Earth Sciences Report 2000-05

Historical Overview of the Fort McMurray Area and Oil Sands Industry in Northeast Alberta

(With expanded bibliographies on oil sands, surficial geology, hydrogeology, minerals and bedrock in northeast Alberta)

Alberta Energy and Utilities Board

Alberta Geological Survey

AGS

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A Geological Survey of Canada field party hauling a scow up the Athabasca River, Alberta, in 1914.

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Overview

This report contains an overview of the exploration and historical development of the Fort McMurray area, with emphasis on development of the oil sands industry in Alberta. This compilation was initiated as part of ongoing work by the Alberta Energy and Utilities Board (EUB), Alberta Geological Survey, on the geology of the Athabasca oil sands deposit. In doing this compilation a number of historical references and survey work were found in Edmonton at the Alberta Energy and Utilities Board, Alberta Geological Survey Office. Other references to this work is scattered throughout the public domain, and has never been compiled as a comprehensive reference list related to the oil sands or to the geology of northeastern Alberta. The following document was produced to make this information known to the general public. Direct general inquiries regarding this report to Fran Hein [Telephone: (403) 297-6929; email: fran.hein@gov.ab.ca] or to the EUB, Alberta Geological Survey Office in Edmonton.

1. Historical Overview of the Fort McMurray Area

Originally the Athabasca area was inhabited by a number of First Nations and Metis people, including the Cree, Chipewyan, Prairie Dene, and Anzac Metis. Descendants of Chipewyan people, who call themselves Dene, inhabit the Cold Lake area. The Dene and Chipewyan people refer to themselves as cousins. According to early government records, the first European to see oil sands was Henry Kelsey, Manager of York Factory on Hudson's Bay, who received in 1719 a sample of oil saturated, bituminous sand, that was delivered to York Fort by a Cree guide, named Wa-Pa-Su. In 1776 Peter Pond, a fur trader and one of the founding members of the Northwest Trading Company (later amalgamated with the Hudson's Bay Company), became the first European to enter the Athabasca region upon crossing the confluence of the Clearwater and Athabasca rivers.

Although the indigenous peoples knew of the bitumen from the oil sands occurring along the Athabasca River, Peter Pond was credited, along with two cases of suspected murder in duels, for first writing about the occurrence of the oil sands in 1778. In 1792 Alexander "Mac" Mackenzie traversed the Methys Portage, crossing the confluence of the Clearwater and Athabasca rivers, and described the oil sands along the outcrops of the Clearwater-Athabasca river system. This was followed by other explorations in 1799 by David Thompson and in 1819 by Sir John Franklin who travelled and surveyed the Athabasca River between Lake Athabasca and the confluence of the Athabasca and Clearwater rivers. Sir John Richardson did the first geological assessment of the oil sands in 1848 along his journey to the Arctic to search for the missing Franklin expedition. Sir John Richardson correlated the oil sands with the Devonian shales of the Marcellus Formation of New York and also did acid tests on the oil and microscopic examination of the sand, identifying the principal component as quartz. In 1875 "oil springs" (seeps) were found on the Peace River by John Macoun of the Geological Survey of Canada.

In 1870 a fur trading post, located at the confluence of the Clearwater and Athabasca rivers, was founded by John Moberly and named Fort McMurray after William McMurray who was chief factor of the Athabasca region for the Hudson's Bay Company. The Hudson's Bay Company closed Fort McMurray in 1898 due to a dwindling fur trade, but reopened the fort again in 1912 as a large-freight storage warehouse. Until 1921 there was only river access to Fort McMurray, and the fort served as the gateway to the Arctic. Goods were shipped from Fort McMurray on the Athabasca River to Lake Athabasca, then on the Mackenzie River to the Arctic. River transportation continued as the only access to the North until 1965 when the Mackenzie Highway and the Great Slave Railway were opened. Until this time the shipyards at Fort McMurray were used for building scows, barges and paddle wheelers. As the age of river transportation was closing and railways were being built, the industry of Fort McMurray started shifting to more local resources, including fishing, logging, lumbering, salt, and the newly emerging development of the vast oil sands resources.

