AGRONOMIC PROPERTIES AND RECLAMATION POSSIBILITIES FOR SURFACE MATERIALS ON SYNCRUDE LEASE #17

by

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ABSTRACT

Reclamation planning for tar sands mining and extraction operation differs greatly from that used in Alberta foothills and plains coal mines. One of the main differences is that the bulk of the surface materials to be placed and vegetated are spent tailings sand. On-site overburden materials suitable for amelioration of the sand consist of peat and glacial till. Tailings sand itself is too low in available moisture and nutrients to support vegetation without amendments. A landscape design concept is described that improves overall nutrient and moisture status of the sands and allows for vegetation diversity on the reclaimed land.

1. SYNCRUDE LEASE #17 SITE FEATURES

Syncrude Canada Ltd. Mildred Lake Project is located approximately 55 miles (40 km) north of Fort McMurray, Alberta, within the lower Beaver Creek watershed. One possible project layout is shown on Figure 1. Areas to be reclaimed will consist of the mining area, tailings pond, and associated lands. At least 5000 acres of land will need to be reclaimed (not including water surfaces). Figure 2 provides a schematic outline of steps in the mining and disposal of tar sands.

2. PRESENT LAND CAPABILITIES

Present land capabilities in the vicinity of the Mildred Lake Project can be summarized as follows:*

VEGETATION

The present non-industrial land uses surrounding the Syncrude Lease 17 are forest oriented, although the land is not highly productive from a forestry viewpoint. Two-thirds of the ground cover comprises non-commercial deciduous, softwood scrub, muskeg and hardwood scrub. The primary commercial species are white spruce *(Picea glauca)* and jackpine *(Pinus banksiana)*.

More specifically, the landscape of Lease 17 can be divided into eight plant communities plus water. Each of these landscape units has different land capabilities. Table 1 provides a resume of these units and their relative land capabilities on the basis of present land management in this part of Alberta.

WILDLIFE HABITAT

Present ungulate habitats primarily support moose *(Alces alces)*, but they also have capability for mule deer *(Odocoileus hemionus)*, white-tailed deer *(Odocoileus virginians)*, elk *(Cervus canadensis)*, woodland caribou *(Rangifer caribou)* and barren ground caribou *(Rangifer tarandus)*.

