climax timothy, red top, Boreal creeping red fescue, Revenue slender wheat grass, Dutch white clover, yellow and white sweet clover) and generally within two years a ground cover has become established.

The landscape is restored to a hilly topography, with slopes averaging 20 - 30%. Replaced soils are similar in texture to natural soils in the areas, but have a slightly higher pH (5.5 - 6.5) and lower organic matter content than in upper horizons of the natural soils. Other soil characteristics are similar (Luscar, 1980). The underlying spoil has characteristics similar to lower (BC & C) horizons of natural soils, and has been suggested as a suitable subsoil for plant growth (Luscar Sterco, 1985).

OVERVIEW OF REFORESTATION RESULTS

Coniferous planting is the main reforestation technique used at Coal Valley, and has been for the past five years. Seedlings used in the program are generally container-grown lodgepole pine seedlings (1 - 0 stock) produced in Spencer-Lemaire 'Fives' (65 c.c. rooting volume). All seedlings are grown from a local provenance.

Several experimental plantings at Coal Valley have been established with the first plots being planted 13 years ago by the Alberta Forest Service. Results of seedling performance in earlier trials were variable. Although many of these results were collected from trials or monitoring programs which were not statistically replicated, it has been possible to explain much of the variability. Based on results of operational plantations and field trials several factors are evident which affect initial survival and establishment of lodgepole pine seedlings under Coal Valley's conditions. These are listed below:

1. Seedling Hardiness/Dormancy

In current planting programs, only well-hardened seedlings are used; ie. firm bud set, woody stem. However, in some earlier trials and plantations, seedlings were used which were not completely hardened - bud set was incomplete, and the stems were still greenish. In most situations, the seedlings appeared stressed (ie. reddening of foliage, partial needle-drop) within two months after planting and subsequently suffered from leader or terminal bud dieback. This occurred most often on exposed, unvegetated sites. Observations indicate the effects of this initial setback can last for 2 - 3 years or longer. Table 1 summarizes results of one of the trials conducted at Coal Valley. Results indicate that unhardened seedling were more susceptible to mortality on exposed sites.

Table 1. Seedling Hardiness/Site Exposure Trial

(50 seedlings per plot, planted September 1981, measured August 1986).

Plot #	Survival (%)	Avg Tot Hgt (cm)	Seedling Hardiness* At Time of Planting	Site Exposure**
1a	90	56.5	well hardened	well protected
2a	92	43.4	well hardened	protected
3a	82	27.8	well hardened	exposed
4a	82	18.1	well hardened	exposed
1b	96	54.8	un-hardened	well protected
2b	90	45.5	un-hardened	protected
3b	58	23.3	un-hardened	exposed
4b	74	18.0**	un-hardened	exposed

* 'Well-hardened' - firm bud set, woody stem; 'unhardened' - active terminal growth, fleshy stem.

** A relative factor, based on aspect, protection from topographic irregularities, residual forest, and ground cover.

To ensure that seedlings are well-hardened at planting time, most pine seedlings are grown the year prior to planting, removed from their containers in the fall, and stored overwinter in an underground storage cellar. The temperature in this unit remains at 0^{o} C from late October until late May, the following spring, and keeps the seedlings in a dormant, well-hardened condition until they can be planted. It also protects their roots from freezing damage over winter (Heyer, et. al., 1982; Havis and Fitzgerald, 1977).

2. Planting Date

Table 2 summarizes results of selected plantations, planted at different times of year. Seedlings planted in spring have had consistantly better survival and height growth than those planted in summer/fall.

Table 2. Planting Date/Site Exposure Trials

(100 Seedlings per plot; results collected in August, 1986).

Plot #	Survival (%)	Planting Date	Site Exposure	Seedling Hardiness At Time of Planting
6	90	May/83	exposed	well hardened
7	82	May/84	protected	well hardened*
8	96	June/84	well protected	un-hardened
9	57	July/84	partially exposed	un-hardened
10	35	July/84	exposed	un-hardened
11	84	Aug./84	protected	un-hardened
12	64	Sept./83	protected	hardened
13	41	Sept./83	exposed	well hardened

* Seedlings were partially root-bound at time of planting.