In 1906 Count Alfred von Hammerstein, originally from the Prussian army, drilled for oil in the Devonian limestone along the banks of the Athabasca River. He was hoping to discover "free" oil that he thought was a reservoir of pure petroleum underneath the oil sands outcrops. He failed to discover oil, but did find salt at the confluence of the Horse and Athabasca rivers. In 1925 a salt mine was opened on the Horse River by the Alberta Salt Company, which closed in 1927 due to problems with transportation and shipping of salt. In 1936 Industrial Minerals Ltd. opened another salt plant at the town site of Waterways that had rail service to Lac La Biche. At

Waterways the salt plant used a hot water pumping process to extract the salt. Hot water was pumped down a shaft to dissolve the salt and the resulting salt-water brine was pumped up within a nearby parallel shaft. The salt brine was then evaporated, the salt retrieved and shipped as table salt until the 1940s. The Waterways salt plant closed in 1950 with the opening of a new salt plant in Elk Point, Alberta.

Fort McMurray served as a military site during World War II and the Cold War. The Canol Project by the United States military was designed to secure safe delivery and supply of oil for North America across the Arctic. The pipeline was started and built at Norman Wells. All troops, supplies and materials for the Norman Wells pipeline were first shipped to Waterways by rail, then from Fort McMurray by barge and boat to Norman Wells. In 1944 oil was shipped along the pipeline from Norman Wells at a cost of $106 U.S. per barrel. During the Cold War a RCAF radar station was established on Stony Mountain south of Fort McMurray as part of the mid-Canada DEW (Distant Early Warning) Line. The Stony Mountain site was dismantled in 1964. In 1989 the railway to Waterways was closed by Canadian National Railway, ending rail service to the area.

2. Historical Overview of the Oil Sands Industry in Northeast Alberta

An historical overview of the discovery and development of the Athabasca Oil Sands is given in Carrigy and Kramers (1973), with updates presented in Strom (1986), Houlihan and Evans (1988), Wightman *et al.* (1992), Mink and Houlihan (1995), Polikar *et al.* (1998), and Sadler and Houlihan (1998). The first published geological descriptions of the Athabasca oil sands were given by Bell (1884) and McConnell (1893). The McMurray Formation was named by McLearn (1917), with assessments done by the Canadian Government surveys from 1926 to 1949 (Ells, 1926; Government of Canada, 1949; Hume, 1947, 1949). A brief summary of this historical work, and how it relates to commercial development of the oil sands, is given as follows[1].

For over 200 years, since the first documentation of the oil sands by Peter Pond in 1778, a number of adventurous entrepreneurs, government and industry scientists have greatly invested time, money and effort in the area to build the oil sands industry of today. In 1870 Canada purchased 'Rupert's Land' from the Hudson's Bay Company. Rupert's Land was a vast tract of land that extended from Ontario to the Rockies and north to the Arctic. At that time Dr. Robert Bell served as director of the Geological and Natural History Survey of Canada and in 1882 Bell identified the oil sands as Lower Cretaceous in age, and proposed that the bitumen was sourced in the Devonian strata. During 1882 to 1884 Bell analyzed samples of the Athabasca oil sands; and, at that time, the Survey initiated experiments using hot water to separate the bitumen from the sand. Following this work, Bell proposed that it would be feasible to extract the bitumen from the oil sands by using a hot water extraction process, and that a pipeline could be constructed from Lake Athabasca to the Hudson's Bay to transport the extracted oil to foreign markets. This was followed in 1888 by Bell's report to a Senate Committee, that stated as follows: "The evidence … points to the existence in the Athabaska and Mackenzie valleys of the most extensive petroleum field in America, if not in the world… it is probable this great

[1] Appendix 1. Lists the historical references and survey work related to oil sands deposits, hydrogeology, bedrock and mineralization in north-northeast Alberta available at the Alberta Energy and Utilities Board, Alberta Geological Survey, Edmonton office.

petroleum field will assume an enormous value in the near future and will rank among [Canada's] chief assets."