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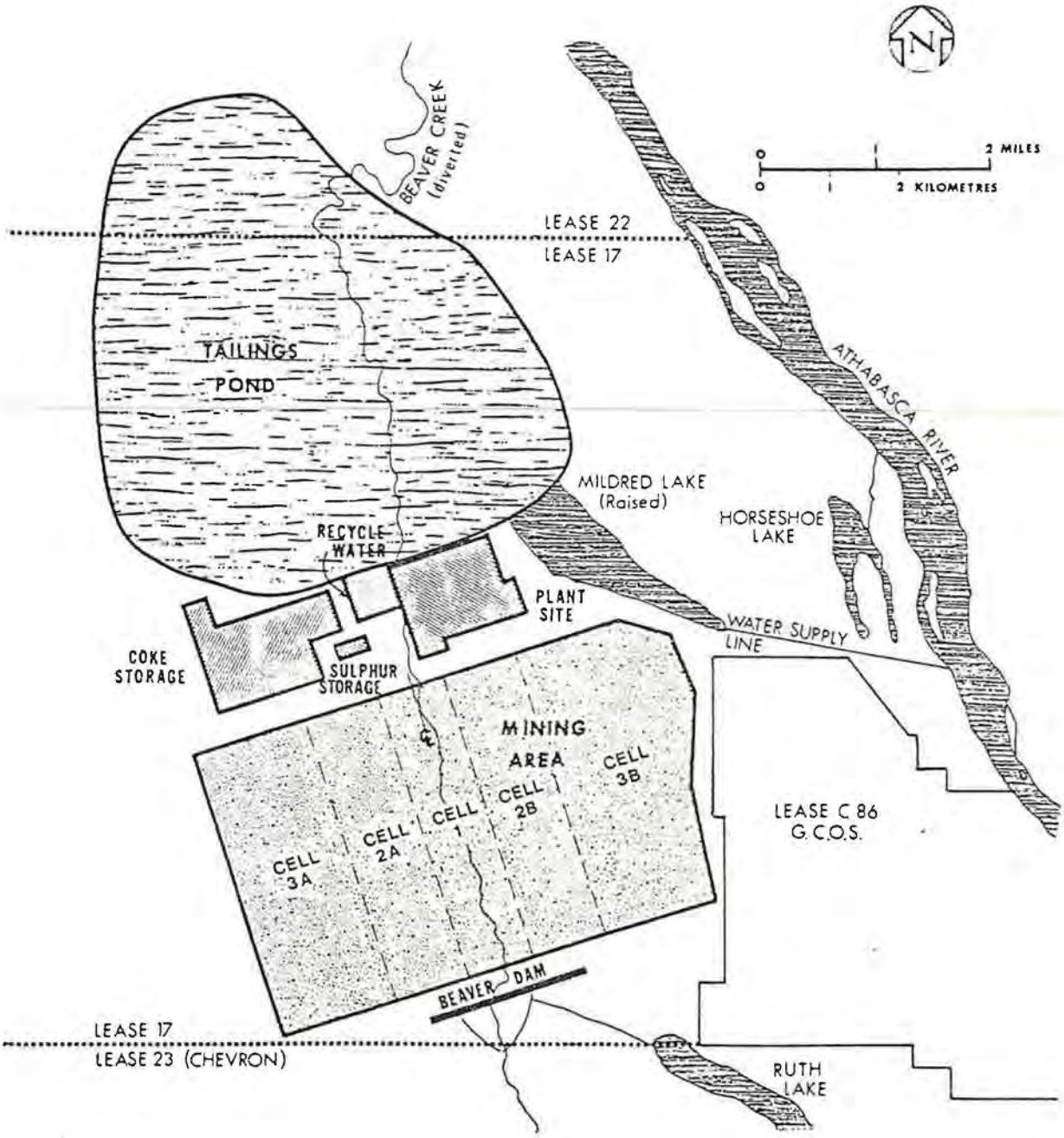
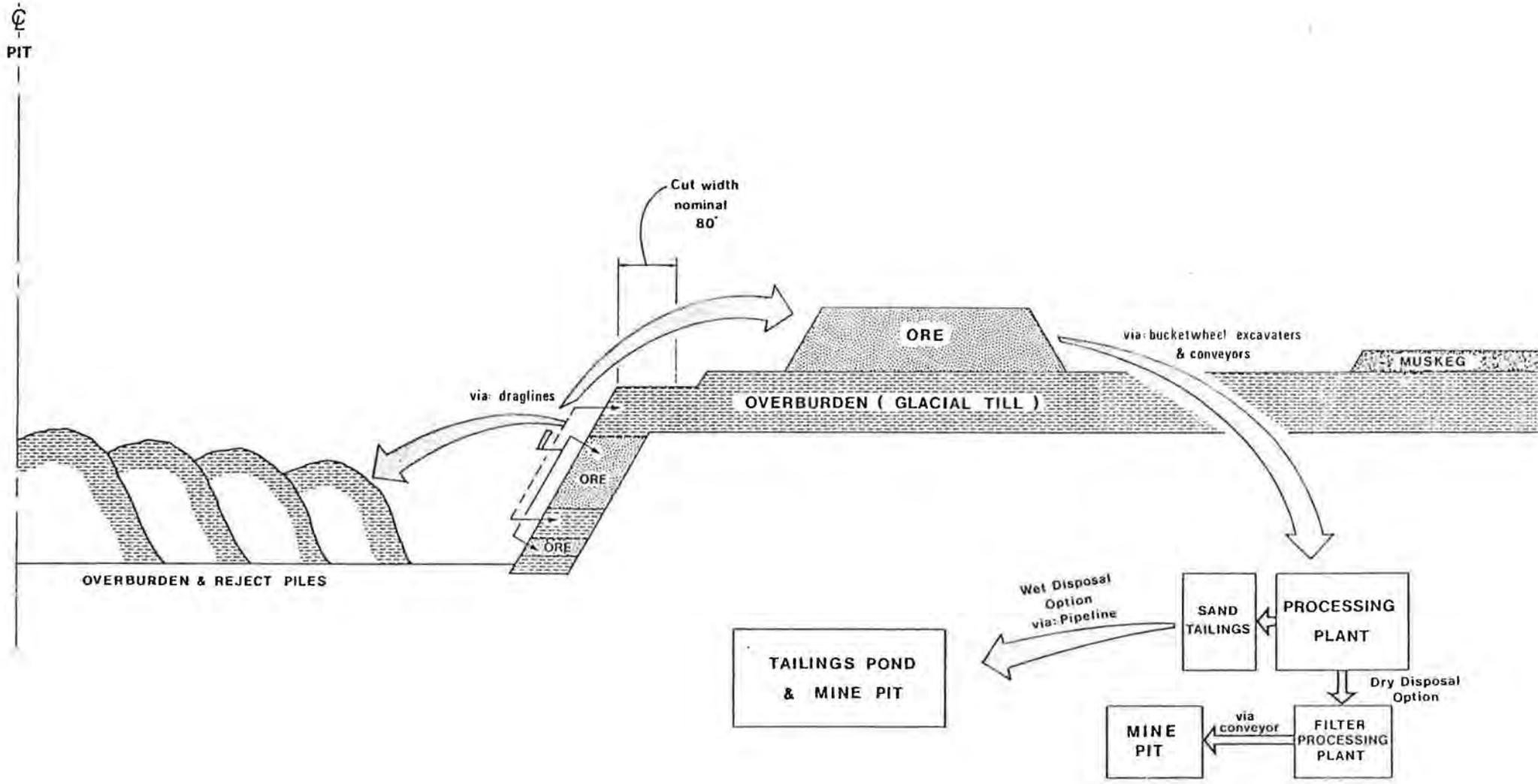
* Based in part on Syncrude Canada Ltd. 1973 Research Monographs 1973-1 and -2.