Several reasons may explain this trend:

- soil moisture conditions are generally more favorable in spring;
- evapo-transpiration losses are lower in spring;
- planting stock grown the previous year can be planted dormant;
- seedlings planted in spring have a longer period to root thus reducing the risk of frost-heaving (Bengtson, et. al., 1971).

At Coal Valley, most seedlings are planted in early spring (late April - early May). Whenever possible contractors have been used to do this. Some seedlings are planted as late as June, provided soil moisture conditions are suitable, the site is not exposed, and the seedlings are in their second growing season (such seedlings tend to be more hardy than those produced in a greenhouse in the same year they are planted).

3. Initial Site Exposure

Exposure from sun and drying winds adversely affects initial seedling performance (Dempster and Higginbotham, 1985). On Coal Valley's reclaimed lands, initial exposure varies considerably from extremely exposed (south west aspect, no natural shelter/forest nearby, low micro-site diversity) to well-protected (north or east aspect, good ground cover, leeward of protective ridge or forest). Plantation performance varies on these sites, with survival and growth being least consistant on the most exposed sites, particularly if the seedlings are not completely hardy, planted late in the season, or planted on areas without protective ground cover or favorable micro-sites.

Several steps are taken to minimize exposure on Coal Valley's reclaimed sites. During and following soil placement operations, site preparation work is done to enhance favorable micro-sites for plant establishment. On level areas, this simply involves leaving the ruts and tire tracks from the equipment in place; on slopes, additional work is done to cross-ditch the area. These operations reduce exposure by producing a greater variety of micro-sites for the grasses and seedlings to establish. Soil erosion is also minimized.

Following surface preparation, sites are seeded with a grass-legume mix and harrowed. The seed mix is designed to provide a protective nurse crop(annual ryegrass and sweet clover) for the first and second years, and a long term, low-competitive ground cover for subsequent years. If possible, seedlings are planted only on sites which have a well-established ground cover (ie. seeded 1 - 2 years earlier). On less exposed, north-facing slopes, seedlings may be planted while the ground cover is still establishing, but this practice is avoided if possible.

Other researchers (King, 1984; Techman, 1983) have noted that competition between ground cover and tree seedlings can be significant on some sites. However, under Coal Valley's conditions we have not observed any detrimental effects from competition which would outweigh the benefits related to exposure amelioration.

4. Planting Quality

The importance of planting quality has been well-documented (Carlsen, 1983). At Coal Valley one of the most important considerations is to ensure that the seedling root plug is planted deep enough such that the top of the root plug is buried 1 - 1 1/2 cm. below the soil surface. This minimizes drying of the root system, and reduces the risk of frost heave. On exposed, south-facing slopes, frost-heaving has increased seedling mortality. This is particularly true for seedlings planted later in the year and where there is no protective ground cover.

5. Other Factors

Other factors have also affected initial seedling performance at Coal Valley - these would include:

Damage from Browsing:

Browse damage to pine seedlings has been moderately severe on certain localized areas. Most of this damage was caused by rabbits. Sites which have been most subject to rabbit browsing appear to be areas adjacent to natural vegetation cover with light or no ground cover. Areas with moderately dense ground cover have not been affected.

Nutrient Availability:

Natural soils in the Coal Valley area generally have relatively low nutrient levels (Knapik, 1984). On reclaimed soils, nutrient levels are low. It has become apparent that tree seedlings given high-phosphate fertilizer at time of planting perform better over at least the first two years (less evidence of planting stress; greener, darker foliage) than those without. It is not known if the prime factor here is improved nutrient status or increased ground cover (fertilized seedlings generally have a heavy grass cover in a 10 cm radius around them) or a combination of the two. Table 3 summarizes preliminary results of some fertilizing trials. As indicated in this table, survival and total height measured two growing seasons after planting do not appear to be different between the treatment and control plots. Research is on-going to further evaluate the effects of fertilizing on survival and initial growth.