In 1888, R. G. McConnell (photo to left, circa 1880, from the Geological Survey of Canada Archives) of the Geological and Natural Survey of Canada gave a geological description of the oil sands and correlated the oil sands with the Cretaceous Dakota sandstone in the Western Interior Basin of the United States. McConnell estimated that the reserves of bitumen in the oil sands were not less than 4.2 million 'long tons,' further suggesting that lighter oil would be found downdip in correlative strata at Pelican Rapids. McConnell agreed with Bell that "The source of these hydrocarbons is probably existing in the porous beds of this Devonian… [and that] The question of their (tar sands) petroliferous character can only be settled in a decided manner by boring." McConnell obtained a $7,000 grant from Parliament to hire a contractor, a drilling rig, and moved the equipment up to the Athabasca River. The well was spudded on August 15, 1894, and after much difficulty in drilling they reached a depth of 1,600 feet at which time "a roar of gas at a pressure of 500 psi could be heard three miles away." In 1897 McConnell drilled another well downstream from the town site of Redwater along the banks of the North Saskatchewan River. From 1906 to 1910 two vibrant entrepreneurs, the Count Alfred von Hammerstein and "Peace River Jim" Campbell drilled wells in the Athabasca area, hoping to tap into an underground liquid pool of oil that they thought underlie the oil sands.

Although much reconnaissance work on the oil sands was done by other people, the recognized 'Father of the Oil Sands' was Sidney Ells (photo to left, circa 1930, from the Alberta Provincial Archives), an engineer and Assistant to the Director, Dominion Department of Mines, Mines Branch in Ottawa. Ells was a genius, rogue, entrepreneur and eccentric who studied oil and oil shale occurrences in eastern Canada and the West Indies. Ells was completely obsessed with the Athabasca oil sands and their origins; and, he is quoted as saying "I was so enthralled with the possibilities of the oil sands that I preferred resigning my position rather than being deprived of making an investigation" (McRory, 1982). In 1913 Ells joined the Mines Branch and launched a field party that year to begin a detailed survey of the oil sands in the Athabasca River valley.

During his first survey of the area, Ells collected 200 samples, totalling nine tons, that were towed by hand on a scow upstream along the Athabasca River to Fort McMurray (title page

figure, 1914, from the Geological Survey of Canada Archives). In 1915 Ells continued his reconnaissance work and backpacked out another seventy pounds of oil sands from Fort McMurray to Edmonton in three weeks. Ells lay bituminous pavement in the City of Edmonton and in Jasper National Park as a practical demonstration of the potential use of the tar sands from the Fort McMurray area. During World War I Sidney Ells was a lieutenant in the Royal Canadian Field Artillery. During the war Ells continued to do his own experiments on hot-water separation processes of the bitumen from the oil sands at the Mellon Institute of Industrial Research in Philadelphia (McRory, 1982). In 1926 Ells, along with support from Max Ball, successfully drilled and cored the oil sands in the Mildred Lake – Ruth Lake area, immediately west of both the present Suncor and Syncrude plants, and also drilled and cored wells east of the Steepbank area, and in the Horse River area. Today some of these original cores are stored at the Geological Survey of Canada in Ottawa.

In 1920 D. Diver was the first to try and produce oil from the bitumen by an *in-situ* method. Diver's method consisted of distilling the oil from the oil sands by lowering a heating unit to the bottom of a well near Fort McMurray. In 1920 work on the oil sands also continued at the Alberta Research Council, with the pioneering work of Dr. Karl Clark, a chemical engineer, who in 1925, working with Sidney Blair at the University of Alberta, built a hot-water separation plant at the Dunvegan railyards in Edmonton. This hot-water separation process became the basis for today's thermal-extraction processes. In 1929 the International Bitumen Company, under the leadership of Robert C. Fitzsimmons, opened the first commercial oil sands hot-water separation plant on the Bitumount lease, with 4,500 drums of asphalt and 2,000 barrels of fuel oil produced.