Syncrude Site Plan
(wet tailings disposal)

FIGUR



MINING AND DISPOSAL SCHEME

FIGURE 2

The highest quality moose winter habitats are found in pure aspen, white spruce-aspen, and riverine plant communities. Shrubs such as willow and red osier dogwood contribute to the importance of these stands for winter browse. Grasses and forbs in spruce-aspen types offer good potential for summer range for deer and elk.

Pine forests have limited value for wildlife except that lichens and moss offer potential food for caribou.

Boggy areas of willow - muskeg and treed muskeg are secondary sources of browse and are heavily hedged by rabbits.

Open water areas such as Mildred Lake and Horseshoe Lake have abundant stands of aquatic plants and are used by spring migrating waterfowl. A few beaver and other furbearers use the aquatic habitats and moose probably feed on aquatic vegetation during the later summer.

RECREATION

Hunting, fishing and scenic touring are the main recreational activities at present in the Athabasca area. A few campsites and parks are available but in general recreational facilities are absent or limited. The nearest provincial park at Gregoire Lake about 20 miles southeast of Fort McMurray is accessible by road.

Moose, deer, caribou, elk, grouse and ptarmigan are all popular game species.

The Beaver Creek watershed is not considered to be of high quality for sport fishing. Occasionally grayling and northern pike are caught.

3. RECLAMATION OBJECTIVES

Reclamation objectives in Alberta are determined by government regulations and by the traditional land use of a disturbed area. Provincial regulations require the reestablishment of a land capability at least as good as it was before land disturbance, and the traditional land use in the Athabasca oil sand region has been forestry oriented. Consequently the most typical choice of future land uses in the reclaimed areas are forestry, wildlife and recreation.

Table 1 RELATIVE LAND CAPABILITIES IN VICINITY OF SYNCRUDE LEASE #17 (Based in part on Syncrude Canada Ltd. 1974 Research Monograph 1974-3.)

Plant community or habitat type	Land capability		
	High	Moderate	Low
Jackpine		Wildlife	Forestry Recreation
Jackpine - aspen		Forestry Wildlife	Recreation
Aspen	Wildlife	Forestry Recreation	
White spruce - aspen	Wildlife	Forestry	Recreation
White spruce		Forestry Wildlife	Recreation
Riverine poplar - spruce	Wildlife	Forestry Recreation	
Black spruce		Wildlife Recreation	Forestry
Sedge Fen		Wildlife Recreation	
Open and shallow water	Wildlife	Recreation	

Apart from providing land for a specific purpose the basic objective of reclamation is the reestablishment of land and water resources for a variety of possible future uses. The most important factors limiting the variety of possible land uses are topography and drainage besides climatic limitations. Therefore the reclaimed land should be level or gently sloping with adequate drainage.

More or less level backfilled lands will be reclaimed for forestry and recreation uses with an average productivity equalling or better than that of the land before disturbance, while steeper slopes will be revegetated primarily for erosion control.

Engineering requirement will create some steeper slopes bordering the backfilled areas which will have land use limitations due to lower soil stability and access problems. However, these steeper sites together with possible poorly drained locations will add ecological variety for wildlife use.

