OIL SANDS RECLAMATION - AN OVERVIEW OF SUNCOR'S PROGRAM

BY

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ABSTRACT

Commercial production of synthetic crude oil from the Athabasca Oil Sands began in 1967 in north-eastern Alberta. Suncor Inc., then known as Great Canadian Oil Sands Ltd., began the development of their lease with a commitment to the reclamation of resultant disturbances. Waste products of the mining and extraction process are the tailings and overburden spoil. This paper describes the revegetation aspects of these substrates and the development of the operational and complementing research program. At present 200 hectares are in some stage of reclamation. These are being scrutinized in terms of soil development and the ability of reclaimed soils to self-support prescribed vegetation.

INTRODUCTION

The Athabasca deposit, the largest of three major deposits of oil sand in Alberta, is located in the north-east corner of the province.

Only a small portion of the Athabasca deposit is shallow enough to be exploited by surface mining techniques. Deeper deposits overlain with greater depths of overburden will likely be tapped by in-situ methods. At present, several pilot-scale plants are extracting oil in-situ. The two commercial surface mining and extraction facilities, located some 40 kilometers north of Fort McMurray, are Suncor Inc. and Syncrude Canada Ltd.

Suncor (formerly known as Great Canadian Oil Sands Ltd.) began producing synthetic crude oil on a commercial basis in 1967. Production of synthetic crude has averaged approximately 45,000 barrels per day. The plant facility has completed an expansion to increase production to approximately 58,000 barrels per day. The surface mining and hot water extraction process creates a need for mine reclamation. On the Suncor lease major land disturbances are the result of overburden handling, tailings disposal, and other construction activities.

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Suncor was granted an Alberta Government Development & Reclamation Approval in 1979. Because the development had commenced prior to the proclamation of the Land Surface Conservation & Reclamation Act, Suncor was in a unique situation with a specific set of conditions.

ENVIRONMENTAL SETTING

The Suncor lease, 3091 hectares in aerial size, is located about 480 kilometers north-east of Edmonton on the west escarpment of the Athabasca River. Geologically, overburden deposits ranging from less than 3 meters to greater than 20 meters on the lease consist of glacial drift overlying marine sandstones of the Clearwater Formation (Moell & Brocke, 1981).

Glaciofluvial sands and gravels are prevalent with a major deposit extending through the centre of the lease in a north-westerly direction and ranging from 0 to 12 meters in thickness. Minor deposits of lacustrine sands, silts and clays are present near the surface. Glacial till is the major overburden member in terms of volume, ranging from 0 to 12 meters. The Clearwater Formation, ranging from 0 to 9 meters, consists of an unconsolidated, interbedded mixture of clay, silt and very fine-grained sand (Moell & Brocke, 1981).

Surface soils on the Suncor lease are dominately organic with fen peat being most prevalent. The organic soils (usually termed muskeg) range from 0.3 to 7 meters in thickness, averaging about two meters.

The Suncor lease is located in the Boreal Forest Region. The major forest cover types are Jack pine, trembling aspen, white spruce, black spruce and tamarack. There are no significant stands of merchantable timber, and therefore, none is salvaged.

The climate of the Fort McMurray region has been described as cold temperate with long, cold winters and short summers. Total annual precipitation recorded at Suncor has been approximately 38 centimeters in 1980 and 1981 which is slightly less than the annual mean of 44 centimeters.

DESCRIPTION OF SOIL RECONSTRUCTION MATERIALS AND METHODS

Overburden handling and tailings disposal create the major land disturbances. Upon site clearing and drainage, the muskeg soil is removed separately and stockpiled for reclamation use or deposited within overburden waste dumps. Mineral overburden of finer texture is used to construct these dumps. Tailings are produced from the extraction process and are composed of tailings sand, water with suspended clay particles, and some bitumen. The sand is used to impound the liquid tailings by a dyking technique. Thus, the two substrates that must be contended with are the tailings sand and overburden spoil, and because these materials are used in construction of dyke and dump embankments most revegetation efforts have been on steep slopes.

Physical and chemical properties of overburden spoil, tailings sand, and the muskeg soil amendment are given in Table 1. Tailings sand is a fine sand in texture and has poor water holding capacity. It is virtually nutrient-free with low organic matter levels. Probably the most adverse chemical property is the above-neutral pH which is the result of sodium hydroxide additions in the extraction process.