In 1936 Max Ball obtained a 6-section lease on the Horse River on which he built an extraction plant. This was followed in 1940 by the Abasand (short for Athabasca Sands) separation plant, built along the Horse River near the present subdivision of Abasand Heights in the town site of Fort McMurray. The Abasand plant, founded by Max Ball along with Sidney Ells, invested a million dollars in research and development. In 1941 the Abasand plant processed 19,000 tons of sand, yielding 17,000 tons of bitumen. This bitumen was then reprocessed into fuel oil, diesel fuel, gasoline and coke. By the time the Canol Project was being built in Norman Wells, the Bitumount plant was shut down, and the Federal Government took over the Abasand plant, which burned down in 1941, rebuilt in 1942 and 1943, destroyed again by fire in 1945. In 1942 the Canadian Government began a reconnaissance drilling and coring program to outline the reserves of the oil sands for wartime contingency plans. By 1947 the Canada Mines Branch completed its drilling and estimated reserves of the oil sands to be 1.75 billion tons of commercial grade oil sands. The richest deposit was located at Tar Island, along the Athabasca River, at the location of the present Suncor tailings pond. In 1948, the Alberta government reopened the Bitumount plant and made a commercial test of Clark's hot-water separation process, with production of 500 tons per day.

In 1942 L.R. Champion took control of International Bitumen Company, renaming the company Oil Sands Ltd., which was taken over by Great Canadian Oil Sands Ltd. in 1954. In 1962 Great Canadian Oil Sands Ltd. received permission from the Alberta Oil and Gas Conservation Board to produce 31,500 barrels per day from the oil sands at the Tar Island plant. In 1967 Great Canadian Oil Sands Ltd., whose controlling interest was held by Sun Oil Company of Pennsylvania, opened the first commercial oil sands plant and showed that the oil sands could be economically developed and that bitumen products could be successfully upgraded to crude oil. The Great Canadian Oil Sands served as the legacy to the Suncor of today.

In the 1950s Royalite, an independent subsidiary of Imperial Oil, also pioneered serious exploration, development and production of the McMurray oil sands. In 1962 Royalite Oil Company formed a consortium with Atlantic Richfield, Cities Service Athabasca Inc., and Imperial Oil Ltd. Royalite was later sold and resold again, the vestiges left in what is now Syncrude, incorporated in 1964. Shell Oil Company of Canada began experiments on in situ steam drive in 1957 on its lease 26, and by 1962 Shell applied to the Alberta Oil and Gas Conservation Board to produce 130,000 barrels per day of bitumen by in situ steam process. In 1978 Shell Canada Ltd. also applied to the Alberta Energy Resources Conservation Board for a 100,000 barrels per day mining operation.

In 1974 the Alberta Oil Sands Technology and Research Authority (AOSTRA) was formed to provide funding and synergies needed for research dedicated for bitumen extraction and upgrading. Ten years later, in 1984, AOSTRA constructed the Underground Test Facility (UTF) at the present Dover River Project operated by Northstar Energy Ltd. The UTF was used to test horizontal wells and Steam Assisted Gravity Drainage (SAGD) technologies for recovery of the bitumen from the oil sands, which by 1990 more than 60% of the bitumen was recovered (Wightman *et al*. 1992). Although the bitumen deposit at UTF is good and high recovery was achieved, this should not be considered as average conditions for the whole Athabasca deposit. In 1991 Phase B of the UTF began its pre-commercial testing, which now, 9 years later, is now in wind-down stages.

Since the historical and pioneering work, at present both Suncor and Syncrude, have successfully produced synthetic crude oil from bitumen in the oil sands at competitive costs. In 1997 established reserves of crude bitumen were 1021 million cubic metres. Until recently large scale surface strip mines were the only economically viable process for extracting the bitumen. Unfortunately, only about 7% of the vast oil sands deposit are accessible using surface mining techniques, confining exploitation of the resource to the Athabasca River valley where the overburden is thin. Recent technological advances, including in situ bitumen and heavy-oil extraction methods along with improved horizontal drilling, may open up the remainder of the Athabasca deposit for potential development and exploitation. In 1998, total remaining established reserves of crude bitumen under active development were 340 million cubic metres for surface mineable and 240 million cubic metres for in situ schemes (AEUB, 1999).