4. SURFACE TOPOGRAPHY OF BACKFILLED MINE PIT

The topography of the backfilled mine pit will be determined by the method of tailings deposition. In case of hydraulic tailings disposal the surface will slope gently (about 5%) from the in pit dykes to the center of the mine pit cells creating a pattern of long flat hills and valleys.

An expected permeability rate of 10^{-3} cm sec $^{-1}$ in the backfilled sand will result in a water table at a 20 m depth. An undulating land surface with a 30 m elevation difference between the valley and the crest will intersect this groundwater table providing wet land in the valley bottoms.

This type of landscape will provide well to moderately well drained soils on the crests and hillsides and poorly drained land in the valley bottoms. Most of this land will support forest communities of medium productivity while the depressions would support marsh plants as shown in Figure 3.

CONCEPTUAL LANDSCAPE DESIGN FOR MINE PIT DISPOSAL AREA

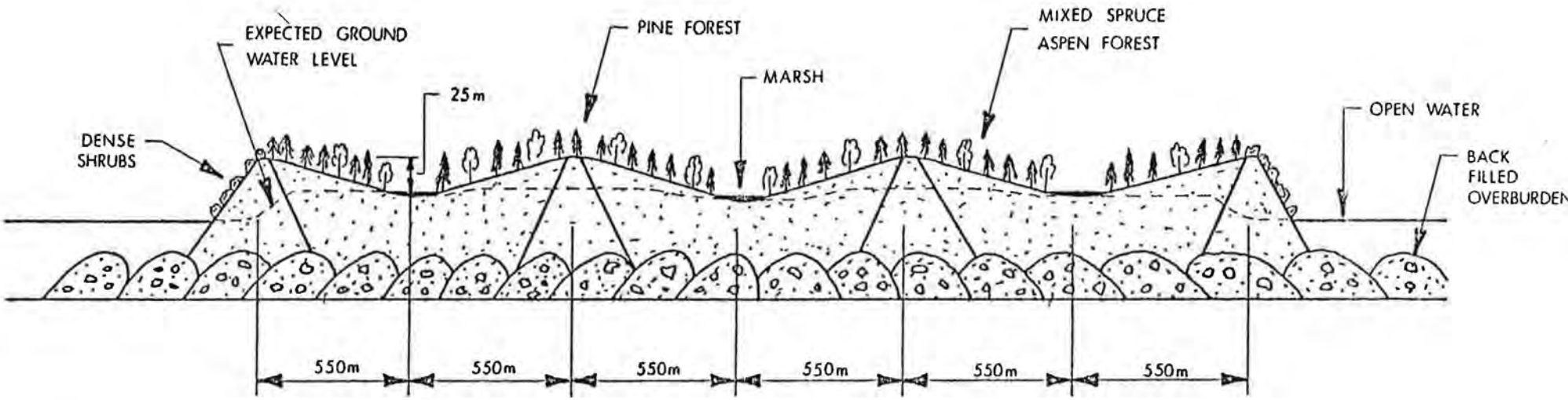


FIGURE 3

Relatively steep 3:1 slopes will occur on the outside dyke surfaces where vegetation will be established mainly for erosion control. These sand dykes will be free draining, with a groundwater surface about 70 m back from the dyke surfaces, causing no problems with saline groundwater discharge.

5. SOIL RECLAMATION

The tailings sand is unsuitable as a plant growth medium when first deposited in dykes or disposal areas. After process water drains from the sand, its toxicity is lost but it remains deficient in several basic physical and chemical properties required for plant growth. Table 2 provides a comparison between key properties of spent tar sands and various textural groupings of existing surface soils on the Syncrude lease.

The presence of soluble sodium in the spent sands is probably its only undesirable chemical property. Since the sands have almost no cation exchange capacity (CEC), soluble sodium is easily drained or leached out. If alkaline process water ponds on or seeps to the surface of the sands, it may raise sands to undesirable sodium levels. Where free drainage and leaching of the surface is possible, sands should be suitable for amelioration and seeding the same year as they are placed.

Tailings sand is deficient or low in nitrogen, organic matter and CEC by comparison to present surface soils on the property. Present data on surface soils (Table 2) that might be used for amelioration of sands indicate that they also are deficient or low in major nutrients. Fertilization will be required to encourage early plant growth in the new soil. As a first step toward long term fertility it will be necessary to build up sufficient CEC in the surface horizons of the new soil to retain soluble ions. Further, the new soil must develop some of the microbiological properties normally found in forest soils including the ability to recycle nitrogen and to decompose organic matter. This biological activity is not subject to amelioration (e.g. by addition of manure) in the present system and will have to build up as

vegetation becomes established and organic material accumulates in the soil.