Overburden spoil on waste dump slopes exhibits variable properties. Texture varies from sandy clay to clay. Nutrient levels are low, with potassium being most abundant. Relatively high salinity and sodicity have been measured, but once this material is handled and deposited these properties have not caused revegetation problems. Spoil may be contaminated with bitumen from uneconomical oil sand which is rejected and excavated with overlying overburden.

Both, overburden spoil and tailings sand substrates are amended with the muskeg soil. When muskeg is excavated, usually 40% by-volume of underlying clay overburden is included and eventually incorporated into the final seedbed. Tailings sand is amended with 15 centimeters of muskeg soil which is tilled and packed creating a seedbed ranging up to 30 centimeters in depth. The identical rate is used for overburden spoil but with minimal mixing. Table 2 shows some chemical and physical properties of these prepared seedbeds.

DESCRIPTION OF OPERATIONAL REVEGETATION

Because of the poor nutrient status of the prepared soils, fertilizers are incorporated in the soil mixing process. Maintenance fertilization rates are determined from criteria such as soil tests, ground cover performance, and ground cover objectives. The latter is of paramount importance in reclaimed areas where a woody plant cover is the end objective. The problem of achieving an erosion-controlling ground cover compatible with tree and shrub seedlings will be addressed in the research program discussion. Table 3 gives fertilization data representative of recent programs.

Prescribed vegetation for reclamation must meet three objectives: it must be useful, self-maintaining, and erosion-controlling. Cultivated herbaceous ground covers are utilized for erosion control. However, seed mixture compositions and rates are selected with the objective of enhancing woody plant establishment and native plant invasion. On tailings sand dyke slopes, where erosion is more critical, an agronomic seed mixture is usually hydroseeded. On overburden waste dump slopes, hydroseeding of an annual species such as barley for initial erosion protection appears adequate. The seed mixture utilized for tailings sand dyke slopes is given in Table 4.

TABLE 1

SOME CHEMICAL & PHYSICAL PROPERTIES OF SOIL BUILDING MATERIALS

(A) PHYSICAL PROPERTIES

	Soil Material	Soil Mixture (%) 1/3 Bar	Soil Mixture (%) 15 Bar	Texture (%) Clay	Texture (%) Silt	Texture (%) Sand
*	Tailings sand	1.4	0.41	3	2	95
*	Overburden Spoil	14.3	5.90	15	25	60
**	Muskeg Soil	23.2	13.20	17	16	67

(B) CHEMICAL PROPERTIES

	Soil Material	pH	Electrical Conductivity (MMHOS/CM)	Organic Carbon (%)	Total Nitrogen (%)	Available Plant Nutrients (ppm) No_2-N	Available Plant Nutrients (ppm) P	Available Plant Nutrients (ppm) K	Cation Exchange Capacity (MEQ/100G)	Sodium Absorption Ratio
*	Tailings Sand	7.49	0.09	0.2	0.01	0.5	1	12	0.28	N/A
*	Overburden Spoil	7.98	0.25	2.3	0.05	1.3	1	64	5.05	0.72
**	Muskeg Soil	7.50	0.97	5.7	0.21	N/A	N/A	N/A	15.00	N/A

* Adapted from Rowell, 1980

** Adapted from Klym and Shopik, 1980

N/A Date not available

TABLE 2

SOME CHEMICAL & PHYSICAL PROPERTIES AFTER SOIL RECONSTRUCTION

(A) Physical Properties

	Amended Substrate	Soil Mixture (%) 1/3 Bar	Soil Mixture (%) 15 Bar	Texture (%) Clay	Texture (%) Silt	Texture (%) Sand
*	Tailings Sand	27	11	10	24	66
	Overburden Spoil	N/A	N/A	N/A	N/A	N/A

(B) Chemical Properties

	Amended Substrate	pH	Electrical Conductivity (MMHOS/CM)	Organic Carbon (%)	Total Nitrogen (%)	Available Plant Nutrients (ppm) NO_2-N	P	K	Cation Exchange Capacity (MEQ/100G)	Sodium Absorption Ratio
*	Tailings sand	7.75	1.01	3.91	0.17	N/A	N/A	N/A	14.9	N/A
**	Overburden spoil	7.40	1.50	1.40	N/A	1.4	3.0	46	12.6	2.1