Along with extensive research and development on the Suncor and Syncrude leases, there was a parallel stream of scientific and technological pioneering work concerning the other, more deeply seated bitumen deposits in the Athabasca, Cold Lake and Peace River areas. For example, at Cold Lake the oil-bearing Clearwater Formation is overlain by more than 400 metres of overburden, making it unsuitable for mining techniques. In 1985 Imperial Oil conducted the first Steam-Assited Gravity Drainage (SAGD) experiment at its Cold Lake Production Project that clearly demonstrated the potential of in situ thermal process to recover bitumen from oil sands. Since that time, as a result of the concentrated effort by AOSTRA at the UTF facility, a number of SAGD projects have been developed in the Athabasca, Cold Lake and Peace River oil sand deposits. Some of these other projects included: for the Athabasca deposit -- Syncrude OSLO (Other Six Leases Operation); Mildred, Kearl, and Gregoire lakes; Hangingstone and Tar rivers; for the Cold Lake deposit – Cold, Burnt, Marie, Marguerite and Wolf lakes, Primrose and Lindbergh; and, for the Peace River deposit – the Cadotte Lake project (Figure 1).

The bitumen deposits at Cold Lake were discovered in the 1920s. In 1962 Imperial Oil drilled 10 evaluation wells, and in 1963 a pilot plant was built. In 1985 commercial production began at the Maskwa processing plant; and today, the Cold Lake Production Project is the

world's largest in situ oil sands steam-generation and bitumen-production operation. Second place, after the Syncrude project, the Cold Lake Project produces about 100,000 barrels of bitumen per day, with production averaging about 35 million barrels per year. Over 30 years of research and technological developments by Imperial, along with 10 years of commercial production, have resulted in various technological schemes including: the development of cyclic steam stimulation (CSS) assisted by formation fracturing; improved water processing techniques; upgrading of well casing designs for cyclic thermal stress; optimization of pad designs and satellite facilities, among other innovations. More than 2,200 producing wells have been directionally drilled from satellite pads at the Cold Lake Production Project. At present, the cyclic steam-stimulation process used at Cold Lake consists of injection of steam under conditions of high temperature and pressure through well bores into the oil sands at depth. Once bitumen melts, and the viscosity is reduced, surface pumps lift the hot water-and-bitumen mixture through the same wellbore to the surface, where separation and processing occurs. Bitumen is blended with lighter hydrocarbons and shipped by pipeline principally to markets in the U.S. Midwest and secondarily to Canadian refineries.