Tailings sand has only about 1% available moisture as compared to about 10% in loamy soils on Lease 17. Assuming the sand weighs about 100 lbs./cu. ft., the upper foot of sand could supply 1 lb. or about 0.2 inches (.5 cm) of water between rainstorms. Daily transpiration requirements vary with climatic conditions during the growing season, but an established covercrop of grass and legumes could use up to 10 inches (25 cm) of water in a growing season (i.e. about 0.1 inches/day). Allowing a day for free draining soil in the root zone to reach field capacity, crops on tailings sand would experience drought within 3 or 4 days after a rainstorm. Increasing the available moisture to 3 or 4% will extend the period between rainstorm and drought to as much as 15 days. Since rainstorms are common during the summer months in this area, 4% available moisture should be adequate for cover crop establishment.

Peat and glacial till are the two materials available on Lease No. 17 to improve the tailings sand before seeding the initial covercrop.

PEAT

As a soil amendment, peat adds organic matter, increases cation exchange capacity and available moisture, lowers bulk density and helps to maintain pH values at or below neutrality. The most desirable peat would have the following properties:

- pH of 7.0 or less
- cation exchange capacity of at least 100 meq/100 g dry wt.
- at least 1.0% dry weight of total nitrogen
- SAR less than 6
- a moderately fine fibrous structure
- relatively small amounts of wood or mineral matter,

A guideline for amelioration of tailings sand is that enough peat be added to bring the sand to a 2% organic matter content on a dry weight basis. Therefore, about 2 lbs. of dry peat would to be incorporated into 1 cu. ft. (100 lbs.) of sand. This means

an application of some 40 metric tons of dry peat per acre. The volume of peat required to obtain this rate will depend upon its water content at the time of application.

Present information indicates that peat on Lease 17 can have a cation exchange capacity (CEC) as high as 200 meq/100 g. Based upon an average value in the peat of about 150 meq/100 g, the increase in CEC to the sand from peat alone would amount to about 3 meq/100 g. if sands are raised to 2% organic matter. Although this is not a large increase in comparison to agricultural soils, it should have a significant effect on the nutrient status of the sand.

CLAY TILL

Clay till can be used to increase available moisture and cation exchange capacity, reduce free drainage and promote the formation of soil structure. While peat may provide the above effects for some years, long term soil improvements will be achieved by the addition of till. Available data indicates the surface soils on Lease 17 contain from 10% as much as 60% clay and it is this fraction that provides most of the CEC on a dry weight basis. CEC of till soils on the lease area range from 3 to 40 meq/100 g. depending on their clay content. If till alone were used to raise the CEC of the tailings sand, material with a CEC of at least 20 meq/100 g. would be required, which would probably mean a clay content of about 50%. Six inches (15 cm) of till would need to be mixed with 6 inches (15 cm) of sand to obtain a CEC of 10 meq/100 g. in the upper foot of soil. To lower the requirements for till a mixture of till and peat will be used.

If clay till were used to increase the available moisture in the tailings sand to the 4% level mentioned above, the till/peat/sand mixture would need to have about 10% clay. About 2½ inches (6 cm) of 50% clay till would need to be mixed with 10 inches (25 cm) of sand to give the desired loamy sand texture. However, to satisfy long term fertility needs, 4 inches (10 cm) of till will be applied to the sand. This mixture would then require addition of peat. Field trials will be conducted to confirm the feasibility of mixing these materials with a rotovator under different

moisture conditions and slopes. We estimate about 400 m^3 of clay till would be required per acre of reclaimed land to reduce the moisture deficit and improve the nutritional properties of tailings sands.

6. RELATED AGRONOMIC PRACTICES

TILLAGE

As discussed above, 4 inches (10 cm) of till and about 39 metric tons of dry peat is required per acre of reclaimed land. On sloped dykes till and moist peat would be dumped at the top of each lift and spread downslope with crawler tractors and drags to obtain an even distribution. The till and peat would then be rotovated into the sand to provide a mixed surface horizon. On a 3:1 slope a self-powered rotovator may need to be towed across the slope from cables attached to tractors at the top and bottom of each lift. Alternatively, a tractor mounted rotovator could be operated downhill with the tractor returning to the top with the rotovator idling.