* Data from 1981 operational program files; sampled prior to seeding

** Adapted from Hardy Associates Ltd., 1979; sampled after one growing season

N/A Data not available

TABLE 3

TYPICAL FERTILIZATION RATES

(A) Starter Fertilizer (First Growing Season)

Soil Medium	Fertilizer in Kg/Ha N	P_2O_5	K_2O
Amended Tailings Sand	20 50*	80	80
Amended Overburden Spoil	20 50*	70	40
Unamended Overburden Spoil (Non-Permanent Areas)	40 50*	120	60

(B) Maintenance Fertilizer (Second Growing Season and Older)

Soil Medium	Fertilizer in Kg/Ha N	P_2O_5	K_2O
Amended Tailings Sand	40	50	40
Amended Overburden Spoil	40	40	20
Unamended Overburden Spoil (Non-Permanent Areas)	80	80	40

* Applied after emergence of seedlings

TABLE 4

HERBACEOUS GROUND COVER SEED MIXTURES

(A) Tailings Sand Dyke Slopes

Species	% by Weight
Slender Wheatgrass (Revenue)	20
Pubescent Wheatgrass (Greenleaf)	20
Bromegrass (Carlton)	5
Creeping Red Fescue (Boreal)	15
Alfalfa (Canada No. 1)	25
White Dutch Clover (Canada No. 1)	15
	100

(Above mixture applied at 56 Kg/Ha)

(B) Overburden Waste Dump Slopes

Species	% by Weight
Barley (Conquest)	100

(Applied at 45 Kg/Ha)

(C) Non-Permanent Overburden Dyke Slopes

Species	% by Weight
Bromegrass (Carlton)	27
Creeping Red Fescue (Boreal)	21
Slender Wheatgrass (Revenue)	11
Tall Wheatgrass (Fairway)	7
Crested Wheatgrass (Norlan)	6
Barley (Conquest)	28
	100

(Above mixture applied at 140 Kg/Ha)

Areas of overburden not being permanently revegetated, but requiring short-term erosion control are not amended with muskeg soil. These areas, usually in-pit overburden dykes, receive the same ratios of fertilizer as permanent overburden areas, but at considerably higher rates. Only agronomic grasses are included in the seeding mixtures with application rates considerably higher than permanent overburden. This mixture appears in Table 4.

Suncor's end land use objective is a forest cover for wildlife utilization with possibilities for recreation. Afforestation efforts are being directed toward this end use. Native species have gradually been incorporated into the program as propagative experience is gained. Certain introduced species are performing satisfactorily in the short-term for consideration in future programs. Table 5 lists the outplanting stock utilized in 1980 and survival after 2 growing seasons. Table 6 presents assessment data for stock planted in 1981. Over the past nine years results have been variable. The presence of the herbaceous ground cover appears to be the greatest contributing factor to seedling mortality. Seedling condition at time of planting contributes to overall performance.

REVEGETATION MAINTENANCE

Since the inception of the program in 1971, some 200 hectares have received revegetation treatment. Monitoring of these reclaimed areas is critical to the success of future reclamation programs. Maintenance programs are designed from monitoring data collected from permanent assessment plots and general surveillance. Permanent plot monitoring commenced in 1977 to study soil development and vegetation performance. Future methodology for primary revegetation is largely based on this program. Maintenance activities may involve erosion repair, erosion control, re-seeding and re-planting poorly performing areas, and maintenance fertilization.

Some interesting trends are developing. With the input of fertilizer, the herbaceous ground cover succeeds from a dominately fescue cover to a dominately bromegrass cover and legumes decrease in proportion. When fertilizer is withheld, legume and native plant content increase, while total (living and dead) cover remains constant. Above ground biomass production increases with the age of reclamation site (Hardy Associates, 1981).

Some changes in soil properties have been detected. Soil pH is decreasing with site age; this probably, is attributable to sulphur-containing fertilizers. Available nutrients, except for nitrogen, are at adequate levels, even after fertilizer withdrawal for several years. Carbon-nitrogen ratios are decreasing with site age (Hardy Associates, 1981).