Table 3. Individual Seedling Fertilizing Trials

(Planted May 1985, Measured August 1986)

Plot #*	Treatment**	Survival (%)	Total Height (cm)	Seedling Qualities (Visual Observations)
1a	fertilized	100	19.6	Foliage, dark green, long needles, heavy grass cover in 15 cm.
1b	fertilized	96	21.0	radius around seedling.
2a	control	94	19.8	Foliage light green, shorter needles,
2b	control	92	19.9	light grass cover around seedlings.

* 50 seedlings per plot

** 'Fertilized' seedlings were individually fertilized with 20 g of 7-40-6 slow release fertilizer. 'Control' seedlings had no fertilized applied.

In Coal Valley's present program, seedlings planted on severely exposed sites are individually fertilized at planting time with a slow-release fertilizer (Mag Amp 7-40-6). The high level of phosphate is provided to promote root growth. Individual seedling fertilizing is carried out as opposed to broadcast fertilizing to minimize potential problems with grass competition.

Other factors probably also affect plantation performance to some degrees (eg. use of nitrogen - fixing groundcover species, seedling root-shoot balance, soil compaction) but those noted above appear to be the most significant ones under Coal Valley's conditions.

CONCLUSIONS

When reclamation regulations in Alberta were being developed in the early 1970's, concerns were expressed as to whether trees could establish on mined lands. These concerns apparently originated from observations of derelict lands originating from old mine workings made prior to reclamation legislation. Some sites still remain devoid of vegetation after 30 years. However, present-day reclamation operations, including resloping and soil salvage/replacement, ensure restoration of suitable site conditions to establish vegetation. Experience at Coal Valley indicates that, with properly implemented techniques reforestation will be consistantly successful.

In summary, it appears that minimizing stress to establishing seedlings and providing adequate time for rooting in the first growing season are the most important considerations in plant establishment at Coal Valley. On plantations where the above steps have been adhered to, results indicate that seedling survival and initial vigor are consistantly acceptable for achieving end land use objectives.

However, further research is still required to evaluate various reforestation techniques. Examples of research trials on-going at Coal Valley include:

- Artificial inoculation of seedling roots with mycorrhizae. The lack of locally isolated inocula has impeded testing on this project.
- Use of the 'shelter cone' technique (as described in Basaraba, 1982).
- Direct seeding for establishing tree and shrub seedlings.
- Confirming the effectiveness of fertilizing individual tree seedlings.
- Continuing to modify the grass-legume seed mix presently being used for ground cover re-establishment.
- Evaluating the effects of variable soil replacement depths on longer-term vegetation growth.

As more information is collected, the reforestation program will be further refined to improve its effectivenss and minimize cost per established seedling.

REFERENCES CITED

BASARABA, Dave. 1982. Evaluation of the Shelter Cone Seedling Method of Direct Seeding the East Kootenays. Crestbrook Forest Industries Ltd. Cranbrook, B. C. (unpublished report).

BENGTSON, G. W., D. A. MAYS and T.G. ZARGER. 1971. Techniques useful in establishing vegetation cover on reclaimed surface mined land. IN: Proceedings of Symposium on Rehabilitation of Drastically Disturbed Surface Mined Lands. Macon, Georgia. November 4 - 5, 1971. Georgia Surface Mined Land Use Board, Macon, Georgia. pp. 79 - 86.

CARLSEN, L.W. 1983. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Revised. Can. For. Serv. Inf. Rep. NOR-X-214E.

DEMPSTER, W.R. and K.O. HIGGINBOTHAM. 1985. Mountain/Foothills Reclamation Research Program: Growth performance of Commercial Timber Species. Prepared by W. R. Dempster and Associates for M-FRRP.

DUMANSKI, J., T.M. MACYK, C.F. VEAUVY and J.D. LINDSAY. 1972. Soil Survey and Land Evaluation of the Hinton-Edson, area, Alberta. Alta. Inst. of Pedology Report No. 5-72-31.

E.P.E.C. CONSULTING WESTERN LTD., 1976. Environmental impact assessment of the proposed Coal Valley mining development. Vol. I and II. Prepared for Luscar Sterco Ltd.

HAVIS, John R. and Robert D. FITZGERALD. 1977. Winter Storage of nursery plants. Cooperative Extension Service, Univ. of Mass., U.S.D.A. and Country Extension Services.