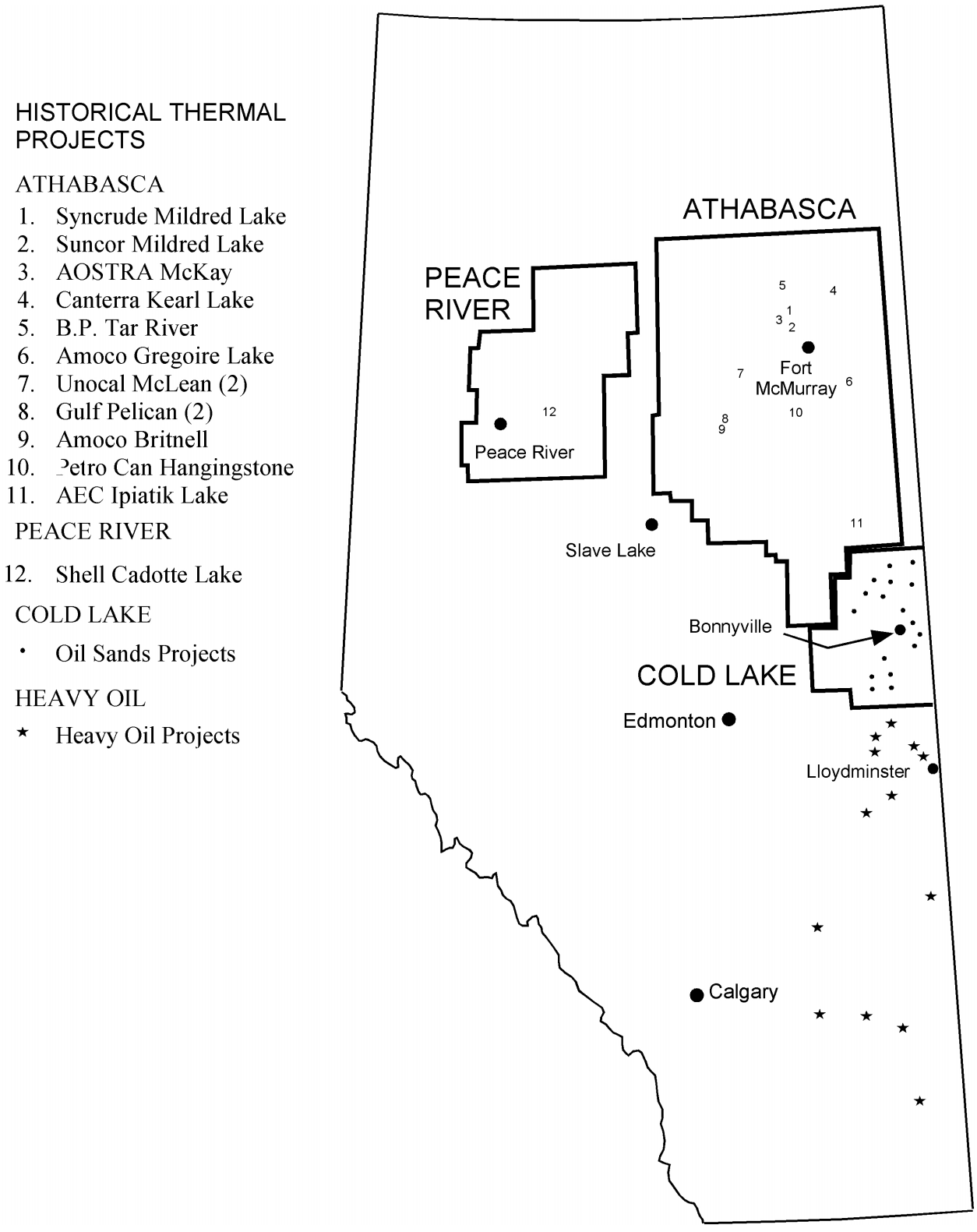

Figure 2.1 Location map showing Alberta oil sands and heavy oil areas with historical thermal projects to December 1988 (from Houlihan and Evans, 1988).

3. The Future

In the past major companies involved with the oil sands development and production were, for the most part, the large integrated companies or consortia, such as Imperial Oil Ltd., Suncor Energy Ltd. and Syncrude. More recently, in today's market of improved technological methods for recovery and upgrading and improved environmental safeguards (Gray, 1999; Luhning and Luhning, 1999), a number of small and medium-size companies have invested in the oil sands (Table 1) (Ross, 1998). At present, according the Oil Sands Developers of Alberta, $24 billion Canadian in projects have been announced for the next decade in the Athabasca, Cold Lake and Peace River oil sands deposits. Part of this shift to development of heavy oil and oil sands, in addition to the technological advances, has been the renovation of North American refineries to increasingly process the heavier crude (Ross, 1998; Auchinleck, 1999; Fisher, 1999). During the previous twenty years, production of crude oil from the oil sands of Alberta have increased ten-fold (Polikar *et al*., 1998). Future production of synthetic crude oil from mining and in situ projects is anticipated to increase even more significantly, as refined products from the oil sands replace the depleting conventional oil and gas reserves of the Province (Polikar *et al.*, 1998). Along with the technological development for in situ recovery have been improved developments in the mining, upgrading and extraction processes, along with more efficient handling and processing procedures (Sadler and Houlihan, 1998). In September 1999 a dedicated issue of the Journal of Canadian Petroleum Technology, "The Canadian Advantage: Oil Sands," highlighted some of these improved methods of in situ and mining operations (Newello, 1999). Overviews included a discussion of Suncor's Project Millennium (George, 1999); updates on the UTF project (Ito and Suzuki, 1999; Komery *et al*., 1999 and O'Rourke *et al*., 1999); secondary bitumen recovery from tailings (Cheng *et al*., 1999); and permeability damage effects associated with thermal recovery at Cold Lake (Zhou *et al*., 1999).