RECLAMATION RESEARCH PRIORITIES

Research priority areas are the reclamation of tailings sludge ponds, post-mining hydrology, the quality of reclamation soils, and woody plant establishment. When Suncor's operational revegetation was commenced in 1971, knowledge and experience in oil sands reclamation was minimal and regulatory requirements were not well defined and instituted at that time. Thus, specific studies are identified for program support and to meet requirements of Alberta's Development and Reclamation Approval process.

TABLE 5

SURVIVAL SUMMARY OF SEEDLINGS PLANTED IN 1980

		% Survival After Two Growing Seasons				
		Overburden Spoil		Tailings Sand		
	Number Planted	Dense Cover	Sparse Cover	Bracke Treatment	Dense Cover	Sparse Cover
*Siberian larch	1,500	78			0	2
Jack Pine	3,100	33			80	
*Lodgepole pine	3,700	40			82	
White spruce	6,400		54		62	24
Paper birch	1,000	4		42		96
*Northwest Poplar	1,500				17	59
Black poplar	1,400	37				
*Walker poplar	1,500				39	59
*Basford willow	1,400					27
*Buffaloberry	1,500	45			31	
*Chokecherry (Indian Head)	1,500				47	
*Chokecherry (Oliver)	1,500				59	
Dogwood	3,600			67		62
Glauca willow	800	0			12	
Green alder	3,200	0			3	
Highbush cranberry	300	3			18	
Lowbush cranberry	300	6			13	
Pincherry	600	0			0	
Raspberry	1,600	0			0	
Rose Spp.	1,000	2			16	
Sandbar willow	1,300	2			0	
*Saskatoon	500	2			7	71
Shrubby cinquefoil	1,900	23		59	53	97
Willow Spp.	600	2				96
TOTAL	41,700					

* Introduced Species

TABLE 6

SURVIVAL SUMMARY OF SEEDLINGS PLANTED IN 1981

		% Survival After One Growing Season			
		Overburden Spoil		Tailings Sand	
	Number Planted	Dense Cover	Sparse Cover	Dense Cover	Sparse Cover
Jack pine	5,623	82	81		
*White spruce	14,381	75	58		
Paper birch	5,167	52		13	22
*Balsam poplar	3,546	32	36	20	23
**Northwest poplar	786	80	62	26	29
*Trembling aspen	3,453	22		22	18
*Walker poplar	571	84	74		
*Acute willow	433	56	65		
**Basford willow	2,358	40	42	13	29
Blueberry	1,838			5	14
*Buffaloberry	984	30	55	16	35
*Chokecherry	986	66	42	20	36
*Dogwood	4,298	31	47	21	22
*Glauca willow	4,232	28	42	9	17
Green alder	4,082	0		9	13
*Laurel willow	533	54	55		
Rose Spp.	1,691	72	68	19	37
Sandbar willow	3,216	84	47	18	40
*Saskatoon	8,147	45	33	19	27
Shrubby cinquefoil	7,473	69	72	15	37
*Silverleaf willow	974	52	59	14	15
TOTAL	74,718				

* Introduced species; except for White spruce, Balsam poplar, Trembling aspen, Dogwood, Glauca willow & Saskatoon of which 12,448, 1,604, 2,932 3,308, 2,508, & 7,250, respectively, were native plants.

** Species propagated from introduced stock established on reclaimed sites.

Most projects are conducted in-house, but cooperative research with government and other oil sand operators is not uncommon. The oil sand industry has formed the Oil Sands Environmental Study Group (O.S.E.S.G.) for the purpose of conducting cooperative environmental research. The Alberta Government's coordinating agency for reclamation research, the Reclamation Research Technical Advisory Committee (R.R.T.A.C.), and O.S.E.S.G. are presently involved in two reclamation projects.

Probably the most important priority area is the tailings sludge problem. As described earlier, the oil sands tailings contain suspended clay particles which must be impounded by dykes. The thrust of this research is the reduction or consolidation of sludge volumes and the detoxification of tailings water with the objective of creating a more desirable land surface upon abandonment. Work has progressed to the pilot scale with implementation of pilot studies on site in 1981.