On nearly level surfaces the till and peat could be dumped in small piles and spread with a drag using a farm or crawler tractor. The rotovator would be attached directly to the tractor for tilling. It is estimated that peat could be spread and tilled at the rate of about 10 acres/day on level ground using two tractors for spreading and one for rotovating. About half of this rate could be maintained on 3:1 slopes and two crawler tractors may be required for rotovating.

Field trials are required to work out the most practical combinations of equipment and soil amendments to obtain specific physical and chemical properties in the new soil. These trials should be undertaken at an early stage so that long term reclamation planning can be based upon proven field methods.

After rotovating, the soil will probably require packing. This operation may be done separately or in conjunction with seeding. The packer must operate across the slopes to reduce the

erosion potential on the new soil. Operational trials will also be required to determine optimal seeding methods, i.e. by broadcasting or drilling. On level surfaces drilling and packing with standard farm implements should prove adequate for grasses and legumes. On sloped surfaces broadcasting and harrowing may be more suitable. Details of seeding rates, timing, depth, mixtures, implements etc. are best determined in field trials.

FERTILIZERS

Fertilizer will need to be applied at the time of seeding and for several years thereafter to promote plant growth. Since fertilizer will be easily leached from the new soil, two applications per year may be necessary. Fertilizer will be rapidly taken up by plants when growth is initiated in the spring and during rapid growth in the summer. Fertilizer rates, timing and mixtures should be worked out in field trials. First year applications should consist of balanced mixtures to ensure normal top and root growth. In subsequent years a higher percentage of nitrogen will be required than of phosphorus or potassium.

Fertilizer is relatively inexpensive by comparison to the cost of soil preparation and seeding; therefore, applications as high as 400 lbs./acre should be considered in the first few years. After adequate cover crop has been established, fertilization would be phased out. When converting to forest types it may be necessary to fertilize tree seedlings for one or two years after transplanting.

PEAT AND TILL INVENTORY

At present there is no quality or quantity inventory of the peat and till materials on the property that can be used as soil amendments. The report by Regier in 1976 is the only information we are aware of on this topic. This work gives a good indication of the range of qualities in the till but provides no quantity estimates. An inventory is required to plan the removal and stockpiling of suitable peat and till materials.

To correct this deficiency Syncrude is currently conducting an overburden survey and a soil survey in the lease area. The

surveys will be followed up by chemical and physical soil analyses to obtain quality information on the inventoried materials.

The soils inventory and field trials will remove many of the uncertainties that still exist in the operational aspects of reclamation. This work will also be essential in demonstrating to government agencies that reclamation plans can in fact be implemented.

7. REFERENCES

ARMSON, K. A. and V. Sadreika (1974); Forest tree nursery soil management and related practices. Ontario Ministry of Natural Resources, 177 p.

REGIER, H. F. (1976); Oil Sand Overburden Characterization within the Mine Area of Syncrude Lease No. 17 for Reclamation of Spent Oil and Alberta Dept. of the Environment, Environmental Protection Services, 29 p.

SYNCRUDE CANADA LTD. (1973); Beaver Creek: An ecological Baseline Survey, Environmental Research Monograph 1973-2.

_____ (1973); The Habitat of Syncrude Tar Sands Lease No. 17. An Initial Evaluation, Environmental Research Monograph, 1973-1.

_____ (1973); Revegetation Species Selection - An Initial Report, Environmental Research Monograph 1974-3, 47 p.

PROCEEDINGS

OF

THE SECOND ANNUAL GENERAL MEETING

OF THE

CANADIAN LAND RECLAMATION ASSOCIATION

August 17, 18, 19 & 20 — 1977 Edmonton, Alberta

(Sponsored by the Faculty of Extension, University of Alberta)

P R O G R A M

Canadian Land Reclamation Association

Second Annual General Meeting

August 17, 18, 19, 20, 1977

Edmonton, Alberta

Wednesday, August 17 (Optional Field Trips)

Field Trip No. 1 (Athabasca Tar Sands)

Leader: Philip Lulman (Syncrude Canada Ltd.)