Coupled with these factors are environmental concerns, mainly focussed on land disturbance, management and reclamation, water and air quality. Land disturbance largely relates to open pit development and overburden and tailings disposal. Water quality is an issue related to tailings disposal from pit mining and for thermal in situ projects obtaining sources of non-potable water, groundwater impacts, and water recycling technology. Finally, air quality relates mainly to emissions of carbon dioxide and other greenhouse gases (Polikar *et al*., 1998; Sadler and Houlihan, 1998).

At present, the responsibility for environmental issues is shared by Alberta Environmental Protection along with the Alberta Energy and Utilities Board (EUB), through their regulatory review, application and approval process. At present, each new project has to conduct an Environmental Impact Assessment (EIA). In addition, government and industry stakeholders are building environmental databases to be able to assess background environmental levels and thresholds for various environmental impacts associated with both open-pit mining and in situ production plants (Sadler and Houlihan, 1998). Forecasts show substantial increases in production of synthetic crude oil and other byproducts from the oil sands in the next ten years. This increased production and activity will have to be balanced with environmental and socio-economic concerns to bring about a prudent planning and mitigation of major issues involved with the development of this vast resource (Sadler and Houlihan, 1998).

Operator	Development*	Deposit Area	Investment	Start-up	Description
Alberta Energy Co. Ltd.	AEC East: Foster Creek	Cold Lake	$13 million	Complete	In situ bitumen (SAGD): pilot plant 1,500 bbls/d
			$200 million	1998-2000	Commercial project: 30,000 bbls/d
	AEC East: Frog Lake	Cold Lake	$12 million	1997-1998	In situ bitumen: increase production to 2,800 bbls/d
Amber Energy Inc.		Athabasca	$300 million	1996-1999	In situ bitumen: pilot plant 6,000 - 9,000 bbls/d
Amoco Canada Ltd.	Primrose - Wolf Lake	Cold Lake	$175 million	1996-1998	In situ bitumen: staged production to 55,000 bbls/d
			$500 million	1998-2000+	
	Brintnell	Athabasca	$100 million	1996-2000	In situ bitumen: production up to 15,000 bbls/d
Black Rock Ventures Ltd.		Cold Lake	$8 million	1996-1997	In situ bitumen (SAGD): pilot plant 600 bbls/d
Canada Oil Sands Co. Ltd.	Hangingstone	Athabasca	$69 million	1997-1998	In situ bitumen (SAGD): pilot plant 2,000 bbls/d
			$128 million	1998-2004	Phase 2: increase to 10,000 bbls/d
Canadian Natural Resources Ltd.	Pelican Lake (inc. Cold Lk)	Athabasca	$800 million	1997-2002	In situ bitumen using primary production
(CNRL)					Commercial project: 60,000 bbls/d of bitumen
	Cold Lake/Beartrap	Cold Lake		1997-2002	In situ bitumen using primary production
					Ultimate production of 20,000 bbls/d of bitumen
	Mic Mac Project	Athabasca	$6.5 billion	planned	In situ bitumen and surface mining (truck and shovel)
					commercial project: 300,000 bbls/d of bitumen (? 7-10 yrs)
Gulf Canada Resources Ltd.	Surmont	Athabasca	$30 million	1996-1997	In situ bitumen (SAGD): pilot plant 1,200 bbls/d
(with Total-Fina)			$1.1 billion	2001-2008	Phase 2: increase to 100,000 bbls/d of bitumen