There is concern regarding the quality and quantity of surface and sub-surface drainage from reclaimed areas after abandonment. Hydrological studies by Suncor encompass the monitoring of groundwater in tailings pond dykes and adjacent undisturbed land.

The quality of reconstructed soils continues to be a priority research area from a revegetation aspect. A project, initiated in response to regulatory conditions is addressing the long-term stability of various amended tailings sand mixtures. At the same time a survey of overburden materials is being conducted as well as an evaluation of Suncor's existing soil reconstruction method and muskeg soil amendment. Also a literature-based study sponsored jointly by the O.S.E.S.G. and R.R.T.A.C. is attempting to define the minimal soil properties of a soil engineered from tailings sand which will evolve to support a prescribed self-sustaining vegetation.

Woody plant establishment research will continue to be a priority as long as erosion controlling ground covers are used in primary revegetation efforts. The manipulation of this ground cover to lessen the competition for nutrients and moisture and reduce small rodent populations is the directive in these studies. Several demonstration trials on overburden spoil dumps and tailings sand dyke are being monitored where the elimination of the standard agronomic grass/legume cover is enhancing survival. An added bonus of this method is the rapid regeneration of native plants from the muskeg soil amendment. Another study is addressing the biological control of small rodents on tailings sand dyke slopes, where erosion is more critical and the overburden method of cover elimination is not as effective. Lastly, in this research area the O.S.E.S.G. and R.R.T.A.C. have embarked on a long-term program of expanded scope to include woody plant propagation and maintenance.

CONCLUSIONS

Other environmental impacts of oil sands development such as air emissions and plant effluents are beyond the scope of this paper. Of the land disturbances resulting from mining and extraction the tailings sludge problem may have the greatest impact on future oil sands reclamation. Research into tailings water detoxication and sludge consolidation is Suncor's major research priority and recent findings are favourable.

More specific to the topic of this paper, operational experience and continuing studies in revegetation of tailings sand and overburden spoil is increasing our capability to predict whether long-term goals will be met. Regulators are concerned about the long-term stability of Suncor's reconstructed soils. Research evidence is accumulating to indicate that initial soil properties satisfy requirements for sustenance of prescribed vegetation.

Reclamation of land disturbances is not a "one-shot" effort. Revegetated sites must be closely monitored and maintained. From Suncor's soils and vegetation monitoring program favourable vegetation successional patterns are being detected whereas soil profile development is, as expected, slight over the short-term of this program.

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INTRODUCTION

Last Spring the Provincial Government's Reclamation Research Technical Advisory Committee presented a two day Reclamation Research Seminar at the Chateau Lacombe. We were surprised by the large turnout and an overwhelming majority of those in attendance indicated the desirability of an Annual Reclamation Conference for Alberta which would focus on Policy and Practice as well as Research and which would include industry, academic and government participation.

These were very sensible suggestions though their implementation would exceed the mandate and manpower of the Reclamation Research Technical Advisory Committee. So various groups were contacted to sponsor and help organize the Conference. Positive responses where received from the Canada Land Reclamation Association (CLRA) The Alberta Government's Land Conservation and Reclamation Council, The Coal Association of Canada and The Oil Sands Environmental Study Group (OSESG).

The CLRA authorized formation of an Alberta Chapter to serve as the umbrella organization with a Program Committee consisting of representatives of the Government and the two Industry groups. Through this Conference and perhaps other functions the Alberta Chapter of the CLRA can fulfill two important roles:

1. To provide an opportunity for members of the Reclamation community to meet, exchange experiences or argue and otherwise improve communications among its industry, government and academic factions.

2. To provide a public forum for reclamation activities, capabilities, issues and challenges.

This was the first function of its kind in Alberta. Special thanks are due the Sponsors, Speakers and the other Members of the organizing Committee: Jennifer Hansen, Malcolm Ross and Al Fedkenheuer. Their talents and efforts made the Conference a success.

One final word on the Speakers: they were given very short notice of the Conference and not only responded enthusiastically but prepared presentations which were of remarkable quality and consistency. We are fortunate to have individuals of this caliber working in the Field of Reclamation in Alberta.

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