Fee: $100.00 (covers bus and air transportation, lunch, and field trip information pamphlets)

Schedule: 7:30 a.m.- delegates board bus at Parking Lot T, located immediately south of the Lister Hall Student Residence complex. Air transportation from Edmonton Industrial Airport to Fort McMurray and return. Guided bus tour of surface mining and reclamation operations on Syncrude Canada Ltd. and Great Canadian Oil Sands Ltd. leases.
6:30 p.m.- delegates arrive back at Parking Lot T, University of Alberta campus.

Field Trip No. 2 (Aspen Parkland; Forestburg Coal Mine Reclamation)

Leader: George Robbins (Luscar Ltd.)

Fee: $25.00 (covers bus transportation, lunch, and field trip information pamphlets)

Schedule: 8:00 a.m. - delegates board bus at Parking Lot T, located immediately south of the Lister Hall student residence complex. Guided bus tour southeast of Edmonton, stopping at various points of interest (oil spill reclamation field plots; Black Nugget Park [abandoned minesite]; trench plots on Dodds-Roundhill Coal Field; solonetzic soil deep ploughing site) on the way to the Luscar Ltd. Coal Mine at Forestburg.
6:30 p.m. - delegates arrive back at Parking Lot T, University of Alberta campus.

Thursday, August 18

Events:	Opening of Formal Meeting; Presentation of Papers
Location:	Multi-Media Room, located on second floor of Education Building, University of Alberta.
8:00 a.m.	Authors of papers being presented on August 18 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching)
9:00 a.m.	Meeting Opened by Dr. Jack Winch (President of the C.L.R.A.; Head of the Department of Crop Science, University of Guelph). Comments by Dr. Winch.
9:15 a.m.	Welcome to delegates on behalf of the Government of Alberta by the Hon. Mr. Dallas Schmidt, (Associate Minister Responsible for Lands, Alberta Department of Energy and Natural Resources)
9:25 a.m.	Commencement of Paper Presentations. Morning session chaired by Mr. Henry Thiessen (Chairman of the Land Surface Conservation and Reclamation Council and Assistant Deputy Minister, Alberta Department of Environment).
9:30 a.m.	Paper 1. Combined Overburden Revegetation and Wastewater Disposal in the Southern Alberta Foothills by H.F. Thimm, G.J. Clark and G. Baker (presented by Harald Thimm of Chemex Reclamation and Sump Disposal Services Ltd., Calgary, Alberta).
10:00 a.m.	Paper 2. Brine Spillage in the Oil Industry; The Natural Recovery of an Area Affected by a Salt Water Spill near Swan Hills, Alberta by M.J. Rowell and J.M. Crepin (presented by Michael Rowell of Norwest Soils Research Ltd., Edmonton, Alberta)
10:30 a.m.	Coffee Recess
11:00 a.m.	Paper 3. The Interaction of Groundwater and Surface Materials in Mine Reclamation by Philip L. Hall of Groundwater Consultants Group Ltd., Edmonton, Alberta.
11:30 a.m.	Paper 4. Subsurface Water Chemistry in Mined Land Reclamation; Key to Development of a Productive Post-Mining Landscape by S.R. Moran and J.A. Cherry (presented by Stephen Moran of the Research Council of Alberta, Edmonton, Alberta).
12:00 noon	Lunch Recess

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Mr. Philip Lulman (member of C.L.R.A. executive; reclamation research ecologist with Syncrude Canada Ltd.).

1:30 p.m. Paper 5. Coal Mine Spoils and Their Revegetation Patterns in Central Alberta by A.E.A. Schumacher, R. Hermesh and A.L. Bedwany (presented by Alex Schumacher of Montreal Engineering Company Ltd., Calgary, Alberta).

2:00 p.m. Paper 6. Surface Reclamation Situations and Practices on Coal Exploration and Surface Mine Sites at Sparwood, B.C. by R.J. Berdusco and A.W. Milligan (presented by Roger Berdusco of Kaiser Resources Ltd., Sparwood, B.C.).

2:30 p.m. Paper 7. Agronomic Properties and Reclamation Possibilities for Surface Materials on Syncrude Lease #17 by H.M. Etter and G.L. Lesko (presented by Harold Etter of Thurber Consultants Ltd., Victoria, B.C.).

3:00 p.m. Paper 8. The Use of Peat, Fertilizers and Mine Overburden to Stabilize Steep Tailings Sand Slopes by Michael J. Rowell of Norwest Soils Research Ltd., Edmonton, Alberta.

3:30 p.m. Coffee Recess

4:00 p.m. Paper 9. Oil Sands Tailings; Integrated Planning to Provide Long-Term Stabilization by David W. Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta.