Imperial Oil Ltd.	Cold Lake Phases 1-10	Cold Lake	$250 million	1996-1997	In situ bitumen: increase production to 130,000 bbls/d
	Cold Lake Mahkeses		$550 million	2000-2002	In situ bitumen: add 30,000 bbls/d plus cogen power
	Cold Lake Phases 14-15		$300 million	Post 2001	Production increase
Koch Oil Sands L.P.	Elk Point	Cold Lake	$200 million	1996-1998	In situ bitumen: 40,000 bbls/d
(with UTS Energy)	Fort Hills (Leases 5 & 52)	Athabasca	$1 billion	1998-2004	New bitumen mine: 90,000 bbls/d
Mobil Oil Canada Ltd.	Kearl Mine (Lease 36)	Athabasca	$1 billion	2000-2003	New bitumen mine: 130,000 bbls/d
	Bonnyville-Iron River	Cold Lake	$16 million	1996-1997	In situ bitumen (SAGD): test program on 54 wells
Murphy Oil Company Ltd.	Lindbergh	Cold Lake	$157 million	1996-1999	In situ bitumen: commercial project
Norman Energy Resources	Cold Lake	Cold Lake	$40 million	1996-1998	In situ bitumen: pilot plant
	Provost/Lindbergh	Cold Lake	$350 million		Commercial project
Northstar Energy Corporation	Dover (formerly UTF)	Athabasca	$10 million	Complete	In situ bitumen (SAGD): increase production to 3,000 bbls/d
Numac Energy Inc.	Manalokan	Cold Lake	$57 million	1996-1998	In situ bitumen; pilot plant
PanCanadian Petroleum Ltd.	Christina Lake	Athabasca	$250 million	1997-2000	In situ bitumen: 50,000 bbls/d
	Elk Point, Lingbergh,	Cold Lake	$100 million	1996-2000+	In situ bitumen: add 4,500 bbls/d to 10,500 bbls/d; increase
	Frog Lake, Marwayne				to 25,000 bbls/d beyond the year 2000
Petro-Canada Ltd.	MacKay River	Athabasca	$210 million	1997-2007	In situ bitumen (SAGD): 20,000 bbls/d of bitumen
Ranger Oil Ltd.	Lindbergh, Elk Point,	Cold Lake	$225 million	1996-2000	In situ bitumen (SAGD): 10,000 bbls/d to 50,000 bbls/d
	Wolf Lake, Cold Lake				
Shell Canada Ltd.Joint Venture -	Muskeg River Mine	Athabasca	$1.2 billion	1998-2002	New bitumen mine & extraction complex:
Albian Sands Energy Inc.	(Lease 13)				155,000 bbls/d of bitumen
Shell Canada Ltd.	Peace River	Peace River	$43 million	Complete	In situ bitumen: project increase production to 12,000 bbls/d
			$120 million	1997-2002	Expand plant and reserves
Suncor Energy Ltd.	Fort McMurray Plant	Athabasca	$200 million	Complete	Environmental: reduce S02 emission; reclamation
	Steepbank Mine	Athabasca	$360 million	1997-2001	New bitumen mine and expansion
	Project Millenium	Athabasca	$190 million	1997-1999	Enhance plant: increase output to 130,000 bbls/d
Syncrude Canada Ltd.	Syncrude 21: North Mine,	Athabasca	$500 million	1998-1999	New bitumen mine and upgrading:increase production
	DB1 (Mildred Lake)				to 82 million bbls/year of light sweet crude
	Syncrude 21: Aurora Mine	Athabasca	$1.5 billion	1998-2004	New bitumen mine, extraction and upgraded:
					increase production to 125 million bbls/y by 2005
	Syncrude 21: other	Athabasca	$1 billion	1997-2007	Continuous improvement, maintain and sustain program
Texaco Canada Petroleum Ltd.	Frog Lake	Cold Lake	$35 million	-1997	In situ bitumen: pilot plant
*Note: includes announced					
projects only, current to June 30,					
1998. Some of these projects					
may be delayed, deferred or					
shut-in (modified from Ross, 1998)					

Table 3.1. Current Alberta oil sands and heavy oil projects to June 30, 1998 (modified from Ross, 1998, based upon information from the Oil Sands Developers of Alberta)

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