HEYER, J.D., George GRAINGER, Pat FLINN, and Herman T. OOSTERHUIS (compilers) 1982. Propogation and production of woody ornamentals in a small nursery. Alberta Agriculature, Print Media Branch, Edmonton, Ab.

KING, P. 1984. Woody Plant Demonstrations and Trials on Disturbances in the Eastern Slopes. In: Ziemkiewicz, P.F. (Editor). 1985. Workshop

Proceedings: Revegetation Methods for Alberta Mountains and Foothills; held April 30 - May 1, 1984, Edmonton, Alberta. Alberta Land Conservation and Reclamation Council Report # RRTAC 85-1.

KNAPIK, L. J. 1984. Evaluation of Soil Overburden Quality for Reclamation at Coal Valley. Prepared for Luscar Sterco (1977) Ltd. by Pedocan Land Evaluations Ltd.

LUSCAR LTD. 1980. Evaluation of Reclamation Materials, Val D'Or Zone, Coal Valley Mine. Prepared for government submission.

LUSCAR STERCO (1977) LTD. 1985. Conceptual Revegetation Plan for Coal Valley Mine. Prepared for government submission.

ROWE, J.A. 1972. Forest Regions of Canada. Department of the Environment, Canadian Forest Service. Publication No. 1300.

TECHMAN ENGINEERS LTD. 1983. Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Report # OSESG-RRTAC 83-5. 130 p.

PROCEEDINGS

ALBERTA RECLAMATION CONFERENCES

1985
Planning and Certification of Land Reclamation
April 16-17, 1985
Edmonton Inn, Edmonton

1986
Reclamation in the Eastern Slopes of Alberta
September 25-26, 1986
Overlander Lodge, Hinton

C.B. Powter
R.J. Fessenden
D.G. Walker
Compilers

CLRA **ALBERTA CHAPTER** AC

CANADIAN LAND RECLAMATION ASSOCIATION

P R O C E E D I N G S

1985 AND 1986
ALBERTA RECLAMATION CONFERENCES
ALBERTA CHAPTER, CANADIAN LAND RECLAMATION ASSOCIATION

1985: Planning and Certification of Land Reclamation, April 16-17, 1985, Edmonton Inn, Edmonton

1986: Reclamation in the Eastern Slopes of Alberta, September 25-26, 1986, Overlander Lodge, Hinton, Alberta

Powter, C.B., R.J. Fessenden and D.G. Walker, compilers.

ACKNOWLEDGEMENTS

The Chapter gratefully acknowledges the time and effort put into organizing the 1985 conference by Paul King, Dave Walker, Bob Fessenden, and Chris Powter and the 1986 conference by Chris Powter, Dave Walker, and Bob Fessenden. The Chapter also thanks Debra Scott, Glen Singleton, and Doug Mead for assistance during the conferences.

Much appreciation is also due to the Research Management Division, Alberta Environment, the Reclamation and Reforestation Branch, Alberta Forest Service, and the Terrain Sciences Department, Alberta Research Council for providing manpower, supplies and mailing facilities for the conference pamphlets. Special thanks to Meliza Canafranca and Susan Panker, Research Management Division for typing (patiently) the programs and other material and to Dave Walker and his Mac for the cover art.

Most of the work, however, was done by the speakers who prepared the papers and delivered the talks to us and we offer them a strong vote of thanks.

Last, but not least, thanks to the two hotels for excellent accomodations and facilities.

For more information on the Alberta Chapter of the Canadian Land Reclamation Association please write to CLRA, Box 682, Guelph, Ontario, Canada N1H 6L3.

The papers contained in this proceedings are the original, unedited manuscripts provided by the authors.

This report may be cited as:

Powter, C.B., R.J. Fessenden and D.G. Walker. 1987. Proceedings of the 1985 and 1986 Alberta Reclamation Conferences. Alberta Chapter, Canadian Land Reclamation Association. AC/CLRA Report #87-1. 272 pp.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONCLUDED)

NOTE: N/A means the paper was not submitted. We suggest you contact the speakers directly for more information.