4:30 p.m. Paper 10. Bioengineering. The Use of Plant Biomass to Stabilize and Reclaim Highly Disturbed Sites by H. Schiechtel and K. (Nick) Horstmann (presented by Margit Kuttler).

5:00 p.m. End of August 18 Sessions.

Friday, August 19

Events: Presentation of Papers; C.L.R.A. Annual General Business Meeting; C.L.R.A. Annual Dinner.

Locations: Paper presentations and C.L.R.A. Annual General Business Meeting in Multi-Media Room, located on second floor of Education Building, University of Alberta.
- Annual Dinner held in Banquet Room located on second floor of Lister Hall.

8:00 a.m. Authors of Papers being presented on August 19 meet with paper presentation chairmen and audio-visual co-ordinator (Douglas Patching).

8:30 a.m. Showing of Film Rye on the Rocks. This film depicts reclamation situations at Copper Cliff, Ontario and is being shown for the purpose of introducing delegates to the site of the 1978 C.L.R.A. meeting (Sudbury, Ontario).

8:55 a.m. Continuation of Paper Presentations. Morning session chaired by Dr. J.V. Thirgood (Vice-President of C.L.R.A.; member of Forestry Faculty, University of British Columbia).

9:00 a.m. Paper 11. Reclamation of Coal Refuse Material on an Abandoned Mine Site at Staunton, Illinois by M.L. Wilkey and S.D. Zellmer (presented by Michael Wilkey of the Argonne National Laboratory, Argonne, Illinois).

9:30 a.m. Paper 12. A Case Study of Materials and Techniques Used in the Rehabilitation of a Pit and a Quarry in Southern Ontario by Sherry E. Yundt of the Ontario Ministry of Natural Resources, Toronto, Ontario).

10:00 a.m. Coffee Recess.

10:30 a.m. Paper 13. Amelioration and Revegetation of Smelter-Contaminated Soils in the Coeur D'Alene Mining District of Northern Idaho by D.B. Carter, H. Loewenstein and F.H. Pitkin (presented by Daniel Carter of Technicolor Graphic Services Inc., Sioux Falls, South Dakota).

11:00 a.m. Paper 14. The Influence of Uranium Mine Tailings on Tree Growth at Elliot Lake, Ontario by David R. Murray of the Elliot Lake Laboratory, Elliot Lake, Ontario.

11:30 a.m. Paper 15. Weathering Coal Mine Waste. Assessing Potential Side Effects at Luscar, Alberta by D.W. Devenny and D.E. Ryder (presented by David Devenny of E.B.A. Engineering Consultants Ltd., Edmonton, Alberta).

12:00 noon Lunch Recess.

1:25 p.m. Continuation of Paper Presentations. Afternoon session chaired by Dr. John Railton, (Manager, Environmental Planning, Calgary Power Ltd., Calgary, Alberta).

1:30 p.m. Paper 16. The Distribution of Nutrients and Organic Matter in Native Mountain Grasslands and Reclaimed Coalmined Areas in Southeastern B.C. by Paul F. Ziemkiewicz of the Faculty of Forestry, University of B.C., Vancouver, British Columbia.

2:00 p.m. Paper 17. Systems Inventory of Surficial Disturbance, Peace River Coal Block, B.C. by D.M. (Murray) Galbraith of the British Columbia Ministry of Mines and Petroleum Resources, Victoria, British Columbia.

2:30 p.m. Paper 18. The Selection and Utilization of Native Grasses for Reclamation in the Rocky Mountains of Alberta by D. Walker, R.S. Sadasivaiah and J. Weijer (presented by David Walker of the Department of Genetics, University of Alberta, Edmonton, Alberta).

3:00 p.m. Coffee Recess; Distribution of Proceedings.

3:30 p.m. Commencement of 1977 General Business Meeting of the Canadian Land Reclamation Association. Meeting chaired by Dr. J.V. Winch, C.L.R.A. President.

7:30 p.m. Commencement of C.L.R.A. Annual Dinner in Banquet Room, second floor of Lister Hall.

Guest Speaker: William T. Plass, Principal Plant Ecologist, U.S.D.A. Forest Service, Northeastern Forest Experiment Station, Princeton, West Virginia.

Topic of Speech: Challenges in Co-operative Reclamation Research.

Note: Following the Annual Dinner and Mr. Plass's speech, delegates may retire to the adjacent Gold Room. A bartender will be on service until midnight.